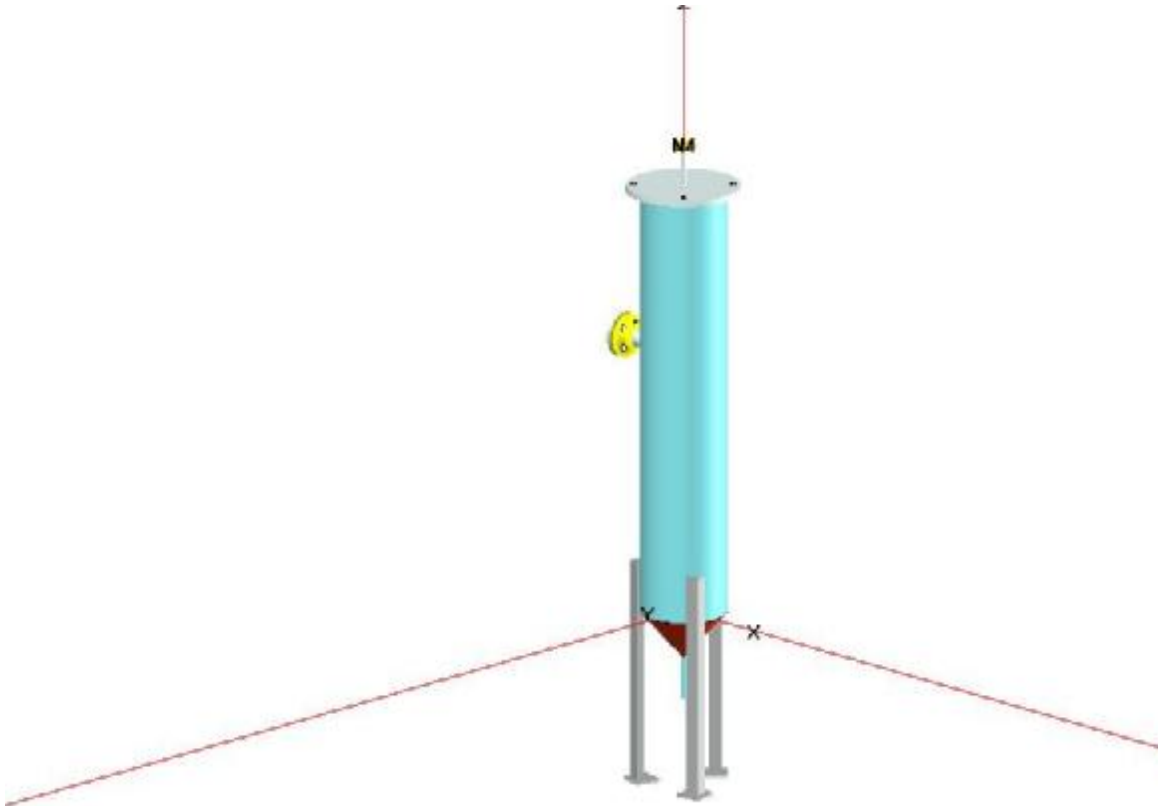


ASTRA EVANGELISTA S.A.

PLANTA CANNING



COMPRESS Pressure Vessel Design Calculations

Vessel No: V-01
Customer: FIUBA
Contract:
Designer: HRI/SEG
Date: lunes, agosto 09, 2004

Table Of Contents

1. [Deficiencies Summary](#)
2. [Nozzle Schedule](#)
3. [Nozzle Summary](#)
4. [Pressure Summary](#)
5. [Revision History](#)
6. [Settings Summary](#)
7. [Thickness Summary](#)
8. [Weight Summary](#)
9. [Hydrostatic Test](#)
10. [Welded Cover #1](#)
11. [Cylinder #1](#)
12. [Legs #1](#)
13. [Transition #1](#)
14. [Cylinder #2](#)
15. [VENT \(N3\)](#)
16. [U.C. \(N4\)](#)

Deficiencies Summary

No deficiencies found.

Nozzle Schedule

Nozzle mark	Service	Size	Materials								
			Nozzle	Impact	Norm	Fine Grain	Pad	Impact	Norm	Fine Grain	Flange
N3	VENT	0,750" Sch 160 DN 20	SA-106 B Smls pipe	No	No	No	N/A	N/A	N/A	N/A	SW A105 150#
N4	U.C.	2" Sch 80 (XS) DN 50	SA-106 B Smls pipe	No	No	No	N/A	N/A	N/A	N/A	WN A105 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	26,67	5,56	5,51	Yes	Yes	9,52*	N/A		N/A	N/A	3,00	Exempt
N4	60,32	5,54	5,50	Yes	Yes	6,35	N/A		N/A	N/A	3,00	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 Welded Cover #1 and Welded Cover #1

Identifier	P Design (kg/cm ²)	T Design (°C)	MAWP (kg/cm ²)	MAP (kg/cm ²)	MDMT Rating		Corrosion Allowance (mm)	Impact Test
					MDMT (°C)	Exemption		
Welded Cover #1	2,0	80,0	2,98	6,59	-47,1	Note 1	3,00	No
Cylinder #1	2,0	80,0	16,24	35,55	-103,9	Note 2	3,00	No
Transition #1	2,0	80,0	14,59	27,79	-103,9	Note 3	3,00	No
Cylinder #2	2,0	80,0	152,83	434,38	-103,9	Note 4	3,00	No
Legs #1	2,0	80,0	2,00	N/A	N/A	N/A	N/A	N/A
VENT (N3)	2,0	80,0	2,97	6,58	-48,3	Note 5	3,00	No
U.C. (N4)	2,0	80,0	18,70	20,04	-32,6	Note 5	3,00	No

Chamber design MDMT is 0,00°C
 Chamber rated MDMT is -32,61°C

Chamber MAWP hot & corroded is 2,00 kg/cm² @ 80,0°C

Chamber MAP cold & new is 6,58 kg/cm² @ 21,1°C

This pressure chamber is not designed for external pressure.

