

Regeneratoriaus R-202 keičiamų elementų stiprumo skaičiavimas

Priedas Nr.2

DESIGN CALCULATION

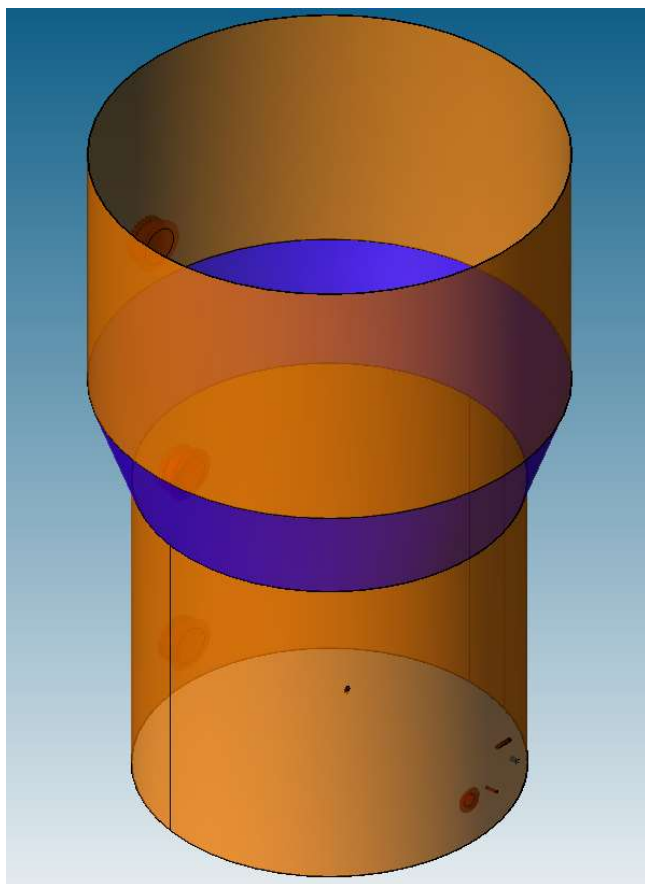
In Accordance with European Code EN 13445

Analysis Performed by : AB "ORLENLietuva"

Job File : ...\\R-202-NOZZLES.pvdb

Date of Analysis : Jul 22,2026 10:41am

PV Elite 26, January 2024



Atliko: Vyresnysis inžinierius projektuotojas

A. Žukovas

Tikrino: Projektavimo darbų vadovas

D. Virkutis

PV Elite 26 Licensee: Unknown Company
 FileName : R-202-NOZZLES-----
 Vessel Design Summary: Step: 24 10:41am Jul 22,2026

Vessel Design Summary:

European Std: EN 13445-3:2021

Diameter Spec : 9000.000 x 11000.000 mm ID
 Vessel Design Length, Tangent to Tangent 16950.00 mm

 Distance of Bottom Tangent above Grade 7950.00 mm
 Distance of Base above Grade 0.00 mm
 Specified Datum Line Distance 0.00 mm
 Shell Material P355NH, EN 10028-3:2017
 Shell Material 09G2S, GOST 5520-79 92
 Nozzle Material A-106 B, ASTM Not Normative
 Nozzle Material A-105, ASTM Not Normative
 Nozzle Material P355NH, EN 10028-3:2017
 Re-Pad Material P355NH, EN 10028-3:2017

 Internal Design Temperature 300 °C
 Internal Design Pressure 0.350 MPa

 External Design Temperature 0 °C

 Maximum Allowable Working Pressure 0 MPa
 Shop Test Pressure 0.567 MPa

 Wind Design Code Euro Code
 Earthquake Design Code No Seismic

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
Cylinder	0.350	0.00	1.000	1.0000	N/A	...
Conical	0.350	0.00	1.000	1.0000	N/A	...
Cylinder	0.350	0.00	1.000	1.0000	N/A	...

