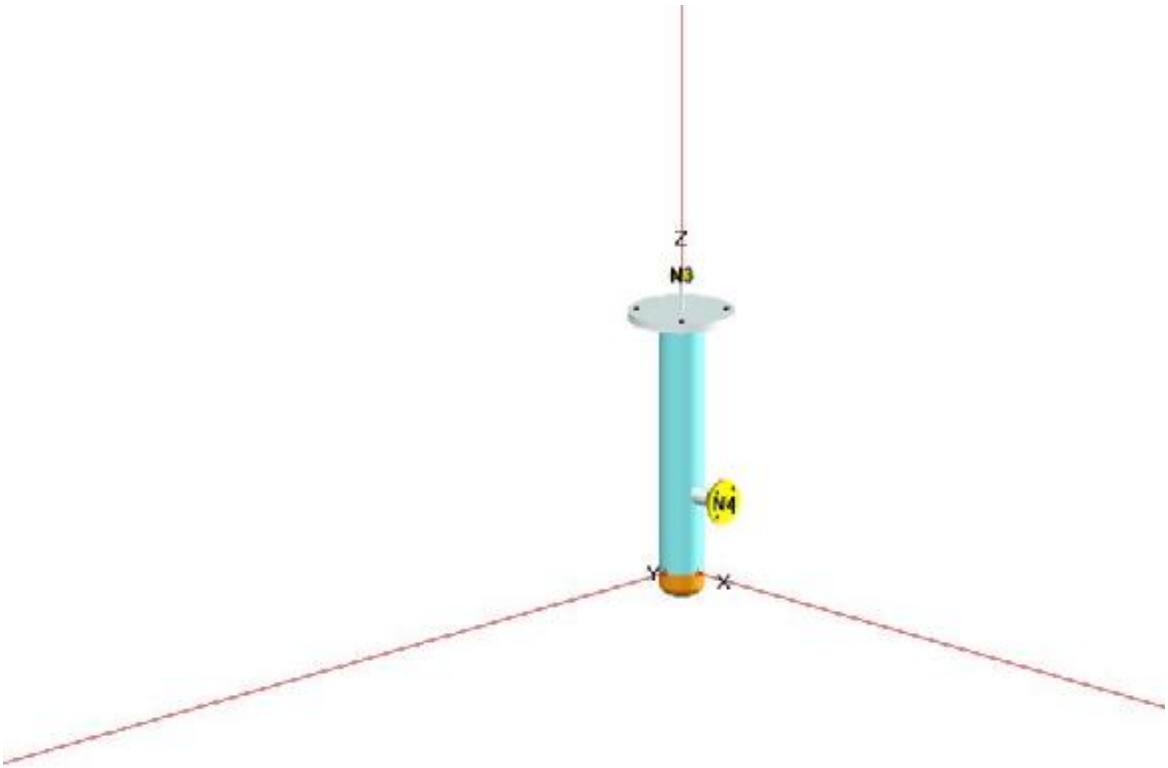
ASTRA EVANGELISTA S.A.

PLANTA CANNING



COMPRESS Pressure Vessel Design Calculations

Vessel No: V-02
Customer: FIUBA
Contract:
Designer: HRI/SEG
Date: lunes, agosto 09, 2004

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Deficiencies Summary

Deficiencies for Hydrostatic Test

Flange #1: Stress (Pm + Pb)=(1.266,162+5.286,277) during the shop hydro test exceeds 3.606,744 kg/cm^2

Nozzle Schedule

Nozzle mark	Service	Size	Materials								
			Nozzle	Impact	Norm	Fine Grain	Pad	Impact	Norm	Fine Grain	Flange
N3	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#
N4	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)		
N3	21,34	2,77	2,42	Yes	Yes	16,00*	N/A		N/A	N/A	0,00	Exempt
N4	60,32	2,77	1,59	Yes	Yes	2,77	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 Ellipsoidal Head #1 and Bolted Cover #1

Identifier	P Design (kg/cm²)	T Design (°C)	MAWP (kg/cm²)	MAP (kg/cm²)	MAEP (kg/cm²)	T_e external (°C)	MDMT Rating		Corrosion Allowance (mm)	Impact Test
							MDMT (°C)	Exemption		
Bolted Cover #1	7,0	343,3	9,05	9,63	18,05	343,3	-103,9	Note 1	0,00	No
Cylinder #1	2,0	120,0	28,86	29,61	6,66	120,0	0,0	Note 2	0,00	No
Straight Flange on Ellipsoidal Head #1	2,0	120,0	38,82	39,87	8,66	120,0	0,0	Note 4	0,00	No
Ellipsoidal Head #1	2,0	120,0	22,37	22,98	6,46	120,0	0,0	Note 3	0,00	No
Flange #1	2,0	120,0	2,71	2,71	7,63	120,0	-28,9	Note 5	0,00	No
VENT (N3)	7,0	343,3	8,79	9,62	18,05	343,3	-28,9	Note 6	0,00	No
U.C. (N4)	2,0	120,0	15,33	19,33	6,66	120,0	0,0	Note 7	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 2,71 kg/cm^2 @ 120,0°C

Chamber MAP cold & new is 2,71 kg/cm^2 @ 21,1°C

Chamber MAEP is 6,46 kg/cm^2 @ 120,0°C
Vacuum rings did not govern the external pressure rating.