Notes for MDMT Rating:

Note #	Exemption	Details
1.	Head impact test exemption temperature from Fig UCS-66 Curve B = -28,88889 °C Fig UCS-66.1 MDMT reduction = 18,22222 °C, (coincident ratio = 0,6719922)	UCS-66 governing thickness = 0,25 in (6,35 mm).
2.	Material is impact test exempt to -103,8889 °C per UCS-66(b)(3) (coincident ratio = 0,10528)	
3.	Material is impact test exempt to -103,8889 °C per UCS-66(b)(3) (coincident ratio = 0,10727)	
4.	Material is impact test exempt per UCS-66(d)(NPS 4 or smaller pipe)	
5.	UCS-66(b)(1)(b)	

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: 301,00 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:	2,00 mm
Juncture calculations for $\alpha > 30$ only:	Yes
Preheat P-No 1 Materials $> 1,25"$ and $\leq 1,50"$ 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
Welded Cover #1	SA-516 70	311,15 OD	9,52	9,52*	8,35	1,0000	Internal
Cylinder #1	SA-106 B Smls pipe	323,85 OD	970,00	6,35	3,32	0,8500	Internal
Transition #1	SA-516 70	26,00/323,85 OD	151,00	6,35	3,46	0,7000	Internal
Cylinder #2	SA-106 B Smls pipe	26,67 OD	150,00	5,56	3,03	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
Welded Cover #1	5,63	3,86	0,00	0,00	0,00	0,00	0,03
Cylinder #1	47,98	25,56	0,00	0,00	0,00	0,00	73,86
Transition #1	5,50	3,72	0,00	0,00	0,00	0,00	3,80
Cylinder #2	0,43	0,23	0,00	0,00	0,00	0,00	0,03
Legs #1	12,40	12,40	0,00	0,00	0,00	0,00	0,00
TOTAL:	71,95	45,76	0,00	0,00	0,00	0,00	77,71

* 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
Welded Cover #1	0,00	1,32	0,00	0,00	0,00	0,00	0,00
Cylinder #1	0,00	6,16	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:	0,00	7,48	0,00	0,00	0,00	0,00	0,00

Vessel operating weight, Corroded: 53 kg

Vessel empty weight, Corroded: 53 kg

Vessel empty weight, New: 79 kg

Vessel test weight, New: 157 kg

Vessel center of gravity location (from datum)

Vessel Lift Weight, New: 79 kg

Center of Gravity: 424,10 mm

Vessel Capacity

Vessel Capacity** (New): 78 liters

Vessel Capacity** (Corroded): 81 liters

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

Hydrostatic Test

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

Shop hydrostatic test gauge pressure is 2,60 kg/cm² at 21,11 °C (the chamber MAWP = 2,00 kg/cm²)

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)	2,65	0,05	1,0000	1,30	75,424	2.214,667	No
Transition #1	2,65	0,05	1,0000	1,30	89,563	2.404,496	No
Cylinder #2	2,63	0,03	1,0000	1,30	5,416	2.214,667	No
Welded Cover #1	2,65	0,05	1,0000	1,30	932,030	3.606,744	No
U.C. (N4)	2,62	0,02	1,0000	1,30	98,402	3.322,001	No
VENT (N3)	2,63	0,03	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 -15,94 °C so the brittle fracture provision of UG-99(h) has been met.

Welded Cover #1**ASME Section VIII Division 1, 2001 Edition, A03 Addenda**

Component: Welded Cover
 Material specification: SA-516 70 (ASME II-D p. 14, ln. 31)
 Head impact test exemption temperature from Fig UCS-66 Curve B = -28,88889 °C
 Fig UCS-66.1 MDMT reduction = 18,22222 °C, (coincident ratio = 0,6719922)
 UCS-66 governing thickness = 0,25 in (6,35 mm).

Internal design pressure: $P = 2,0000 \text{ kg/cm}^2 @ 80,00^\circ\text{C}$

Static liquid head:

$P_{th} = 0,0312 \text{ kg/cm}^2$ (SG=1,0000, $H_s = 311,92 \text{ mm}$, Horizontal test head)

Corrosion allowance: Inner C = 3,00 mm Outer C = 0,00 mm

Design MDMT = 0,00°C No impact test performed
 Rated MDMT = -47,11°C 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 = 5,6 kg corr = 3,9 kg

Head outside diameter = 311,15 mm
 Cover thickness = 9,52 mm

Factor C from Fig. UG-34, sketch (b-2), (e through g)

$$C = 0,33 * tr / ts = 0,33 * 0,0104 / 0,1319 = 0,026$$

As factor $C < 0,2$ let $C = 0,2$

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

$$t = d * \text{Sqr}(C * P / (S * E)) + \text{Corrosion}$$

$$= 12,4862 * \text{Sqr}(0,2 * 28,44669 / (20.000,00 * 1)) + 0,1181$$

$$= 0,3287 \text{ in (8,35 mm)}$$

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

$$C = 0,33 * tr / ts = 0,33 * 0,0155 / 0,1319 = 0,0388$$

As factor $C < 0,2$ let $C = 0,2$

$$P = (S * E / C) * (t / d)^2 - P_s$$

$$= (20.000,00 * 1 / 0,2) * (0,2569 / 12,4862)^2 - 0$$

$$= 42,332 \text{ psi (2,98 kg/cm}^2\text{)}$$

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

$$C = 0,33 * tr / ts = 0,33 * 0,0337 / 0,25 = 0,0445$$

As factor $C < 0,2$ let $C = 0,2$

$$P = (S * E / C) * (t / d)^2$$

$$= (20.000,00 * 1 / 0,2) * (0,375 / 12,25)^2$$

$$= 93,711 \text{ psi (6,59 kg/cm}^2\text{)}$$

Cylinder #1**ASME Section VIII Division 1, 2001 Edition, A03 Addenda**

Component: Cylinder
 Material specification: SA-106 B Smls pipe (ASME II-D p. 10, ln. 15)
 Pipe NPS and Schedule: 12" Sch 20 DN 300
 Material is impact test exempt to -103,8889 °C per UCS-66(b)(3) (coincident ratio = 0,10528)

