PULSATION DAMPER MECHANICAL STRENGHT CALCULATION FOR NITROGEN GAS BOOSTER

BUSHEHR PETROCHEMICAL COMPANY MEG PLANT	
Document Review	
Issue Purpose:	AFC
Result Code: AP,AN,CM,RE,NC	AN
Next Status : IFC,IFA,IFI,AFC,AB	AFC
Responsible Department	MECHANICAL
Commented Date	Jul /02/2022
Approval or review hereunder shall not be construed to relieve Vendor / Subcontractor of his responsibilities and liability under the contract.	

Rev.	Date	Purpose of Issue	Prepared	Checked	Approved	AC Code
04	30/06/2022	**Approved for Construction**	**KP**	**CL**	**JR**	
03	27/06/2022	**Approved for Construction**	**KP**	**CL**	**JR**	
02	23/06/2022	**For Information**	**KP**	**CL**	**JR**	
01	09/05/2022	**For Information**	**KP**	**CL**	**JR**	
00	26/04/2022	**For Information**	**KP**	**CL**	**JR**	

Class: 1 **Phase: P**

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7.	X	X	X	X	
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9.	X	X	X	X	
10.	X	X	X	X	
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Report – 2nd-stage Discharge_LI4736 C220006CLC012

PV-Elite Calculation Summary

Client: Airpack Nederland BV.
Client location: Zierikzee
Ref number client: 17811-OO-0702(KP)

PPV Engineering

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June 22, 2022
Order number: P22-115-01
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Revision: 1

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N2 Pulsation damper second stage suction
C220006CLC011
Static Calculation

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

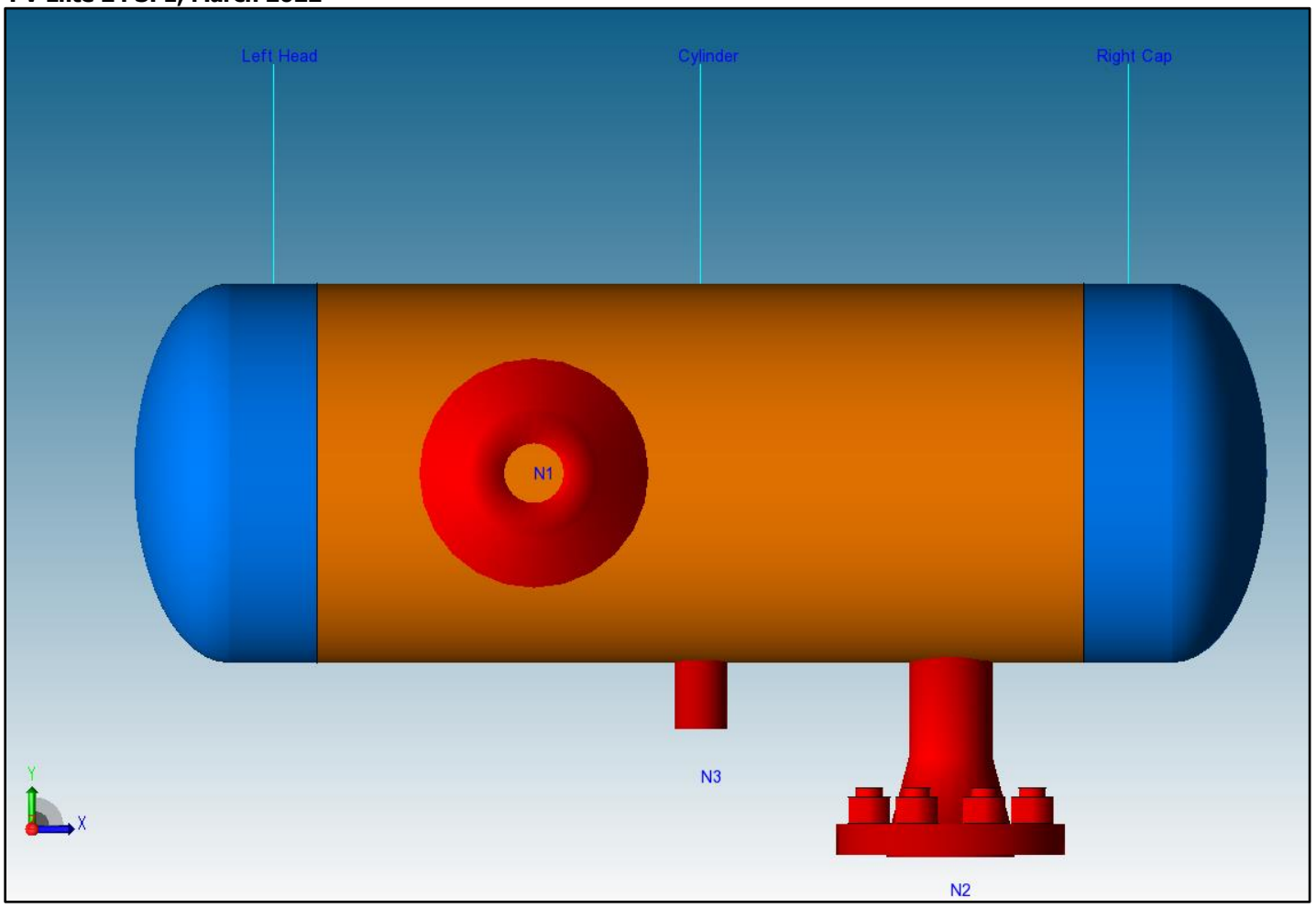
ASME Code Version : 2021

Analysis Performed by : PPV-Engineering B.V.

Job File : ...\2nd-stage Suction_LI4735.pvdb

Date of Analysis : Jun 21,2022 9:05am

PV Elite 24 SP1, March 2022



Vessel Design Summary:

ASME Code, Section VIII Division 1, 2021

Diameter Spec : 273.000 mm OD		
Vessel Design Length, Tangent to Tangent	678.72	mm
Specified Datum Line Distance	63.36	mm
Internal Design Temperature	85	°C
Internal Design Pressure	2.400	MPa
External Design Temperature	85	°C
Maximum Allowable Working Pressure	3.809	MPa
Shop Test Pressure	6.640	MPa
Required Minimum Design Metal Temperature	-28.9	°C
Warmest Computed Minimum Design Metal Temperature	-46.0	°C
Wind Design Code	No Wind Loads	
Earthquake Design Code	No Seismic	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-106 B	...	...	K03006	No	No
Head	SA-234 WPB	...	...	K03006	No	No
Nozzle	SA-106 B	...	...	K03006	No	No
Nozzle Flg	SA-105	...	...	K03504	No	No

Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.
Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (MPa & mm):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Total Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Left Head	2.400	0.00	4.690	3.0000	Yes	No
Cylinder	2.400	0.00	3.809	3.0000	N/A	No
Right Cap	2.400	0.00	4.690	3.0000	Yes	No

Element Types and Properties:

Element Type	"To" Elev mm	Element Length mm	Nominal Thickness mm	Finished Thickness mm	Reqd Thk Internal mm	Reqd Thk External mm	Long Eff	Circ Eff
Ellipse	0.0	63.4	9.3	9.3	6.1	...	0.85	0.85
Cylinder	552.0	552.0	9.3	8.1	6.2	...	0.85	0.85
Ellipse	615.4	63.4	9.3	9.3	6.1	...	0.85	0.85

Weights:

Fabricated	- Bare W/O Removable Internals	63.3	kgm
Shop Test	- Fabricated + Water (Full)	102.6	kgm
Shipping	- Fab. + Rem. Intls.+ Shipping App.	63.3	kgm
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	63.3	kgm
Empty	- Fab. + Intls. + Details + Wghts.	63.3	kgm
Operating	- Empty + Operating Liquid (No CA)	63.3	kgm
Field Test	- Empty Weight + Water (Full)	102.6	kgm

Nozzle Calculation Summary (MPa & mm):

Description	MAWP	Ext	MAPNC	UG-45	[tr]	Weld Path	Areas or Stresses
N2	3.809	...	...	OK	5.68	OK	No Calc[*]
N3	3.809	...	...	OK	5.68	OK	No Calc[*]
N1	3.809	...	...	OK	5.68	OK	No Calc[*]

Nozzle MAWP Summary:

Minimum MAWP Nozzles	:	3.809 Nozzle	: N1
Minimum MAWP Shells/Flanges	:	3.809 Element	: Cylinder
Minimum MAPnc Shells/Flanges	:	6.099 Element	: Cylinder
Computed Vessel M.A.W.P.	:	3.809 MPa	

[*] - This was a small opening and the areas were not computed.

Note: MAWPs (Internal Case) shown above are at the High Point.

Multiple output lines for the same nozzle indicates required Code calculations in both the longitudinal and circumferential planes of reinforcement where applicable.

Check the Spatial Relationship between the Nozzles:

From Node	Nozzle Description	X Coordinate mm	Layout Angle deg	Dia. Limit mm
20	N2	519.360	270.000	97.700
20	N3	339.360	270.000	54.672
20	N1	219.360	0.000	97.700

The nozzle spacing is computed by the following:

= sqrt(ll² + lc²) where

ll - Arc length along the inside vessel surface in the long. direction.
lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.

No interference violations have been detected!

Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia mm	Wall Thk mm	Reinforcing Pad Diameter mm	Reinforcing Pad Thk mm	Cut Length mm	Flg Class
N3	38 mm	Actual	None	38.1	8.382	...	...	57	...
N2	50 mm	160	WNF	60.3	8.738	...	...	79	300
N1	50 mm	160	WNF	60.3	8.738	...	...	68	...

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows: Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
N3	SA-106 B	8.340	6.000	...	...	...
N2	SA-106 B	8.340	6.000	...	...	...
N1	SA-106 B	8.340	6.000	...	...	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
N3	276.000	270.0	47.62	0.00	Cylinder
N2	456.000	270.0	68.00	0.00	Cylinder
N1	156.000	0.0	57.00	0.00	Cylinder

Bill of Materials:

QTY	DESCRIPTION	MATERIAL
2	ELLIPTICAL HEAD: 2.0 X 1, 9.3mm THK X 254.5mm ID X 63.4mm	SA-234 WPB
1	CYLINDER: 9.3mm THK X 256.8mm ID X 552.0mm	SA-106 B
1	NAMEPLATE	...

Units used in this Analysis (SI_ASME):

Name	System Unit	Constant	User Unit
Length	Feet	304.8000	mm
Force	Pounds	4.4480	N
Mass	Pounds	0.4536	kgm
Area	sq. inches	645.1600	mm²
Moment	ft. lbs.	1356.3000	N-mm
Stress	lbs./sq.in.	0.0069	MPa
Temperature	Degrees F	0.5556	°C
Pressure	psig	0.0069	MPa
Elast. Modulus	lbs./sq.in.	0.0069	MPa
Pipe Density	lbs./cu.in.	0.0277	kg/cm³
Ins. Density	lbs./cu.ft.	0.1602E-04	kg/cm³
Fluid Density	lbs./cu.ft.	0.1602E-04	kg/cm³
Wind Speed	miles/hr	1.6093	km/hr
Tray Weight	lbs./sq.ft.	0.0005	kg/cm²
Inertia	in.**4	416231.0000	mm**4
G Load	G's	1.0000	g's
Wind Load	lbs./sq.ft.	0.0479	kPa
Elevation	Feet	304.8000	mm
Volume	in.**3	0.0164	ltr
Diameter	inches	25.4000	mm
Thickness	inches	25.4000	mm

PV Elite Vessel Analysis Program: Input Data

N2 Pulsation damper second stage suction
C220006CLC011
Static Calculation

Design Internal Pressure (for Hydrotest)	2.4	MPa
Design Internal Temperature	85.0	°C
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-28.9	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-3	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	

Shop Pressure Test:

Type of Pressure Test	User Entered Pressure
Pressure Test Position	Horizontal
Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE

Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW
Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW
Wind Design Code	No Wind Loads
Seismic Design Code	No Seismic
Design Pressure + Static Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Use ASME VIII-1 Appendix 1-9	N
Perform Blast Load Analysis	No
Material Database Year	Current w/Addenda or Code Year

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	Yes
Shell Head Joints are Tapered	Yes
Compute "K" in corroded condition	Yes
Use Code Case 2286	No
Use the MAWP to compute the MDMT	Yes
For thickness ratios <= 0.35, MDMT will be -155F (-104C)	Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)	No
Using Metric Material Databases, ASME II D	No
Calculate B31.3 type stress for Nozzles with Loads	Yes
Reduce the MDMT due to lower membrane stress	Yes
Consider Longitudinal Stress in MDMT Calculations	Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Elliptical	
Description	Left Head	
Distance "FROM" to "TO"	63.36	mm
Element Outside Diameter	273	mm
Element Thickness	9.27	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.27	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	2.4	MPa
Design Temperature Internal Pressure	85	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	

Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.28	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	222.99	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	

Element From Node	20	
Element To Node	30	
Element Type	Cylinder	
Description	Cylinder	
Distance "FROM" to "TO"	552	mm
Element Outside Diameter	273	mm
Element Thickness	8.11	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.27	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	2.4	MPa
Design Temperature Internal Pressure	85	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-106 B	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.28	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	222.99	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. pipe	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	N2	
Dist. from "FROM" Node / Offset dist	456	mm
Nozzle Diameter	50	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	270.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	GR 1.1	

Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N3	
Dist. from "FROM" Node / Offset dist	276	mm
Nozzle Diameter	38.1	mm
Nozzle Schedule	None	
Nozzle Class	None	
Layout Angle	270.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	None	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N1	
Dist. from "FROM" Node / Offset dist	156	mm
Nozzle Diameter	50	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	None	
Nozzle Matl	SA-106 B	

Element From Node	30	
Element To Node	40	
Element Type	Elliptical	
Description	Right Cap	
Distance "FROM" to "TO"	63.36	mm
Element Outside Diameter	273	mm
Element Thickness	9.27	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.27	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	2.4	MPa
Design Temperature Internal Pressure	85	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.28	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	222.99	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	

Weld is pre-Heated	No

Internal Pressure Results Summary:

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd MPa	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) MPa
Left Head		2.4	9.27	3	273	100.22
Cylinder		2.4	9.27	3	273	100.22
Right Cap		2.4	9.27	3	273	100.22

Element Required Thickness and MAWP :

From	To	Design Pressure MPa	M.A.W.P. Corroded MPa	M.A.P. New & Cold MPa	Minimum Thickness mm	Required Thickness mm
Left Head		2.4	4.69	7.249	9.27	6.10705
Cylinder		2.4	3.809	6.099	8.11	6.23783
Right Cap		2.4	4.69	7.249	9.27	6.10705
Minimum			3.809	5.11		

Note : The M.A.P.(NC) is Governed by a Flange !

MAWP: 3.809 MPa, limited by: Cylinder.

Elements Suitable for Design Internal Pressure.

Internal Pressure Calculation Results:

ASME Code, Section VIII Division 1, 2021

Elliptical Head From 10 To 20 SA-234 WPB , UCS-66 Crv. B at 85 °C

Left Head

Longitudinal Joint: User Defined

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (2.4*273*0.97)/(2*117.9*0.85+2*2.4*(0.97-0.1))
= 3.1071 + 3.0000 = 6.1071 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.27)/(0.97*273-2*6.27*(0.97-0.1))
= 4.948 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*9.27)/(1*273-2*9.27*(1-0.1))
= 7.249 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (2.4*(0.97*273-2*6.27*(0.97-0.1)))/(2*0.85*6.27)
= 57.187 MPa

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (2.4*136.5)/(117.9*0.85+0.4*2.4)+3
= 6.238 mm

Straight Flange Maximum Allowable Working Pressure:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 6.27)/(136.5 - 0.4 * 6.27)
= 4.69 MPa

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 +(260.5/(2 * 66.61))^2)/6
= 0.970315

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 9.27, tr = 4.873, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.661, Temp. Reduction = 19 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 9.27, tr = 5.11, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.693, Temp. Reduction = 17 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-46 °C

Cylindrical Shell From 20 To 30 SA-106 B , UCS-66 Crv. B at 85 °C

Cylinder

Longitudinal Joint: Spot Radiography per UW-11(b) Type 1

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (2.4*136.5)/(117.9*0.85+0.4*2.4)
= 3.2378 + 3.0000 = 6.2378 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*5.11)/(136.5-0.4*5.11)
= 3.809 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*8.11)/(136.5-0.4*8.11)
= 6.099 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (2.4*((136.5-0.4*5.11))/(0.85*5.11)
= 74.294 MPa

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 8.11, tr = 2.478, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.412, Temp. Reduction = 48 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

Elliptical Head From 30 To 40 SA-234 WPB , UCS-66 Crv. B at 85 °C

Right Cap

Longitudinal Joint: User Defined

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (2.4*273*0.97)/(2*117.9*0.85+2*2.4*(0.97-0.1))
= 3.1071 + 3.0000 = 6.1071 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.27)/(0.97*273-2*6.27*(0.97-0.1))
= 4.948 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*9.27)/(1*273-2*9.27*(1-0.1))
= 7.249 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (2.4*(0.97*273-2*6.27*(0.97-0.1)))/(2*0.85*6.27)
= 57.187 MPa

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (2.4*136.5)/(117.9*0.85+0.4*2.4)+3
= 6.238 mm

Straight Flange Maximum Allowable Working Pressure:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 6.27)/(136.5 - 0.4 * 6.27)
= 4.69 MPa

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 +(260.5/(2 * 66.61))^2)/6
= 0.970315

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 9.27, tr = 4.873, c = 3 mm, E✱ = 0.85

Thickness Ratio = tr * E✱/(tg - c) = 0.661, Temp. Reduction = 19 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 9.27, tr = 5.11, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.693, Temp. Reduction = 17 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-46 °C

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

Pressure per UG99b	= 1.30 * M.A.W.P. * Sa/S	4.951 MPa
Pressure per UG99b[35]	= 1.30 * Design Pres * Sa/S	3.120 MPa
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	6.643 MPa
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	4.190 MPa
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	3.432 MPa
Pressure per App 27-4	= M.A.W.P.	3.809 MPa
User Defined Hydrostatic Test Pressure at High Point		6.640 MPa

Horizontal Test performed per: User Hydro Pressure

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (MPa):

From To	Stress	Allowable	Ratio	Pressure
Left Head	108.0	153.3	0.705	6.64
Cylinder	128.4	153.3	0.838	6.64
Right Cap	108.0	153.3	0.705	6.64

Stress ratios for Nozzle and Pad Materials (MPa):

Description	Pad/Nozzle	Ambient	Operating	Ratio
N2	Nozzle	117.90	117.90	1.000
N3	Nozzle	117.90	117.90	1.000
N1	Nozzle	117.90	117.90	1.000
Minimum				1.000

Stress ratios for Pressurized Vessel Elements (MPa):

Description	Ambient	Operating	Ratio
Left Head	117.90	117.90	1.000
Cylinder	117.90	117.90	1.000
Right Cap	117.90	117.90	1.000

Minimum	1.000

Hoop Stress in Nozzle Wall during Pressure Test (MPa):

Description	Ambient	Operating	Ratio
N2	20.27	153.28	0.132
N3	12.44	153.28	0.081
N1	20.27	153.28	0.132

Elements Suitable for Test Pressure.

Nozzle Flange MAWP Results: (MPa & °C)

Nozzle Description	Flange Rating Ope.	Flange Rating Ambient	Design Temp	Class	Grade/ Group	Equiv. Press	Max Pressure UG-44(b)	Max Pressure 50%	Max Pressure DNV
N2	4.77	5.11	85	300	GR 1.1	...	...	...	...
Min Rating	4.765	5.110 MPa [for Core Elements]				...	...	...	...

Pressure Ratings are per ASME B16.5 2017 Metric Edition

Input, Nozzle Desc: N2 From: 20

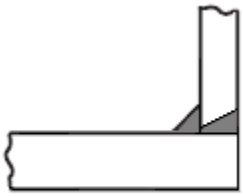
Pressure for Reinforcement Calculations	P	2.4000	MPa
Temperature for Internal Pressure	Temp	85	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	254.46	mm
Shell Finished (Minimum) Thickness	t	8.1100	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		519.36	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		50.0000	mm
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	68.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N2

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	60.325	mm.
Actual Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 2.4*130.2/(117.9*1-0.6*2.4)
= 2.6837 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 2.4*30.16/(117.9*1+0.4*2.4)
= 0.6090 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	97.6996	mm
Parallel to Vessel Wall, opening length	d	48.8498	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	12.7750	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N2.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.6090 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 5.6837 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 5.6837 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 6.4200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.42, max(5.684, 4.5)]
= 5.6837 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)

= max(3.609, 5.684)
= 5.6837 mm

Available Nozzle Neck Thickness = 0.875 * 8.738 = 7.645 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:B, Curve:A)

Govrn. thk, tg = 7.645, tr = 0.609, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.131, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 7.645, tr = 0.609, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.131, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)	-48 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 2.40/5.11 = 0.470

Weld Size Calculations, Description: N2

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.809 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 3.6270 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 79.7370 mm

Input, Nozzle Desc: N3 From: 20

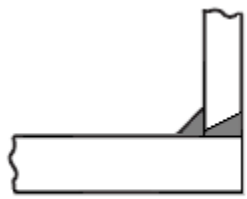
Pressure for Reinforcement Calculations	P	2.4000	MPa
Temperature for Internal Pressure	Temp	85	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	254.46	mm
Shell Finished (Minimum) Thickness	t	8.1100	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		339.36	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		38.1000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	8.3820	mm
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	47.6250	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N3

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation		38.100	mm.
Actual Thickness Used in Calculation		8.382	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 2.4*130.2/(117.9*1-0.6*2.4)
= 2.6837 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 2.4*19.05/(117.9*1+0.4*2.4)
= 0.3846 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	54.6720	mm
Parallel to Vessel Wall, opening length	d	27.3360	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	12.7750	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N3.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta	= 3.3846 mm
Wall Thickness per UG16(b),	tr16b	= 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1	= 5.6837 mm
Wall Thickness	tb1 = max(trb1, tr16b)	= 5.6837 mm
Wall Thickness	tb2 = max(trb2, tr16b)	= 4.5000 mm
Wall Thickness per table UG-45	tb3	= 6.1200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.12, max(5.684, 4.5)]
= 5.6837 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(3.385, 5.684)
= 5.6837 mm

Available Nozzle Neck Thickness = 8.3820 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 8.11, tr = 2.684, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.525, Temp. Reduction = 29 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -48 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -48 °C

Weld Size Calculations, Description: N3

Intermediate Calc. for nozzle/shell Welds Tmin 5.3820 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.7674 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.809 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 1.4343 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 57.1692 mm

Input, Nozzle Desc: N1 From: 20

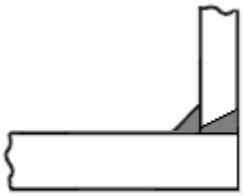
Pressure for Reinforcement Calculations	P	2.4000	MPa
Temperature for Internal Pressure	Temp	85	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	254.46	mm
Shell Finished (Minimum) Thickness	t	8.1100	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		219.36	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		0.00	deg
Diameter		50.0000	mm
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	57.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N1

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	60.325	mm.
Actual Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 2.4*130.2/(117.9*1-0.6*2.4)
= 2.6837 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 2.4*30.16/(117.9*1+0.4*2.4)
= 0.6090 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	97.6996	mm
Parallel to Vessel Wall, opening length	d	48.8498	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	12.7750	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N1.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.6090 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 5.6837 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 5.6837 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 6.4200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.42, max(5.684, 4.5)]
= 5.6837 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)

= max(3.609, 5.684)
= 5.6837 mm

Available Nozzle Neck Thickness = 0.875 * 8.738 = 7.645 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 7.645, tr = 0.609, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.131, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 7.645, tr = 0.609, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.131, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Weld Size Calculations, Description: N1

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.809 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 3.6270 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 68.7370 mm

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Report – 2nd-stage Suction_LI4735 C220006CLC011

PV-Elite Calculation Summary

Client: Airpack Nederland BV.
Client location: Zierikzee
Ref number client: 17811-OO-0702(KP)

PPV Engineering

Author: H.Hoezen
- Telephone: +31 (0)594 581010
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June 22, 2022
Order number: P22-115-01
Document number: 22-11501-C04
Revision: 1

