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SIGMAPHI
Rue des Frères Montgolfier – ZI du Prat
56000 VANNES

Written by :
D. JOST

Attention to M. PORHIEL

V/Réf : QPOLE

Saint Herblain, le 09/07/15

N/Réf : 15N122 - 15350943

DELIVERY ORDER

SUBJECT : Mechanical calculation report

Nbre	Référence du document	Désignation - Observation
1	15N122 - 15350943	Mechanical calculation report Of inner and outer tube (with nozzles) of Helium Vessel following drawing 318711-JLA-703-001 Rév B Following ASME VIII division 1

Mechanical Calculation Engineer

Donatien JOST

Inspection
Assistance Technique
Formation professionnelle
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56000 VANNES

Attention to M. PORHIEL

V/Réf : QPOLE

N/Réf : 15N122 - 15350943

CALCULATION DEPARTMENT

CALCULATION REPORT

Of inner and outer tube (with nozzles) of Helium Vessel following drawing 318711-JLA-703-001 Rév B

Following ASME VIII division 1

C			
B			
A	09/07/15	D. JOST	J. P. LUCIANI
Rév.	Date	Name Signature	Name Signature
		Written by	Checked up by

REVISION RECORD

REV	DATE	PAGE / PARAGRAPHE CONCERNED	REVISION DECRIPION
A	09/07/15	All	First edition

Pages	*Révision Index*		
0	**A**		
to			
6	**A**		
APPENDIX A	**A**		
APPENDIX B	**A**		

TABLE OF CONTENTS

1. OBJECT

The goal of this calculation note is to review the mechanical strength under static pressure of all components we can calculate following analytical rules of ASME VIII division 1. Components concerned are internal and external cylindrical shells and nozzles on the external shell.

All other components (flanges, …) mechanical strength is covered by Sigmaphi finite element calculation (reference 318711 JLAB_2015-01-23_ANSYS). This finite element calculation take also in account all loadings not covered by the analytical calculation (magnetic loads, pré-loads on suspension links, …).

2. REFERENCES

2.1. Drawings

- 318711-JLA-703-001 Rév B (Assembly drawing)
- 318711-JLA-703-003 Rév A (Detail drawing of inner tube)
- 318711-JLA-703-002 Rév A (Detail drawing of outer tube)
- 318711-JLA-703-015 Rév B (Detail drawing of outer tube #2)
- 318711-JLA-703-011 Rév B (Detail drawing of rustine on outer tube)
- 318711-JLA-703-012 Rév B (Detail drawing of Socolé #2)
- 318711-JLA-703-013 Rév B (Detail drawing of Socolé)
- 318711-JLA-703-014 Rév B (Detail drawing of Socolé #3)

Above listed drawings are jointed in appendix A.

2.2. Codes standards used

- ASME VIII division 1 (July 2013)
- ASME II Part D (nuance SA240 grade 304L, SA249 grade 304L)

2.3. Calculation software

- Bentley AutoPIPE Vessel (Microprotol) V33.2.2.4 sofware is used for analytical calculations under static pressure.

3. DESIGN SPECIFICATION

3.1. General calculation conditions

- Corrosion allowance : 0 mm
- Welding joint efficiency : 1
- Nominal stress : According to ASME II Part D (see §3.5)
- Fluid: liquid and/or gaseous nitrogen
  - → Calculations with : Density of 1
- Operating temperature : -196°C (77K)
  - → Calculations at : 20°C (conservative)
- Internal/external pressures (for operating & strength test conditions) : See §3.2 & 3.3)
- Wind : Not applicable
- Earthquake : Not applicable
- Fatigue : Not applicable
- Loads and moments : Not applicable

Other loads not taken in account in this calculation note (but covered by Sigmaphi finite element analysis report 318711 JLAB_2015-01-23_ANSYS)

- Preload applied on suspension links
- Gravity 9808.6mm/s²+ Weight collar + coil
- Magnetic forces on two directions –X axis and Y axis
- Acceleration 1G on the Y axis
- Thermal contraction

3.2. Calculation conditions for inner tube (external pressure)

The inner tube is only subject to external pressures.

Operating conditions are :

1. Condition with the vacuum on internal diameter (this condition is covered by the second operating condition)
2. Condition with 6 bar on external diameter and vacuum on internal diameter.

→ ***Calculation conditions for operating condition are :***

- Internal pressure : 0 bar
- External pressure : 7 bar *(cover the 2 operating conditions)*
- Calculation temperature : 20 °C *(conservating / operating temperature at -268°C)*

Strength test condition is :

During strength test, the internal diameter is not subject to vacuum.

→ ***Calculation conditions for strength test condition are :***

- Internal pressure : 0 bar
- External pressure : 10 bar *(following §3.6)*
- Calculation temperature : 20 °C

3.3. Calculation conditions for outer tube (internal pressure)

The outer tube is only subject to internal pressures.

Operating conditions are :

3. Condition with the vacum on external diameter (this condition is covered by the second operating condition)
4. Condition with 6 bar on internal diameter and vacuum on external diameter.

→ ***Calculation conditions for operating condition are :***

- Internal pressure : 7 bar *(cover the 2 operating conditions)*
- External pressure : 0 bar
- Calculation temperature : 20 °C *(conservating / operating temperature at -268°C)*

Strength test condition is :

During strength test, the external diameter is not subject to vacuum.

→ ***Calculation conditions for strength test condition are :***

- Internal pressure : 10 bar *(following §3.6*
- External pressure : 0 bar
- Calculation temperature : 20 °C

3.4. Calculation conditions for nozzles on outer tube (internal pressure)

Calculation conditions are those applied on the outer tube.

3.5. Materials and allowable stresses

				Units: MPa				
Element	**Material**	**Standard**	**Température**	**R_P**	**R_m**	**σ_R**	**$f_{operating}$**	**f_{test}**
Inner and outer tubes	304L	ASME SA240	20°C	172	483	/	**115**	**155**
			20°C	172	483	/	**115**	/
Nozzles (Socolé, Socolé #2 & Socolé #3)	304L	ASME SA312 ASME SA403	20°C	172	483	/	**115**	**155**
			20°C	172	483	/	**115**	/
	304L	ASME SA249	20°C	172	483	/	**97.8**	**155**
			20°C	172	483	/	**97.8**	/

Nominal stresses are issued of l'ASME II Part D.

3.6. Strength test pressure calculation

Strength test shall be done at 1,3 time the operating pressure multiplied by the smallest ratio of LSR stresses (following §UG99 of ASME VIII division 1).

With LSR, the ratio of the calculation stress in operating condition at strength test temperature with the calculation stress in operating condition at operating temperature. LSR is determined for each material.

For this helium vessel, calculations in operating conditions are realized at 20°C like for strength test condition. → LSR ratio is equal to 1 for all materials.

So helium vessel strength test pressure is 1,3 time the operating pressure (following §UG99 of ASME VIII division 1).

Helium vessel operating pressure is 6 bar with vacuum outside the equipment (corresponding to 7 bar of internal pressure). Helium vessel is hydro tested at atmospheric pressure so the operating pressure used for the calculation of strength test pressure is 7 bar.

The minimal strength test pressure required following §UG99 of ASME VIII division 1 is 9.1 bar.

Calculation pressure used in this calculation note for strength test condition is 10 bar.

4. RESULTS

4.1. Cylindrical shells calculations

All cylindrical shell thicknesses are sufficient as per ASME VIII division 1 for calculation conditions detailed on paragraph 3.

Calculations are detailed in appendix B.

The following table presents calculation results.

Component	Nominal thickness *(mm)*	Thickness + corrosion allowance *(mm)*	Thickness used for calculation *(mm)*	Mechanical strength verification
Inner tube Ø713.4 in operating condition	12	0.5	11.5	OK (7.8 mm mini nécessaire)
Inner tube Ø713.4 in strength test condition	12	0.5	11.5	OK (9.6 mm mini nécessaire)
Outer tube Ø1230 in operating condition	20	0.5	19.5	OK (*) (3.8 mm mini nécessaire)
Outer tube Ø1230 in strength test condition	20	0.5	19.5	OK (*) (4.1 mm mini nécessaire)
3 Nozzles (Socolé, Socolé #2 & Socolé #3) Øint 52.5	6	0.5	5.5	OK (see §4.2)

(*) Additional calculations are realized to check the mechanical strength of the outer tube in the area of nozzles.

Additional calculations are also realized (for all above components) to take in account all other loading cases (see Sigmaphi finite element analysis reference 318711 JLAB_2015-01-23_ANSYS).

4.2. Nozzels calculations – opening strength calculations

The 3 nozzles (Socolé, Socolé #2 & Socolé #3) on drawing 703-011 Rév A (in outer tube rustine) are calculated taking in account :

- An opening diameter of 53.5 mm,
- Nozzles walls abbuting the outer tube wall (nozzles not inserted)
- Nozzle thickness 6 mm (for 10 mm minimum on drawing),
- A thickness allowance of 0.5 mm (for the outer tube and nozzles)

Reinforcement calculations are detailed in appendix B.

Openings in the outer tube are compliant to ASME VIII division 1 rules for calculation conditions described in parapgraph 3.3 and above.

No reinforcing pad is required.

Remark : No external loads and moments are considered in nozzles calculations.

5. CONCLUSION

This calculation report shows that the mechanical strength under static pressure of inner and outer tube (including the 3 nozzles openings) are compliant to ASME VIII division 1 analytical rules for design conditions defined in paragraph §3.

Remarks :

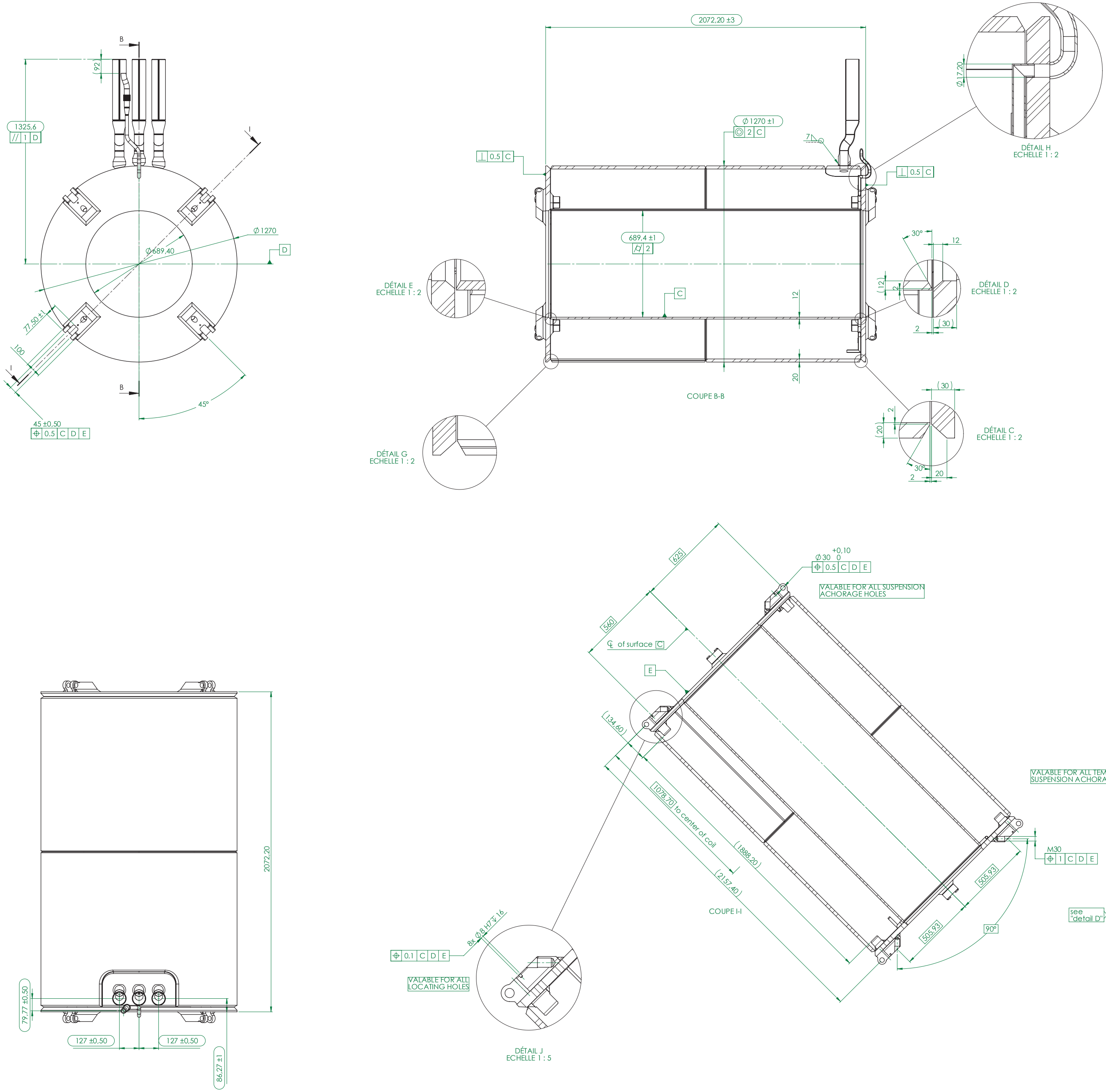
Additional calculations are realized to take in account all other loading cases (see Sigmaphi finite element analysis reference 318711 JLAB_2015-01-23_ANSYS).