Internal design pressure: $P = 2 \text{ kg/cm}^2 @ 80^\circ\text{C}$

Static liquid head:

$P_{th} = 0,0467 \text{ kg/cm}^2$ (SG=1,0000, $H_s = 467,50 \text{ mm}$, Horizontal test head)

Corrosion allowance: Inner C = 3,00 mm Outer C = 0,00 mm

Design MDMT = 0,00°C No impact test performed
 Rated MDMT = -103,89°C 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 = 48,1271 kg corr = 25,6318 kg
 Capacity: New = 73,7567 liters corr = 76,6284 liters

OD = 323,85 mm
 Length $L_c = 970,00 \text{ mm}$
 $t = 6,35 \text{ mm}$

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

$$\begin{aligned} t &= P \cdot R_o / (S \cdot E + 0,40 \cdot P) + \text{Corrosion} \\ &= 2,0000 \cdot 161,93 / (1202,2498 \cdot 0,85 + 0,40 \cdot 2,0000) + 3,00 \\ &= 3,3172 \text{ mm} \end{aligned}$$

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

$$\begin{aligned} P &= S \cdot E \cdot t / (R_o - 0,40 \cdot t) - P_s \\ &= 1202,2498 \cdot 0,85 \cdot 2,5565 / (161,93 - 0,40 \cdot 2,5565) - 0,0000 \\ &= 16,2367 \text{ kg/cm}^2 \end{aligned}$$

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

$$\begin{aligned} P &= S \cdot E \cdot t / (R_o - 0,40 \cdot t) \\ &= 1202,2498 \cdot 0,85 \cdot 5,5563 / (161,93 - 0,40 \cdot 5,5563) \\ &= 35,5536 \text{ kg/cm}^2 \end{aligned}$$

Design thickness = 3,32 mm

The governing condition is due to internal pressure.

The cylinder thickness of 6,35 mm is adequate.

Thickness Required Due to Pressure + External Loads

Condition	Pressure P (kg/cm ²)	Allowable Stress Before UG-23 Stress Increase (kg/cm ²)		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	1202,25	1050,59	80,00	3,0000	top	Weight	0,1308	0,1270
						Bottom	Weight	0,1289	0,1289
Operating, Hot & New	2,00	1202,25	1189,88	80,00	0,0000	top	Weight	0,1264	0,1223
						Bottom	Weight	0,1244	0,1244
Hot Shut Down, Corroded	0,00	1202,25	1050,59	80,00	3,0000	top	Weight	0,0013	0,0055
						Bottom	Weight	0,0034	0,0034
Hot Shut Down, New	0,00	1202,25	1189,88	80,00	0,0000	top	Weight	0,0030	0,0071
						Bottom	Weight	0,0051	0,0051
Empty, Corroded	0,00	1202,25	1050,59	-17,78	3,0000	top	Weight	0,0013	0,0055
						Bottom	Weight	0,0034	0,0034
Empty, New	0,00	1202,25	1189,88	-17,78	0,0000	top	Weight	0,0030	0,0071
						Bottom	Weight	0,0051	0,0051
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0,00	1202,25	1050,59	80,00	3,0000	top	Weight	0,0019	0,0021
						Bottom	Weight	0,0000	0,0000

Legs #1

Leg material:		SA-36
Leg description:		2.5x2.5x1/4 Equal Angle (Leg in)
Number of legs:	N =	3
Overall length:		22,1654 in (563,00 mm)
Base to girth seam length:		15,7480 in (400,00 mm)
Bolt circle:		10,3150 in (262,00 mm)
Anchor bolt size:		0,75 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) (0,0408 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:		0,2189 in (5,56 mm) (0,0008 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 kgf	Shear resisted kgf	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	0	18,6	0,0	2,419	5,705	0,000	0,0048	0,0050
Weight operating new		120	34,4	0,0	4,479	10,564	0,000	0,0089	0,0093
Moment = 1,9 kg-m		240	34,4	0,0	4,479	10,564	0,000	0,0089	0,0093

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

$$P_1 = W/N + 48 \cdot M_v / (N \cdot D)$$

$$= 175,1129 / 3 + 48 \cdot 13,89221 / (3 \cdot 12,75)$$

$$= 75,8043 \text{ lb (34,38427 kgf)}$$

Allowable axial compressive stress, F_a (AISC chapter E)

Local buckling check (AISC 5-99)

$$b/t = (2,5/0,25) < (76 / \text{Sqr}(36)) \text{ so } Q_s = 1$$

Flexural-torsional buckling (AISC 5-317)