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
Cylinder	7950.0	7950.0	22.0	22.0	11.5	...	1.00	1.00
Conical	10700.0	2750.0	25.0	25.0	14.7	...	1.00	1.00
Cylinder	16950.0	6250.0	22.0	22.0	13.8	...	1.00	1.00

The Wind and Seismic loads were not load factored in this analysis.

Weights:

Fabricated - Bare W/O Removable Internals 95301.3 kg
 Shop Test - Fabricated + Water (Full) 1411152.4 kg
 Shipping - Fab. + Rem. Intls.+ Shipping App. 95301.3 kg
 Erected - Fab. + Rem. Intls.+ Insul. (etc) 95301.3 kg
 Empty - Fab. + Intls. + Details + Wghts. 95301.3 kg
 Operating - Empty + Operating Liquid (No CA) 95301.3 kg
 Field Test - Empty Weight + Water (Full) 1411152.4 kg

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Nozzle Calculation Summary (MPa & mm):

Per EN 13445 Section 9:

Description	Pressure Area Result	Pmax(Long)	Pmax(Trans)
Nozzle L	Passed	0.701	1.394
Nozzle F	Passed	0.695	1.389
Nozzle T12	Passed	0.677	1.389
Nozzle T17	Passed	0.677	1.389
Nozzle K6	Passed	0.682	1.349
Manhole Z5	Passed	0.543	1.069
Manhole Z4	Passed	0.543	1.069
Manhole Z3	Passed	0.454	0.897
Minimum		0	1

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	Y Coordinate mm	Layout Angle deg	Mean Radius mm
20	Nozzle L	1200.000	270.000	172.950
20	Nozzle F	1200.000	278.000	35.200
20	Nozzle T12	5175.000	230.000	35.200
20	Nozzle T17	2075.000	285.000	35.200
20	Nozzle K6	1200.000	294.149	50.090
20	Manhole Z5	1015.000	90.000	459.500
20	Manhole Z4	5775.000	90.000	459.500
40	Manhole Z3	11650.000	90.000	459.500

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

Items not derived explicitly will be found in the individual nozzle calculations. These items include such values as Afls etc.

Nozzles Nozzle L, and Nozzle F are a Group per EN 13445 para 9.6.4

The Nozzles are Installed In a Cylinder

Average radius [ris]:
 $= (ris1 + ris2)/2 = (4501.0 + 4501.0)/2 = 4501.0 \text{ mm}$
 $Lb = 628.4582 \text{ mm}$ (= Inside center to center distance)

Dimensions [a1, a2]:
a1 = deb1/2 = 177.8 and a2 = deb2/2 = 42.0 mm

Factor [k]:
 $= 2 - (Lb + a1 + a2)/(Iso1 + Iso2)$
 $= 2 - (628.458 + 177.8 + 42.0)/(435.296 + 435.296) = 1.0257$
 as $k > 1$, set k to 1.0

Dimension [Lb1]:

$$\begin{aligned}
 &= Lb + a1 + a2 + k(Iso1 + Iso2) \\
 &= 628.458 + 177.8 + 42.0 + 1.0(435.296 + 435.296) \\
 &= 1718.8511 \text{ mm}
 \end{aligned}$$

Angle [psi]:

$$\begin{aligned}
 &= \text{atan}(\text{ris} * \text{abs}(\text{Angle2} - \text{Angle1}) / \text{abs}(y2 - y1)) \\
 &= \text{atan}(4501.0 * \text{abs}(270.0 - 278.0) / \text{abs}(1200.0 - 1200.0)) \\
 &= 90.0 \text{ Deg}
 \end{aligned}$$

Area [Apls]:

$$\begin{aligned}
 &= 0.5 * \text{ris}^2 * Lb * (1 + \cos(\text{psi})) / (\text{ris} + 0.5 * \text{eas} * \sin(\text{psi})) \\
 &= 0.5 * 4501.0^2 * 628.46 * (1 + \cos(90.0)) / (4501.0 + 0.5 * 21.0 * \sin(90.0)) \\
 &= 1411.0515 \times 10^3 \text{ mm}^2
 \end{aligned}$$