* * *

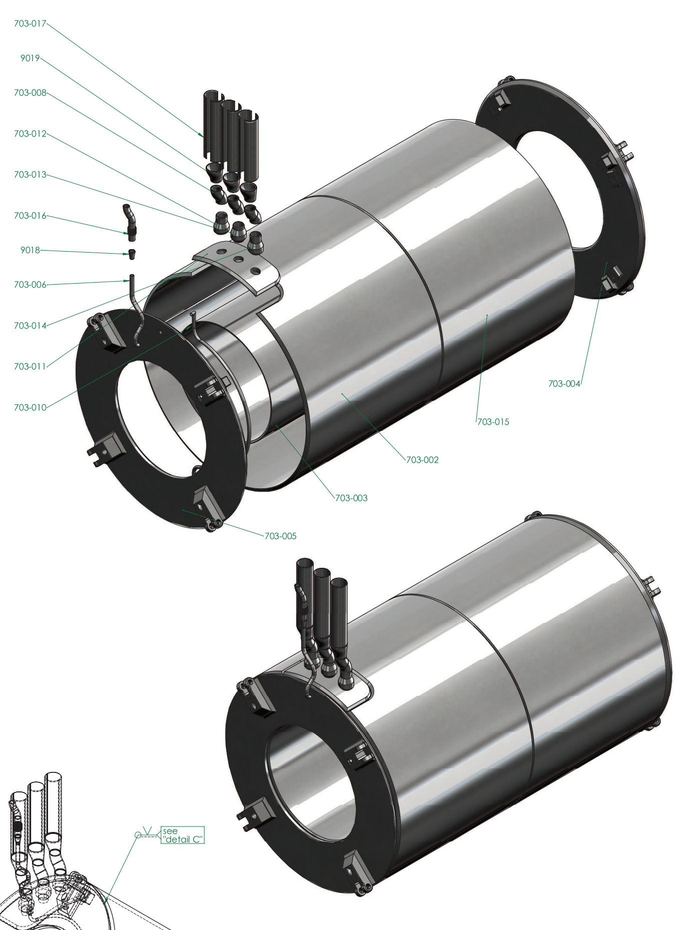
APPENDIX A

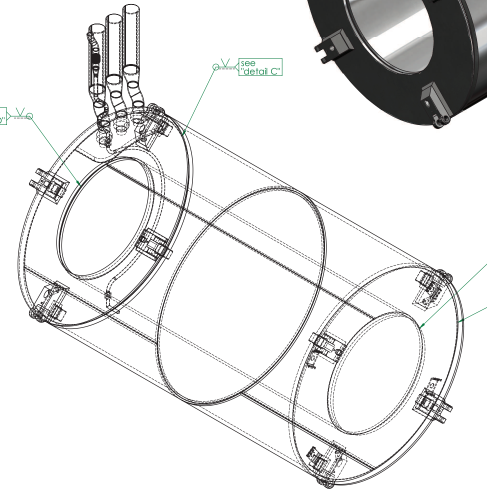
Drawings

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	AUTHOR
	A	CREATION	28/06/2013	M. DELBECQ
	B	modification of component (clevis on flange) + bellows remplaced by half-pipes	24/02/2015	MD



REP	REFERENCE	DESIGNATION	QTY	REV	MATERIAL	MASS (Kg)
703-002	318711-JLA-703-002	OUTER TUBE	1	A	304L (X2CrNi18-9)	599.09
703-003	318711-JLA-703-003	INNER TUBE	1	A	304L (X2CrNi18-9)	417.66
703-004	318711-JLA-703-004	FLANGE	1	B	304L (X2CrNi18-9)	246.40
703-005	318711-JLA-703-005	FLANGE #2	1	B	304L (X2CrNi18-9)	245.35
703-006	318711-JLA-703-006	FEEDING	1	B	304L (X2CrNi18-9)	0.66
703-008	318711-JLA-703-008	HELIUM PIPES	3	B	304L (X2CrNi18-9)	0.62
703-010	318711-JLA-703-010	Internal piping	1	A	304L (X2CrNi18-9)	1.03
703-011	318711-JLA-703-011	Rustine	1	A	304L (X2CrNi18-9)	15.28
703-012	318711-JLA-703-012	Socolé #2	1	B	304L (X2CrNi18-9)	1.47
703-013	318711-JLA-703-013	Socolé	1	B	304L (X2CrNi18-9)	1.46
703-014	318711-JLA-703-014	Socolé #3	1	B	304L (X2CrNi18-9)	1.47
703-015	318711-JLA-703-015	OUTER TUBE #2	1	B	304L (X2CrNi18-9)	616.97
703-016	318711-JLA-703-016	Bellow for Ø33.7 pipe	1	B	304L (X2CrNi18-9)	0.83
703-017	318711-JLA-703-017	Half pipe	6	A	304L (X2CrNi18-9)	1.23
9018	reduction-concentrique-0.5pouce-1pouce-80S	reduction concentrique 1"-1/2" 80S	1		304L (X2CrNi18-9)	0.11
9019	5933-Réduction-excentrique-2-3pouces-ANSI-40S	réduction excentrique ANSI 40S	3		304L (X2CrNi18-9)	0.61



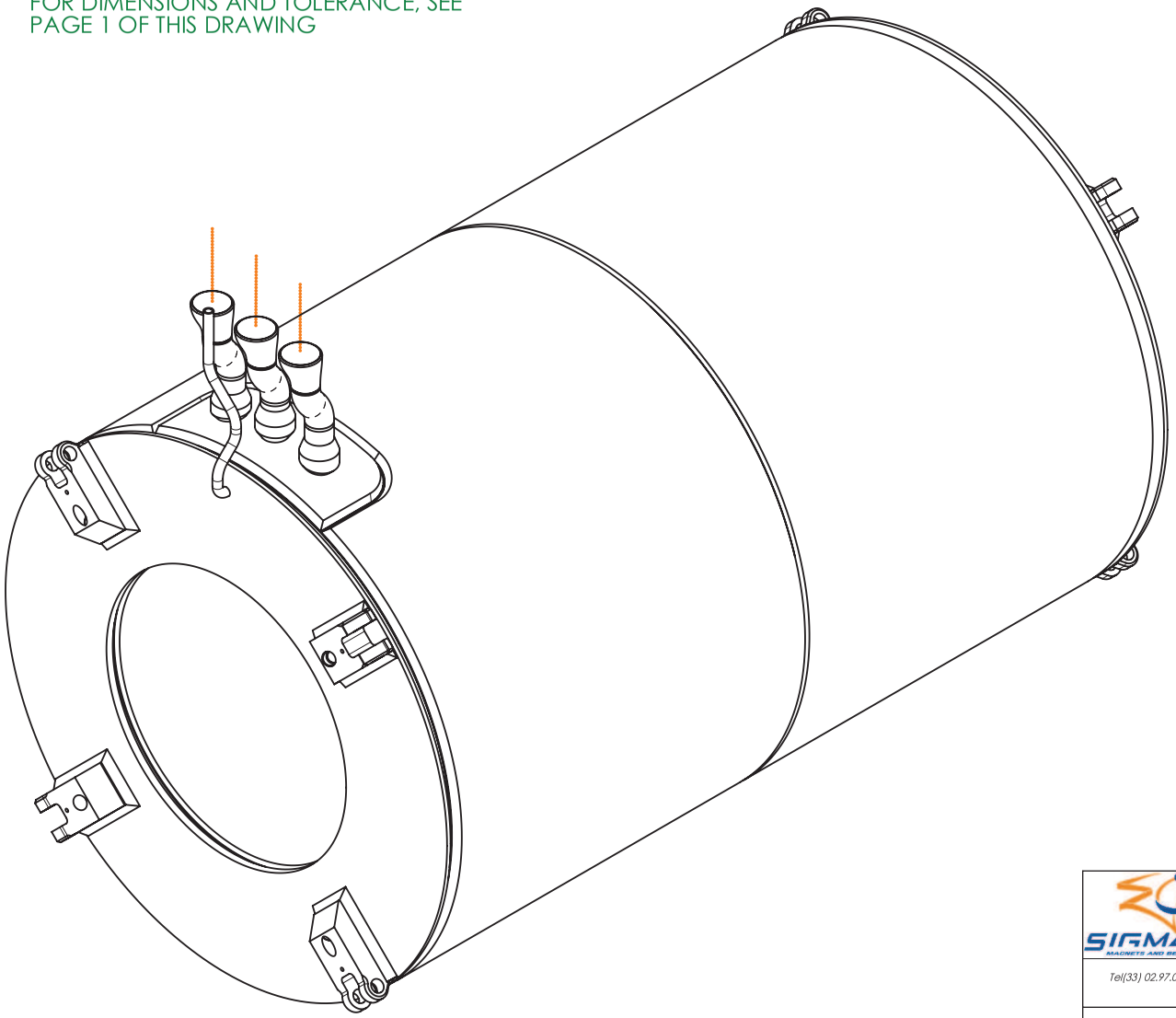


For Manufacturing

NOTE:
- Content liquid and gaseous helium at 4K.
- Design pressure: 6atm absolute from 4K to 300K.
- Design and manufacturing according to ASME BPV (2010) RT1.

SIGMAPHI — ZI du prat, Rue des frères Mongolfier, F-56000 Vannes		Name	Date
	Drawing	M. DELBECQ	09/04/2015
	Checked		
	Approved		
Tel(33) 02.97.01.08.80 Fax (33)02.97.01.08.81 EMAIL Contact@sigmaphi.fr	MATERIAL:	See assembly	
	Trait.:		
QPOLE	Roughness :		
	Tol Gen	SEE NOTE	
	Supplier:		
HELIUM VESSEL	Weight:	2158.75 Kg	
	File name:318711-JLA-703-001		
DWG NO. 318711-JLA-703-001			Rev: B
This drawing may not be used without special licence or authorisation express (Law of the 11 march 1957)	A0	SCALE:1:10	SHEET 1 OF 2

STATE OF DELIVERY RECEIVED AT SIGMAPHI:
(collared coil inside)
FOR DIMENSIONS AND TOLERANCE, SEE
PAGE 1 OF THIS DRAWING



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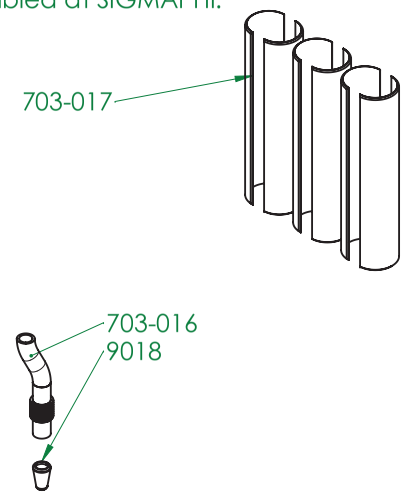

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	Name	Date
Drawing	M. DELBECQ	09/04/2015
Checked		
Approved		

MATERIAL:	See assembly
Trait.:	
Roughness :	
Tol Gen	SEE NOTE
Supplier:	
Weight:	2158.75 Kg

QPOLE

HELIUM VESSEL

File name:318711-JLA-703-001

DWG NO. **318711-JLA-703-001**

Rev: **B**

A3 SCALE:1:5

REVISIONS				
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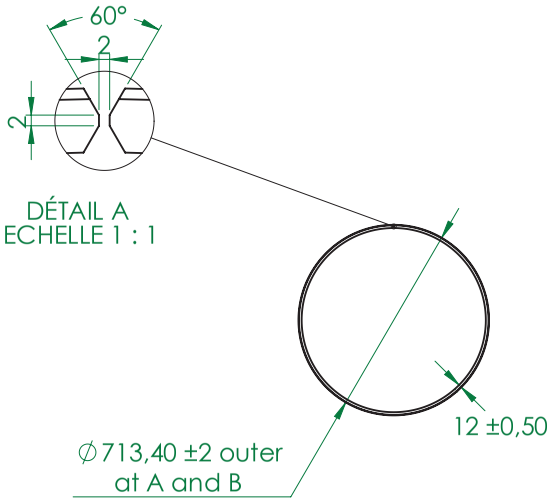
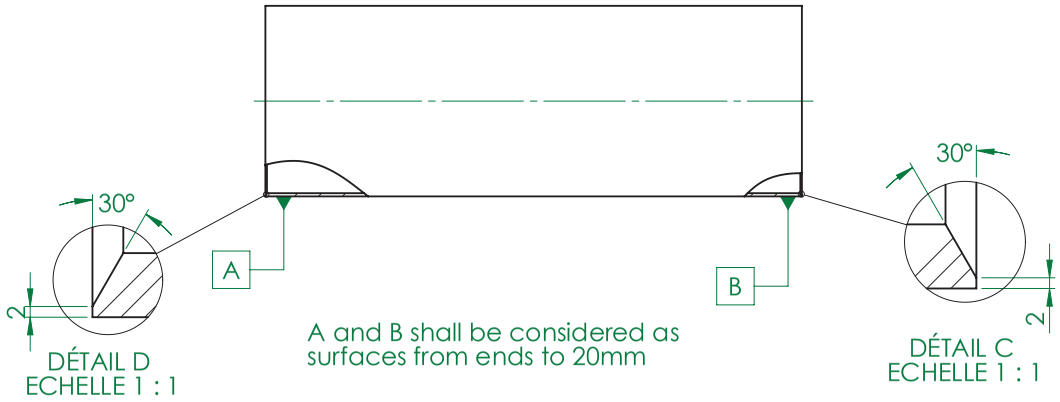
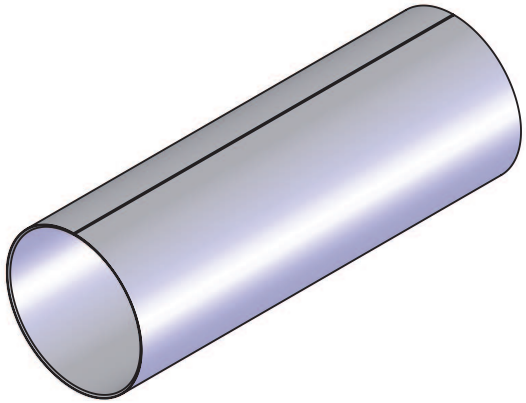
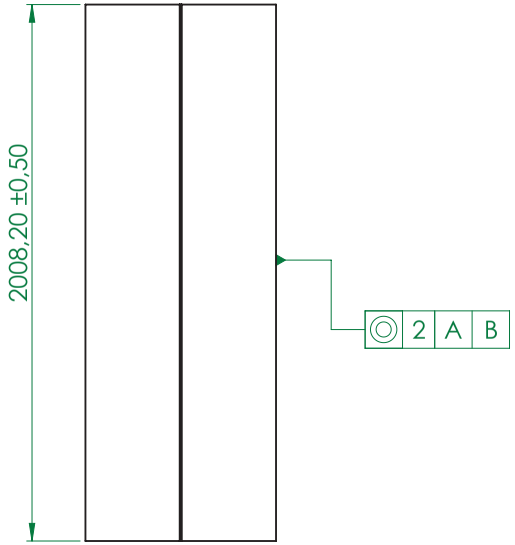
	A	CREATION	28/06/2013	M. DELBECQ