Shear center distance $w_o = 0,8372141$

$$r_o^2 = w_o^2 + (I_x + I_w) / A$$

$$= 0,8372141^2 + (0,2866625 + 1,119311) / 1,19$$

$$= 1,882417$$

Torsional constant $J = 2,479167E-02$

Shear modulus $G = 11.165,00 \text{ kips/in}^2$

$$F_{ej} = G \cdot J / (A \cdot r_o^2)$$

$$= 11.165,00 \cdot 2,479167E-02 / (1,19 \cdot 1,882417)$$

$$= 123,5667$$

$$K \cdot l / r_w = 1,2 \cdot 16,74803 / 0,9698439 = 20,72255$$

$$F_{ew} = \pi^2 \cdot E / (Kl/r_w)^2$$

$$= \pi^2 \cdot 29.000,00 / (20,72255)^2$$

$$= 666,5171$$

$$H = 1 - (w_o^2 / r_o^2)$$

$$= 1 - (0,8372141^2 / 1,882417)$$

$$= 0,627645$$

$$F_e = ((F_{ew} + F_{ej}) / (2 \cdot H)) \cdot (1 - \text{Sqr}(1 - (4 \cdot F_{ew} \cdot F_{ej} \cdot H) / (F_{ew} + F_{ej})^2))$$

$$= ((666,5171 + 123,5667) / (2 \cdot 0,627645)) \cdot (1 - \text{Sqr}(1 - (4 \cdot 666,5171 \cdot 123,5667 \cdot 0,627645) / (666,5171 + 123,5667)^2))$$

$$= 114,6908$$

Equivalent slenderness ratio

$$Kl/r = \pi \cdot \text{Sqr}(E / F_e)$$

$$= \pi \cdot \text{Sqr}(29.000,00 / 114,6908)$$

$$= 49,95564$$

$$C_c = \text{Sqr}(2 \cdot \pi^2 \cdot E / (F_y \cdot Q_s))$$

$$= \text{Sqr}(2 \cdot \pi^2 \cdot 29.000,000 / (36.000,00 \cdot 1))$$

$$= 126,0993$$

$$K^*/r = 1,2 * 16,74803 / 0,4908084 = 40,94804$$

$$\begin{aligned} F_a &= 1 * (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / (5/3 + 3 * (Kl/r) / (8 * C_c) - (Kl/r)^3 / (8 * C_c^3)) \\ &= 1 * (1 - (49,95564)^2 / (2 * 126,0993^2)) * 36.000,00 / (5/3 + 3 * (49,95564) / (8 * 126,0993) - (49,95564)^3 / (8 * 126,0993^3)) \\ &= 18.354,54 \text{ psi (1.290,451 kg/cm}^2\text{)} \end{aligned}$$

Allowable axial compression and bending (AISC chapter H)

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

$$\begin{aligned} F'_{ex} &= 1 * 12 * \pi^2 * E / (23 * (Kl/r)^2) \\ &= 1 * 12 * \pi^2 * 29.000.000 / (23 * (55,27985)^2) \\ &= 48.867,20 \text{ psi (3.435,701 kg/cm}^2\text{)} \end{aligned}$$

$$\begin{aligned} F'_{ey} &= 1 * 12 * \pi^2 * E / (23 * (Kl/r)^2) \\ &= 1 * 12 * \pi^2 * 29.000.000 / (23 * (27,97544)^2) \\ &= 190.808,3 \text{ psi (13.415,137 kg/cm}^2\text{)} \end{aligned}$$

$$\begin{aligned} F_b &= 1 * 0,66 * F_y \\ &= 23.760,00 \text{ psi (1.670,492 kg/cm}^2\text{)} \end{aligned}$$

Compressive axial stress

$$\begin{aligned} f_a &= P_1 / A \\ &= 75,80434 / 1,19 \\ &= \mathbf{63,70113} \text{ psi (4,479 kg/cm}^2\text{)} \end{aligned}$$

Bending stresses

$$\begin{aligned} f_{bx} &= F * \cos(\alpha) * L / (I_x / C_x) + P_1 * E_{cc} / (I_x / C_x) \\ &= 0 * \cos(120) * 16,74803 / (0,2866625 / 0,7537591) + 75,80434 * 0,7538 / (0,2866625 / 0,7537591) \\ &= \mathbf{150,2491} \text{ psi (10,564 kg/cm}^2\text{)} \end{aligned}$$

$$\begin{aligned} f_{by} &= F * \sin(\alpha) * L / (I_y / C_y) \\ &= 0 * \sin(120) * 16,74803 / (1,119311 / 1,76775) \\ &= \mathbf{0} \text{ psi (0,000 kg/cm}^2\text{)} \end{aligned}$$

AISC equation H1-1

$$\begin{aligned} H_{1-1} &= f_a / F_a + C_{mx} * f_{bx} / ((1 - f_a / F'_{ex}) * F_{bx}) + C_{my} * f_{by} / ((1 - f_a / F'_{ey}) * F_{by}) \\ &= 63,70113 / 18.354,54 + 0,85 * 150,2491 / ((1 - 63,70113 / 48.867,20) * 23.760,00) + 0,85 * 0 / ((1 - 63,70113 / 190.808,3) * 23.760,00) \\ &= \mathbf{8,85268E-03} \end{aligned}$$

AISC equation H1-2

$$\begin{aligned} H_{1-2} &= f_a / (0,6 * 1 * F_y) + f_{bx} / F_{bx} + f_{by} / F_{by} \\ &= 63,70113 / (0,6 * 1 * 36.000,00) + 150,2491 / 23.760,00 + 0 / 23.760,00 \\ &= \mathbf{9,272741E-03} \end{aligned}$$

3, 2.5x2.5x1/4 Equal Angle legs are adequate.

Anchor bolts - Weight operating corroded condition governs

Tensile loading per leg (1 bolt per leg)

$$\begin{aligned} R &= 48 * M / (N * BC) - W / N \\ &= 48 * 13,05944 / (3 * 10,31496) - 116,1203 / 3 \\ &= -18,44967 \text{ lbf (-8,368629 kgf)} \end{aligned}$$

There is no net uplift (R is negative).

0,75 inch series 8 threaded bolts are satisfactory.