Metal Areas [Afb1, Afb2]:

$$Afb1 = 765.5662 \text{ and } Afb2 = 916.8277 \text{ mm}^2$$

Area [Afls]:

$$\begin{aligned}
 &= \text{eas}(Lb - a1 - a2) \\
 &= 21.0(628.458 - 177.8 - 42.0) = 8581.8223 \text{ mm}^2
 \end{aligned}$$

Area [Afw]:

$$= Afw1 + Afw2 = 212.0 + 50.0 = 262.0 \text{ mm}^2$$

Force [f1]:

$$\begin{aligned}
 &= (Afls + Afw) * (fs - 0.5 * p) + \\
 &\quad Afb1(fob1 - 0.5 * p) + Afb2(fob2 - 0.5 * p) + \\
 &\quad Afp1(fop1 - 0.5 * p) + Afp2(fop2 - 0.5 * p) \\
 &= (8581.822 + 262.0) * (150.012 - 0.5 * 0.35) + \\
 &\quad 765.566(125.341 - 0.5 * 0.35) + 916.828(129.341 - 0.5 * 0.35) + \\
 &\quad 2986.2(150.012 - 0.5 * 0.35) + 0.0(0.0 - 0.5 * 0.35) \\
 &= 1986.653 \times 10^3 \text{ N}
 \end{aligned}$$

Force [f2]:

$$\begin{aligned}
 &= P(Apls + Apb1 + 0.5 * APpsi1 + Apb2 + 0.5 * APpsi2) \\
 &= 0.35(1411052 + 13267.183 + 0.5 * 0.0 + 1475.168 + 0.50 * 0.0) \\
 &= 498.9855 \times 10^3 \text{ N}
 \end{aligned}$$

Because $f1 > f2$: The Group Is Adequately Reinforced

No interference violations have been detected!

Please refer to the nozzles treated as isolated openings for more information.

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Nozzle Schedule: Step: 22 10:41am Jul 22, 2026

Description	Nominal or	Schd	Flg	Nozzle	Wall	Reinforcing Pad	Cut	Flg	
	Actual	or FVC	Type	O/Dia	Thk	Diameter	Thk	Length	Class
	Size	Type		mm	mm		mm	mm	
Nozzle F	84 mm	Actual	LWN	84.0	16.600	...	...	287	300
Nozzle T12	84 mm	Actual	LWN	84.0	16.600	...	...	402	300
Nozzle T17	84 mm	Actual	LWN	84.0	16.600	...	...	402	300
Nozzle K6	114 mm	Actual	WNF	114.3	17.120	...	...	148	150
Nozzle L	355 mm	Actual	None	355.6	12.700	640.00	22.00	145	0
Manhole Z5	900 mm	Actual	Socket	932.0	16.000	1300.00	22.00	296	16
Manhole Z4	900 mm	Actual	Socket	932.0	16.000	1300.00	22.00	296	16
Manhole Z3	900 mm	Actual	Socket	932.0	16.000	1300.00	22.00	291	16

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
Nozzle F	A-105, ASTM Not Nor	22.000	10.000	...	...	...
Nozzle T12	A-105, ASTM Not Nor	22.000	10.000	...	...	...
Nozzle T17	A-105, ASTM Not Nor	22.000	10.000	...	...	...
Nozzle K6	A-106 B, ASTM Not N	22.000	10.000	...	...	...
Nozzle L	A-106 B, ASTM Not N	22.000	10.000	18.000	22.000	...
Manhole Z5	P355NH, EN 10028-3:	22.000	10.000	18.000	22.000	...
Manhole Z4	P355NH, EN 10028-3:	22.000	10.000	18.000	22.000	...
Manhole Z3	P355NH, EN 10028-3:	22.000	10.000	18.000	22.000	...