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	Name	Date
Drawing	M. DELBECQ	08/04/2015
Checked		
Approved		

MATERIAL:	304L (X2CrNi18-9)
Trait.:	SEE NOTE
Roughness :	SEE NOTE
Tol Gen	SEE NOTE
Supplier:	
Weight:	417.66 Kg
File name:318711-JLA-703-003	

703-Helium-Vessel

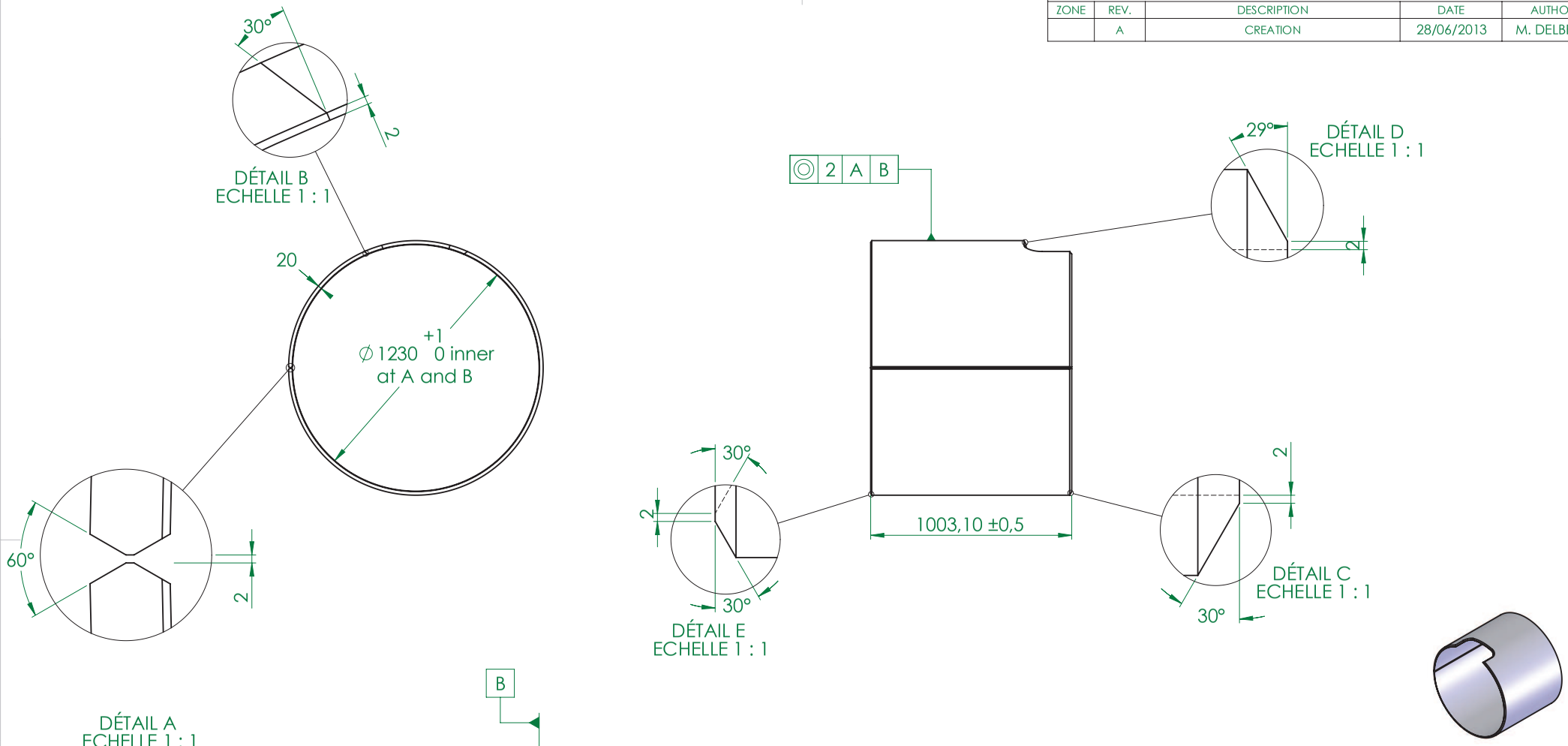
INNER TUBE

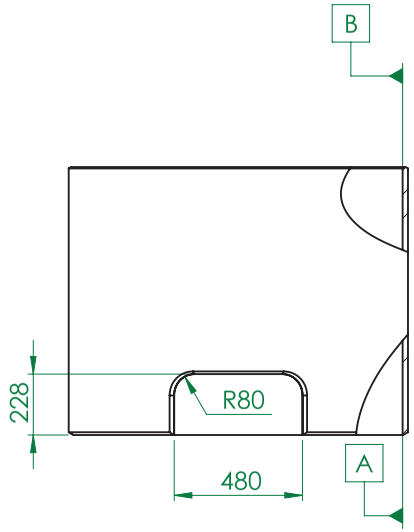
DWG NO. **318711-JLA-703-003**

Rev: **A**

A3 SCALE:1:20 SHEET 1 OF 1

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	AUTHOR
	A	CREATION	28/06/2013	M. DELBECQ





A and B have to be considered as surfaces from ends to 20mm

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	Name	Date
Drawing	M. DELBECQ	08/04/2015
Checked		
Approved		

MATERIAL:	304L (X2CrNi18-9)
Trait.:	SEE NOTE
Roughness :	SEE NOTE
Tol Gen	SEE NOTE
Supplier:	
Weight:	599.09 Kg

703-Helium-Vessel

OUTER TUBE

File name:318711-JLA-703-002

DWG NO. **318711-JLA-703-002**

Rev: **A**

A3 SCALE:1:20 SHEET 1 OF 1

REVISIONS				
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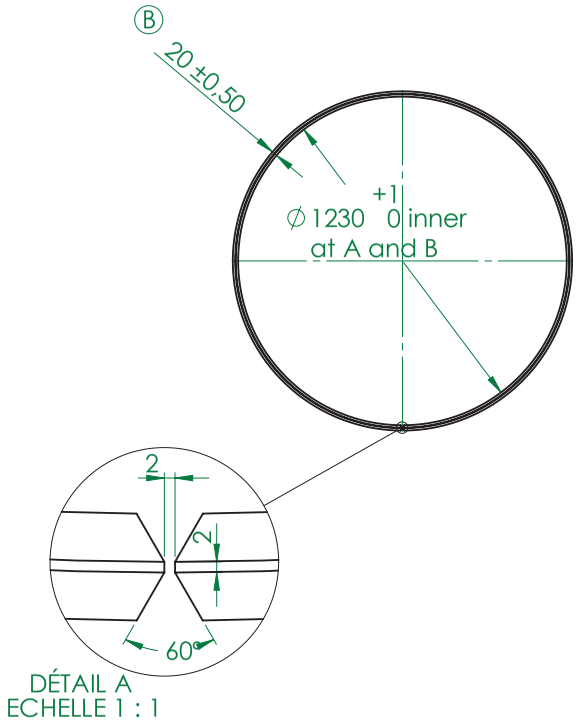
	B	added tolerance on thickness	08/04/2015	



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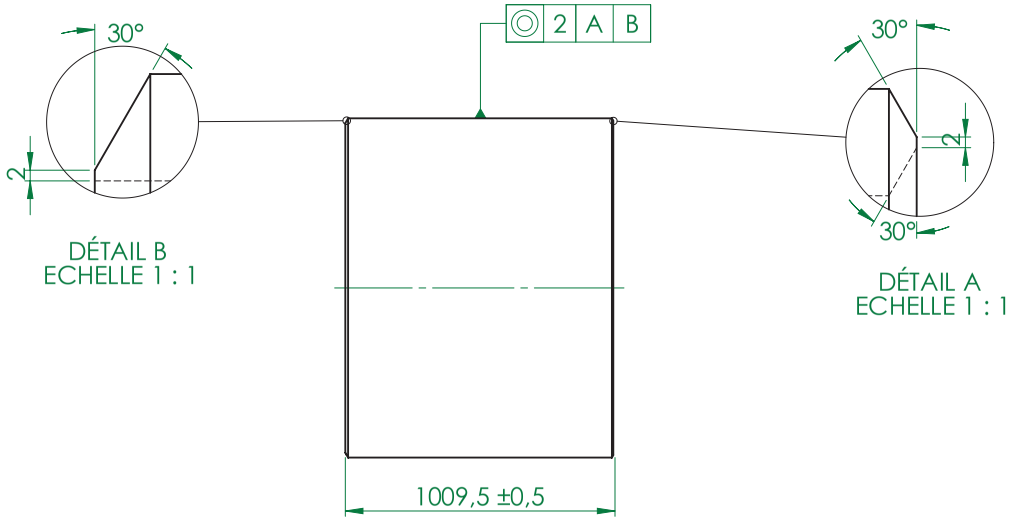

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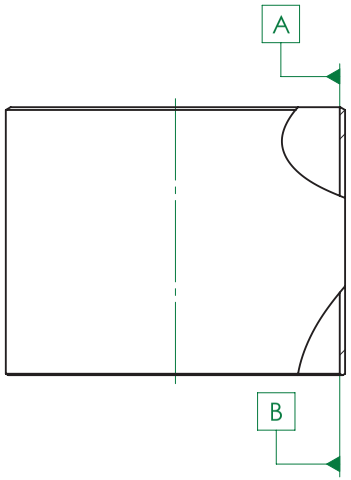
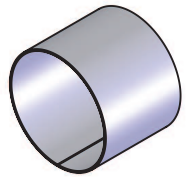
ECHELLE 1 : 1

DÉTAIL A
ECHELLE 1 : 1



A and B have to be considered as surfaces from ends to 20mm



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	Name	Date
Drawing	M. DELBECQ	08/04/2015
Checked		
Approved		

MATERIAL:	304L (X2CrNi18-9)
Trait.:	SEE NOTE
Roughness :	SEE NOTE
Tol Gen	SEE NOTE
Supplier:	
Weight:	616.97 Kg
	File name:318711-JLA-703-015

703-Helium-Vessel

OUTER TUBE #2

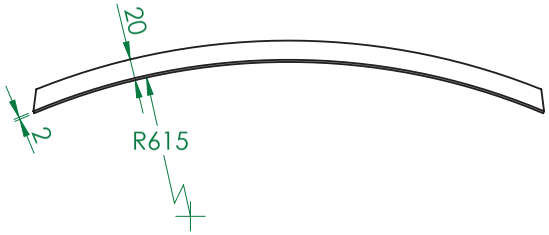
DWG NO. **318711-JLA-703-015**

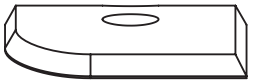
Rev: **B**

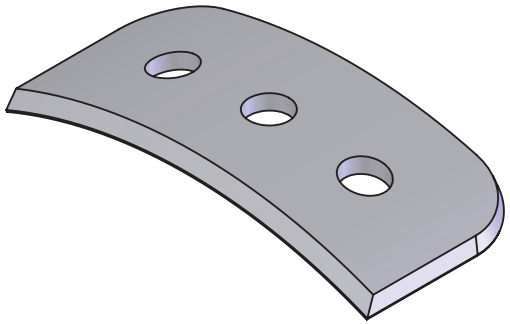
A3 SCALE:1:20 SHEET 1 OF 1

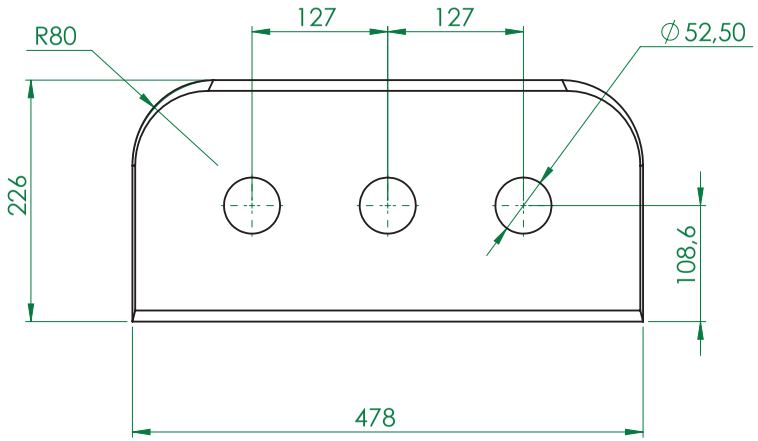
REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	AUTHOR
	A	CREATION	26/08/2013	M. DELBECQ

For Manufacturing









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Tel(33) 02.97.01.08.80 Fax (33)02.97.01.08.81 EMAIL Contact@sigmaphi.fr

	Name	Date
Drawing	M. DELBECQ	08/04/2015
Checked		
Approved		

MATERIAL:	304L (X2CrNi18-9)
Trait.:	
Roughness :	
Tol Gen	±1
Supplier:	
Weight:	15.28 Kg