Check the leg to vessel fillet weld, Bednar 10.3, Weight operating new 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).

$$\begin{aligned} Z_w &= (2*b*d + d^2)/3 \\ &= (2*3,5355*5,417322 + 5,417322^2)/3 \\ &= 22,55109 \end{aligned}$$

$$\begin{aligned} J_w &= (b + 2*d)^3/12 - d^2*(b + d)^2/(b + 2*d) \\ &= (3,5355 + 2*5,417322)^3/12 - 5,417322^2*(3,5355 + 5,417322)^2/(3,5355 + 2*5,417322) \\ &= 83,59525 \end{aligned}$$

$$\begin{aligned} E &= d^2/(b + 2*d) \\ &= 5,417322^2/(3,5355 + 2*5,417322) \\ &= 2,042247 \end{aligned}$$

$$\text{Governing weld load } f_x = \text{Cos}(120)*0 = 0 \text{ lb}_f$$

$$\text{Governing weld load } f_y = \text{Sin}(120)*0 = 0 \text{ lb}_f$$

$$\begin{aligned} f_1 &= P_1/L_{\text{weld}} \\ &= 75,80434/14,37014 \\ &= 5,275128 \text{ lb}_f/\text{in} \text{ (0,9420302 Kg}_f/\text{cm) (V}_L \text{ direct shear)} \end{aligned}$$

$$\begin{aligned} f_2 &= f_y * L_{\text{leg}} * 0,5 * b / J_w \\ &= 0 * 16,74803 * 0,5 * 3,5355 / 83,59525 \\ &= 0 \text{ lb}_f/\text{in} \text{ (0 Kg}_f/\text{cm) (V}_L \text{ torsion shear)} \end{aligned}$$

$$\begin{aligned} f_3 &= f_y / L_{\text{weld}} \\ &= 0 / 14,37014 \\ &= 0 \text{ lb}_f/\text{in} \text{ (0 Kg}_f/\text{cm) (V}_c \text{ direct shear)} \end{aligned}$$

$$\begin{aligned} f_4 &= f_y * L_{\text{leg}} * E / J_w \\ &= 0 * 16,74803 * 2,042247 / 83,59525 \\ &= 0 \text{ lb}_f/\text{in} \text{ (0 Kg}_f/\text{cm) (V}_c \text{ torsion shear)} \end{aligned}$$

$$\begin{aligned} f_5 &= f_x * L_{\text{leg}} / Z_w \\ &= 0 * 16,74803 / 22,55109 \\ &= 0 \text{ lb}_f/\text{in} \text{ (0 Kg}_f/\text{cm) (M}_L \text{ bending)} \end{aligned}$$

$$\begin{aligned} f_6 &= f_x / L_{\text{weld}} \\ &= 0 / 14,37014 \\ &= 0 \text{ lb}_f/\text{in} \text{ (0 Kg}_f/\text{cm) (Direct outward radial shear)} \end{aligned}$$

$$\begin{aligned} f &= \text{Sqr}((f_1 + f_2)^2 + (f_3 + f_4)^2 + (f_5 + f_6)^2) \\ &= \text{Sqr}((5,275128 + 0)^2 + (0 + 0)^2 + (0 + 0)^2) \\ &= 5,275128 \text{ lb}_f/\text{in} \text{ (0,9420302 Kg}_f/\text{cm) (Resultant shear load)} \end{aligned}$$

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

$$\begin{aligned} t_w &= f / (0,707 * 0,55 * S_a) \\ &= 5,275128 / (0,707 * 0,55 * 17.100,00) \\ &= 0,0008 \text{ in} \text{ (0,0202 mm)} \end{aligned}$$

The 5,56 mm leg to vessel attachment fillet weld size is adequate.

Base plate thickness check, AISC 3-106

$$\begin{aligned} f_p &= P/(B*N) \\ &= 79,91982/(3,937008*3,937008) \\ &= 5,156106 \text{ psi} \text{ (0,363 kg/cm}^2\text{)} \end{aligned}$$

Required base plate thickness is the largest of the following: (0,0408 in)

$$t_b = \text{Sqr}(0,5 * P / S_b)$$

$$= \text{Sqr}(0,5*79,91982/24.000,00)$$
$$= 0,0408 \text{ in } (1,0364 \text{ mm})$$

$$t_b = 0,5*(N - d)*\text{Sqr}(3*f_p/S_b)$$
$$= 0,5*(3,937008 - 2,5)*\text{Sqr}(3*5,156106/24.000,00)$$
$$= 0,0182 \text{ in } (0,4633 \text{ mm})$$

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 kgf
Circumferential moment:	$M_c =$	0,00 kg-m
Circumferential shear:	$V_c =$	0,00 kgf
Longitudinal moment:	$M_L =$	0,48 kg-m
Longitudinal shear:	$V_L =$	24,99 kgf
Torsion moment:	$M_t =$	0,00 kg-m
Internal pressure:	$P =$	2,00 kg/cm ²
Mean shell radius:	$R_m =$	161,75 mm
Local shell thickness:	$t =$	3,35 mm
Shell yield stress:	$S_y =$	2.283,85 kg/cm ²

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

$$R_m/t = 48,2798$$

$$C_1 = 44,90, C_2 = 68,80 \text{ mm}$$

$$\text{Local circumferential pressure stress} = P \cdot R_i / t = 1.359,00 \text{ psi (95,54707 kg/cm}^2\text{)}$$

$$\text{Local longitudinal pressure stress} = P \cdot R_i / 2t = 680 \text{ psi (47,80869 kg/cm}^2\text{)}$$

$$\text{Maximum combined stress (} P_L + P_b + Q \text{)} = 103,63 \text{ kg/cm}^2$$

$$\text{Allowable combined stress (} P_L + P_b + Q \text{)} = +-3 \cdot S = +-3.606,74 \text{ kg/cm}^2$$

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

$$\text{Maximum local primary membrane stress (} P_L \text{)} = 98,85 \text{ kg/cm}^2$$

$$\text{Allowable local primary membrane (} P_L \text{)} = +-1,5 \cdot S = +-1.803,37 \text{ kg/cm}^2$$