Table of Contents

N2 Pulsation damper second stage discharge
C220006CLC012
Static Calculation

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

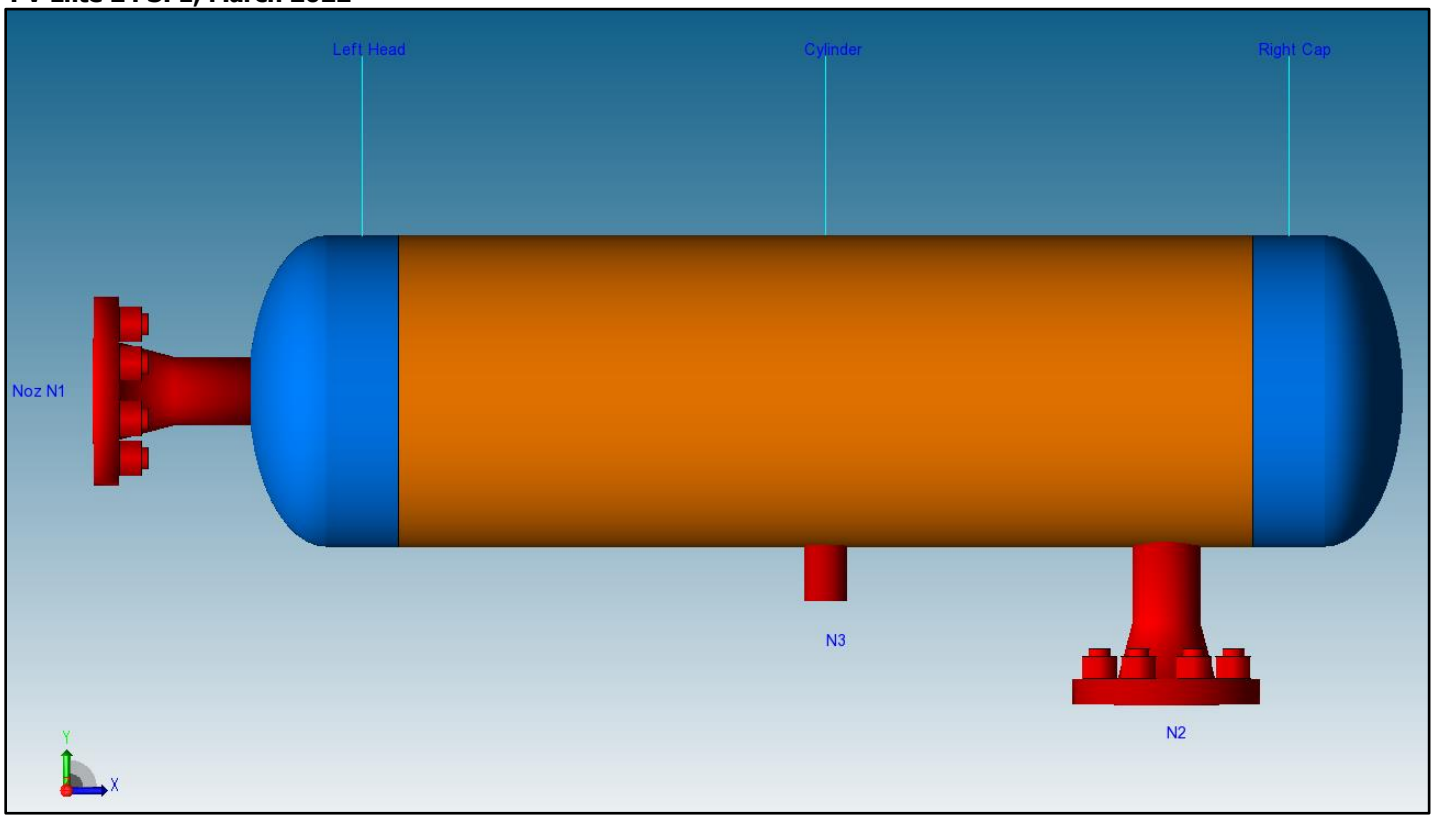
ASME Code Version : 2021

Analysis Performed by : PPV-Engineering B.V.

Job File : ...\2nd-stage Discharge_LI4736.pvdb

Date of Analysis : Jun 21,2022 9:13am

PV Elite 24 SP1, March 2022



Vessel Design Summary:

ASME Code, Section VIII Division 1, 2021

Diameter Spec : 273.000 mm OD		
Vessel Design Length, Tangent to Tangent	876.72	mm
Specified Datum Line Distance	63.36	mm
Internal Design Temperature	100	°C
Internal Design Pressure	2.500	MPa
External Design Temperature	100	°C
Maximum Allowable Working Pressure	3.809	MPa
Shop Test Pressure	6.640	MPa
Required Minimum Design Metal Temperature	-28.9	°C
Warmest Computed Minimum Design Metal Temperature	-46.0	°C
Wind Design Code	No Wind Loads	
Earthquake Design Code	No Seismic	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-106 B	...	...	K03006	No	No
Head	SA-234 WPB	...	...	K03006	No	No
Nozzle	SA-106 B	...	...	K03006	No	No
Nozzle Flg	SA-105	...	...	K03504	Yes	No

Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.
Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (MPa & mm):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Total Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Left Head	2.500	0.00	4.690	3.0000	Yes	No
Cylinder	2.500	0.00	3.809	3.0000	N/A	No
Right Cap	2.500	0.00	4.690	3.0000	Yes	No

Element Types and Properties:

Element Type	"To" Elev mm	Element Length mm	Nominal Thickness mm	Finished Thickness mm	Reqd Thk Internal mm	Reqd Thk External mm	Long Eff	Circ Eff
Ellipse	0.0	63.4	9.3	9.3	6.2	...	0.85	0.85
Cylinder	750.0	750.0	9.3	8.1	6.4	...	0.85	0.85
Ellipse	813.4	63.4	9.3	9.3	6.2	...	0.85	0.85

Weights:

Fabricated	- Bare W/O Removable Internals	75.3	kgm
Shop Test	- Fabricated + Water (Full)	124.9	kgm
Shipping	- Fab. + Rem. Intls.+ Shipping App.	75.3	kgm
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	75.3	kgm
Empty	- Fab. + Intls. + Details + Wghts.	75.3	kgm
Operating	- Empty + Operating Liquid (No CA)	75.3	kgm
Field Test	- Empty Weight + Water (Full)	124.9	kgm

Nozzle Calculation Summary (MPa & mm):

Description	MAWP	Ext	MAPNC	UG-45	[tr]	Weld Path	Areas or Stresses
Noz N1	4.69	...	...	OK	5.69	OK	No Calc[*]
N2	3.809	...	...	OK	5.80	OK	No Calc[*]
N3	3.809	...	...	OK	5.80	OK	No Calc[*]

Nozzle MAWP Summary:

Minimum MAWP Nozzles	:	3.809	Nozzle : N3
Minimum MAWP Shells/Flanges	:	3.809	Element : Cylinder
Minimum MAPnc Shells/Flanges	:	6.099	Element : Cylinder
Computed Vessel M.A.W.P.	:	3.809	MPa

[*] - This was a small opening and the areas were not computed.

Note: MAWPs (Internal Case) shown above are at the High Point.

Multiple output lines for the same nozzle indicates required Code calculations in both the longitudinal and circumferential planes of reinforcement where applicable.

Check the Spatial Relationship between the Nozzles:

From Node	Nozzle Description	X Coordinate mm	Layout Angle deg	Dia. Limit mm
10	Noz N1	0.000	0.000	97.700
20	N2	737.360	270.000	97.700
20	N3	438.360	270.000	54.672

The nozzle spacing is computed by the following:

= sqrt($ll^2 + lc^2$) where

ll - Arc length along the inside vessel surface in the long. direction.
lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.

No interference violations have been detected!

Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia mm	Wall Thk mm	Reinforcing Pad Diameter	Reinforcing Pad Thk mm	Cut Length mm	Flg Class
N3	38 mm	Actual	None	38.1	8.382	...	...	57	...
Noz N1	50 mm	160	WNF	60.3	8.738	...	...	76	300
N2	50 mm	160	WNF	60.3	8.738	...	...	79	300

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows: Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
N3	SA-106 B	8.340	6.000	...	...	...
Noz N1	SA-106 B	8.110	7.000	...	...	...
N2	SA-106 B	8.340	6.000	...	...	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
N3	375.000	270.0	47.62	0.00	Cylinder
Noz N1	...	0.0	65.00	0.00	Left Head
N2	674.000	270.0	68.00	0.00	Cylinder

Bill of Materials:

QTY	DESCRIPTION	MATERIAL
2	ELLIPTICAL HEAD: 2.0 X 1, 9.3mm THK X 254.5mm ID X 63.4mm	SA-234 WPB
1	CYLINDER: 9.3mm THK X 256.8mm ID X 750.0mm	SA-106 B
1	NAMEPLATE	...

Units used in this Analysis (SI_ASME):

Name	System Unit	Constant	User Unit
Length	Feet	304.8000	mm
Force	Pounds	4.4480	N
Mass	Pounds	0.4536	kgm
Area	sq. inches	645.1600	mm²
Moment	ft. lbs.	1356.3000	N-mm
Stress	lbs./sq.in.	0.0069	MPa
Temperature	Degrees F	0.5556	°C
Pressure	psig	0.0069	MPa
Elast. Modulus	lbs./sq.in.	0.0069	MPa
Pipe Density	lbs./cu.in.	0.0277	kg/cm³
Ins. Density	lbs./cu.ft.	0.1602E-04	kg/cm³
Fluid Density	lbs./cu.ft.	0.1602E-04	kg/cm³
Wind Speed	miles/hr	1.6093	km/hr
Tray Weight	lbs./sq.ft.	0.0005	kg/cm²
Inertia	in.**4	416231.0000	mm**4
G Load	G's	1.0000	g's
Wind Load	lbs./sq.ft.	0.0479	kPa
Elevation	Feet	304.8000	mm
Volume	in.**3	0.0164	ltr
Diameter	inches	25.4000	mm
Thickness	inches	25.4000	mm

PV Elite Vessel Analysis Program: Input Data

N2 Pulsation damper second stage discharge
C220006CLC012
Static Calculation

Design Internal Pressure (for Hydrotest)	2.5	MPa
Design Internal Temperature	100.0	°C
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-28.9	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-3	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	

Shop Pressure Test:

Type of Pressure Test	User Entered Pressure
Pressure Test Position	Horizontal
Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE

Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW
Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW
Wind Design Code	No Wind Loads
Seismic Design Code	No Seismic
Design Pressure + Static Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Use ASME VIII-1 Appendix 1-9	N
Perform Blast Load Analysis	No
Material Database Year	Current w/Addenda or Code Year

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	Yes
Shell Head Joints are Tapered	Yes
Compute "K" in corroded condition	Yes
Use Code Case 2286	No
Use the MAWP to compute the MDMT	Yes
For thickness ratios <= 0.35, MDMT will be -155F (-104C)	Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)	No
Using Metric Material Databases, ASME II D	No
Calculate B31.3 type stress for Nozzles with Loads	Yes
Reduce the MDMT due to lower membrane stress	Yes
Consider Longitudinal Stress in MDMT Calculations	Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Elliptical	
Description	Left Head	
Distance "FROM" to "TO"	63.36	mm
Element Outside Diameter	273	mm
Element Thickness	9.27	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.27	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	2.5	MPa
Design Temperature Internal Pressure	100	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	

Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.28	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	220.34	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	
Element From Node	10	
Detail Type	Nozzle	
Detail ID	Noz N1	
Dist. from "FROM" Node / Offset dist	0	mm
Nozzle Diameter	50	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	20	
Element To Node	30	
Element Type	Cylinder	
Description	Cylinder	
Distance "FROM" to "TO"	750	mm
Element Outside Diameter	273	mm
Element Thickness	8.11	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.27	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	2.5	MPa
Design Temperature Internal Pressure	100	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-106 B	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.28	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	220.34	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. pipe	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	

Weld is pre-Heated	No	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N2	
Dist. from "FROM" Node / Offset dist	674	mm
Nozzle Diameter	50	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	270.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N3	
Dist. from "FROM" Node / Offset dist	375	mm
Nozzle Diameter	38.1	mm
Nozzle Schedule	None	
Nozzle Class	None	
Layout Angle	270.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	None	
Nozzle Matl	SA-106 B	

Element From Node	30	
Element To Node	40	
Element Type	Elliptical	
Description	Right Cap	
Distance "FROM" to "TO"	63.36	mm
Element Outside Diameter	273	mm
Element Thickness	9.27	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.27	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	2.5	MPa
Design Temperature Internal Pressure	100	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.28	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	220.34	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	

Weld is pre-Heated	No

Internal Pressure Results Summary:

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd MPa	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) MPa
Left Head		2.5	9.27	3	273	100.22
Cylinder		2.5	9.27	3	273	100.22
Right Cap		2.5	9.27	3	273	100.22

Element Required Thickness and MAWP :

From	To	Design Pressure MPa	M.A.W.P. Corroded MPa	M.A.P. New & Cold MPa	Minimum Thickness mm	Required Thickness mm
Left Head		2.5	4.69	7.249	9.27	6.23376
Cylinder		2.5	3.809	6.099	8.11	6.37141
Right Cap		2.5	4.69	7.249	9.27	6.23376
Minimum			3.809	5.11		

Note : The M.A.P.(NC) is Governed by a Flange !

MAWP: 3.809 MPa, limited by: Cylinder.

Elements Suitable for Design Internal Pressure.