Notes for MDMT Rating:

Note #	Exemption	Details
1.	Bolted cover is impact test exempt to -103,8889 °C per UCS-66(b)(3) (coincident ratio = 0,28121).	
2.	Impact test exempt per UHA-51(g)(coincident ratio = 0,07854)	
3.	Straight Flange governs MDMT	
4.	Impact test exempt per UHA-51(g)(coincident ratio = 0,05842)	
5.	Flange is impact test exempt per UG-20(f) UCS-66 governing thickness = 0,1090551 in (2,77 mm)	Bolts rated MDMT per Fig UCS-66 note (e) = -48,33333 °C
6.	Impact test exempt per UHA-51(g)(coincident ratio = 0,00647)	
7.	Impact test exempt per UHA-51(g)(coincident ratio = 0,07862)	

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: 0,00 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:	1,00 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:	No
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:	No
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	400,00 OD	16,00	16,00*	14,10	1,0000	Internal
Cylinder #1	SA-312 TP304 Wld pipe	168,27 OD	880,00	2,77	1,16	0,8500	External
Straight Flange on Ellipsoidal Head #1	SA-240 304	168,27 OD	50,80	2,77	1,16	0,8500	External
Ellipsoidal Head #1	SA-240 304	168,27 OD	42,86	1,59*	0,45	0,8500	External

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	15,71	15,71	0,00	0,00	0,00	0,00	0,02
Cylinder #1	10,11	10,11	0,00	0,00	0,00	0,00	18,54
Ellipsoidal Head #1	1,00	1,00	0,00	0,00	0,00	0,00	1,64
TOTAL:	**26,81**	**26,81**	**0,00**	**0,00**	**0,00**	**0,00**	**20,21**

* 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	0,63	0,00	0,00	0,00	0,00	0,00
Cylinder #1	10,68	3,09	0,00	0,00	0,00	0,00	0,00
Ellipsoidal Head #1	0,00	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL:	**10,68**	**3,72**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

Vessel operating weight, Corroded: 41 kg
Vessel empty weight, Corroded: 41 kg
Vessel empty weight, New: 41 kg
Vessel test weight, New: 61 kg

Vessel center of gravity location (from datum)

Vessel Lift Weight, New: 41 kg
Center of Gravity: 708,02 mm

Vessel Capacity

Vessel Capacity** (New): 20 liters
Vessel Capacity** (Corroded): 20 liters
**The vessel capacity does not include volume of nozzle, piping or other attachments.

Hydrostatic Test

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

Shop hydrostatic test gauge pressure is 8,39 kg/cm^2 at 21,11 °C (the chamber MAWP = 2,71 kg/cm^2). External pressure governs the test pressure per UG-99(f).

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	8,42	0,03	1,0261	1,30	286,939	1.898,286	No
Straight Flange on Ellipsoidal Head #1	8,42	0,03	1,0271	1,30	251,600	1.898,286	No
Ellipsoidal Head #1	8,42	0,03	1,0271	1,30	393,555	1.898,286	No
Bolted Cover #1	8,42	0,03	1,0638	1,30	1.230,296	3.606,744	No
Flange #1 (1)	8,42	0,03	1,0000	1,30	6.552,438	3.606,744	***Yes***
U.C. (N4)	8,41	0,01	1,0261	1,30	624,886	2.847,429	No
VENT (N3)	8,42	0,02	1,2319	1,30	NI	NI	NI

Notes:
(1) Flange #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 -12,22 °C so the brittle fracture provision of UG-99(h) has been met.

Vacuum Summary

Component	Line of Support	Elevation above Datum (mm)	Length Le (mm)
Bolted Cover #1	-	898,77	N/A
-	1/3 depth of Bolted Cover #1	882,77	N/A
Cylinder #1 Top	-	880,00	947,33
Cylinder #1 Bottom	-	0,00	947,33
Straight Flange on Ellipsoidal Head #1 Top	-	0,00	947,33
Straight Flange on Ellipsoidal Head #1 Bottom	-	-50,80	947,33
-	1/3 depth of Ellipsoidal Head #1	-64,56	N/A
Ellipsoidal Head #1	-	-93,66	N/A

Note
For main components, the listed value of 'Le' is the largest unsupported length for the component.

Bolted Cover #1

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Component: Bolted Cover
Material specification: SA-516 70 (ASME II-D p. 14, ln. 31)
Bolted cover is impact test exempt to -103,8889 °C per UCS-66(b)(3) (coincident ratio = 0,28121).