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*	1,3982	0,4200	0	0	0	0	0	0	0	0
4C*	4,1582	0,3755	0	0	0	0	0	0	0	0
1C	0,0619	0,3245	0	0	0	0	0	0	0	0
2C-1	0,0121	0,3245	0	0	0	0	0	0	0	0
3A*	1,5356	0,3200	0	0	0	0	0	0	0	0
1A	0,0599	0,3498	0	0	0	0	0	0	0	0
3B*	2,5606	0,3690	-3,304	-3,304	3,304	3,304	0	0	0	0
1B-1	0,0107	0,3535	-4,781	4,781	4,781	-4,781	0	0	0	0
Pressure stress*			95,547	95,547	95,547	95,547	95,547	95,547	95,547	95,547
Total circumferential stress			87,462	97,024	103,632	94,071	95,547	95,547	95,547	95,547
Primary membrane circumferential stress*			92,243	92,243	98,851	98,851	95,547	95,547	95,547	95,547
3C*	1,6860	0,3755	0	0	0	0	0	0	0	0
4C*	3,7041	0,4200	0	0	0	0	0	0	0	0
1C-1	0,0215	0,3834	0	0	0	0	0	0	0	0
2C	0,0300	0,3834	0	0	0	0	0	0	0	0
4A*	4,7570	0,3200	0	0	0	0	0	0	0	0
2A	0,0241	0,4033	0	0	0	0	0	0	0	0
4B*	1,4782	0,3690	-2,390	-2,390	2,390	2,390	0	0	0	0
2B-1	0,0179	0,4009	-7,031	7,031	7,031	-7,031	0	0	0	0
Pressure stress*			47,809	47,809	47,809	47,809	47,809	47,809	47,809	47,809
Total longitudinal stress			38,388	52,449	57,230	43,168	47,809	47,809	47,809	47,809
Primary membrane longitudinal stress*			45,418	45,418	50,199	50,199	47,809	47,809	47,809	47,809
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	-2,742	-2,742	2,742	2,742
Total Shear stress			0	0	0	0	-2,742	-2,742	2,742	2,742
Combined stress (P _L +P _b +Q)			87,462	97,024	103,632	94,071	95,688	95,688	95,688	95,688

Note: * denotes primary stress.

Transition #1**ASME Section VIII Division 1, 2001 Edition, A03 Addenda**

Component: Transition
 Material specification: SA-516 70 (ASME II-D p. 14, ln. 31)
 Material is impact test exempt to -103,8889 °C per UCS-66(b)(3) (coincident ratio = 0,10727)

Internal design pressure: $P = 2,0000 \text{ kg/cm}^2 @ 80,00^\circ\text{C}$

Static liquid head:

$P_{th}=0,0316 \text{ kg/cm}^2$ (SG=1,0000, $H_s=316,01 \text{ mm}$, Horizontal test head at small end)

$P_{th}=0,0465 \text{ kg/cm}^2$ (SG=1,0000, $H_s=464,93 \text{ mm}$, Horizontal test head at large end)

Corrosion allowance: Inner C = 3,00 mm Outer C = 0,00 mm

Design MDMT = 0,00°C No impact test performed
 Rated MDMT = -103,89°C 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 = 5,5 kg corr = 3,7 kg
 Capacity: New = 3,8 liters corr = 4,0 liters

Axial length = 151,00 mm
 Large End OD = 323,8500 mm
 Small End OD = 26,0000 mm
 Cone $t_c = 6,35 \text{ mm}$

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

$$\begin{aligned} t &= P \cdot D_o / (2 \cdot \cos(\alpha) \cdot (S \cdot E + 0,40 \cdot P)) + C \\ &= 2,0000 \cdot 323,8500 / (2 \cdot \cos(44,603611) \cdot (1406,1400 \cdot 0,70 + 0,4 \cdot 2,0000)) + 2,9997 \\ &= 3,46 \text{ mm} \end{aligned}$$

Small End design thickness ($t = 3,04 \text{ mm}$) does not govern.

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

$$\begin{aligned} P &= 2 \cdot S \cdot E \cdot t \cdot \cos(\alpha) / (D_o - 0,80 \cdot t \cdot \cos(\alpha)) - P_s \\ &= 2 \cdot 1406,1400 \cdot 0,70 \cdot 3,3503 \cdot \cos(44,603611) / (323,8500 - 0,80 \cdot 3,3503 \cdot \cos(44,603611)) - 0,0000 \\ &= 14,5857 \text{ kg/cm}^2 \end{aligned}$$

Small End MAWP ($194,9107 \text{ kg/cm}^2$) does not govern.

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

$$\begin{aligned} P &= 2 \cdot S \cdot E \cdot t \cdot \cos(\alpha) / (D_o - 0,80 \cdot t \cdot \cos(\alpha)) - P_s \\ &= 2 \cdot 1406,1400 \cdot 0,70 \cdot 6,3500 \cdot \cos(44,603611) / (323,8500 - 0,80 \cdot 6,3500 \cdot \cos(44,603611)) - 0,0000 \\ &= 27,7928 \text{ kg/cm}^2 \end{aligned}$$

Small End MAP ($397,6293 \text{ kg/cm}^2$) does not govern.

% Extreme fiber elongation - UCS-79

$$= (50 * t / Rf) * (1 - Rf / Ro)$$

$$= (50 * 8,9188 / 8,5406) * (1 - 8,5406 / \infty)$$

$$= 52,2138$$

Transition design thickness = 3,46 mm

The governing condition is due to internal pressure.

The transition thickness of 6,35 mm is adequate.