File name:318711-JLA-703-011

703-Helium-Vessel

Rustine

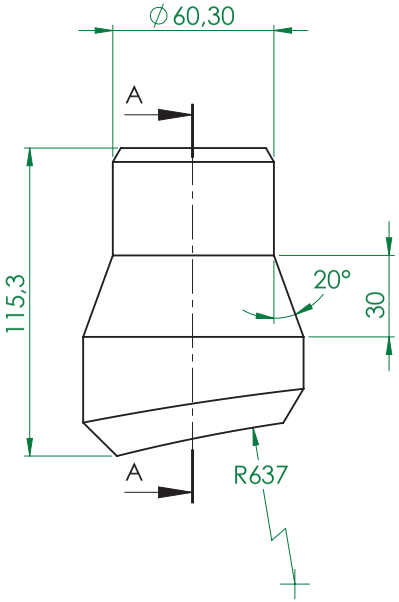
DWG NO. **318711-JLA-703-011**

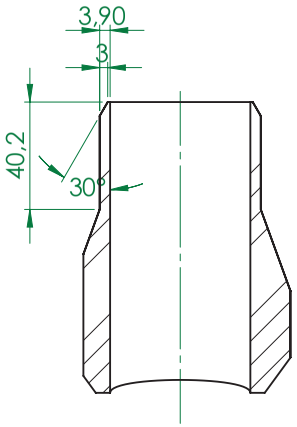
Rev: **A**

A3 SCALE:1:5 SHEET 1 OF 1

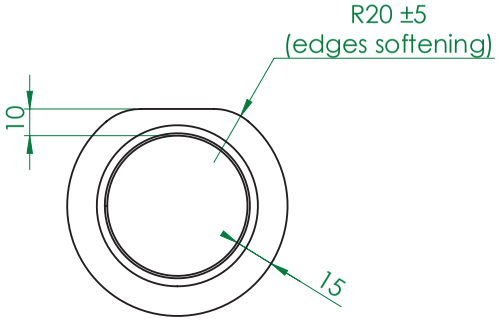
REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	AUTHOR
	A	CREATION	26/08/2013	M. DELBECQ
	B	added note	08/04/2015	MD

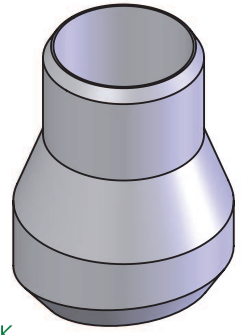
For Manufacturing





COUPE A-A





NOTE:
- All dimensions in mm.
- Material: 304L or 316L
- Content liquid helium at 4K.
- Design pressure: 7atm absolute from 4K to 300K (inner pressure).
- Design and manufacturing according to AMSE BPV.
- Helium leakage test: 10^-9 mbar.l/s

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	Name	Date
Drawing	M. DELBECQ	08/04/2015
Checked		
Approved		

MATERIAL:	304L (X2CrNi18-9)
Trait.:	
Roughness :	
Tol Gen	±0.5
Supplier:	
Weight:	1.47 Kg

File name:318711-JLA-703-012

703-Helium-Vessel

Socolé #2

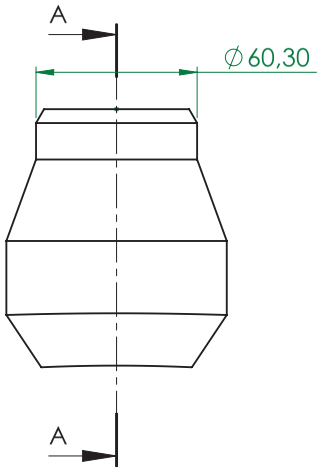
DWG NO. **318711-JLA-703-012**

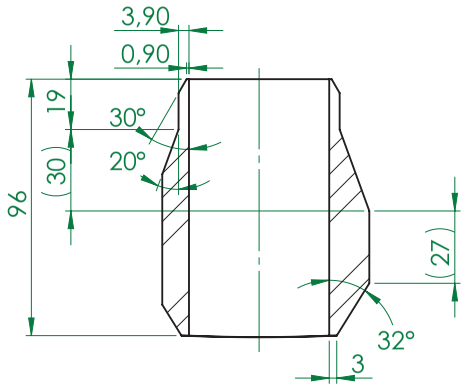
Rev: **B**

A3 SCALE:1:2 SHEET 1 OF 1

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	AUTHOR
	A	CREATION	26/08/2013	M. DELBECQ
	B	added note	08/04/2015	MD

For Manufacturing





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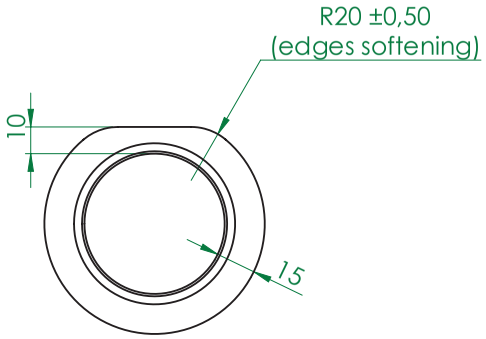

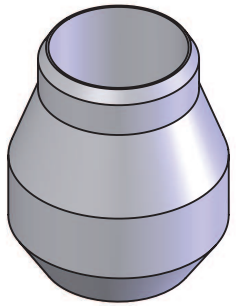

NOTE:
- All dimensions in mm.
- Material: 304L or 316L
- Content liquid helium at 4K.
- Design pressure: 7atm absolute from 4K to 300K (inner pressure).
- Design and manufacturing according to AMSE BPV.
- Helium leakage test: 10^-9 mbar.l/s

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	Name	Date
Drawing	M. DELBECQ	08/04/2015
Checked		
Approved		

MATERIAL:	304L (X2CrNi18-9)
Trait.:	
Roughness :	
Tol Gen	±0.5
Supplier:	
Weight:	1.46 Kg

703-Helium-Vessel

Socolé

File name:318711-JLA-703-013

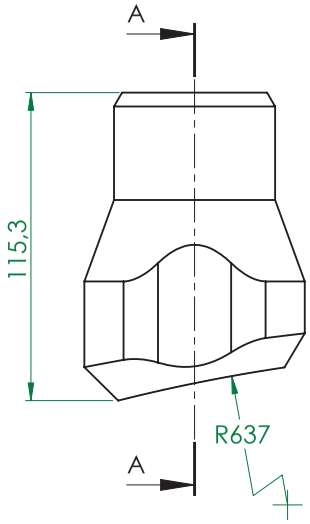
DWG NO. **318711-JLA-703-013**

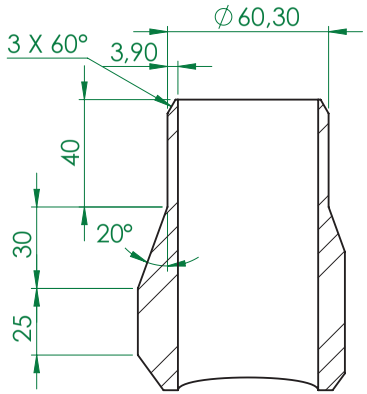
Rev: **B**

A3 SCALE:1:2 SHEET 1 OF 1

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	AUTHOR
	A	CREATION	26/08/2013	M. DELBECQ
	B	added note	08/04/2015	MD

For Manufacturing





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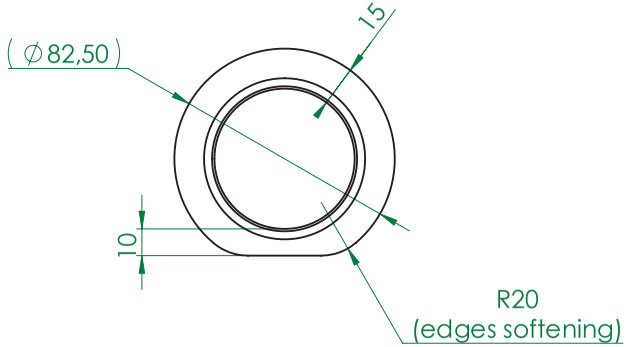

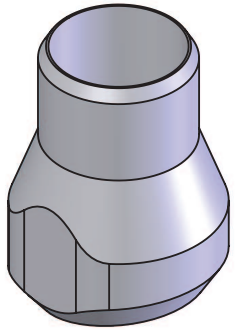

NOTE:
- All dimensions in mm.
- Material: 304L or 316L
- Content liquid helium at 4K.
- Design pressure: 7atm absolute from 4K to 300K (inner pressure).
- Design and manufacturing according to AMSE BPV.
- Helium leakage test: 10^-9 mbar.l/s

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	Name	Date
Drawing	M. DELBECQ	08/04/2015
Checked		
Approved		

MATERIAL:	304L (X2CrNi18-9)
Trait.:	
Roughness :	
Tol Gen	±0.5
Supplier:	
Weight:	1.47 Kg

703-Helium-Vessel

Socolé #3

File name:318711-JLA-703-014

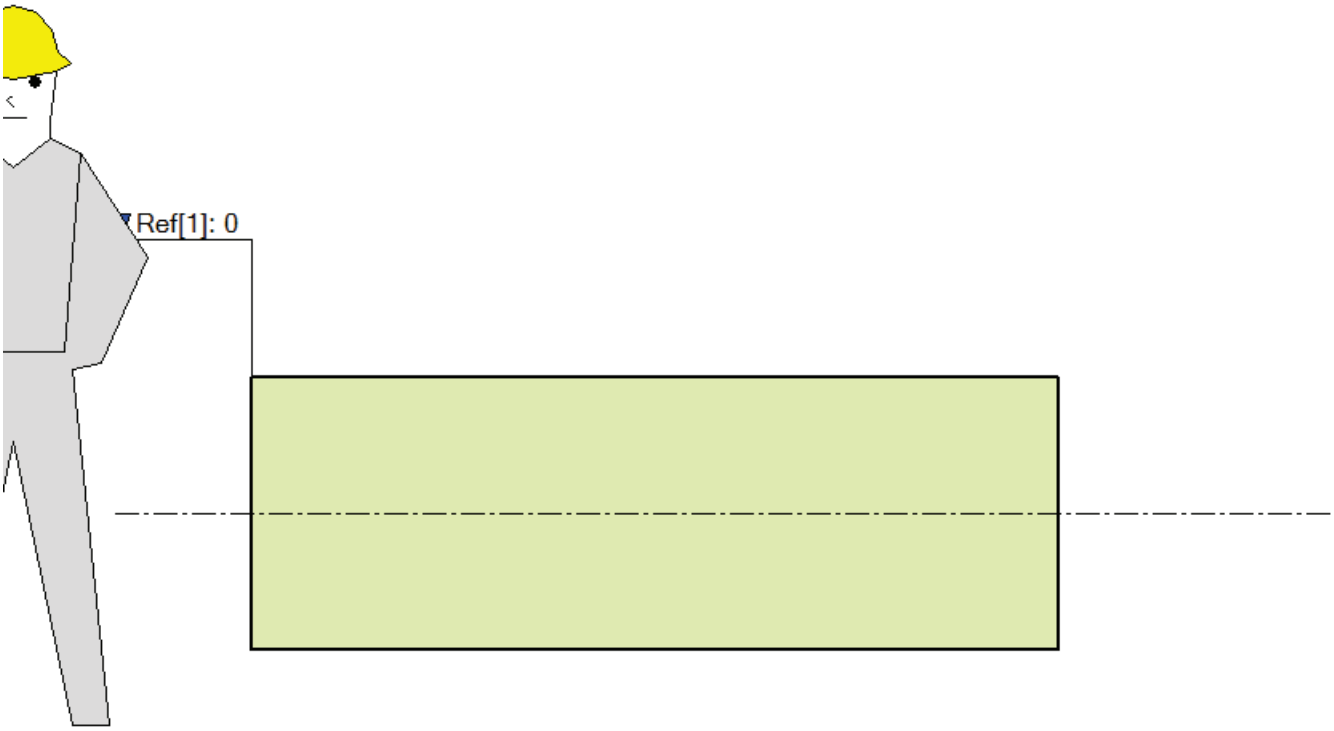
DWG NO. **318711-JLA-703-014**

Rev: **B**

A3 SCALE:1:2 SHEET 1 OF 1

APPENDIX B

Detailed calculation notes



Job Tag :	Virole interne en service	Description :	
Job Name :		Drawing No :	
Vessel Tag :			

Element(s) of geometry under external pressure
External Pressure – Shell (Section No. 1) (in operation)

Ends of section :

Bottom :		Support line level : 0,000 mm
top :		Support line level : 2 100,000 mm

Elements considered :

Tag	Diameter (mm)	Thickness (mm)	modulus of elasticity (MPa)	Vacuum curve	Temperature (°C)
001 31.05 Virole	713,50	12,000	193 100	HA-3	20,0 °C

ASME VIII DIV.1

External Pressure : P = 0,7 MPa	Design Temperature : 20 °C
Allowable stress : S = 115 MPa	modulus of elasticity : E = 193 100 MPa
Unsupported shell length : 2 100 mm	Pipe, tolerance on the new thickness : c_1 = /
Diameter of section : D_o = 713,5 mm	Vacuum curve : HA-3
Checked thickness : t = 11,5 mm	