Internal design pressure: P = 7,0307 kg/cm^2 @ 343,33°C
External design pressure: P_e = 1,0546 kg/cm^2 @ 343,33°C

Static liquid head:

P_{th}=0,0230 kg/cm^2(SG=1,0000, H_s=230,00 mm, Horizontal test head)

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

Design MDMT = -28,89°C
Rated MDMT = -103,89°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 = 15,7 kg corr = 15,7 kg

Head outside diameter = 400,00 mm
Cover thickness = 16,00 mm

Design thickness, (at 343,33 °C) UG-34 (c)(2), flange operating

t = d*Sqr(C*P/(S*E) + 1,9*W*h_G/(S*E*d^3)) + Corrosion
= 9,84252*Sqr(0,3*100/(18.800,00*1) + 1,9*7.604,703*1,968504/(18.800,00*1*9,84252^3)) + 0
= 0,5552 in (14,10 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
= 9,84252*Sqr(1,9*4.471,643*1,968504/(20.000,00*1*9,84252^3)) + 0
= 0,2915 in (7,40 mm)

Maximum allowable working pressure, (at 343,33 °C)

P = (S*E/C)*((t/d)^2 - (1,9*W*h_G/(S*E*d^3))) - P_s
= (18.800,00*1/0,3)*((0,6299213/9,84252)^2 - (1,9*9.787,717*1,968504/(18.800,00*1*9,84252^3))) - 0
= 128,706 psi (9,05 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)*((0,6299213/9,84252)^2 - (1,9*10.412,44*1,968504/(20.000,00*1*9,84252^3)))
= 136,921 psi (9,63 kg/cm^2)

Design thickness for external pressure, (at 343,33 °C) U-2(g)

t = d*Sqr(C*P_a/(S*E)) + Corrosion
= 9,84252*Sqr(0,3*15/(18.800,00*1)) + 0
= 0,1523 in (3,87 mm)

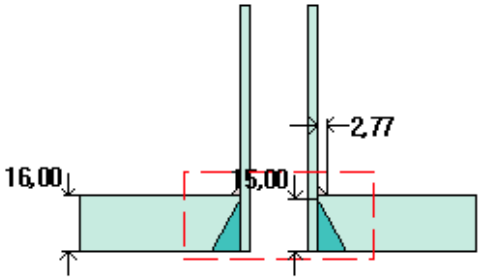
Maximum allowable external pressure, (At 343,33 °C) U-2(g)

$P_a = (S*E/C)*(t/d)^2$
$= (18.800,00*1/0,3)*(0,6299213/9,84252)^2$
$= 256,683$ psi (18,05 kg/cm^2)

VENT (N3)

ASME Section VIII Division 1, 2001 Edition, A03 Addenda

$t_{w(lower)}$ = 15,00 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:	125,00 psi @ 650,00°F (8,79 kg/cm^2 @ 343,33°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:	0,6299 in (16,00 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:	4,8909 in (124,23 mm)
Distance to head center, R:	0,0000 in (0,00 mm)

Reinforcement Calculations for Internal Pressure

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

UG-39 Area Calculation Summary (cm^2) For P = 8,79 kg/cm^2 @ 343,33 °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
Nozzle to shell groove (Lower)	1,94	15,00	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 = 9,62 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
Nozzle to shell groove (Lower)	1,94	15,00	weld size is adequate

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

Reinforcement Calculations for External Pressure

UG-39 Area Calculation Summary (cm^2) For Pe = 18,05 kg/cm² @ 343,33 °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
Weld strength calculations are not required for external pressure

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
Nozzle to shell groove (Lower)	1,94	15,00	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:	6" Sch 5S DN 150

Impact test exempt per UHA-51(g)(coincident ratio = 0,07854)

Internal design pressure: P = 2 kg/cm^2 @ 120°C
External design pressure: P_e = 1.05461 kg/cm^2 @ 120°C

Static liquid head:

P_{th}=0,0311 kg/cm^2(SG=1,0000, H_s=311,37 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 = 10,1736 kg corr = 10,1736 kg
Capacity: New = 18,3024 liters corr = 18,3024 liters

OD = 168,27 mm
Length L_c = 880,00 mm
t = 2,77 mm

Design thickness, (at 120,00°C) Appendix 1-1

t = $P*R_o/(S*E + 0,40*P)$ + Corrosion
= 2,0000*84,14/(1164,8464*0,85 + 0,40*2,0000) + 0,00
= 0,1702 mm

Maximum allowable working pressure, (at 120,00°C) Appendix 1-1

P = $S*E*t/(R_o - 0,40*t) - P_s$
= 1164,8464*0,85*2,4237 / (84,14 - 0,40*2,4237) - 0,0000
= 28,8557 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*2,4237 / (84,14 - 0,40*2,4237)
= 29,6081 kg/cm^2

External Pressure, (Corroded & at 120,00°C) UG-28(c)

L/D_o = 947,3278/168,2700 = 5,6298
D_o/t = 168,2700/1,157318 = 145,3965
From table G: A = 0,000122
From table HA-1: B = 1635,7080

P_a = 4*B/(3*(D_o/t))
= 4*1635,7080/(3*(168,2700/1,157318))
= 15,0000 psi (1,0546 kg/cm^2)

Design thickness for external pressure P_a = 1,0546 kg/cm^2

= t + Corrosion = 1,157318 + 0,00 = 1,16 mm

Maximum Allowable External Pressure, (Corroded & at 120,00°C) UG-28(c)