Thickness Required Due to Pressure + External Loads

Condition	Pressure P (kg/cm ²)	Allowable Stress Before UG-23 Stress Increase (kg/cm ²)		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	1029,95	80,00	3,0000	top	Weight	0,2248	0,2248
						Bottom	Weight	0,0123	0,0123
Operating, Hot & New	2,00	1406,14	1160,97	80,00	0,0000	top	Weight	0,2191	0,2191
						Bottom	Weight	0,0070	0,0070
Hot Shut Down, Corroded	0,00	1406,14	1029,95	80,00	3,0000	top	Weight	0,0006	0,0006
						Bottom	Weight	0,0005	0,0005
Hot Shut Down, New	0,00	1406,14	1160,97	80,00	0,0000	top	Weight	0,0009	0,0009
						Bottom	Weight	0,0012	0,0012
Empty, Corroded	0,00	1406,14	1029,95	21,11	3,0000	top	Weight	0,0006	0,0006
						Bottom	Weight	0,0005	0,0005
Empty, New	0,00	1406,14	1160,97	21,11	0,0000	top	Weight	0,0009	0,0009
						Bottom	Weight	0,0012	0,0012
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0,00	1406,14	1029,95	80,00	3,0000	top	Weight	0,0006	0,0006
						Bottom	Weight	0,0005	0,0005

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cylinder Internal pressure = 14,59 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	-2.193,942	2.891,838	-2.193,942	2.891,838	3.606,744	3.606,744	-702,042	-702,042	1.803,372

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cone Internal pressure = 14,59 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	-2.052,781	3.032,998	-2.052,781	3.032,998	4.218,414	4.218,414	-419,817	-419,817	2.109,207

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cylinder Internal pressure = 14,59 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	-47,073	115,984	-47,073	115,984	3.606,744	3.606,744	104,052	104,052	1.803,372

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cone Internal pressure = 14,59 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	-10,628	84,591	-10,628	84,591	4.218,414	4.218,414	109,087	109,087	2.109,207

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cylinder Internal pressure = 14,59 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 New	-778,614	1.143,443	-778,614	1.143,443	3.606,744	3.606,744	-164,346	-164,346	1.803,372

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cone Internal pressure = 14,59 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 New	-704,822	1.217,235	-704,822	1.217,235	4.218,414	4.218,414	-16,837	-16,837	2.109,207

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cylinder Internal pressure = 14,59 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 New	-6,855	34,780	-6,855	34,780	3.606,744	3.606,744	37,742	37,742	1.803,372

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cone Internal pressure = 14,59 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 New	1,211	33,130	1,211	33,130	0,000	4.218,414	44,104	44,104	2.109,207

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cylinder Internal pressure = 27,79 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	-1.482,878	2.177,698	0,000	0,000	3.606,744	3.606,744	-312,641	0,000	1.803,372

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cone Internal pressure = 27,79 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	-1.342,340	2.318,236	0,000	0,000	4.218,414	4.218,414	-31,565	0,000	2.109,207

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cylinder Internal pressure = 27,79 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	-12,953	65,714	0,000	0,000	3.606,744	3.606,744	71,755	0,000	1.803,372

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cone Internal pressure = 27,79 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	2,288	62,597	0,000	0,000	0,000	4.218,414	83,879	0,000	2.109,207

Cylinder #2**ASME Section VIII Division 1, 2001 Edition, A03 Addenda**

Component: Cylinder
 Material specification: SA-106 B Smls pipe (ASME II-D p. 10, ln. 15)
 Pipe NPS and Schedule: 0,750" Sch 160 DN 20
 Material is impact test exempt per UCS-66(d)(NPS 4 or smaller pipe)

Internal design pressure: $P = 2 \text{ kg/cm}^2 @ 80^\circ\text{C}$

Static liquid head:

$P_{th} = 0,0319 \text{ kg/cm}^2$ (SG=1,0000, $H_s = 319,70 \text{ mm}$, Horizontal test head)

Corrosion allowance: Inner C = 3,00 mm Outer C = 0,00 mm

Design MDMT = $0,00^\circ\text{C}$ No impact test performed
 Rated MDMT = $-103,89^\circ\text{C}$ 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 = 0,4333 kg corr = 0,2279 kg
 Capacity: New = 0,0285 liters corr = 0,0547 liters

OD = 26,67 mm
 Length $L_c = 150,00 \text{ mm}$
 $t = 5,56 \text{ mm}$

Design thickness, (at $80,00^\circ\text{C}$) Appendix 1-1

$$\begin{aligned} t &= P \cdot R_o / (S \cdot E + 0,40 \cdot P) + \text{Corrosion} \\ &= 2,0000 \cdot 13,33 / (1202,2498 \cdot 0,85 + 0,40 \cdot 2,0000) + 3,00 \\ &= 3,0277 \text{ mm} \end{aligned}$$

Maximum allowable working pressure, (at $80,00^\circ\text{C}$) Appendix 1-1

$$\begin{aligned} P &= S \cdot E \cdot t / (R_o - 0,40 \cdot t) - P_s \\ &= 1202,2498 \cdot 0,85 \cdot 1,8653 / (13,33 - 0,40 \cdot 1,8653) - 0,0000 \\ &= 152,8268 \text{ kg/cm}^2 \end{aligned}$$

Maximum allowable pressure, (at $21,11^\circ\text{C}$) Appendix 1-1

$$\begin{aligned} P &= S \cdot E \cdot t / (R_o - 0,40 \cdot t) \\ &= 1202,2498 \cdot 0,85 \cdot 4,8650 / (13,33 - 0,40 \cdot 4,8650) \\ &= 434,3824 \text{ kg/cm}^2 \end{aligned}$$

Design thickness = 3,03 mm

The governing condition is due to internal pressure.