UG-28 (c) Cylindrical shell with straight circular section

L = 2 100 mm L/D_o = 2,943 D_o/t = 62,043

$D_o/t \geq 4$: A (Subpart 3 Section II Part D Fig.G) = 0,00087

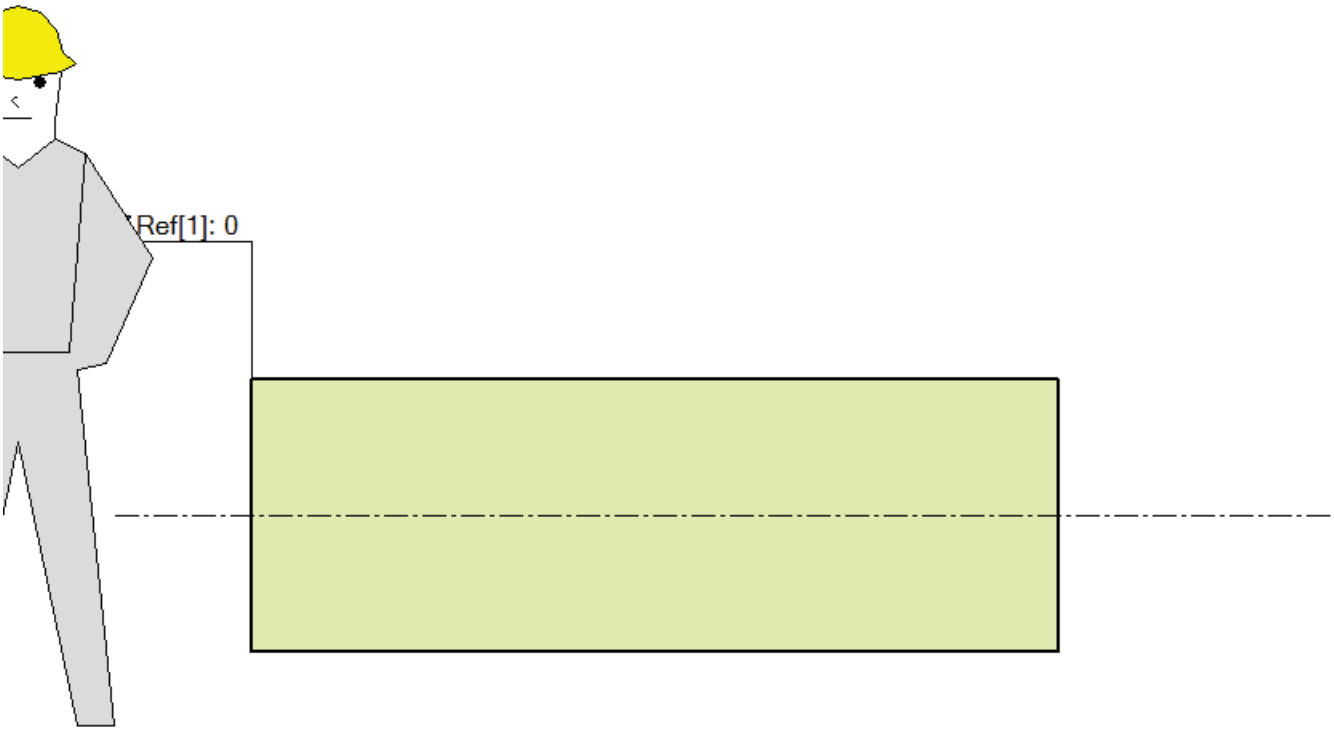
$D_o/t \geq 10$: $P_a = \frac{4}{3}\frac{B}{D_o/t}$

$D_o/t < 4$: $A = \min\left(0.10, \frac{1.1}{(D_o/t)^2}\right)$ = /

$D_o/t < 10$: $P_a = \min\left\{\left[\left(\frac{2.167}{D_o/t} - 0.0833\right)B\right]; \left[\frac{2S}{D_o/t}\left(1 - \frac{1}{D_o/t}\right)\right]\right\}$

B (Subpart 3 Section II Part D or $AE/2$) = 59,3916 MPa

P_a = 1,2763 MPa $\geq$ P Minimum required thickness = 7,77 mm



Job Tag :	Inner tube in strength test con	Description :	
Job Name :		Drawing No :	
Vessel Tag :			

Element(s) of geometry under external pressure
External Pressure – Shell (Section No. 1) (in operation)

Ends of section :

Bottom :		Support line level : 0,000 mm
top :		Support line level : 2 100,000 mm

Elements considered :

Tag	Diameter (mm)	Thickness (mm)	modulus of elasticity (MPa)	Vacuum curve	Temperature (°C)
001 31.05 Virole	713,50	12,000	193 100	HA-3	20,0 °C

ASME VIII DIV.1

External Pressure : P = 1 MPa	Design Temperature : 20 °C
Allowable stress : S = 154,96 MPa	modulus of elasticity : E = 193 100 MPa
Unsupported shell length : 2 100 mm	Pipe, tolerance on the new thickness : c_1 = /
Diameter of section : D_o = 713,5 mm	Vacuum curve : HA-3
Checked thickness : t = 11,5 mm	

UG-28 (c) Cylindrical shell with straight circular section

L = 2 100 mm	L/D_o = 2,943	D_o/t = 62,043

$D_o/t \geq 4$: A (Subpart 3 Section II Part D Fig.G) = 0,00087

$D_o/t \geq 10$: $P_a = \frac{4}{3}\frac{B}{D_o/t}$

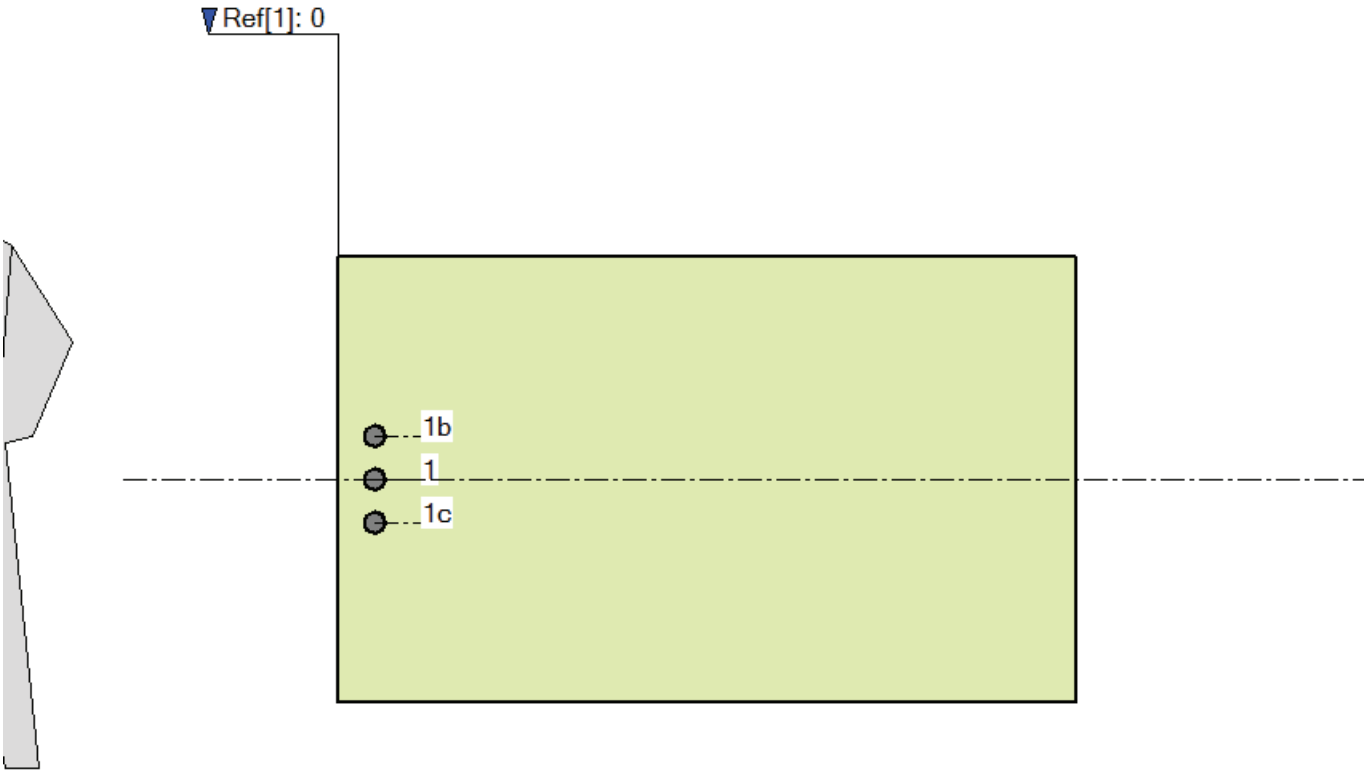
$D_o/t < 4$: $A = \min\left(0.10, \frac{1.1}{(D_o/t)^2}\right) =$ /

$D_o/t < 10$: $P_a = \min\left\{\left[\left(\frac{2.167}{D_o/t} - 0.0833\right)B\right]; \left[\frac{2S}{D_o/t}\left(1 - \frac{1}{D_o/t}\right)\right]\right\}$

B (Subpart 3 Section II Part D or $AE/2$) = 59,3916 MPa

P_a = 1,2763 MPa $\geq$ P

Minimum required thickness = 9,56 mm



Job Tag :	Outer tube in operating and str	Description :	
Job Name :		Drawing No :	
Vessel Tag :			

Element(s) of geometry under internal pressure

Cylindrical shell under internal pressure.

ASME VIII DIV.1 2013

t = minimum required thickness	t_n = nominal thickness	E = Weld joint efficiency
P = internal pressure	S = Allowable stress	T = Temperature
R = Internal Radius	Ca = corrosion + tolerance	σ = circular stress
R_o = outside radius	$Tol_{\%}$ = tolerance for pipes	P_a = maximum allowable pressure
$t_{n,min} = (t+Ca)/Tol_{\%}$ shall be $\leq t_n$	$t_u = (t_n \times Tol_{\%})-Ca$ shall be $\geq t$	P_h = Hydrostatic pressure

UG-27 (c)	$t = P(R+Ca)/(SE-0.6P)$	$\sigma = (P(R+Ca) / t_u + 0.6P) / E$	$P_a = S\,E\,t_u / ((R+Ca)+ 0.6\,t_u)$
Appendix 1-1.(a)(1)	$t = PR_o/(SE+0.4P)$	$\sigma = (PR_o / t_u - 0.4P) / E$	$P_a = S\,E\,t_u / (R_o - 0.4\,t_u)$

Shell (01) : 31.05 (Virole)

SA240GR304L	Plate							Schedule : /	DN : /
t_n = 20,000 mm	R = 615,00 mm	$Tol_{\%}$ = /						PWHT : No	Radiography : Full
	R_o = 635,00 mm	Cor. = 0 mm		Tol. = 0,5 mm		UG-16(b) = 1,5 mm			

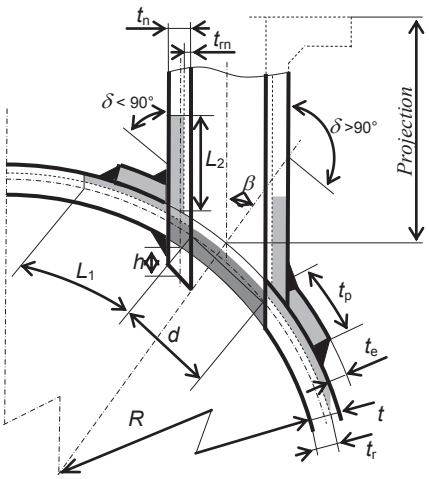
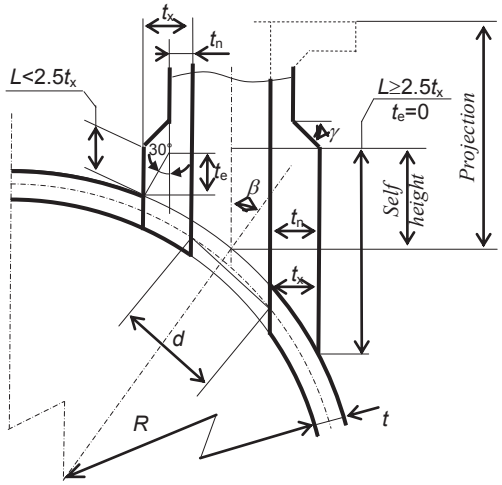
		P (MPa)	P_h (MPa)	T (°C)	S (MPa)	E	t_u (mm)	σ (MPa)	P_a (MPa)	t (mm)	$t_{n,min}$ (mm)
Operation	N	0,7	0	20	115	1	19,500	22,51	3,58	3,760	4,260
Horizontal test	X	1,0121	0,0121	20	154,8	1	19,500	32,55	4,81	4,040	4,540

MAWP (20 °C, Corroded) = 3,58 MPa MAWP (20 °C, new) = 3,58 MPa

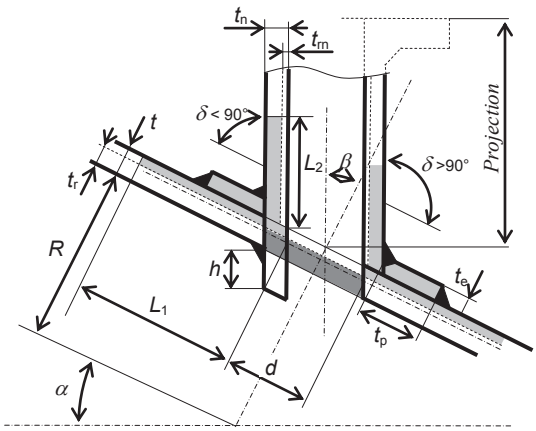
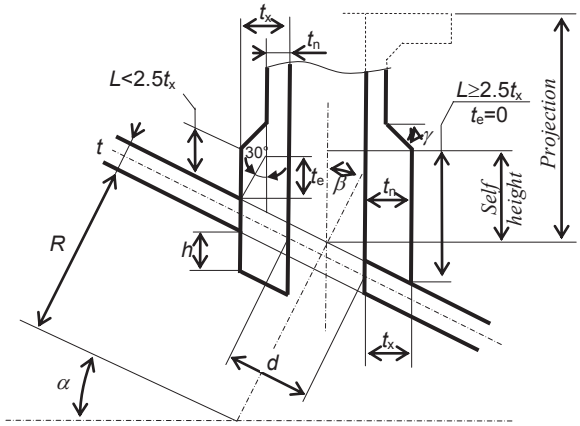
Isolated Opening(s)

Figures for all configurations, from FIG. UG-37.1 And FIG UG-40.