L/D_o = 947,3278/168,27 = 5,6298
D_o/t = 168,27/2,4238 = 69,4255
From table G: A = 0,000368
From table HA-1: B = 4935,9614

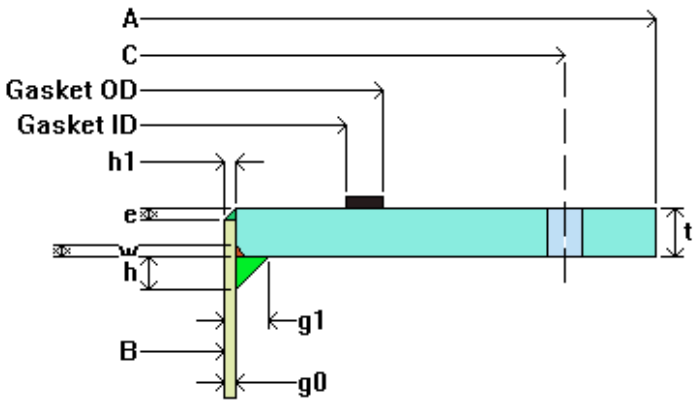
P_a = 4*B/(3*(D_o/t))
= 4*4935,9614/(3*(168,27/2,4238))
= 94,7963 psi (6,6648 kg/cm^2)

Flange #1

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

Flange is attached to:	Cylinder #1 (Top)	
Flange material specification:	SA-516 70 (ASME II-D p. 14, ln. 31)	
Bolt material specification:	SA-193 B7 Bolt <= 2 1/2 (ASME II-D p. 382, ln. 37)	
Internal design pressure, P:	28,44669 psi @ 248 °F	(2,00 kg/cm^2 @ 120,00 °C)
Required flange thickness: t_r=	12,27 mm	
Maximum allowable working pressure, MAWP:	38,50311 psi @ 248 °F	(2,71 kg/cm^2 @ 120,00 °C)
Maximum allowable pressure, MAP:	38,50311 psi @ 70 °F	(2,71 kg/cm^2 @ 21,11 °C)
External design pressure, P_e	15 psi @ 248 °F	(1,05 kg/cm^2 @ 120,00 °C)
Maximum allowable external pressure, MAEP:	108,5722 psi @ 248 °F	(7,63 kg/cm^2 @ 120,00 °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:	-28,89 °C	Flange material is not normalized
		PWHT is not performed
Estimated weight:	New = 10,65942 kg	corroded = 10,65942 kg

Flange dimensions, new



flange OD	A = 400,00 mm
bolt circle	C = 350,00 mm
gasket OD	= 250,00 mm
gasket ID	= 230,00 mm
flange ID	B = 162,73 mm
thickness	t = 13,00 mm
bolting	4- 0,375 in dia
hub thickness	g_1 = 11,84 mm
hub thickness	g_0 = 2,77 mm
lower fillet weld	h = 9,07 mm
upper fillet weld	h1 = 2,77 mm
length	e = 2,77 mm
fillet weld	w = 2,77 mm
gasket factor	m = 0
seating stress	y = 0 kg/cm^2

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

Determination of Flange MDMT

Flange is impact test exempt per UG-20(f)
UCS-66 governing thickness = 0,1090551 in (2,77 mm)
Bolts rated MDMT per Fig UCS-66 note (e) = -48,33333 °C

The rated flange MDMT is -28,89 °C

Longitudinal bending moment on flange

$P_m = 16*M_b/(\pi*G^3)$
$= 16*0/(\pi*9,84252^3)$
$= 0,0000$ psi (0,00 kg/cm^2)

Axial load on flange

$P_r = -4*F/(\pi*G^2)$
$= -4*36,11569/(\pi*9,84252^2)$
$= -0,4747$ psi (-0,03 kg/cm^2)

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

$= P + P_s + P_m + P_r$
$= 28,44669 + 0 + 0 + -0,4747$
$= 28,4467$ 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 = 10,00 mm

$b_0 = N/2 = 0,1968503$ in (5,00 mm)

Effective gasket seating width, $b = b_0 = 0,1968503$ in (5,00 mm)

G = OD of contact face = 9,84252 in (per VIII-1, Appendix 2-5 (c)3(a) for self energizing gaskets) (250,00 mm)

$h_G = (C - G)/2 = (13,77953 - 9,84252)/2 = 1,968504$ in (50,00 mm)

$h_D = R + g_1/2 = 3,220219 + 0,466198/2 = 3,453318$ in (87,71 mm)

$h_T = (R + g_1 + h_G)/2 = (3,220219 + 0,466198 + 1,968504)/2 = 2,827461$ in (71,82 mm)

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

$H = 0,785*G^2*P$
$= 0,785*9,84252^2*28,44669$
$= 2.163,2859$ lb (981,25 kg$_f$)

$H_D = 0,785*B^2*P$
$= 0,785*6,406693^2*28,44669$
$= 916,5776$ lb (415,7526 kg$_f$)