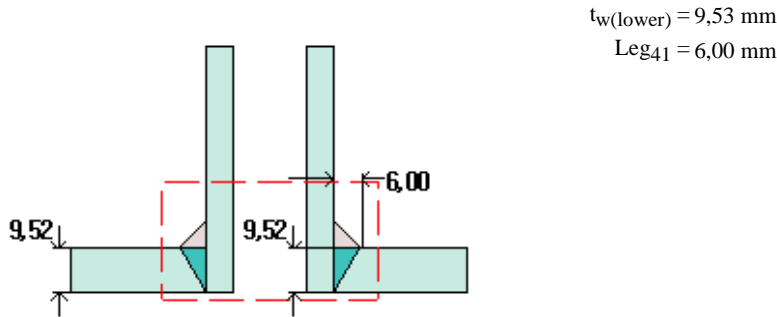
The cylinder thickness of 5,56 mm is adequate.

Thickness Required Due to Pressure + External Loads

Condition	Pressure P (kg/cm ²)	Allowable Stress Before UG-23 Stress Increase (kg/cm ²)		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	1202,25	1202,25	80,00	3,0000	Weight	0,0132	0,0132
Operating, Hot & New	2,00	1202,25	1202,25	80,00	0,0000	Weight	0,0100	0,0100
Hot Shut Down, Corroded	0,00	1202,25	1202,25	80,00	3,0000	Weight	0,0004	0,0004
Hot Shut Down, New	0,00	1202,25	1202,25	80,00	0,0000	Weight	0,0008	0,0008
Empty, Corroded	0,00	1202,25	1202,25	-17,78	3,0000	Weight	0,0004	0,0004
Empty, New	0,00	1202,25	1202,25	-17,78	0,0000	Weight	0,0008	0,0008
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0,00	1202,25	1202,25	80,00	3,0000	Weight	0,0004	0,0004

VENT (N3)

ASME Section VIII Division 1, 2001 Edition, A03 Addenda



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

Located on:	Welded Cover #1
Liquid static head included:	0 psi (0,00 kg/cm ²)
Nozzle material specification:	SA-106 B Smls pipe (ASME II-D p. 10, ln. 15)
Nozzle description:	0,750" Sch 160 DN 20
Flange description:	0,75 inch 150# SW A105
Bolt Material:	SA-193 B7 Bolt <= 2 1/2
Flange rated MDMT: (UCS-66(b)(1)(b))	-55,00 °F (-48,33°C)
Liquid static head on flange:	0 psi (0,00 kg/cm ²)
ASME B16.5 flange rating MAWP:	266,00 psi @ 176,00°F (18,70 kg/cm ² @ 80,00°C)
ASME B16.5 flange rating MAP:	285,00 psi @ 70,00°F (20,04 kg/cm ² @ 21,11°C)
ASME B16.5 flange hydro test:	450,00 psi @ 70,00°F (31,64 kg/cm ² @ 21,11°C)
Nozzle orientation:	0°
Local vessel minimum thickness:	0,3750 in (9,53 mm)
Nozzle inside diameter, new:	0,6120 in (15,54 mm)
Nozzle nominal wall thickness:	0,2190 in (5,56 mm)
Nozzle corrosion allowance:	0,1181 in (3,00 mm)
Projection available outside vessel, Lpr:	5,5305 in (140,48 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 = 2,97 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)							5,51	5,56

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	Actual weld	Status

	throat size (mm)	throat size (mm)	
Nozzle to shell fillet (Leg ₄₁)	1,79	4,20	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 = 6,58 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)							2,51	5,56

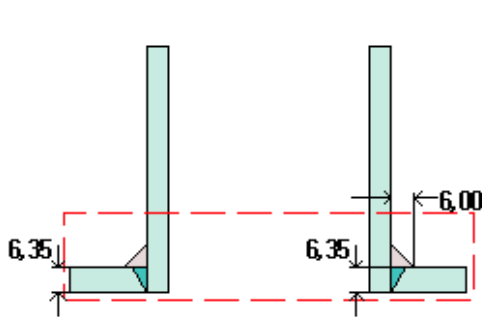
Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (mm)	Actual weld throat size (mm)	Status
Nozzle to shell fillet (Leg ₄₁)	3,89	4,20	weld size is adequate

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

U.C. (N4)

ASME Section VIII Division 1, 2001 Edition, A03 Addenda



$t_{w(lower)} = 6,35 \text{ mm}$
 $Leg_{41} = 6,00 \text{ mm}$

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-106 B Smls pipe (ASME II-D p. 10, ln. 15)
Nozzle description:	2" Sch 80 (XS) DN 50
Flange description:	2 inch 150# WN A105
Bolt Material:	SA-193 B7 Bolt <= 2 1/2
Flange rated MDMT: (UCS-66(b)(1)(b))	-26,70 °F (-32,61°C)
Liquid static head on flange:	0 psi (0,00 kg/cm ²)
ASME B16.5 flange rating MAWP:	266,00 psi @ 176,00°F (18,70 kg/cm ² @ 80,00°C)
ASME B16.5 flange rating MAP:	285,00 psi @ 70,00°F (20,04 kg/cm ² @ 21,11°C)
ASME B16.5 flange hydro test:	450,00 psi @ 70,00°F (31,64 kg/cm ² @ 21,11°C)
Nozzle orientation:	0°
Local vessel minimum thickness:	0,2188 in (5,56 mm)
Nozzle center line offset to datum line:	35,0394 in (890,00 mm)
End of nozzle to shell center:	12,2805 in (311,93 mm)
Nozzle inside diameter, new:	1,9390 in (49,25 mm)
Nozzle nominal wall thickness:	0,2180 in (5,54 mm)
Nozzle corrosion allowance:	0,1181 in (3,00 mm)
Projection available outside vessel, L _{pr} :	5,9055 in (150,00 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 = 18,70 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)							5,50	5,54

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)	1,78	4,20	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 = 20,04 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)							2,68	5,54

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)	3,88	4,20	weld size is adequate

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