Shell ($\alpha = 0$) or Cone ($\alpha > 0$) : in longitudinal plane.

Nozzle with or without pad, set-in or set-on	Self-reinforcing nozzle, set-in or set-on
	

Cylindrical or conical shell: circumferential plane
Head: in the plane that contains the axis of the nozzle and the longitudinal axis of the vessel.

Nozzle with or without pad, set-in or set-on	Self-reinforcing nozzle, set-in or set-on
	

Opening 1 [in operation Int.P.] *(Process)*

ASME VIII DIV.1

Nozzle without pad on Shell (No. 1)		Set On
Pressure : P = 0,7 MPa	Temperature : 20 °C	
Shell Joint efficiency : 1 E_1 = 1 Ext. Diameter : D_o = 1 270 mm	Material :SA240GR304L Corrosion + tolerance : Ca_v = 0,5 mm Thickness as new : 20 mm	Allowable stress : S_v = 115 MPa Allowable stress : S = 115 MPa Tolerance for seamless pipe : /
Nozzle Neck Weld joint efficiency : 1 Ext. Diameter : D_{on} = 64,5 mm External Projection : 20 mm Inclination : 0 °	Material : SA249TP304L Corrosion + tolerance : Ca_n = 0,5 mm Thickness as new : 6 mm Internal Projection : 0 mm Eccentricity : 0 mm	Allowable stress : S_n = 97,8 MPa Tolerance for seamless pipe : /
Flange Rating : /	Material : / Height : /	Type : / /
Pad Height : /	Material : / Width : /	Allowable stress : S_p = / Ext. Diameter : D_{op} = /
Weld Outside : leg_{41}= 6 mm	outer reinforcement : leg_{42}= /	Inside : leg_{43}= /

fr_1 = 1 fr_2 = min(1,S_n/S_v) = 0,85 fr_3 = min(1,min(S_n, S_p)/S_v) = 0,85 fr_4 = min(1,S_p/S_v) = 0,964

Required thickness of the nozzle neck UG-27

$t_{rn} = P\,R_n / (S_nE\text{-}0.6P)$ = 0,192 mm	R_n = 26,75 mm	E = 1

The nozzle neck thickness is adequate per UG-27.

Required thickness of the nozzle neck UG-45

$t_a = t_{rn}+Ca_n$= 0,69 mm ; t_{b1} = max[$t_{UG\text{-}27}$, UG-16(b)]+Ca_v= 4,26 mm ; t_{b3} = Table UG-45+Ca_n= 5,02 mm
$t_{UG\text{-}45}$ = max [t_a , min [t_{b3} , t_{b1}]] = 4,26 mm

The nozzle neck thickness is adequate per UG-45.

Dimensions FIG. UG-40

angle of plane with longitudinal axis : angle of each side / wall of the vessel :	Longitudinal plane : θ = 0° δ = 90 ° δ = 90 °	Circumferential plane : θ = 90° δ = / δ = /
β = deflection angle / normal line	0 °	
d = diameter of the opening	53,5 mm	
R_n = radius of the finished opening	26,75 mm	
t_i = thickness of internal projection	/	
t_p = Reinforcing ring width	/	
t_x = thickness of selfreinforcing	/	
L = height of selfreinforcing	/ /	
Configuration of the reinforcement :	/ /	
t_e = thickness or height of the reinforcement	0 mm 0 mm	
t_n = Nozzle thickness	5,5 mm 5,5 mm	
h = height of internal projection	0 mm 0 mm	

Reinforcement checking UG-37 *opening 1 [in operation Int.P.]*

Required thicknesses UG-37(a)		
t_r = 3,76 mm [UG-27(c)]	t = 19,5 mm	E = 1
$t_{rn} = P\,R_n / (S_nE\text{-}0.6P)$ = 0,192 mm	R_n = 26,75 mm	E = 1

Limits of reinforcement UG-40 :	Longitudinal plane : θ = 0° δ = 90 ° δ = 90 °	Circumferential plane : θ = 90° δ = / δ = /
UG-40 (b) : max [d , R_n+t_n+t] =	53,5 mm 53,5 mm	
UG-40 (c) : min [2.5t , 2.5t_n+t_e] =	13,75 mm 13,75 mm	

Area required UG-37 (c) :	Longitudinal plane : θ = 0°	Circumferential plane : θ = 90°
F = Correction factor FIG.UG-37	1	
$A = d\,t_r\,F + 2\,t_n/\cos(\beta)\,t_r\,F\,(1\text{-}f_{r1})$	201,2 mm^2	

Lengths and heights of calculation of the areas :	Longitudinal plane : θ = 0° δ = 90 ° δ = 90 °	Circumferential plane : θ = 90° δ = / δ = /
L_1 = min [UG-40(b)-Radius , length available]	26,75 mm 26,75 mm	
L_2 = min [UG-40(c) , height available]	13,75 mm 13,75 mm	
L_3 = min [h , 2.5t , 2.5t_i] =	0 mm 0 mm	
L_5 = min [UG-40 (b)-R_{on} , t_p , length available]	0 mm 0 mm	

Area available (mm^2) :	Longitudinal plane : $\theta = 0°$ $\delta = 90°$	 $\delta = 90°$	Circumferential plane : $\theta = 90°$ $\delta = /$	 $\delta = /$
$A_1 = L_1\ (E_1\ t\text{-}t_r\ F) - t_n/\cos(\beta)\ (E_1\ t\text{-}t_r\ F)\ (1\text{-}f_{r1})$	421	421		
$A_2 = L_2\ (t_n\text{-}t_{rn})\ fr_2$	62,1	62,1		
$A_3 = L_3\ t_i\ f_{r2}$	0	0		
$A_{41} = leg_{41}^2\ /2\ f_{r2}$	15,3	15,3		
$A_{42} = leg_{42}^2\ /2\ f_{r4}$	0	0		
$A_{43} = leg_{43}^2\ /2\ f_{r2}$	0	0		
$A_5 = L_5\ t_e\ f_{r4}$	0	0		
$A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 =$	498,4	498,4		
	small opening UG-36(c)(3)			

The opening is adequately reinforced per UG-37.

Weld sizes check UW-16(c). *opening 1 [in operation Int.P.]*

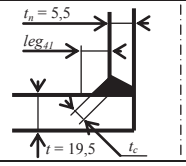


Fig. UW-16.1(a) full penetration weld		
	Minimum throat required	actual
t_c	min[¼ in.(6 mm);0.7×t_{min}]= 3,85 mm t_{min} = min[¾ in.(19 mm) ; t , t_n]	0.7×leg_{41} = 4,2 mm
Weld sizes are adequate		

Weld loads check UG-41(b).

No verification is required for this type of nozzle, in accordance with UW-15(b).

Opening 1 [in test Int.P.] *(Process)*

ASME VIII DIV.1

Nozzle without pad on Shell (No. 1)		Set On
Pressure : P = 1,006 MPa	Temperature : 20 °C	
Shell Joint efficiency : 1 E_1 = 1 Ext. Diameter : D_o = 1 270 mm	Material :SA240GR304L Corrosion + tolerance : Ca_v = 0,5 mm Thickness as new : 20 mm	Allowable stress : S_v = 154,8 MPa Allowable stress : S = 154,8 MPa Tolerance for seamless pipe : /
Nozzle Neck Weld joint efficiency : 1 Ext. Diameter : D_{on} = 64,5 mm External Projection : 20 mm Inclination : 0 °	Material : SA249TP304L Corrosion + tolerance : Ca_n = 0,5 mm Thickness as new : 6 mm Internal Projection : 0 mm Eccentricity : 0 mm	Allowable stress : S_n = 154,8 MPa Tolerance for seamless pipe : /
Flange Rating : /	Material : / Height : /	Type : / /
Pad Height : /	Material : / Width : /	Allowable stress : S_p = / Ext. Diameter : D_{op} = /
Weld Outside : leg_{41}= 6 mm	outer reinforcement : leg_{42}= /	Inside : leg_{43}= /

fr_1 = 1 fr_2 = min(1,S_n/S_v) = 1 fr_3 = min(1,min(S_n, S_p)/S_v) = 1 fr_4 = min(1,S_p/S_v) = 1

Required thickness of the nozzle neck UG-27

$t_{rn} = P\,R_n / (S_nE\text{-}0.6P)$ = 0,175 mm	R_n = 26,75 mm	E = 1

The nozzle neck thickness is adequate per UG-27.

Required thickness of the nozzle neck UG-45

$t_a = t_{rn}+Ca_n$= 0,67 mm ; t_{b1} = max[$t_{UG\text{-}27}$, UG-16(b)]+Ca_v= 4,52 mm ; t_{b3} = Table UG-45+Ca_n= 5,02 mm

$t_{UG\text{-}45}$ = max [t_a , min [t_{b3} , t_{b1}]] = 4,516 mm

The nozzle neck thickness is adequate per UG-45.

Dimensions FIG. UG-40

angle of plane with longitudinal axis : angle of each side / wall of the vessel :	Longitudinal plane : θ = 0° δ = 90 ° δ = 90 °	Circumferential plane : θ = 90° δ = / δ = /
β = deflection angle / normal line	0 °	
d = diameter of the opening	53,5 mm	
R_n = radius of the finished opening	26,75 mm	
t_i = thickness of internal projection	/	
t_p = Reinforcing ring width	/	
t_x = thickness of selfreinforcing	/	
L = height of selfreinforcing	/ /	
Configuration of the reinforcement :	/ /	
t_e = thickness or height of the reinforcement	0 mm 0 mm	
t_n = Nozzle thickness	5,5 mm 5,5 mm	
h = height of internal projection	0 mm 0 mm	

Reinforcement checking UG-37 *opening 1 [in test Int.P.]*

Required thicknesses UG-37(a)		
t_r = 4,016 mm [UG-27(c)]	t = 19,5 mm	E = 1
$t_{rn} = P\,R_n / (S_nE\text{-}0.6P)$ = 0,175 mm	R_n = 26,75 mm	E = 1

Limits of reinforcement UG-40 :	Longitudinal plane : θ = 0° δ = 90 ° δ = 90 °	Circumferential plane : θ = 90° δ = / δ = /
UG-40 (b) : max [d , R_n+t_n+t] =	53,5 mm 53,5 mm	
UG-40 (c) : min [2.5t , 2.5t_n+t_e] =	13,75 mm 13,75 mm	

Area required UG-37 (c) :	Longitudinal plane : θ = 0°	Circumferential plane : θ = 90°
F = Correction factor FIG.UG-37	1	
$A = d\,t_r\,F + 2\,t_n/\cos(\beta)\,t_r\,F\,(1\text{-}f_{r1})$	214,8 mm^2	

Lengths and heights of calculation of the areas :	Longitudinal plane : θ = 0° δ = 90 ° δ = 90 °	Circumferential plane : θ = 90° δ = / δ = /
L_1 = min [UG-40(b)-Radius , length available]	26,75 mm 26,75 mm	
L_2 = min [UG-40(c) , height available]	13,75 mm 13,75 mm	
L_3 = min [h , 2.5t , 2.5t_i] =	0 mm 0 mm	
L_5 = min [UG-40 (b)-R_{on} , t_p , length available]	0 mm 0 mm	

Area available (mm^2) :	Longitudinal plane : $\theta = 0°$ $\delta = 90°$	 $\delta = 90°$	Circumferential plane : $\theta = 90°$ $\delta = /$	 $\delta = /$
$A_1 = L_1 (E_1\ t\text{-}t_r\ F) - t_n/\cos(\beta)\ (E_1\ t\text{-}t_r\ F)\ (1\text{-}f_{r1})$	414,2	414,2		
$A_2 = L_2\ (t_n\text{-}t_{rn})\ fr_2$	73,2	73,2		
$A_3 = L_3\ t_i\ f_{r2}$	0	0		
$A_{41} = leg_{41}^2\ /2\ f_{r2}$	18	18		
$A_{42} = leg_{42}^2\ /2\ f_{r4}$	0	0		
$A_{43} = leg_{43}^2\ /2\ f_{r2}$	0	0		
$A_5 = L_5\ t_e\ f_{r4}$	0	0		
$A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 =$	505,4	505,4		
	small opening UG-36(c)(3)			

The opening is adequately reinforced per UG-37.

Opening 1b [in operation Int.P.] *(Process)*

ASME VIII DIV.1

Nozzle without pad on Shell (No. 1)		Set On
Pressure : P = 0,7 MPa	Temperature : 20 °C	
Shell Joint efficiency : 1 E_1 = 1 Ext. Diameter : D_o = 1 270 mm	Material :SA240GR304L Corrosion + tolerance : Ca_v = 0,5 mm Thickness as new : 20 mm	Allowable stress : S_v = 115 MPa Allowable stress : S = 115 MPa Tolerance for seamless pipe : /
Nozzle Neck Weld joint efficiency : 1 Ext. Diameter : D_{on} = 64,5 mm External Projection : 20 mm Inclination : 0 °	Material : SA249TP304L Corrosion + tolerance : Ca_n = 0,5 mm Thickness as new : 6 mm Internal Projection : 0 mm Eccentricity : 127 mm	Allowable stress : S_n = 97,8 MPa Tolerance for seamless pipe : /
Flange Rating : /	Material : / Height : /	Type : / /
Pad Height : /	Material : / Width : /	Allowable stress : S_p = / Ext. Diameter : D_{op} = /
Weld Outside : leg_{41}= 6 mm	outer reinforcement : leg_{42}= /	Inside : leg_{43}= /

fr_1 = 1 fr_2 = min(1,S_n/S_v) = 0,85 fr_3 = min(1,min(S_n, S_p)/S_v) = 0,85 fr_4 = min(1,S_p/S_v) = 0,964

Required thickness of the nozzle neck UG-27

$t_{rn} = P\,R_n / (S_nE\text{-}0.6P)$ = 0,192 mm	R_n = 26,75 mm	E = 1

The nozzle neck thickness is adequate per UG-27.