$H_T = H - H_D$
$= 2.163,286 - 916,5776$
$= 1.246,7083$ lb (565,4974 kg$_f$)

$W_{m1} = H + H_p$
$= 2.163,286 + 0$
$= 2.163,2859$ lb (981,25 kg$_f$)

$W_{m2} = 3,14*b*G*y$
$= 3,14*0,1968503*9,84252*0$
$= 0,0000$ lb (0 kg$_f$)

Required bolt area, A_m = greater of A_{m1}, A_{m2} = 0,5582662 cm^2

$A_{m1} = W_{m1}/S_b$ = 2.163,286/25.000,00 = 8,653144E-02 in^2 (0,5582662 cm^2)

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

Total area for 4- 0,375 in dia bolts, corroded, A_b = 0,2712 in^2

$W = (A_m + A_b)*S_a/2$
= (8,653144E-02 + 0,2712)*25.000,00/2
= 4.471,6431 lb (2.028,303 kg_f)

$M_D = H_D*h_D$ = 916,5776*3,453318 = 3.165,234 lb-in (36,46729 kg-m)
$M_T = H_T*h_T$ = 1.246,708*2,827461 = 3.525,018 lb-in (40,61244 kg-m)

$H_G = W_{m1} - H$ = 2.163,286 - 2.163,286 = 0 lb (0 kg_f)

$M_G = H_G*h_G$ = 0*1,968504 = 0 lb-in (0 kg-m)

$M_o = M_D + M_T + M_G$ = 3.165,234 + 3.525,018 + 0 = 6.690,252 lb-in (77,07973 kg-m)

$M_g = W*h_G$ = 4.471,643*1,968504 = 8.802,447 lb-in (101,4147 kg-m)

Hub and Flange Factors

$h_0 = (B*g_0)^{1/2} = (6,406693*0,1090551)^{1/2} = 0,8358724$ in (21,23 mm)

From FIG. 2-7.1, where K = A/B = 15,74803/6,406693 = 2,458059

T = 1,351864 Z = 1,396664 Y = 2,293664 U = 2,520504

$h/h_0 = 0,42727$ $g_1/g_0 = 4,27488$

F = 0,8413061 V = 0,1507961 $e = F/h_0 = 1,006501$

$d = (U/V)*h_0*g_0^2 = (2,520504/0,1507961)*0,8358724*0,1090551^2$
$= 0,1661611$

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

f = 7,162902

$L = (t*e + 1)/T + t^3/d$
$= (0,511811*1,006501 + 1)/1,351864 + 0,511811^3/0,1661611$
$= 1,92764$

$S_H = f*M_o/(L*g_1^2*B)$
$= 7,162902*6.690,252/(1,92764*0,466198^2*6,406693)$
$= 17.853,81$ psi (1.255,246 kg/cm^2)

$S_R = (1,33*t*e + 1)*M_o/(L*t^2*B)$
$= (1,33*0,511811*1,006501 + 1)*6.690,252/(1,92764*0,511811^2*6,406693)$
$= 3.484,96$ psi (245,0167 kg/cm^2)

$S_T = Y*M_o/(t^2*B) - Z*S_R$
$= 2,293664*6.690,252/(0,511811^2*6,406693) - 1,396664*3.484,96$
$= 4.276,32$ psi (300,6549 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}
$0,5(S_H + S_R)$ = 10.669,39 psi (750,1315 kg/cm^2) does not exceed S_{fo}
$0,5(S_H + S_T)$ = 11.065,07 psi (777,9506 kg/cm^2) does not exceed S_{fo}

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

$S_H = f*M_g/(L*g_1^2*B)$
$= 7,162902*8.802,447/(1,92764*0,466198^2*6,406693)$
$= 23.490,48$ psi (1.651,543 kg/cm^2)

$S_R = (1,33*t*e + 1)*M_g/(L*t^2*B)$
$= (1,33*0,511811*1,006501 + 1)*8.802,447/(1,92764*0,511811^2*6,406693)$
$= 4.585,20$ psi (322,3715 kg/cm^2)

$S_T = Y*M_g/(t^2*B) - Z*S_R$
$= 2,293664*8.802,447/(0,511811^2*6,406693) - 1,396664*4.585,205$
$= 5.626,41$ psi (395,5754 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}
$0,5(S_H + S_R)$ = 14.037,84 psi (986,9572 kg/cm^2) does not exceed S_{fa}
$0,5(S_H + S_T)$ = 14.558,45 psi (1.023,559 kg/cm^2) does not exceed S_{fa}

Flange calculations for External Pressure per VIII-1, Appendix 2-11

Longitudinal bending moment on flange

$P_m = 16*M_b/(\pi*G^3)$
$= 16*0/(\pi*9,84252^3)$
= 0,0000 psi (0,00 kg/cm^2)

Axial load on flange

$P_r = 4*F/(\pi*G^2)$
$= 4*36,11569/(\pi*9,84252^2)$
= 0,4747 psi (0,03 kg/cm^2)

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

$= P + P_s + P_m + P_r$
$= 15 + 0 + 0 + 0,4747$
= 15,4747 psi (1,09 kg/cm^2)