Internal Pressure Calculation Results:

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Elliptical Head From 10 To 20 SA-234 WPB , UCS-66 Crv. B at 100 °C

Left Head

Longitudinal Joint: User Defined

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (2.5*273*0.97)/(2*117.9*0.85+2*2.5*(0.97-0.1))
= 3.2338 + 3.0000 = 6.2338 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.27)/(0.97*273-2*6.27*(0.97-0.1))
= 4.948 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*9.27)/(1*273-2*9.27*(1-0.1))
= 7.249 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (2.5*(0.97*273-2*6.27*(0.97-0.1)))/(2*0.85*6.27)
= 59.570 MPa

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (2.5*136.5)/(117.9*0.85+0.4*2.5)+3
= 6.371 mm

Straight Flange Maximum Allowable Working Pressure:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 6.27)/(136.5 - 0.4 * 6.27)
= 4.69 MPa

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 +(260.5/(2 * 66.61))^2)/6
= 0.970315

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 9.27, tr = 4.873, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.661, Temp. Reduction = 19 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 9.27, tr = 5.11, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.693, Temp. Reduction = 17 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-46 °C

Cylindrical Shell From 20 To 30 SA-106 B , UCS-66 Crv. B at 100 °C

Cylinder

Longitudinal Joint: Spot Radiography per UW-11(b) Type 1

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (2.5*136.5)/(117.9*0.85+0.4*2.5)
= 3.3714 + 3.0000 = 6.3714 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*5.11)/(136.5-0.4*5.11)
= 3.809 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*8.11)/(136.5-0.4*8.11)
= 6.099 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (2.5*((136.5-0.4*5.11))/(0.85*5.11)
= 77.389 MPa

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 8.11, tr = 2.478, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.412, Temp. Reduction = 48 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

Elliptical Head From 30 To 40 SA-234 WPB , UCS-66 Crv. B at 100 °C

Right Cap

Longitudinal Joint: User Defined

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (2.5*273*0.97)/(2*117.9*0.85+2*2.5*(0.97-0.1))
= 3.2338 + 3.0000 = 6.2338 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.27)/(0.97*273-2*6.27*(0.97-0.1))
= 4.948 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*9.27)/(1*273-2*9.27*(1-0.1))
= 7.249 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (2.5*(0.97*273-2*6.27*(0.97-0.1)))/(2*0.85*6.27)
= 59.570 MPa

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (2.5*136.5)/(117.9*0.85+0.4*2.5)+3
= 6.371 mm

Straight Flange Maximum Allowable Working Pressure:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 6.27)/(136.5 - 0.4 * 6.27)
= 4.69 MPa

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 +(260.5/(2 * 66.61))^2)/6
= 0.970315

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 9.27, tr = 4.873, c = 3 mm, E✱ = 0.85

Thickness Ratio = tr * E✱/(tg - c) = 0.661, Temp. Reduction = 19 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 9.27, tr = 5.11, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.693, Temp. Reduction = 17 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-46 °C

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

Pressure per UG99b	= 1.30 * M.A.W.P. * Sa/S	4.951 MPa
Pressure per UG99b[35]	= 1.30 * Design Pres * Sa/S	3.250 MPa
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	6.643 MPa
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	4.190 MPa
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	3.575 MPa
Pressure per App 27-4	= M.A.W.P.	3.809 MPa
User Defined Hydrostatic Test Pressure at High Point		6.640 MPa

Horizontal Test performed per: User Hydro Pressure

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (MPa):

From To	Stress	Allowable	Ratio	Pressure
Left Head	108.0	153.3	0.705	6.64
Cylinder	128.4	153.3	0.838	6.64
Right Cap	108.0	153.3	0.705	6.64

Stress ratios for Nozzle and Pad Materials (MPa):

Description	Pad/Nozzle	Ambient	Operating	Ratio
Noz N1	Nozzle	117.90	117.90	1.000
N2	Nozzle	117.90	117.90	1.000
N3	Nozzle	117.90	117.90	1.000
Minimum				1.000

Stress ratios for Pressurized Vessel Elements (MPa):

Description	Ambient	Operating	Ratio
Left Head	117.90	117.90	1.000
Cylinder	117.90	117.90	1.000
Right Cap	117.90	117.90	1.000

Minimum	1.000

Hoop Stress in Nozzle Wall during Pressure Test (MPa):

Description	Ambient	Operating	Ratio
Noz N1	20.27	153.28	0.132
N2	20.27	153.28	0.132
N3	12.44	153.28	0.081

Elements Suitable for Test Pressure.

Element and Detail Weights:

From	To	Element Metal Wgt. kgm	Element ID Volume ltr	Corroded Metal Wgt. kgm	Corroded ID Volume ltr	Extra due Misc % kgm
10	20	9.75261	5.37984	6.59643	5.68983	...
20	30	45.0385	38.8465	30.8064	40.6831	...
30	40	9.75261	5.37984	6.59643	5.68983	...
Total		64	49.61	43	52.06	0

Weight of Details:

From	Type	Weight of Detail kgm	X Offset, Dtl. Cent. mm	Y Offset, Dtl. Cent. mm	Z Offset Dtl. Cent. mm	Description
10	Nozl	5.21238	-63.615	...	...	Noz N1
20	Nozl	5.24528	674	-158.553	...	N2
20	Nozl	0.28886	375	-147.44	...	N3

Total Weight of Each Detail Type:

Nozzles	10.7
Sum of the Detail Weights	10.7 kgm

Weight Summation Results: (kgm)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	64.5	64.5	64.5	64.5	64.5	64.5
Nozzles	10.7	10.7	10.7	10.7	10.7	10.7
Test Liquid	...	49.6	...	...	...	...
Totals	75.3	124.9	75.3	75.3	75.3	75.3

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	75.3 kgm
Shop Test Wt.	- Fabricated Weight + Water (Full)	124.9 kgm
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	75.3 kgm
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	75.3 kgm
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	75.3 kgm
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	75.3 kgm
Oper. Wt. + CA	- Corr Wt. + Operating Liquid	54.7 kgm
Field Test Wt.	- Empty Weight + Water (Full)	124.9 kgm

Note:
The Corroded Weight and thickness are used in the Horizontal
Vessel Analysis (Ope Case) and Earthquake Load Calculations.

Outside Surface Areas of Elements:

From	To	Surface Area

		mm²
10	20	135129
20	30	648708
30	40	135129
Total		918966.188 mm²

Nozzle Flange MAWP Results: (MPa & °C)

Nozzle Description	Flange Rating Ope.	Flange Rating Ambient	Design Temp	Class	Grade/ Group	Equiv. Press	Max Pressure UG-44(b)	Max Pressure 50%	Max Pressure DNV
Noz N1	4.66	5.11	100	300	GR 1.1	...	...	...	...
N2	4.66	5.11	100	300	GR 1.1	...	...	...	...
Min Rating	4.660	5.110 MPa [for Core Elements]				...	...	...	...

Pressure Ratings are per ASME B16.5 2017 Metric Edition

Input, Nozzle Desc: Noz N1 From: 10

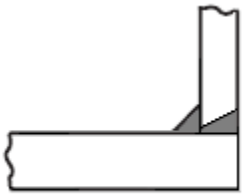
Pressure for Reinforcement Calculations	P	2.5000	MPa
Temperature for Internal Pressure	Temp	100	°C
Parent Material		SA-234 WPB	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Elliptical Head	D	254.46	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	9.2700	mm
Head Internal Corrosion Allowance	c	3.0000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	0.0000	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		0.00	deg
Diameter		50.0000	mm
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	65.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	7.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.1100	mm
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: Noz N1

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	60.325	mm.
Actual Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, tr [Int. Press]
= P*D*K1/(2*Sv*E-0.2*P) per Appendix 1-4(c)
= 0.881*2.5*260.5/(2*117.9*1-0.2*2.5)
= 2.4371 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 2.5*30.16/(117.9*1+0.4*2.5)
= 0.6342 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	97.6996	mm
Parallel to Vessel Wall, opening length	d	48.8498	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	14.3440	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: Noz N1.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.6342 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 5.6851 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 5.6851 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 6.4200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.42, max(5.685, 4.5)]
= 5.6851 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)

= max(3.634, 5.685)
= 5.6851 mm

Available Nozzle Neck Thickness = 0.875 * 8.738 = 7.645 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 7.645, tr = 0.634, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.137, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 7.645, tr = 0.634, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.137, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -48 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 2.50/5.11 = 0.489

Weld Size Calculations, Description: Noz N1

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * tmin.	4.9490 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 4.69 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 1.9319 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 76.2019 mm

Input, Nozzle Desc: N2 From: 20

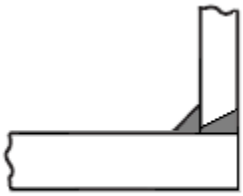
Pressure for Reinforcement Calculations	P	2.5000	MPa
Temperature for Internal Pressure	Temp	100	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	254.46	mm
Shell Finished (Minimum) Thickness	t	8.1100	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		737.36	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		50.0000	mm
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	68.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N2

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	60.325	mm.
Actual Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 2.5*130.2/(117.9*1-0.6*2.5)
= 2.7969 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 2.5*30.16/(117.9*1+0.4*2.5)
= 0.6342 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	97.6996	mm
Parallel to Vessel Wall, opening length	d	48.8498	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	12.7750	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N2.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.6342 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 5.7969 mm
Wall Thickness tb1 = max(trb1, tr16b)	= 5.7969 mm
Wall Thickness tb2 = max(trb2, tr16b)	= 4.5000 mm
Wall Thickness per table UG-45	tb3 = 6.4200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.42, max(5.797, 4.5)]
= 5.7969 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)

= max(3.634, 5.797)
= 5.7969 mm

Available Nozzle Neck Thickness = 0.875 * 8.738 = 7.645 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:B, Curve:A)

Govrn. thk, tg = 7.645, tr = 0.634, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.137, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 7.645, tr = 0.634, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.137, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Gov. MDMT of the nozzle to shell joint welded assembly :	-104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)	-48 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 2.50/5.11 = 0.489

Weld Size Calculations, Description: N2

Intermediate Calc. for nozzle/shell Welds	Tmin	5.7376	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.809 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 3.6270 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 79.7370 mm

Input, Nozzle Desc: N3 From: 20

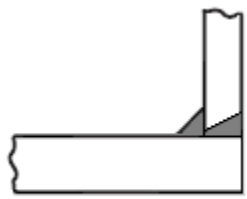
Pressure for Reinforcement Calculations	P	2.5000	MPa
Temperature for Internal Pressure	Temp	100	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	254.46	mm
Shell Finished (Minimum) Thickness	t	8.1100	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		438.36	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		38.1000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	8.3820	mm
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	47.6250	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N3

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation          38.100  mm.
 Actual Thickness Used in Calculation                  8.382  mm
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
```
  = P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
  = 2.5*130.2/(117.9*1-0.6*2.5)
  = 2.7969 mm
```

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
```
  = P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = 2.5*19.05/(117.9*1+0.4*2.5)
  = 0.4005 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)           Dl    54.6720  mm
 Parallel to Vessel Wall, opening length             d    27.3360  mm
 Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    12.7750  mm
```

Taking a UG-36(c)(3)(a) exemption for nozzle: N3.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
 Wall Thickness for Internal/External pressures      ta = 3.4005 mm
 Wall Thickness per UG16(b),                      tr16b = 4.5000 mm
 Wall Thickness, shell/head, internal pressure     trb1 = 5.7969 mm
 Wall Thickness                 tb1 = max(trb1, tr16b) = 5.7969 mm
 Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5000 mm
 Wall Thickness per table UG-45                   tb3 = 6.1200 mm
```

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 6.12, max( 5.797, 4.5 ) ]
  = 5.7969 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 3.401, 5.797 )
  = 5.7969 mm
```

Available Nozzle Neck Thickness = 8.3820 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 8.11, tr = 2.797, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.547, Temp. Reduction = 27 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -48 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -48 °C

Weld Size Calculations, Description: N3

Intermediate Calc. for nozzle/shell Welds Tmin 5.3820 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.7674 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.809 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 1.4343 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 57.1692 mm

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Report – N2-Inlet_LI4734 C220006CLC009

PV-Elite Calculation Summary

Client: Airpack Nederland BV.
Client location: Zierikzee
Ref number client: 17811-OO-0702(KP)

PPV Engineering

Author: H.Hoezen
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June 22, 2022
Order number: P22-115-01
Document number: 22-11501-C01
Revision: 1