Required thickness of the nozzle neck UG-45

$t_a = t_{rn}+Ca_n$= 0,69 mm ; t_{b1} = max[$t_{UG\text{-}27}$, UG-16(b)]+Ca_v= 4,26 mm ; t_{b3} = Table UG-45+Ca_n= 5,02 mm

$t_{UG\text{-}45}$ = max [t_a , min [t_{b3} , t_{b1}]] = 4,26 mm

The nozzle neck thickness is adequate per UG-45.

Dimensions FIG. UG-40

angle of plane with longitudinal axis : angle of each side / wall of the vessel :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
β = deflection angle / normal line	0 °		11,54 °	
d = diameter of the opening	53,5 mm		54,64 mm	
R_n = radius of the finished opening	26,75 mm		27,32 mm	
t_i = thickness of internal projection	/		/	
t_p = Reinforcing ring width	/		/	
t_x = thickness of selfreinforcing	/		/	
L = height of selfreinforcing	/	/	/	/
Configuration of the reinforcement :	/	/	/	/
t_e = thickness or height of the reinforcement	0 mm	0 mm	0 mm	0 mm
t_n = Nozzle thickness	5,5 mm	5,5 mm	5,5 mm	5,5 mm
h = height of internal projection	0 mm	0 mm	0 mm	0 mm

Reinforcement checking UG-37 *opening 1b [in operation Int.P.]*

Required thicknesses UG-37(a)		
t_r = 3,76 mm [UG-27(c)]	t = 19,5 mm	E = 1
$t_{rn} = P\,R_n / (S_nE\text{-}0.6P)$ = 0,192 mm	R_n = 26,75 mm	E = 1

Limits of reinforcement UG-40 :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
UG-40 (b) : max [d , R_n+t_n+t] =	53,5 mm	53,5 mm	54,64 mm	54,64 mm
UG-40 (c) : min [2.5t , 2.5t_n+t_e] =	13,75 mm	13,75 mm	13,75 mm	13,75 mm

Area required UG-37 (c) :	Longitudinal plane : θ = 0°	Circumferential plane : θ = 90°
F = Correction factor FIG.UG-37	1	0,5
$A = d\,t_r\,F + 2\,t_n/\cos(\beta)\,t_r\,F\,(1\text{-}f_{r1})$	201,2 mm^2	102,7 mm^2

Lengths and heights of calculation of the areas :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
L_1 = min [UG-40(b)-Radius , length available]	26,75 mm	26,75 mm	27,31 mm	27,31 mm
L_2 = min [UG-40(c) , height available]	13,75 mm	13,75 mm	13,75 mm	13,75 mm
L_3 = min [h , 2.5t , 2.5t_i] =	0 mm	0 mm	0 mm	0 mm
L_5 = min [UG-40 (b)-R_{on} , t_p , length available]	0 mm	0 mm	0 mm	0 mm

Area available (mm^2) :	Longitudinal plane : θ = 0°		Circumferential plane : θ = 90°	
	δ = 90 °	δ = 90 °	δ = 78,46 °	δ = 101,54 °
$A_1 = L_1\ (E_1\ t\text{-}t_r\ F)$ - $t_n/\cos(\beta)\ (E_1\ t\text{-}t_r\ F)\ (1\text{-}f_{r1})$	421	421	481,2	481,2
$A_2 = L_2\ (t_n\text{-}t_{rn})\ fr_2$	62,1	62,1	62,1	62,1
$A_3 = L_3\ t_i\ f_{r2}$	0	0	0	0
$A_{41} = leg_{41}^2\ /2\ f_{r2}$	15,3	15,3	15,3	15,3
$A_{42} = leg_{42}^2\ /2\ f_{r4}$	0	0	0	0
$A_{43} = leg_{43}^2\ /2\ f_{r2}$	0	0	0	0
$A_5 = L_5\ t_e\ f_{r4}$	0	0	0	0
$A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 =$	498,4	498,4	558,6	558,6
	small opening UG-36(c)(3)		small opening UG-36(c)(3)	

The opening is adequately reinforced per UG-37.

Weld sizes check UW-16(c). *opening 1b [in operation Int.P.]*

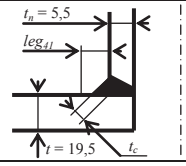


Fig. UW-16.1(a) full penetration weld		
	Minimum throat required	actual
t_c	min[¼ in.(6 mm);0.7×t_{min}]= 3,85 mm t_{min} = min[¾ in.(19 mm) ; t , t_n]	0.7×leg_{41} = 4,2 mm
Weld sizes are adequate		

Weld loads check UG-41(b).

No verification is required for this type of nozzle, in accordance with UW-15(b).

Opening 1b [in test Int.P.] *(Process)*

ASME VIII DIV.1

Nozzle without pad on Shell (No. 1)		Set On
Pressure : P = 1,0048 MPa	Temperature : 20 °C	
Shell	Material :SA240GR304L	Allowable stress : S_v = 154,8 MPa
Joint efficiency : 1 E_1 = 1	Corrosion + tolerance : Ca_v = 0,5 mm	Allowable stress : S = 154,8 MPa
Ext. Diameter : D_o = 1 270 mm	Thickness as new : 20 mm	Tolerance for seamless pipe : /
Nozzle Neck	Material : SA249TP304L	Allowable stress : S_n = 154,8 MPa
Weld joint efficiency : 1	Corrosion + tolerance : Ca_n = 0,5 mm	Tolerance for seamless pipe : /
Ext. Diameter : D_{on} = 64,5 mm	Thickness as new : 6 mm	
External Projection : 20 mm	Internal Projection : 0 mm	
Inclination : 0 °	Eccentricity : 127 mm	
Flange	Material : /	Type : /
Rating : /	Height : /	/
Pad	Material : /	Allowable stress : S_p = /
Height : /	Width : /	Ext. Diameter : D_{op} = /
Weld Outside : leg_{41}= 6 mm	outer reinforcement : leg_{42}= /	Inside : leg_{43}= /

$fr_1 = 1$ $fr_2 = \min(1, S_n/S_v) = 1$ $fr_3 = \min(1, \min(S_n, S_p)/S_v) = 1$ $fr_4 = \min(1, S_p/S_v) = 1$

Required thickness of the nozzle neck UG-27

$t_{rn} = P\,R_n / (S_nE - 0.6P) = 0{,}174$ mm $R_n = 26{,}75$ mm $E = 1$

The nozzle neck thickness is adequate per UG-27.

Required thickness of the nozzle neck UG-45

$t_a = t_{rn} + Ca_n = 0{,}67$ mm ; $t_{b1} = \max[t_{UG\text{-}27}$, UG-16(b)$] + Ca_v = 4{,}51$ mm ; t_{b3} = Table UG-45$+Ca_n = 5{,}02$ mm

$t_{UG\text{-}45} = \max[t_a , \min[t_{b3} , t_{b1}]] = 4{,}511$ mm

The nozzle neck thickness is adequate per UG-45.

Dimensions FIG. UG-40

angle of plane with longitudinal axis : angle of each side / wall of the vessel :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
β = deflection angle / normal line	0 °		11,54 °	
d = diameter of the opening	53,5 mm		54,64 mm	
R_n = radius of the finished opening	26,75 mm		27,32 mm	
t_i = thickness of internal projection	/		/	
t_p = Reinforcing ring width	/		/	
t_x = thickness of selfreinforcing	/		/	
L = height of selfreinforcing	/	/	/	/
Configuration of the reinforcement :	/	/	/	/
t_e = thickness or height of the reinforcement	0 mm	0 mm	0 mm	0 mm
t_n = Nozzle thickness	5,5 mm	5,5 mm	5,5 mm	5,5 mm
h = height of internal projection	0 mm	0 mm	0 mm	0 mm

Reinforcement checking UG-37 *opening 1b [in test Int.P.]*

Required thicknesses UG-37(a)		
t_r = 4,011 mm [UG-27(c)]	t = 19,5 mm	E = 1
$t_{rn} = P\,R_n / (S_nE - 0.6P) = 0{,}174$ mm	R_n = 26,75 mm	E = 1

Limits of reinforcement UG-40 :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
UG-40 (b) : max [d , R_n+t_n+t] =	53,5 mm	53,5 mm	54,64 mm	54,64 mm
UG-40 (c) : min [$2.5t$, $2.5t_n+t_e$] =	13,75 mm	13,75 mm	13,75 mm	13,75 mm

Area required UG-37 (c) :	Longitudinal plane : θ = 0°	Circumferential plane : θ = 90°
F = Correction factor FIG.UG-37	1	0,5
$A = d\,t_r\,F + 2\,t_n/\cos(\beta)\,t_r\,F\,(1-f_{r1})$	214,6 mm^2	109,6 mm^2

Lengths and heights of calculation of the areas :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
L_1 = min [UG-40(b)-Radius , length available]	26,75 mm	26,75 mm	27,31 mm	27,31 mm
L_2 = min [UG-40(c) , height available]	13,75 mm	13,75 mm	13,75 mm	13,75 mm
L_3 = min [h , $2.5t$, $2.5t_i$] =	0 mm	0 mm	0 mm	0 mm
L_5 = min [UG-40 (b)-R_{on} , t_p , length available]	0 mm	0 mm	0 mm	0 mm

Area available (mm^2) :	Longitudinal plane : $\theta = 0°$		Circumferential plane : $\theta = 90°$	
	$\delta = 90$ °	$\delta = 90$ °	$\delta = 78,46$ °	$\delta = 101,54$ °
$A_1 = L_1 (E_1 t\text{-}t_r F) - t_n/\cos(\beta) (E_1 t\text{-}t_r F) (1\text{-}f_{r1})$	414,3	414,3	477,8	477,8
$A_2 = L_2 (t_n\text{-}t_{rn}) fr_2$	73,2	73,2	73,2	73,2
$A_3 = L_3 t_i f_{r2}$	0	0	0	0
$A_{41} = leg_{41}^2 /2 f_{r2}$	18	18	18	18
$A_{42} = leg_{42}^2 /2 f_{r4}$	0	0	0	0
$A_{43} = leg_{43}^2 /2 f_{r2}$	0	0	0	0
$A_5 = L_5 t_e f_{r4}$	0	0	0	0
$A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 =$	505,6	505,6	569	569
	small opening UG-36(c)(3)		small opening UG-36(c)(3)	

The opening is adequately reinforced per UG-37.

Opening 1c [in operation Int.P.] *(Process)*

ASME VIII DIV.1

Nozzle without pad on Shell (No. 1)		Set On
Pressure : P = 0,7 MPa	Temperature : 20 °C	
Shell	Material :SA240GR304L	Allowable stress : S_v = 115 MPa
Joint efficiency : 1 E_1 = 1	Corrosion + tolerance : Ca_v = 0,5 mm	Allowable stress : S = 115 MPa
Ext. Diameter : D_o = 1 270 mm	Thickness as new : 20 mm	Tolerance for seamless pipe : /
Nozzle Neck	Material : SA249TP304L	Allowable stress : S_n = 97,8 MPa
Weld joint efficiency : 1	Corrosion + tolerance : Ca_n = 0,5 mm	Tolerance for seamless pipe : /
Ext. Diameter : D_{on} = 64,5 mm	Thickness as new : 6 mm	
External Projection : 20 mm	Internal Projection : 0 mm	
Inclination : 0 °	Eccentricity : -127 mm	
Flange	Material : /	Type : /
Rating : /	Height : /	/
Pad	Material : /	Allowable stress : S_p = /
Height : /	Width : /	Ext. Diameter : D_{op} = /
Weld Outside : leg_{41}= 6 mm	outer reinforcement : leg_{42}= /	Inside : leg_{43}= /

fr_1 = 1 fr_2 = min(1,S_n/S_v) = 0,85 fr_3 = min(1,min(S_n, S_p)/S_v) = 0,85 fr_4 = min(1,S_p/S_v) = 0,964

Required thickness of the nozzle neck UG-27

$t_{rn} = P\,R_n / (S_nE-0.6P)$ = 0,192 mm R_n = 26,75 mm E = 1

The nozzle neck thickness is adequate per UG-27.

Required thickness of the nozzle neck UG-45

$t_a = t_{rn}+Ca_n$= 0,69 mm ; t_{b1} = max[t_{UG-27} , UG-16(b)]+Ca_v= 4,26 mm ; t_{b3} = Table UG-45+Ca_n= 5,02 mm

t_{UG-45} = max [t_a , min [t_{b3} , t_{b1}]] = 4,26 mm

The nozzle neck thickness is adequate per UG-45.