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 = 10,00 mm

$b_0 = N/2$ = 0,1968503 in (5,00 mm)

Effective gasket seating width, $b = b_0$ = 0,1968503 in (5,00 mm)

G = OD of contact face = 9,84252 in (per VIII-1, Appendix 2-5 (c)3(a) for self energizing gaskets) (250,00 mm)

$h_G = (C - G)/2 = (13,77953 - 9,84252)/2$ = 1,968504 in (50,00 mm)

$h_D = R + g_1/2 = 3,220219 + 0,466198/2$ = 3,453318 in (87,71 mm)

$h_T = (R + g_1 + h_G)/2 = (3,220219 + 0,466198 + 1,968504)/2$ = 2,827461 in (71,82 mm)

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

$H = 0,785*G^2*P$
$= 0,785*9,84252^2*15,4747$
= 1.176,8049 lb (533,7897 kg_f)

$H_D = 0,785*B^2*P$
$= 0,785*6,406693^2*15$
= 483,3134 lb (219,2273 kg_f)

$H_T = H - H_D$
$= 1.176,805 - 483,3134$
= 693,4916 lb (314,5625 kg_f)

$W_{m1} = H + H_p$
$= 1.176,805 + 0$
= 1.176,8049 lb (533,7897 kg_f)

$W_{m2} = 3,14*b*G*y$
$= 3,14*0,1968503*9,84252*0$
= 0,0000 lb (0 kg_f)

Required bolt area, A_m = greater of A_{m1}, A_{m2} = 0 cm^2

$A_{m1} = 0,785*G^2*(P_m - P_r)/S_b = 0/25.000,00 = 0$ in^2 (0 cm^2)

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

Total area for 4- 0,375 in dia bolts, corroded, $A_b = 0,2712$ in^2

$W = (A_{m2} + A_b)*S_a/2$
$= (0 + 0,2712)*25.000,00/2$
$= 3.390,0000$ lb (1.537,678 kg_f)

$M_o = H_D*(h_D - h_G) + H_T*(h_T - h_G)$
$= 483,3134*(3,453318 - 1,968504) + 693,4916*(2,827461 - 1,968504)$
$= 1.313,31$ lb-in (15,1309 kg-m)

$M_g = W*h_G = 3.390,00*1,968504 = 6.673,229$ lb-in (76,8836 kg-m)

Hub and Flange Factors

$h_0 = (B*g_0)^{1/2} = (6,406693*0,1090551)^{1/2} = 0,8358724$ in (21,23 mm)

From FIG. 2-7.1, where K = A/B = 15,74803/6,406693 = 2,458059

T = 1,351864 Z = 1,396664 Y = 2,293664 U = 2,520504

$h/h_0 = 0,42727$ $g_1/g_0 = 4,27488$

F = 0,8413061 V = 0,1507961 $e = F/h_0 = 1,006501$

$d = (U/V)*h_0*g_0^2 = (2,520504/0,1507961)*0,8358724*0,1090551^2$
$= 0,1661611$

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

f = 7,162902

$L = (t*e + 1)/T + t^3/d$
$= (0,511811*1,006501 + 1)/1,351864 + 0,511811^3/0,1661611$
$= 1,92764$

$S_H = f*M_o/(L*g_1^2*B)$
$= 7,162902*1.313,31/(1,92764*0,466198^2*6,406693)$
$= 3.504,74$ psi (246,4073 kg/cm^2)

$S_R = (1,33*t*e + 1)*M_o/(L*t^2*B)$
$= (1,33*0,511811*1,006501 + 1)*1.313,31/(1,92764*0,511811^2*6,406693)$
$= 684,10$ psi (48,09726 kg/cm^2)

$S_T = Y*M_o/(t^2*B) - Z*S_R$
$= 2,293664*1.313,31/(0,511811^2*6,406693) - 1,396664*684,1045$
$= 839,45$ psi (59,01915 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}
$0,5(S_H + S_R)$ = 2.094,422 psi (147,2523 kg/cm^2) does not exceed S_{fo}
$0,5(S_H + S_T)$ = 2.172,094 psi (152,7132 kg/cm^2) does not exceed S_{fo}

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

$S_H = f*M_g/(L*g_1^2*B)$
$= 7,162902*6.673,229/(1,92764*0,466198^2*6,406693)$
$= 17.808,38$ psi (1.252,052 kg/cm^2)

$S_R = (1,33*t*e + 1)*M_g/(L*t^2*B)$
$= (1,33*0,511811*1,006501 + 1)*6.673,229/(1,92764*0,511811^2*6,406693)$
$= 3.476,09$ psi (244,3933 kg/cm^2)

$S_T = Y*M_g/(t^2*B) - Z*S_R$
$= 2,293664*6.673,229/(0,511811^2*6,406693) - 1,396664*3.476,092$
$= 4.265,44$ psi (299,8899 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}
$0,5(S_H + S_R)$ = 10.642,24 psi (748,2227 kg/cm^2) does not exceed S_{fa}
$0,5(S_H + S_T)$ = 11.036,91 psi (775,9711 kg/cm^2) does not exceed S_{fa}