Table of Contents

N2 Pulsation damper inlet
C220006CLC009
Static Calculation

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

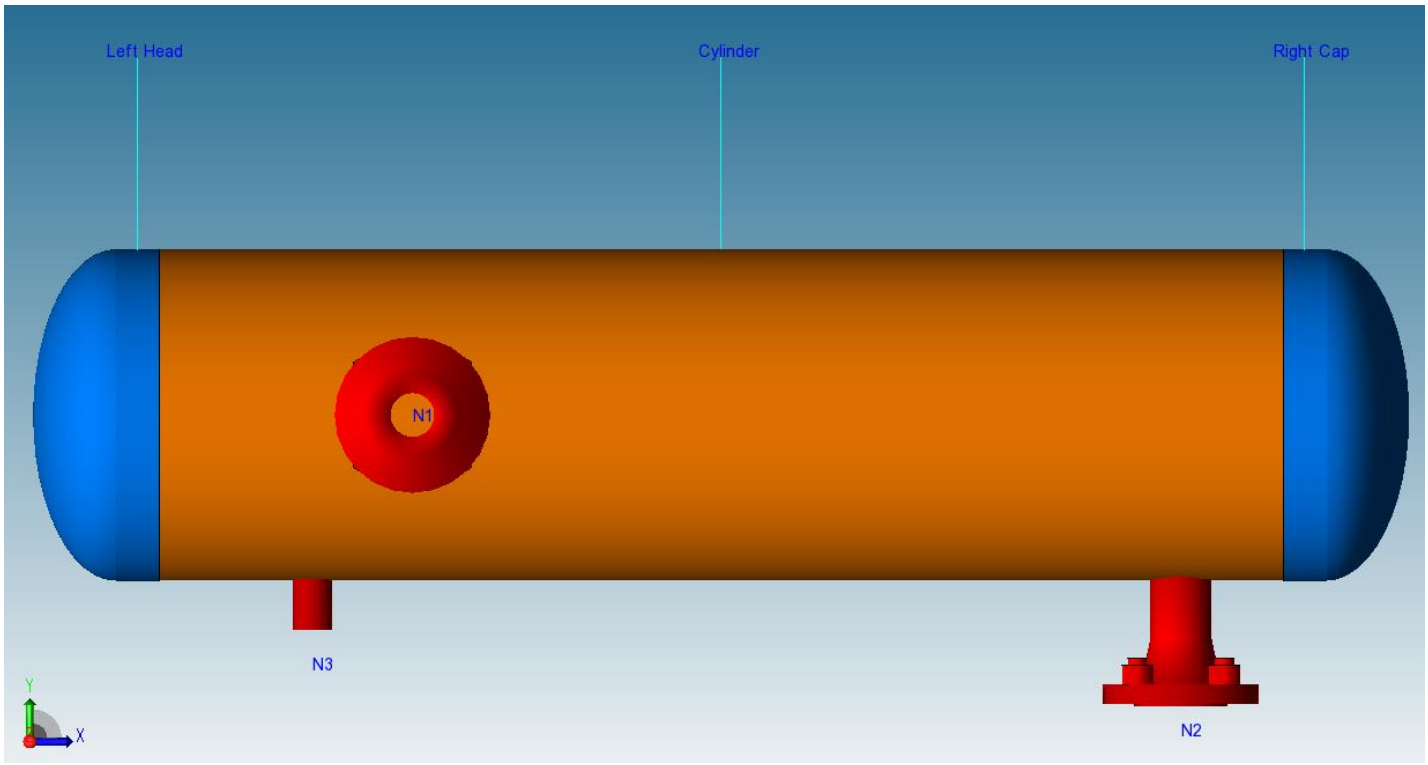
ASME Code Version : 2021

Analysis Performed by : PPV-Engineering B.V.

Job File : ...\N2-Inlet_LI4734.pvdb

Date of Analysis : Jun 21,2022 8:26am

PV Elite 24 SP1, March 2022



Vessel Design Summary:

ASME Code, Section VIII Division 1, 2021

Diameter Spec : 323.800 mm OD		
Vessel Design Length, Tangent to Tangent	1184.63	mm
Specified Datum Line Distance	42.31	mm
Internal Design Temperature	85	°C
Internal Design Pressure	1.250	MPa
External Design Temperature	85	°C
Maximum Allowable Working Pressure	1.815	MPa
Shop Test Pressure	2.550	MPa
Required Minimum Design Metal Temperature	-28.9	°C
Warmest Computed Minimum Design Metal Temperature	-38.0	°C
Wind Design Code	No Wind Loads	
Earthquake Design Code	No Seismic	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-106 B	...	...	K03006	No	No
Head	SA-234 WPB	...	...	K03006	No	No
Nozzle	SA-106 B	...	...	K03006	No	No
Nozzle Flg	SA-105	...	...	K03504	No	No

Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.
Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (MPa & mm):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Total Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Left Head	1.250	0.00	3.942	3.0000	Yes	No
Cylinder	1.250	0.00	3.204	3.0000	N/A	No
Right Cap	1.250	0.00	4.107	3.0000	Yes	No

Element Types and Properties:

Element Type	"To" Elev mm	Element Length mm	Nominal Thickness mm	Finished Thickness mm	Reqd Thk Internal mm	Reqd Thk External mm	Long Eff	Circ Eff
Ellipse	0.0	42.3	9.3	9.3	4.9	...	0.85	0.85
Cylinder	1100.0	1100.0	9.5	8.1	5.0	...	0.85	0.85
Ellipse	1142.3	42.3	9.5	9.5	4.9	...	0.85	0.85

Weights:

Fabricated	- Bare W/O Removable Internals	112.5	kgm
Shop Test	- Fabricated + Water (Full)	207.8	kgm
Shipping	- Fab. + Rem. Intls.+ Shipping App.	112.5	kgm
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	112.5	kgm
Empty	- Fab. + Intls. + Details + Wghts.	112.5	kgm
Operating	- Empty + Operating Liquid (No CA)	112.5	kgm
Field Test	- Empty Weight + Water (Full)	207.8	kgm

Nozzle Calculation Summary (MPa & mm):

Description	MAWP	Ext	MAPNC	UG-45	[tr]	Weld Path	Areas or Stresses
N2	3.204	...	...	OK	4.66	OK	No Calc[*]
N3	3.204	...	...	OK	4.66	OK	No Calc[*]
N1	3.204	...	...	OK	4.66	OK	No Calc[*]

Nozzle MAWP Summary:

Minimum MAWP Nozzles	:	3.204 Nozzle : N1
Minimum MAWP Shells/Flanges	:	1.815 MPa
Computed Vessel M.A.W.P.	:	1.815 MPa

[*] - This was a small opening and the areas were not computed.

Note: MAWPs (Internal Case) shown above are at the High Point.

Multiple output lines for the same nozzle indicates required Code calculations in both the longitudinal and circumferential planes of reinforcement where applicable.

Check the Spatial Relationship between the Nozzles:

From Node	Nozzle Description	X Coordinate mm	Layout Angle deg	Dia. Limit mm
20	N2	1042.315	270.000	97.700
20	N3	192.315	270.000	54.672
20	N1	290.315	0.000	97.700

The nozzle spacing is computed by the following:

= sqrt($ll^2 + lc^2$) where

ll - Arc length along the inside vessel surface in the long. direction.
lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.

No interference violations have been detected!

Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia mm	Wall Thk mm	Reinforcing Pad Diameter mm	Reinforcing Pad Thk mm	Cut Length mm	Flg Class
N3	38 mm	Actual	None	38.1	8.382	...	...	56	...
N2	50 mm	160	WNF	60.3	8.738	...	...	68	150
N1	50 mm	160	WNF	60.3	8.738	...	...	68	150

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows: Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
N3	SA-106 B	8.340	6.000	...	...	...
N2	SA-106 B	8.340	6.000	...	...	...
N1	SA-106 B	8.340	6.000	...	...	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
N3	150.000	270.0	47.62	0.00	Cylinder
N2	1000.000	270.0	57.00	0.00	Cylinder
N1	248.000	0.0	57.00	0.00	Cylinder

Bill of Materials:

QTY	DESCRIPTION	MATERIAL
1	ELLIPTICAL HEAD: 2.0 X 1, 9.3mm THK X 305.3mm ID X 42.3mm	SA-234 WPB
1	CYLINDER: 9.5mm THK X 307.6mm ID X 1100.0mm	SA-106 B
1	ELLIPTICAL HEAD: 2.0 X 1, 9.5mm THK X 304.8mm ID X 42.3mm	SA-234 WPB
1	NAMEPLATE	...

Units used in this Analysis (SI_ASME):

Name	System Unit	Constant	User Unit
Length	Feet	304.8000	mm
Force	Pounds	4.4480	N
Mass	Pounds	0.4536	kgm
Area	sq. inches	645.1600	mm²
Moment	ft. lbs.	1356.3000	N-mm
Stress	lbs./sq.in.	0.0069	MPa
Temperature	Degrees F	0.5556	°C
Pressure	psig	0.0069	MPa
Elast. Modulus	lbs./sq.in.	0.0069	MPa
Pipe Density	lbs./cu.in.	0.0277	kg/cm³
Ins. Density	lbs./cu.ft.	0.1602E-04	kg/cm³
Fluid Density	lbs./cu.ft.	0.1602E-04	kg/cm³
Wind Speed	miles/hr	1.6093	km/hr
Tray Weight	lbs./sq.ft.	0.0005	kg/cm²
Inertia	in.**4	416231.0000	mm**4
G Load	G's	1.0000	g's
Wind Load	lbs./sq.ft.	0.0479	kPa
Elevation	Feet	304.8000	mm
Volume	in.**3	0.0164	ltr
Diameter	inches	25.4000	mm
Thickness	inches	25.4000	mm

PV Elite Vessel Analysis Program: Input Data

N2 Pulsation damper inlet
C220006CLC009
Static Calculation

Design Internal Pressure (for Hydrotest)	1.25	MPa
Design Internal Temperature	85.0	°C
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-28.9	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-3	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	

Shop Pressure Test:

Type of Pressure Test	User Entered Pressure
Pressure Test Position	Horizontal
Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE

Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW
Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW
Wind Design Code	No Wind Loads
Seismic Design Code	No Seismic
Design Pressure + Static Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Use ASME VIII-1 Appendix 1-9	N
Perform Blast Load Analysis	No
Material Database Year	Current w/Addenda or Code Year

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	Yes
Shell Head Joints are Tapered	Yes
Compute "K" in corroded condition	Yes
Use Code Case 2286	No
Use the MAWP to compute the MDMT	Yes
For thickness ratios <= 0.35, MDMT will be -155F (-104C)	Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)	No
Using Metric Material Databases, ASME II D	No
Calculate B31.3 type stress for Nozzles with Loads	Yes
Reduce the MDMT due to lower membrane stress	Yes
Consider Longitudinal Stress in MDMT Calculations	Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Elliptical	
Description	Left Head	
Distance "FROM" to "TO"	42.315	mm
Element Outside Diameter	323.8	mm
Element Thickness	9.27	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.27	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	1.25	MPa
Design Temperature Internal Pressure	85	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	

Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.28	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	222.99	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	

Element From Node	20	
Element To Node	30	
Element Type	Cylinder	
Description	Cylinder	
Distance "FROM" to "TO"	1100	mm
Element Outside Diameter	323.8	mm
Element Thickness	8.11	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.53	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	1.25	MPa
Design Temperature Internal Pressure	85	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-106 B	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.28	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	222.99	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. pipe	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	N2	
Dist. from "FROM" Node / Offset dist	1000	mm
Nozzle Diameter	50	mm
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	270.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	GR 1.1	

Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N3	
Dist. from "FROM" Node / Offset dist	150	mm
Nozzle Diameter	38.1	mm
Nozzle Schedule	None	
Nozzle Class	None	
Layout Angle	270.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	None	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N1	
Dist. from "FROM" Node / Offset dist	248	mm
Nozzle Diameter	50	mm
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	30	
Element To Node	40	
Element Type	Elliptical	
Description	Right Cap	
Distance "FROM" to "TO"	42.315	mm
Element Outside Diameter	323.9	mm
Element Thickness	9.53	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.53	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	1.25	MPa
Design Temperature Internal Pressure	85	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.28	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	222.99	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	

Weld is pre-Heated	No

Internal Pressure Results Summary:

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd MPa	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) MPa
Left Head		1.25	9.27	3	323.8	100.22
Cylinder		1.25	9.53	3	323.8	100.22
Right Cap		1.25	9.53	3	323.9	100.22

Element Required Thickness and MAWP :

From	To	Design Pressure MPa	M.A.W.P. Corroded MPa	M.A.P. New & Cold MPa	Minimum Thickness mm	Required Thickness mm
Left Head		1.25	3.942	6.05	9.27	4.94764
Cylinder		1.25	3.204	5.123	8.11	5.00931
Right Cap		1.25	4.107	6.227	9.53	4.94817
Minimum			1.815	1.96		

Note : The M.A.W.P is Governed by a Standard Flange !

Note : The M.A.P.(NC) is Governed by a Flange !

Elements Suitable for Design Internal Pressure.