Dimensions FIG. UG-40

angle of plane with longitudinal axis : angle of each side / wall of the vessel :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
β = deflection angle / normal line	0 °		11,54 °	
d = diameter of the opening	53,5 mm		54,64 mm	
R_n = radius of the finished opening	26,75 mm		27,32 mm	
t_i = thickness of internal projection	/		/	
t_p = Reinforcing ring width	/		/	
t_x = thickness of selfreinforcing	/		/	
L = height of selfreinforcing	/	/	/	/
Configuration of the reinforcement :	/	/	/	/
t_e = thickness or height of the reinforcement	0 mm	0 mm	0 mm	0 mm
t_n = Nozzle thickness	5,5 mm	5,5 mm	5,5 mm	5,5 mm
h = height of internal projection	0 mm	0 mm	0 mm	0 mm

Reinforcement checking UG-37 *opening 1c [in operation Int.P.]*

Required thicknesses UG-37(a)		
t_r = 3,76 mm [UG-27(c)]	t = 19,5 mm	E = 1
$t_{rn} = P\,R_n / (S_nE-0.6P)$ = 0,192 mm	R_n = 26,75 mm	E = 1

Limits of reinforcement UG-40 :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
UG-40 (b) : max [d , R_n+t_n+t] =	53,5 mm	53,5 mm	54,64 mm	54,64 mm
UG-40 (c) : min [2.5t , 2.5t_n+t_e] =	13,75 mm	13,75 mm	13,75 mm	13,75 mm

Area required UG-37 (c) :	Longitudinal plane : θ = 0°	Circumferential plane : θ = 90°
F = Correction factor FIG.UG-37	1	0,5
$A = d\,t_r\,F + 2\,t_n/\cos(\beta)\,t_r\,F\,(1-f_{r1})$	201,2 mm^2	102,7 mm^2

Lengths and heights of calculation of the areas :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
L_1 = min [UG-40(b)-Radius , length available]	26,75 mm	26,75 mm	27,31 mm	27,31 mm
L_2 = min [UG-40(c) , height available]	13,75 mm	13,75 mm	13,75 mm	13,75 mm
L_3 = min [h , 2.5t , 2.5t_i] =	0 mm	0 mm	0 mm	0 mm
L_5 = min [UG-40 (b)-R_{on} , t_p , length available]	0 mm	0 mm	0 mm	0 mm

Area available (mm^2) :	Longitudinal plane : $\theta = 0°$		Circumferential plane : $\theta = 90°$	
	$\delta = 90$ °	$\delta = 90$ °	$\delta = 78,46$ °	$\delta = 101,54$ °
$A_1 = L_1\ (E_1\ t\text{-}t_r\ F)$ - $t_n/\cos(\beta)\ (E_1\ t\text{-}t_r\ F)\ (1\text{-}f_{r1})$	421	421	481,2	481,2
$A_2 = L_2\ (t_n\text{-}t_{rn})\ fr_2$	62,1	62,1	62,1	62,1
$A_3 = L_3\ t_i\ f_{r2}$	0	0	0	0
$A_{41} = leg_{41}^2\ /2\ f_{r2}$	15,3	15,3	15,3	15,3
$A_{42} = leg_{42}^2\ /2\ f_{r4}$	0	0	0	0
$A_{43} = leg_{43}^2\ /2\ f_{r2}$	0	0	0	0
$A_5 = L_5\ t_e\ f_{r4}$	0	0	0	0
$A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 =$	498,4	498,4	558,6	558,6
	small opening UG-36(c)(3)		small opening UG-36(c)(3)	

The opening is adequately reinforced per UG-37.

Weld sizes check UW-16(c). *opening 1c [in operation Int.P.]*

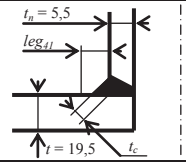


Fig. UW-16.1(a) full penetration weld		
	Minimum throat required	actual
t_c	min[¼ in.(6 mm);0.7×t_{min}]= 3,85 mm t_{min} = min[¾ in.(19 mm) ; t , t_n]	0.7×leg_{41} = 4,2 mm
Weld sizes are adequate		

Weld loads check UG-41(b).

No verification is required for this type of nozzle, in accordance with UW-15(b).

Opening 1c [in test Int.P.] *(Process)*

ASME VIII DIV.1

Nozzle without pad on Shell (No. 1)		Set On
Pressure : P = 1,0073 MPa	Temperature : 20 °C	
Shell	Material :SA240GR304L	Allowable stress : S_v = 154,8 MPa
Joint efficiency : 1 E_1 = 1	Corrosion + tolerance : Ca_v = 0,5 mm	Allowable stress : S = 154,8 MPa
Ext. Diameter : D_o = 1 270 mm	Thickness as new : 20 mm	Tolerance for seamless pipe : /
Nozzle Neck	Material : SA249TP304L	Allowable stress : S_n = 154,8 MPa
Weld joint efficiency : 1	Corrosion + tolerance : Ca_n = 0,5 mm	Tolerance for seamless pipe : /
Ext. Diameter : D_{on} = 64,5 mm	Thickness as new : 6 mm	
External Projection : 20 mm	Internal Projection : 0 mm	
Inclination : 0 °	Eccentricity : -127 mm	
Flange	Material : /	Type : /
Rating : /	Height : /	/
Pad	Material : /	Allowable stress : S_p = /
Height : /	Width : /	Ext. Diameter : D_{op} = /
Weld Outside : leg_{41}= 6 mm	outer reinforcement : leg_{42}= /	Inside : leg_{43}= /

$fr_1 = 1$ $fr_2 = \min(1, S_n/S_v) = 1$ $fr_3 = \min(1, \min(S_n, S_p)/S_v) = 1$ $fr_4 = \min(1, S_p/S_v) = 1$

Required thickness of the nozzle neck UG-27

$t_{rn} = P\,R_n / (S_nE - 0.6P) = 0,175$ mm $R_n = 26,75$ mm $E = 1$

The nozzle neck thickness is adequate per UG-27.

Required thickness of the nozzle neck UG-45

$t_a = t_{rn} + Ca_n = 0,67$ mm ; $t_{b1} = \max[t_{UG\text{-}27}$, UG-16(b)$] + Ca_v = 4,52$ mm ; t_{b3} = Table UG-45$+Ca_n = 5,02$ mm

$t_{UG\text{-}45} = \max[t_a , \min[t_{b3} , t_{b1}]] = 4,521$ mm

The nozzle neck thickness is adequate per UG-45.

Dimensions FIG. UG-40

angle of plane with longitudinal axis : angle of each side / wall of the vessel :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
β = deflection angle / normal line	0 °		11,54 °	
d = diameter of the opening	53,5 mm		54,64 mm	
R_n = radius of the finished opening	26,75 mm		27,32 mm	
t_i = thickness of internal projection	/		/	
t_p = Reinforcing ring width	/		/	
t_x = thickness of selfreinforcing	/		/	
L = height of selfreinforcing	/	/	/	/
Configuration of the reinforcement :	/	/	/	/
t_e = thickness or height of the reinforcement	0 mm	0 mm	0 mm	0 mm
t_n = Nozzle thickness	5,5 mm	5,5 mm	5,5 mm	5,5 mm
h = height of internal projection	0 mm	0 mm	0 mm	0 mm

Reinforcement checking UG-37 *opening 1c [in test Int.P.]*

Required thicknesses UG-37(a)		
t_r = 4,021 mm [UG-27(c)]	t = 19,5 mm	E = 1
$t_{rn} = P\,R_n / (S_nE - 0.6P) = 0,175$ mm	R_n = 26,75 mm	E = 1

Limits of reinforcement UG-40 :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
UG-40 (b) : max [d , R_n+t_n+t] =	53,5 mm	53,5 mm	54,64 mm	54,64 mm
UG-40 (c) : min [$2.5t$, $2.5t_n+t_e$] =	13,75 mm	13,75 mm	13,75 mm	13,75 mm

Area required UG-37 (c) :	Longitudinal plane : θ = 0°	Circumferential plane : θ = 90°
F = Correction factor FIG.UG-37	1	0,5
$A = d\,t_r\,F + 2\,t_n/\cos(\beta)\,t_r\,F\,(1-f_{r1})$	215,1 mm^2	109,8 mm^2

Lengths and heights of calculation of the areas :	Longitudinal plane : θ = 0° δ = 90 °	 δ = 90 °	Circumferential plane : θ = 90° δ = 78,46 °	 δ = 101,54 °
L_1 = min [UG-40(b)-Radius , length available]	26,75 mm	26,75 mm	27,31 mm	27,31 mm
L_2 = min [UG-40(c) , height available]	13,75 mm	13,75 mm	13,75 mm	13,75 mm
L_3 = min [h , $2.5t$, $2.5t_i$] =	0 mm	0 mm	0 mm	0 mm
L_5 = min [UG-40 (b)-R_{on} , t_p , length available]	0 mm	0 mm	0 mm	0 mm

Area available (mm^2) :	Longitudinal plane : $\theta = 0°$		Circumferential plane : $\theta = 90°$	
	$\delta = 90$ °	$\delta = 90$ °	$\delta = 78{,}46$ °	$\delta = 101{,}54$ °
$A_1 = L_1 (E_1 t\text{-}t_r F) - t_n/\cos(\beta) (E_1 t\text{-}t_r F) (1\text{-}f_{r1})$	414,1	414,1	477,7	477,7
$A_2 = L_2 (t_n\text{-}t_{rn}) fr_2$	73,2	73,2	73,2	73,2
$A_3 = L_3 t_i f_{r2}$	0	0	0	0
$A_{41} = leg_{41}^2 / 2 f_{r2}$	18	18	18	18
$A_{42} = leg_{42}^2 / 2 f_{r4}$	0	0	0	0
$A_{43} = leg_{43}^2 / 2 f_{r2}$	0	0	0	0
$A_5 = L_5 t_e f_{r4}$	0	0	0	0
$A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 =$	505,3	505,3	568,9	568,9
	small opening UG-36(c)(3)		small opening UG-36(c)(3)	

The opening is adequately reinforced per UG-37.

Summary

Summary of nozzles [Location and Dimensions].

Tag	Location				Dimensions (mm)								Flange		
	Loc. (mm)	Ori. (°)	Inc. (°)	Exc. (mm)	Neck Diam.	Neck Thk.	Neck Sch.	Neck DN	Reinforcement Type	Reinforcement (a)	Reinforcement (b)	Projection	DN	Rating	Typ.
1	108,0	0,00	0,00	0,00	64,50	6,000	/		/	/	/	20,00	/	/	/
1b	108,0	0,00	0,00	127,00	64,50	6,000	/		/	/	/	20,00	/	/	/
1c	108,0	0,00	0,00	-127,00	64,50	6,000	/		/	/	/	20,00	/	/	/
(a),(b) : Pad (ring) = thickness, Width ; Self Reinforcing = Height, over thickness ; Internal Plate = thickness, Height															

NB : The external projection and the overthickness height of a self are measured along the axis of the nozzle.

Summary of nozzles [Adjacent Openings, Goose and Material].

Tag	Set-in (+) Set-on(-)	Operating	Adjacent openings	Goose Radius (mm)	Goose Loc. (mm)	hydrostatic height Operating (mm)	hydrostatic height Test (mm)	Material Neck	Material Pad	Material Flange
1	(-)	A	/	/	/	0,00	615,0	SA249TP304L	/	/
1b	(-)	A	/	/	/	0,00	488,0	SA249TP304L	/	/
1c	(-)	A	/	/	/	0,00	742,0	SA249TP304L	/	/
Nozzle Type	A = Process, H = manhole, E = With Blind Flange, L = Instrument, AP = Boot, XT = transition by head, CA = Shell Inlet, CS = Shell Outlet, TA = Tubeside inlet, TS = Tubeside Outlet.									

Summary of nozzles [Type, Weight and Local Loads].

Tag	Loc. Shell No.	Operating	Mass Nozzle (kg)	Mass Flange (kg)	Local Loads Longitudinal Shear Load (daN)	Circumferential Shear Load (daN)	Radial Load (daN)	Longitudinal Bending Moment (daN·m)	Circular Bending Moment (daN·m)	Torsional moment (daN·m)
1	01[01]	A	0,2	0,0	0	0	0	0	0	0
1b	01[01]	A	0,2	0,0	0	0	0	0	0	0
1c	01[01]	A	0,2	0,0	0	0	0	0	0	0
Nozzle Type	A = Process, H = manhole, E = With Blind Flange, L = Instrument, AP = Boot, XT = transition by head, CA = Shell Inlet, CS = Shell Outlet, TA = Tubeside inlet, TS = Tubeside Outlet.									
Flange Weight	With blind flange if present.									

Summary of Geometry.

Type Tag	Diameter Internal (mm)	Length (mm)	Cumulative height (mm)	Thickness (mm)	Angle (°)	Mass (kg)	Flanges ratings	Specific Gravity	Material
01[01] 31.05	1 230,0	2 100,0	2 100,0	20,000	0	1 319,5		8,00	SA240GR304L

Angle : half angle at apex for a concentric cone ; maximum angle between cone and cylinder for an eccentric cone.
Material: (N) = normalized
NB: Italic line indicates an element for which the calculation under pressure has not been done.

Summary of Weights, Capacities and Painting Areas.

Designation		Mass (kg)	Lifted	Erected	Operating	Test	Shutdown
Shells		1 319	X	X	X	X	X
Cones							
Heads							
Shell flanges							
Skirts							
Support saddles							
Anchor boxes							
Fireproofing							
Man holes							
Nozzles		1	X	X	X	X	X
Piping							
Support Ring							
Trays							
Liquid on trays							
Packing							
Helicoidal plates							
Internal lining							
Insulation supports							
Insulation (Vessel)							
Insulation (Piping)							
Coil							
Liquid in Coils							
Stiffening rings							
Piping Clips							
Structural Clips							
Ladders							
Platforms							
Tubesheets							
Tubes and Tie Rods							
Baffles and Support Baffles							
Floating head flange							
Split ring and splices							
Internals	Operating						
	Test						
	Lifting						
	Erection						
External loads	Operating						
	Test						
	Lifting						
	Erection						

			Compartment	Compartment 1	/	/
Capacity (m^3)				2,495	/	/
Mass (kg)	Liquid	Operating		0	/	/
		Test		2 495	/	/
	Total	Test		3 815	/	/

		Vessel
Mass (kg)	Operating	1 320
	Lifted	1 320
	Erected	1 320
	Shutdown	1 320

Area (m^2)	Vessel Tag	8,4
	Support	0

NB : New weight.