U.C. (N4)

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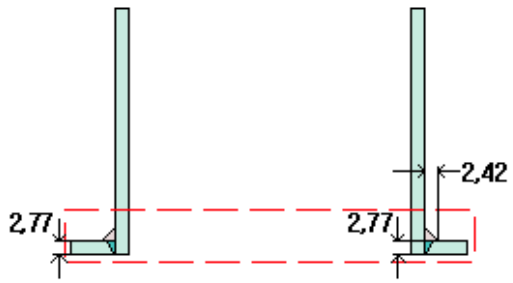
$t_{w(lower)}$ = 2,77 mm
Leg_{41} = 2,42 mm



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:	218,00 psi @ 248,00°F (15,33 kg/cm^2 @ 120,00°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:	0,0954 in (2,42 mm)
Nozzle center line offset to datum line:	10,7087 in (272,00 mm)
End of nozzle to shell center:	9,0551 in (230,00 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:	5,7427 in (145,87 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 = 15,33 kg/cm^2 @ 120,00 °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)							1,59	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})	1,70	1,70	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)							1,59	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})	1,70	1,70	weld size is adequate

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (cm^2) For Pe = 6,66 kg/cm^2 @ 120,00 °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)							1,59	2,77

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 (mm)**	**Actual weld throat size (mm)**	**Status**
Nozzle to shell fillet (Leg_{41})	1,70	1,70	weld size is adequate

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

Straight Flange on Ellipsoidal Head #1

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Component: Straight Flange
Material specification: SA-240 304 (ASME II-D p. 86, ln. 16)
Impact test exempt per UHA-51(g)(coincident ratio = 0,05842)

Internal design pressure: P = 2 kg/cm^2 @ 120°C
External design pressure: P_e = 1.05461 kg/cm^2 @ 120°C

Static liquid head:

P_{th}=0,0311 kg/cm^2(SG=1,0000, H_s=311,37 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
Circumferential joint - None UW-11(c) Type 1

Estimated weight: New = 0,5873 kg corr = 0,5873 kg
Capacity: New = 1,0566 liters corr = 1,0566 liters

OD = 168,27 mm
Length L_c = 50,80 mm
t = 2,77 mm

Design thickness, (at 120,00°C) Appendix 1-1

t = $P*R_o/(S*E + 0,40*P)$ + Corrosion
= 2,0000*84,14/(1369,0179*0,85 + 0,40*2,0000) + 0,00
= 0,1448 mm

Maximum allowable working pressure, (at 120,00°C) Appendix 1-1

P = $S*E*t/(R_o - 0,40*t) - P_s$
= 1369,0179*0,85*2,7700 / (84,14 - 0,40*2,7700) - 0,0000
= 38,8218 kg/cm^2

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

P = $S*E*t/(R_o - 0,40*t)$
= 1406,1400*0,85*2,7700 / (84,14 - 0,40*2,7700)
= 39,8745 kg/cm^2

External Pressure, (Corroded & at 120,00°C) UG-28(c)

L/D_o = 947,3278/168,2750 = 5,6296
D_o/t = 168,2750/1,157332 = 145,3990
From table G: A = 0,000122
From table HA-1: B = 1635,7134

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P_a = 4*B/(3*(D_o/t))
= 4*1635,7134/(3*(168,2750/1,157332))
= 14,9998 psi (1,0546 kg/cm^2)

Design thickness for external pressure P_a = 1,0546 kg/cm^2

= t + Corrosion = 1,157332 + 0,00 = 1,16 mm

Maximum Allowable External Pressure, (Corroded & at 120,00°C) UG-28(c)

L/D_o = 947,3278/168,27 = 5,6296
D_o/t = 168,27/2,7700 = 60,7491
From table G: A = 0,000434
From table HA-1: B = 5611,2109

P_a = 4*B/(3*(D_o/t))
= 4*5611,2109/(3*(168,27/2,7700))
= 123,1560 psi (8,6587 kg/cm^2)

% Extreme fiber elongation - UHA-44

= (50 * t / R_f) * (1 - R_f / R_o)
= (50 * 2,77 / 82,7525) * (1 - 82,7525 / ∞)
= 1,6737

V-02

Ellipsoidal Head #1

ASME Section VIII, Division 1, 2001 Edition, A03 Addenda

Component:	Ellipsoidal Head
Material Specification:	SA-240 304 (ASME II-D p.86, ln. 16)

Straight Flange governs MDMT

Internal design pressure: P = 2 kg/cm^2 @ 120 °C
External design pressure: P_e = 1,0546 kg/cm^2 @ 120 °C

Static liquid head:

P_s= 0 kg/cm^2 (SG=1, H_s=0 mm Operating head)
P_{th}= 0,0312 kg/cm^2 (SG=1, H_s=312,55 mm Horizontal test head)

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

Design MDMT = 0°C	No impact test performed
Rated MDMT = 0°C	Material is not normalized
	Material is not produced to fine grain practice
	PWHT is not performed
	Do not Optimize MDMT / Find MAWP