Internal Pressure Calculation Results:

ASME Code, Section VIII Division 1, 2021

Elliptical Head From 10 To 20 SA-234 WPB , UCS-66 Crv. B at 85 °C

Left Head

Longitudinal Joint: User Defined

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (1.25*323.8*0.975)/(2*117.9*0.85+2*1.25*(0.975-0.1))
= 1.9476 + 3.0000 = 4.9476 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.27)/(0.975*323.8-2*6.27*(0.975-0.1))
= 4.124 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*9.27)/(1*323.8-2*9.27*(1-0.1))
= 6.05 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (1.25*(0.975*323.8-2*6.27*(0.975-0.1)))/(2*0.85*6.27)
= 35.737 MPa

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (1.25*161.9)/(117.9*0.85+0.4*1.25)+3
= 5.009 mm

Straight Flange Maximum Allowable Working Pressure:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 6.27)/(161.9 - 0.4 * 6.27)
= 3.942 MPa

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 +(311.3/(2 * 79.31))^2)/6
= 0.975023

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 9.27, tr = 2.814, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.382, Temp. Reduction = 56 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 9.27, tr = 2.911, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.395, Temp. Reduction = 52 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

Cylindrical Shell From 20 To 30 SA-106 B , UCS-66 Crv. B at 85 °C

Cylinder

Longitudinal Joint: Spot Radiography per UW-11(b) Type 1

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (1.25*161.9)/(117.9*0.85+0.4*1.25)
= 2.0093 + 3.0000 = 5.0093 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*5.11)/(161.9-0.4*5.11)
= 3.204 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*8.11)/(161.9-0.4*8.11)
= 5.123 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (1.25*((161.9-0.4*5.11))/(0.85*5.11)
= 46.004 MPa

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 8.11, tr = 1.415, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.235, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Elliptical Head From 30 To 40 SA-234 WPB , UCS-66 Crv. B at 85 °C

Right Cap

Longitudinal Joint: User Defined

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (1.25*323.9*0.975)/(2*117.9*0.85+2*1.25*(0.975-0.1))
= 1.9482 + 3.0000 = 4.9482 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.53)/(0.975*323.9-2*6.53*(0.975-0.1))
= 4.3 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*9.53)/(1*323.9-2*9.53*(1-0.1))
= 6.227 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (1.25*(0.975*323.9-2*6.53*(0.975-0.1)))/(2*0.85*6.53)
= 34.273 MPa

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (1.25*161.9)/(117.9*0.85+0.4*1.25)+3
= 5.010 mm

Straight Flange Maximum Allowable Working Pressure:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 6.53)/(161.9 - 0.4 * 6.53)
= 4.107 MPa

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 +(310.8/(2 * 79.21))^2)/6
= 0.974990

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 9.53, tr = 2.815, c = 3 mm, E✱ = 0.85

Thickness Ratio = tr * E✱/(tg - c) = 0.366, Temp. Reduction = 66 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 9.53, tr = 2.912, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.379, Temp. Reduction = 56 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

Pressure per UG99b	= 1.30 * M.A.W.P. * Sa/S	2.360 MPa
Pressure per UG99b[35]	= 1.30 * Design Pres * Sa/S	1.625 MPa
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	2.548 MPa
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	1.997 MPa
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	1.787 MPa
Pressure per App 27-4	= M.A.W.P.	1.815 MPa
User Defined Hydrostatic Test Pressure at High Point		2.550 MPa

Horizontal Test performed per: User Hydro Pressure

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (MPa):

From To	Stress	Allowable	Ratio	Pressure
Left Head	49.8	153.3	0.325	2.55
Cylinder	58.8	153.3	0.383	2.55
Right Cap	48.3	153.3	0.315	2.55

Stress ratios for Nozzle and Pad Materials (MPa):

Description	Pad/Nozzle	Ambient	Operating	Ratio
N2	Nozzle	117.90	117.90	1.000
N3	Nozzle	117.90	117.90	1.000
N1	Nozzle	117.90	117.90	1.000
Minimum				1.000

Stress ratios for Pressurized Vessel Elements (MPa):

Description	Ambient	Operating	Ratio
Left Head	117.90	117.90	1.000
Cylinder	117.90	117.90	1.000
Right Cap	117.90	117.90	1.000

Minimum	1.000

Hoop Stress in Nozzle Wall during Pressure Test (MPa):

Description	Ambient	Operating	Ratio
N2	7.79	153.28	0.051
N3	4.78	153.28	0.031
N1	7.79	153.28	0.051

Elements Suitable for Test Pressure.

Element and Detail Weights:

From	To	Element Metal Wgt. kgm	Element ID Volume ltr	Corroded Metal Wgt. kgm	Corroded ID Volume ltr	Extra due Misc % kgm
10	20	11.5111	6.82157	7.78581	7.16848	...
20	30	80.9422	81.7479	55.9867	84.9683	...
30	40	11.8235	6.79771	8.10149	7.14383	...
Total		104	95.37	71	99.28	0

Weight of Details:

From	Type	Weight of Detail kgm	X Offset, Dtl. Cent. mm	Y Offset, Dtl. Cent. mm	Z Offset Dtl. Cent. mm	Description
20	Nozl	3.95534	1000	-183.952	...	N2
20	Nozl	0.28886	150	-172.84	...	N3
20	Nozl	3.95534	248	...	183.952	N1

Total Weight of Each Detail Type:

Nozzles	8.2
Sum of the Detail Weights	8.2 kgm

Weight Summation Results: (kgm)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	104.3	104.3	104.3	104.3	104.3	104.3
Nozzles	8.2	8.2	8.2	8.2	8.2	8.2
Test Liquid	...	95.3	...	...	...	...
Totals	112.5	207.8	112.5	112.5	112.5	112.5

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	112.5 kgm
Shop Test Wt.	- Fabricated Weight + Water (Full)	207.8 kgm
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	112.5 kgm
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	112.5 kgm
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	112.5 kgm
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	112.5 kgm
Oper. Wt. + CA	- Corr Wt. + Operating Liquid	80.1 kgm
Field Test Wt.	- Empty Weight + Water (Full)	207.8 kgm

Note:
The Corroded Weight and thickness are used in the Horizontal
Vessel Analysis (Ope Case) and Earthquake Load Calculations.

Outside Surface Areas of Elements:

From	To	Surface Area

		mm²
10	20	156697
20	30	1128786
30	40	156780
Total		1442264.125 mm²

Nozzle Flange MAWP Results: (MPa & °C)

Nozzle Description	Flange Rating Ope.	Flange Rating Ambient	Design Temp	Class	Grade/ Group	Equiv. Press	Max Pressure UG-44(b)	Max Pressure 50%	Max Pressure DNV
N2	1.82	1.96	85	150	GR 1.1	...	...	...	...
N1	1.82	1.96	85	150	GR 1.1	...	...	...	...
Min Rating	1.815	1.960 MPa [for Core Elements]				...	...	...	...

Pressure Ratings are per ASME B16.5 2017 Metric Edition

Input, Nozzle Desc: N2 From: 20

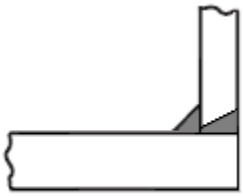
Pressure for Reinforcement Calculations	P	1.2500	MPa
Temperature for Internal Pressure	Temp	85	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	304.74	mm
Shell Finished (Minimum) Thickness	t	8.1100	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		1042.31	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		50.0000	mm
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	57.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N2

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	60.325	mm.
Actual Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 1.25*155.4/(117.9*1-0.6*1.25)
= 1.6577 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 1.25*30.16/(117.9*1+0.4*1.25)
= 0.3184 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	97.6996	mm
Parallel to Vessel Wall, opening length	d	48.8498	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	12.7750	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N2.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.3184 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 4.6577 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 4.6577 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 6.4200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.42, max(4.658, 4.5)]
= 4.6577 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)

= max(3.318, 4.658)
= 4.6577 mm

Available Nozzle Neck Thickness = 0.875 * 8.738 = 7.645 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:B, Curve:A)

Govrn. thk, tg = 7.645, tr = 0.318, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.0685, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 7.645, tr = 0.318, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.0685, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)	-38 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 1.25/1.96 = 0.638

Weld Size Calculations, Description: N2

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.204 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 3.0153 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 68.1253 mm

Input, Nozzle Desc: N3 From: 20

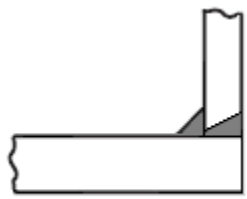
Pressure for Reinforcement Calculations	P	1.2500	MPa
Temperature for Internal Pressure	Temp	85	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	304.74	mm
Shell Finished (Minimum) Thickness	t	8.1100	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		192.32	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		38.1000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	8.3820	mm
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	47.6250	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N3

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation		38.100	mm.
Actual Thickness Used in Calculation		8.382	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 1.25*155.4/(117.9*1-0.6*1.25)
= 1.6577 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 1.25*19.05/(117.9*1+0.4*1.25)
= 0.2011 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	54.6720	mm
Parallel to Vessel Wall, opening length	d	27.3360	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	12.7750	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N3.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta	= 3.2011 mm
Wall Thickness per UG16(b),	tr16b	= 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1	= 4.6577 mm
Wall Thickness	tb1 = max(trb1, tr16b)	= 4.6577 mm
Wall Thickness	tb2 = max(trb2, tr16b)	= 4.5000 mm
Wall Thickness per table UG-45	tb3	= 6.1200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.12, max(4.658, 4.5)]
= 4.6577 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(3.201, 4.658)
= 4.6577 mm

Available Nozzle Neck Thickness = 8.3820 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 8.11, tr = 1.658, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.324, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Weld Size Calculations, Description: N3

Intermediate Calc. for nozzle/shell Welds Tmin 5.3820 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.7674 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.204 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 1.1956 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 56.9305 mm

Input, Nozzle Desc: N1 From: 20

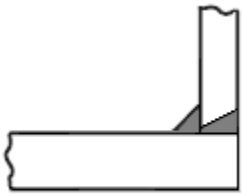
Pressure for Reinforcement Calculations	P	1.2500	MPa
Temperature for Internal Pressure	Temp	85	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	304.74	mm
Shell Finished (Minimum) Thickness	t	8.1100	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		290.32	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		0.00	deg
Diameter		50.0000	mm
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	57.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N1

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	60.325	mm.
Actual Thickness Used in Calculation	8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 1.25*155.4/(117.9*1-0.6*1.25)
= 1.6577 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 1.25*30.16/(117.9*1+0.4*1.25)
= 0.3184 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	97.6996	mm
Parallel to Vessel Wall, opening length	d	48.8498	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	12.7750	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N1.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.3184 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 4.6577 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 4.6577 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 6.4200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.42, max(4.658, 4.5)]
= 4.6577 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)

= max(3.318, 4.658)
= 4.6577 mm

Available Nozzle Neck Thickness = 0.875 * 8.738 = 7.645 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 7.645, tr = 0.318, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.0685, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 7.645, tr = 0.318, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.0685, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -38 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 1.25/1.96 = 0.638

Weld Size Calculations, Description: N1

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.204 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 3.0153 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 68.1253 mm

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Report – 1-stage Discharge_LI4734 C220006CLC010

PV-Elite Calculation Summary

Client: Airpack Nederland BV.
Client location: Zierikzee
Ref number client: 17811-OO-0702(KP)

PPV Engineering

Author: H.Hoezen
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June 22, 2022
Order number: P22-115-01
Document number: 22-11501-C02
Revision: 1

Table of Contents

N2 Pulsation damper first stage discharge
C220006CLC010
Static Calculation

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

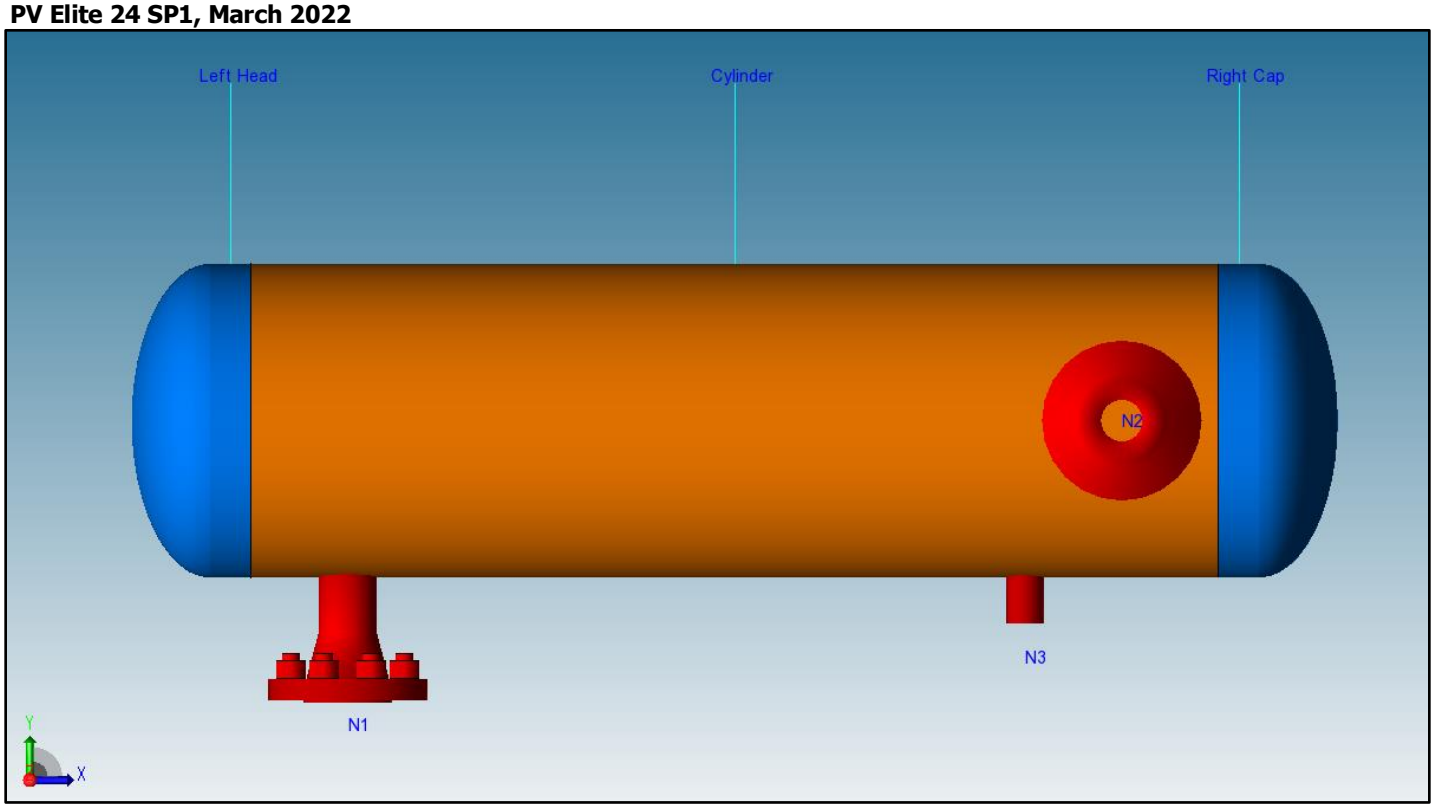
ASME Code Version : 2021

Analysis Performed by : PPV-Engineering B.V.

Job File : ...\1-stage Discharge_LI4734.pvdb

Date of Analysis : Jun 21,2022 1:55pm

PV Elite 24 SP1, March 2022



Vessel Design Summary:

ASME Code, Section VIII Division 1, 2021

Diameter Spec : 323.800 mm OD		
Vessel Design Length, Tangent to Tangent	1084.63	mm
Specified Datum Line Distance	42.31	mm
Internal Design Temperature	170	°C
Internal Design Pressure	2.400	MPa
External Design Temperature	170	°C
Maximum Allowable Working Pressure	3.35	MPa
Shop Test Pressure	6.640	MPa
Required Minimum Design Metal Temperature	-28.9	°C
Warmest Computed Minimum Design Metal Temperature	-46.0	°C
Wind Design Code	No Wind Loads	
Earthquake Design Code	No Seismic	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-106 B	...	...	K03006	No	No
Head	SA-234 WPB	...	...	K03006	No	No
Nozzle	SA-106 B	...	...	K03006	No	No
Nozzle Flg	SA-105	...	...	K03504	No	No

Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.
Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (MPa & mm):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Total Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Left Head	2.400	0.00	4.108	3.0000	Yes	No
Cylinder	2.400	0.00	3.350	3.0000	N/A	No
Right Cap	2.400	0.00	4.108	3.0000	Yes	No

Element Types and Properties:

Element Type	"To" Elev mm	Element Length mm	Nominal Thickness mm	Finished Thickness mm	Reqd Thk Internal mm	Reqd Thk External mm	Long Eff	Circ Eff
Ellipse	0.0	42.3	9.5	9.5	6.7	...	0.85	0.85
Cylinder	1000.0	1000.0	9.5	8.3	6.8	...	0.85	0.85
Ellipse	1042.3	42.3	9.5	9.5	6.7	...	0.85	0.85

Weights:

Fabricated	- Bare W/O Removable Internals	107.7	kgm
Shop Test	- Fabricated + Water (Full)	195.3	kgm
Shipping	- Fab. + Rem. Intls.+ Shipping App.	107.7	kgm
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	107.7	kgm
Empty	- Fab. + Intls. + Details + Wghts.	107.7	kgm
Operating	- Empty + Operating Liquid (No CA)	107.7	kgm
Field Test	- Empty Weight + Water (Full)	195.3	kgm

Nozzle Calculation Summary (MPa & mm):

Description	MAWP	Ext	MAPNC	UG-45	[tr]	Weld Path	Areas or Stresses
N1	3.35	...	...	OK	6.20	OK	No Calc[*]
N2	3.35	...	...	OK	6.20	OK	No Calc[*]
N3	3.35	...	...	OK	6.12	OK	No Calc[*]

Nozzle MAWP Summary:

Minimum MAWP Nozzles	:	3.35	Nozzle : N3
Minimum MAWP Shells/Flanges	:	3.35	Element : Cylinder
Minimum MAPnc Shells/Flanges	:	5.271	Element : Cylinder
Computed Vessel M.A.W.P.	:	3.35 MPa	

[*] - This was a small opening and the areas were not computed.

Note: MAWPs (Internal Case) shown above are at the High Point.

Multiple output lines for the same nozzle indicates required Code calculations in both the longitudinal and circumferential planes of reinforcement where applicable.

Check the Spatial Relationship between the Nozzles:

From Node	Nozzle Description	X Coordinate mm	Layout Angle deg	Dia. Limit mm
20	N1	142.315	270.000	97.700
20	N2	942.315	0.000	97.700
20	N3	842.315	270.000	54.672

The nozzle spacing is computed by the following:

= sqrt(ll² + lc²) where

ll - Arc length along the inside vessel surface in the long. direction.
lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.

No interference violations have been detected!

Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia mm	Wall Thk mm	Reinforcing Pad Diameter mm	Reinforcing Pad Thk mm	Cut Length mm	Flg Class
N3	38 mm	Actual	None	38.1	8.382	...	...	57	...
N1	50 mm	160	WNF	60.3	8.738	...	...	68	300
N2	50 mm	160	WNF	60.3	8.738	...	...	68	300

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows: Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
N3	SA-106 B	8.340	6.000	...	...	...
N1	SA-106 B	8.340	6.000	...	...	...
N2	SA-106 B	8.340	6.000	...	...	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
N3	800.000	270.0	47.62	0.00	Cylinder
N1	100.000	270.0	57.10	0.00	Cylinder
N2	900.000	0.0	57.10	0.00	Cylinder

Bill of Materials:

QTY	DESCRIPTION	MATERIAL
2	ELLIPTICAL HEAD: 2.0 X 1, 9.5mm THK X 304.7mm ID X 42.3mm	SA-234 WPB
1	CYLINDER: 9.5mm THK X 307.1mm ID X 1000.0mm	SA-106 B
1	NAMEPLATE	...

Units used in this Analysis (SI_ASME):

Name	System Unit	Constant	User Unit
Length	Feet	304.8000	mm
Force	Pounds	4.4480	N
Mass	Pounds	0.4536	kgm
Area	sq. inches	645.1600	mm²
Moment	ft. lbs.	1356.3000	N-mm
Stress	lbs./sq.in.	0.0069	MPa
Temperature	Degrees F	0.5556	°C
Pressure	psig	0.0069	MPa
Elast. Modulus	lbs./sq.in.	0.0069	MPa
Pipe Density	lbs./cu.in.	0.0277	kg/cm³
Ins. Density	lbs./cu.ft.	0.1602E-04	kg/cm³
Fluid Density	lbs./cu.ft.	0.1602E-04	kg/cm³
Wind Speed	miles/hr	1.6093	km/hr
Tray Weight	lbs./sq.ft.	0.0005	kg/cm²
Inertia	in.**4	416231.0000	mm**4
G Load	G's	1.0000	g's
Wind Load	lbs./sq.ft.	0.0479	kPa
Elevation	Feet	304.8000	mm
Volume	in.**3	0.0164	ltr
Diameter	inches	25.4000	mm
Thickness	inches	25.4000	mm

PV Elite Vessel Analysis Program: Input Data

N2 Pulsation damper first stage discharge
C220006CLC010
Static Calculation

Design Internal Pressure (for Hydrotest)	2.4	MPa
Design Internal Temperature	170.0	°C
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-28.9	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-3	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	

Shop Pressure Test:

Type of Pressure Test	User Entered Pressure
Pressure Test Position	Horizontal

Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE

Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW
Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW
Wind Design Code	No Wind Loads
Seismic Design Code	No Seismic
Design Pressure + Static Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Use ASME VIII-1 Appendix 1-9	N
Perform Blast Load Analysis	No
Material Database Year	Current w/Addenda or Code Year

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	Yes
Shell Head Joints are Tapered	Yes
Compute "K" in corroded condition	Yes
Use Code Case 2286	No
Use the MAWP to compute the MDMT	Yes
For thickness ratios <= 0.35, MDMT will be -155F (-104C)	Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)	No
Using Metric Material Databases, ASME II D	No
Calculate B31.3 type stress for Nozzles with Loads	Yes
Reduce the MDMT due to lower membrane stress	Yes
Consider Longitudinal Stress in MDMT Calculations	Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Elliptical	
Description	Left Head	
Distance "FROM" to "TO"	42.315	mm
Element Outside Diameter	323.8	mm
Element Thickness	9.53	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.53	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	2.4	MPa
Design Temperature Internal Pressure	170	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	170	°C
Effective Diameter Multiplier	1.2	

Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.31	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	210.91	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	

Element From Node	20	
Element To Node	30	
Element Type	Cylinder	
Description	Cylinder	
Distance "FROM" to "TO"	1000	mm
Element Outside Diameter	323.8	mm
Element Thickness	8.34	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.53	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	2.4	MPa
Design Temperature Internal Pressure	170	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	170	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-106 B	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.31	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	210.91	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. pipe	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	N1	
Dist. from "FROM" Node / Offset dist	100	mm
Nozzle Diameter	50	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	270.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	GR 1.1	

Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N2	
Dist. from "FROM" Node / Offset dist	900	mm
Nozzle Diameter	50	mm
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N3	
Dist. from "FROM" Node / Offset dist	800	mm
Nozzle Diameter	38.1	mm
Nozzle Schedule	None	
Nozzle Class	None	
Layout Angle	270.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	None	
Nozzle Matl	SA-106 B	

Element From Node	30	
Element To Node	40	
Element Type	Elliptical	
Description	Right Cap	
Distance "FROM" to "TO"	42.315	mm
Element Outside Diameter	323.8	mm
Element Thickness	9.53	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	9.53	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	2.4	MPa
Design Temperature Internal Pressure	170	°C
Design External Pressure	0	MPa
Design Temperature External Pressure	170	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	MPa
Allowable Stress, Operating	117.9	MPa
Allowable Stress, Hydrotest	153.31	MPa
Material Density	0.00775	kg/cm³
P Number Thickness	30.988	mm
Yield Stress, Operating	210.91	MPa
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	

Internal Pressure Results Summary:

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd MPa	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) MPa
Left Head		2.4	9.53	3	323.8	100.22
Cylinder		2.4	9.53	3	323.8	100.22
Right Cap		2.4	9.53	3	323.8	100.22

Element Required Thickness and MAWP :

From	To	Design Pressure MPa	M.A.W.P. Corroded MPa	M.A.P. New & Cold MPa	Minimum Thickness mm	Required Thickness mm
Left Head		2.4	4.108	6.229	9.53	6.70255
Cylinder		2.4	3.35	5.271	8.34	6.84034
Right Cap		2.4	4.108	6.229	9.53	6.70255
Minimum			3.35	5.11		

Note : The M.A.P.(NC) is Governed by a Flange !

MAWP: 3.35 MPa, limited by: Cylinder.

Elements Suitable for Design Internal Pressure.