Radiography:	Category A joints -	Seamless No RT
	Head to shell seam -	None UW-11(c) Type 1

Estimated weight*:	new = 1 kg	corr = 1 kg
Capacity*:	new = 1,6 liters	corr = 1,6 liters

* includes straight flange

Outer diameter	=	168,28 mm
Minimum head thickness	=	1,59 mm
Head ratio D/2h	=	2 (new)
Head ratio D/2h	=	2 (corroded)
Straight flange length L_{sf}	=	50,8 mm
Nominal straight flange thickness t_{sf}	=	2,77 mm

Insulation thk*:	0 mm	density: 0 kg/m^3	weight: 0 kg
Insulation support ring spacing:	0 mm	individual weight: 0 kg	total weight: 0 kg
Lining/ref thk*:	0 mm	density: 0 kg/m^3	weight: 0 kg

* includes straight flange if applicable

Results Summary

The governing condition is UG-16.

Minimum thickness per UG-16	=	1,59 mm + 0 mm = 1,59 mm
Design thickness due to internal pressure (t)	=	0,14 mm
Design thickness due to external pressure (t_e)	=	0,45 mm
Maximum allowable working pressure (MAWP)	=	22,371 kg/cm^2
Maximum allowable pressure (MAP)	=	22,9776 kg/cm^2
Maximum allowable external pressure (MAEP)	=	6,4551 kg/cm^2

K (Corroded)

K = (1/6)*[2 + (D / (2*h))^2]
= (1/6)*[2 + (165,1 / (2*41,27))^2]
= 1

K (New)

K = (1/6)*[2 + (D / (2*h))^2]
= (1/6)*[2 + (165,1 / (2*41,27))^2]

V-02

= 1

Design thickness for internal pressure, (Corroded at 120 °C) Appendix 1-4(c)

t = $P*D_o*K / (2*S*E + 2*P*(K - 0,1)) + Corrosion$
= $2*168,28*1 / (2*1369,016*0,85 + 2*2*(1 - 0,1)) + 0$
= 0,14 mm

The head internal pressure design thickness is 0,14 mm.

Maximum allowable working pressure, (Corroded at 120 °C) Appendix 1-4(c)

P = $2*S*E*t / (K*D_o - 2*t*(K - 0,1)) - P_s$
= $2*1369,016*0,85*1,59 / (1*168,28 - 2*1,59*(1 - 0,1)) - 0$
= 22,371 kg/cm^2

The maximum allowable working pressure (MAWP) is 22,371 kg/cm^2.

Maximum allowable pressure, (New at 21,11 °C) Appendix 1-4(c)

P = $2*S*E*t / (K*D_o - 2*t*(K - 0,1)) - P_s$
= $2*1406,138*0,85*1,59 / (1*168,28 - 2*1,59*(1 - 0,1)) - 0$
= 22,9776 kg/cm^2

The maximum allowable pressure (MAP) is 22,9776 kg/cm^2.

Design thickness for external pressure, (Corroded at 120 °C) UG-33(d)

Equivalent outside spherical radius (R_o)
R_o = K_o*D_o
= 0,8833 * 168,28
= 148,64 mm

A = $0,125 / (R_o/t)$
= $0,125 / (148,64/0,44)$
= 0,000374

From Table HA-1: B=352,5027

P_a = $B/(R_o/t)$
= $352,5027/(148,64/0,44)$
= 1,0546 kg/cm^2

t = 0,44 mm + Corrosion = 0,44 mm + 0 mm = 0,44 mm

Check the external pressure per UG-33(a)(1) Appendix 1-4(c)

t = $1,67*P_e*D_o*K / (2*S*E + 2*1,67*P_e*(K - 0,1)) + Corrosion$
= $1,67*1,0546*168,28*1 / (2*1369,016*1 + 2*1,67*1,0546*(1 - 0,1)) + 0$
= 0,11 mm

The head external pressure design thickness (t_e) is 0,44 mm.

Maximum Allowable External Pressure, (Corroded at 120 °C) UG-33(d)

Equivalent outside spherical radius (R_o)
R_o = K_o*D_o
= 0,8833 * 168,28
= 148,64 mm

A = $0,125 / (R_o/t)$

V-02

= 0,125 / (148,64/1,59)
= 0,001337

From Table HA-1: B=603,4406

P_a = $B/(R_o/t)$
= 603,4406/(148,64/1,59)
= 6,4551 kg/cm^2

Check the Maximum External Pressure, UG-33(a)(1) Appendix 1-4(c)

P = $2*S*E*t / ((K*D_o - 2*t*(K - 0,1))*1,67) - P_{s2}$
= 2*1369,016*1*1,59 / ((1*168,28 - 2*1,59*(1 - 0,1))*1,67) - 0
= 15,7598 kg/cm^2

The maximum allowable external pressure (MAEP) is 6,4551 kg/cm^2.

UHA-44(a)(2)(a) Forming Strain

= $(75*t / R_f)*(1 - R_f / R_o)$
= (75*2,77 / 29,45)*(1 - 29,45 / ∞)
= 7,0541%

V-02