Internal Pressure Calculation Results:

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Elliptical Head From 10 To 20 SA-234 WPB , UCS-66 Crv. B at 170 °C

Left Head

Longitudinal Joint: User Defined

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (2.4*323.8*0.975)/(2*117.9*0.85+2*2.4*(0.975-0.1))
= 3.7025 + 3.0000 = 6.7025 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.53)/(0.975*323.8-2*6.53*(0.975-0.1))
= 4.302 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*9.53)/(1*323.8-2*9.53*(1-0.1))
= 6.229 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (2.4*(0.975*323.8-2*6.53*(0.975-0.1)))/(2*0.85*6.53)
= 65.783 MPa

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (2.4*161.9)/(117.9*0.85+0.4*2.4)+3
= 6.840 mm

Straight Flange Maximum Allowable Working Pressure:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 6.53)/(161.9 - 0.4 * 6.53)
= 4.108 MPa

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 +(310.7/(2 * 79.18))^2)/6
= 0.974982

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 9.53, tr = 5.126, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.667, Temp. Reduction = 18 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-47 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 9.53, tr = 5.34, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.695, Temp. Reduction = 17 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-46 °C

Cylindrical Shell From 20 To 30 SA-106 B , UCS-66 Crv. B at 170 °C

Cylinder

Longitudinal Joint: Spot Radiography per UW-11(b) Type 1

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (2.4*161.9)/(117.9*0.85+0.4*2.4)
= 3.8403 + 3.0000 = 6.8403 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*5.34)/(161.9-0.4*5.34)
= 3.35 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9*0.85*8.34)/(161.9-0.4*8.34)
= 5.271 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (2.4*((161.9-0.4*5.34))/(0.85*5.34)
= 84.475 MPa

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 8.34, tr = 2.599, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.414, Temp. Reduction = 47 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

Elliptical Head From 30 To 40 SA-234 WPB , UCS-66 Crv. B at 170 °C

Right Cap

Longitudinal Joint: User Defined

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (2.4*323.8*0.975)/(2*117.9*0.85+2*2.4*(0.975-0.1))
= 3.7025 + 3.0000 = 6.7025 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*6.53)/(0.975*323.8-2*6.53*(0.975-0.1))
= 4.302 MPa

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*117.9*0.85*9.53)/(1*323.8-2*9.53*(1-0.1))
= 6.229 MPa

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (2.4*(0.975*323.8-2*6.53*(0.975-0.1)))/(2*0.85*6.53)
= 65.783 MPa

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (2.4*161.9)/(117.9*0.85+0.4*2.4)+3
= 6.840 mm

Straight Flange Maximum Allowable Working Pressure:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (117.9 * 0.85 * 6.53)/(161.9 - 0.4 * 6.53)
= 4.108 MPa

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 +(310.7/(2 * 79.18))^2)/6
= 0.974982

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 9.53, tr = 5.126, c = 3 mm, E✱ = 0.85

Thickness Ratio = tr * E✱/(tg - c) = 0.667, Temp. Reduction = 18 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-47 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 9.53, tr = 5.34, c = 3 mm, E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.695, Temp. Reduction = 17 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-46 °C

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

Pressure per UG99b	= 1.30 * M.A.W.P. * Sa/S	4.355 MPa
Pressure per UG99b[35]	= 1.30 * Design Pres * Sa/S	3.120 MPa
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	6.643 MPa
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	3.685 MPa
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	3.432 MPa
Pressure per App 27-4	= M.A.W.P.	3.350 MPa
User Defined Hydrostatic Test Pressure at High Point		6.640 MPa

Horizontal Test performed per: User Hydro Pressure

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (MPa):

From To	Stress	Allowable	Ratio	Pressure
Left Head	125.7	153.3	0.820	6.64
Cylinder	148.6	153.3	0.969	6.64
Right Cap	125.7	153.3	0.820	6.64

Stress ratios for Nozzle and Pad Materials (MPa):

Description	Pad/Nozzle	Ambient	Operating	Ratio
N1	Nozzle	117.90	117.90	1.000
N2	Nozzle	117.90	117.90	1.000
N3	Nozzle	117.90	117.90	1.000
Minimum				1.000

Stress ratios for Pressurized Vessel Elements (MPa):

Description	Ambient	Operating	Ratio
Left Head	117.90	117.90	1.000
Cylinder	117.90	117.90	1.000
Right Cap	117.90	117.90	1.000

Minimum	1.000

Hoop Stress in Nozzle Wall during Pressure Test (MPa):

Description	Ambient	Operating	Ratio
N1	20.28	153.28	0.132
N2	20.28	153.28	0.132
N3	12.44	153.28	0.081

Elements Suitable for Test Pressure.

Element and Detail Weights:

From	To	Element Metal Wgt. kgm	Element ID Volume ltr	Corroded Metal Wgt. kgm	Corroded ID Volume ltr	Extra due Misc % kgm
10	20	11.8169	6.79203	8.09701	7.13797	...
20	30	73.4771	74.0942	50.8239	77.0175	...
30	40	11.8169	6.79203	8.09701	7.13797	...
Total		97	87.68	67	91.29	0

Weight of Details:

From	Type	Weight of Detail kgm	X Offset, Dtl. Cent. mm	Y Offset, Dtl. Cent. mm	Z Offset Dtl. Cent. mm	Description
20	Nozl	5.12569	100	-183.723	...	N1
20	Nozl	5.12569	900	...	183.723	N2
20	Nozl	0.28886	800	-172.61	...	N3

Total Weight of Each Detail Type:

Nozzles	10.5
Sum of the Detail Weights	10.5 kgm

Weight Summation Results: (kgm)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	97.1	97.1	97.1	97.1	97.1	97.1
Nozzles	10.5	10.5	10.5	10.5	10.5	10.5
Test Liquid	...	87.6	...	...	...	...
Totals	107.7	195.3	107.7	107.7	107.7	107.7

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	107.7 kgm
Shop Test Wt.	- Fabricated Weight + Water (Full)	195.3 kgm
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	107.7 kgm
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	107.7 kgm
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	107.7 kgm
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	107.7 kgm
Oper. Wt. + CA	- Corr Wt. + Operating Liquid	77.6 kgm
Field Test Wt.	- Empty Weight + Water (Full)	195.3 kgm

Note:
The Corroded Weight and thickness are used in the Horizontal
Vessel Analysis (Ope Case) and Earthquake Load Calculations.

Outside Surface Areas of Elements:

From	To	Surface Area

		mm²
10	20	156697
20	30	1024724
30	40	156697
Total		1338118.375 mm²

Nozzle Flange MAWP Results: (MPa & °C)

Nozzle Description	Flange Rating Ope.	Flange Rating Ambient	Design Temp	Class	Grade/ Group	Equiv. Press	Max Pressure UG-44(b)	Max Pressure 50%	Max Pressure DNV
N1	4.46	5.11	170	300	GR 1.1	...	...	...	...
N2	4.46	5.11	170	300	GR 1.1	...	...	...	...
Min Rating	4.458	5.110 MPa [for Core Elements]				...	...	...	...

Pressure Ratings are per ASME B16.5 2017 Metric Edition

Input, Nozzle Desc: N1 From: 20

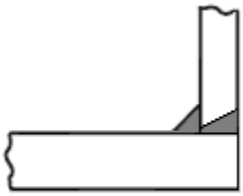
Pressure for Reinforcement Calculations	P	2.4000	MPa
Temperature for Internal Pressure	Temp	170	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	304.74	mm
Shell Finished (Minimum) Thickness	t	8.3400	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		142.32	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		50.0000	mm
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	57.1000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N1

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation		60.325	mm.
Actual Thickness Used in Calculation		8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 2.4*155.4/(117.9*1-0.6*2.4)
= 3.2017 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 2.4*30.16/(117.9*1+0.4*2.4)
= 0.6090 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	97.6996	mm
Parallel to Vessel Wall, opening length	d	48.8498	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	13.3500	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N1.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta	= 3.6090 mm
Wall Thickness per UG16(b),	tr16b	= 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1	= 6.2017 mm
Wall Thickness	tb1 = max(trb1, tr16b)	= 6.2017 mm
Wall Thickness	tb2 = max(trb2, tr16b)	= 4.5000 mm
Wall Thickness per table UG-45	tb3	= 6.4200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.42, max(6.202, 4.5)]
= 6.2017 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)

= max(3.609, 6.202)
= 6.2017 mm

Available Nozzle Neck Thickness = 0.875 * 8.738 = 7.645 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:B, Curve:A)

Govrn. thk, tg = 7.645, tr = 0.609, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.131, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 7.645, tr = 0.609, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.131, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)	-48 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 2.40/5.11 = 0.470

Weld Size Calculations, Description: N1

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.35 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 3.0152 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 68.4552 mm

Input, Nozzle Desc: N2 From: 20

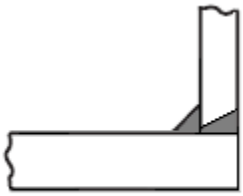
Pressure for Reinforcement Calculations	P	2.4000	MPa
Temperature for Internal Pressure	Temp	170	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	304.74	mm
Shell Finished (Minimum) Thickness	t	8.3400	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		942.32	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		0.00	deg
Diameter		50.0000	mm
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	57.1000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N2

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation		60.325	mm.
Actual Thickness Used in Calculation		8.738	mm

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 2.4*155.4/(117.9*1-0.6*2.4)
= 3.2017 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 2.4*30.16/(117.9*1+0.4*2.4)
= 0.6090 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	97.6996	mm
Parallel to Vessel Wall, opening length	d	48.8498	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	13.3500	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N2.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta	= 3.6090 mm
Wall Thickness per UG16(b),	tr16b	= 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1	= 6.2017 mm
Wall Thickness	tb1 = max(trb1, tr16b)	= 6.2017 mm
Wall Thickness	tb2 = max(trb2, tr16b)	= 4.5000 mm
Wall Thickness per table UG-45	tb3	= 6.4200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.42, max(6.202, 4.5)]
= 6.2017 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)

= max(3.609, 6.202)
= 6.2017 mm

Available Nozzle Neck Thickness = 0.875 * 8.738 = 7.645 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, min(Curve:B, Curve:A)

Govrn. thk, tg = 7.645, tr = 0.609, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.131, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve A	-8 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C
Min Metal Temp. w/o impact per UG-20(f)	-29 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 7.645, tr = 0.609, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.131, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)	-48 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 2.40/5.11 = 0.470

Weld Size Calculations, Description: N2

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.35 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 3.0152 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 68.4552 mm

Input, Nozzle Desc: N3 From: 20

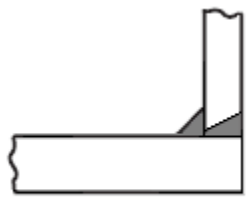
Pressure for Reinforcement Calculations	P	2.4000	MPa
Temperature for Internal Pressure	Temp	170	°C
Parent Material		SA-106 B	
Parent Allowable Stress at Temperature	Sv	117.90	MPa
Parent Allowable Stress At Ambient	Sva	117.90	MPa
Inside Diameter of Cylindrical Shell	D	304.74	mm
Shell Finished (Minimum) Thickness	t	8.3400	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		842.32	mm
User Entered Minimum Design Metal Temperature		-28.89	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	MPa
Allowable Stress At Ambient	Sna	117.90	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		38.1000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	8.3820	mm
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	47.6250	mm
Weld leg size between Nozzle and Pad/Shell	Wo	6.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	8.3400	mm

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Abutting/Set-on Nozzle No Pad

Reinforcement CALCULATION, Description: N3

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

```
 Actual Outside Diameter Used in Calculation          38.100  mm.
 Actual Thickness Used in Calculation                  8.382  mm
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
```
  = P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
  = 2.4*155.4/(117.9*1-0.6*2.4)
  = 3.2017 mm
```

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
```
  = P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = 2.4*19.05/(117.9*1+0.4*2.4)
  = 0.3846 mm
```

UG-40, Limits of Reinforcement : [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)           Dl    54.6720  mm
 Parallel to Vessel Wall, opening length             d    27.3360  mm
 Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    13.3500  mm
```

Taking a UG-36(c)(3)(a) exemption for nozzle: N3.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
 Wall Thickness for Internal/External pressures      ta = 3.3846 mm
 Wall Thickness per UG16(b),                      tr16b = 4.5000 mm
 Wall Thickness, shell/head, internal pressure     trb1 = 6.2017 mm
 Wall Thickness                  tb1 = max(trb1, tr16b) = 6.2017 mm
 Wall Thickness                  tb2 = max(trb2, tr16b) = 4.5000 mm
 Wall Thickness per table UG-45                    tb3 = 6.1200 mm
```

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 6.12, max( 6.202, 4.5 ) ]
  = 6.1200 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 3.385, 6.12 )
  = 6.1200 mm
```

Available Nozzle Neck Thickness = 8.3820 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 8.34, tr = 3.202, c = 3 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.6, Temp. Reduction = 23 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
Min Metal Temp. at Required thickness (UCS 66.1) -48 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -48 °C

Weld Size Calculations, Description: N3

Intermediate Calc. for nozzle/shell Welds Tmin 5.3820 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.7674 = 0.7 * tmin.	4.2420 = 0.7 * Wo mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 3.35 MPa

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 1.1956 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 57.1605 mm

e