Description	Elev/Distance From Datum mm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
Nozzle F	1200.000	278.0	240.00	25.00	Node: 20
Nozzle T12	5175.000	230.0	300.00	80.00	Node: 20
Nozzle T17	2075.000	285.0	300.00	80.00	Node: 20
Nozzle K6	1200.000	294.1	47.80	50.00	Node: 20
Nozzle L	1200.000	270.0	120.00	0.00	Node: 20
Manhole Z5	1015.000	90.0	250.00	0.00	Node: 20
Manhole Z4	5775.000	90.0	250.00	0.00	Node: 20
Manhole Z3	11650.000	90.0	250.00	0.00	Node: 40

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Bill of Materials:

QTY	DESCRIPTION	MATERIAL
1	CONE: 25.0mm THK X 11000.0mm ID X 2750.0mm	P355NH
1	CYLINDER: 22.0mm THK X 11000.0mm ID X 6250.0mm	09G2S
3	CLASS 16 3E0 50<v, 900.0mm BLIND FLANGE(S)	P355NH
2	CYLINDRICAL SEGMENT 22.0mm THK X 13499.8mm X 7950.0mm	P355NH
1	CYLINDRICAL SEGMENT 22.0mm THK X 1274.3mm X 7950.0mm	P355NH
1	NAMEPLATE	...

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Class From To : Basic Element Checks.

Class From To: Check of Additional Element Data

Derivation of EN 13445-3 Allowable Stresses

Non Austenitic Steel:

The formula for deriving the allowable stress is as follows:
 $f_d = \min(R_{p0,2/t} / 1,5; R_m/20 / 2,4)$

Where:

$R_m/20$ = the lower of the tensile strengths at room temperature
 $R_{p0,2/t}$ = the 0,2% proof stress at design temperature
 f_d = the allowable stress

Austenitic Steel:

Elongation must be considered. The two elongation ranges below usually refer the direct and transverse material directions.

When $30\% \leq A < 35\%$,

$f_d = R_{p1,0/t} / 1,5$ (also the allowable for flanges)

When $A \geq 35\%$,

$f_d = \max[(R_{p1,0/t} / 1,5); \min(R_{p1,0/t} / 1,2; R_m/t / 3)]$

Where:

$R_{p1,0/t}$ = the 1,0% proof stress at design temperature
 R_m/t = the tensile stress at design temperature

Choosing the Elongation from the Material Specification.

This is an abridged sample of a fictitious material specification.

Steel Description:

Name	Number	0,2% Proof Stress	1,0% Proof Stress	Tensile Stress	Elong. aft. Fract.%	Impact Energy (ISO-V) kV
XXX	1.2345	200	240	480	35 40	60
YYY	1.7777	210	250	490	35 45	55
ZZZ	1.8888	305	315	580	35 40	65

In the above table, there are two values for the elongation. PV Elite uses the equation for the larger elongation.

There were no geometry errors or warnings.

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 Input Echo: Step: 1 10:41am Jul 22,2026

Units used in this Analysis (Newtons):

Name	System Unit	Constant	User Unit
Length	Feet	304.8000	mm
Force	Pounds	4.4480	N
Mass	Pounds	0.4536	kg
Area	sq. inches	645.1600	mm ²
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/cm ³
Ins. Density	lbs./cu.ft.	0.1600E-04	kg/cm ³
Fluid Density	lbs./cu.ft.	0.1600E-04	kg/cm ³
Wind Speed	miles/hr	1.6093	km/hr
Tray Weight	lbs./sq.ft.	0.0005	kg/cm ²
Inertia	in.^4	416231.0000	mm^4
G Load	G's	1.0000	g's
Wind Load	lbs./sq.ft.	4.8825	kg/m ²
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

Design Internal Pressure (for Hydrotest)	0.35	MPa
Design Internal Temperature	300.0	°C
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-40.0	°C
Testing Group	1a	
Use Higher Longitudinal Stresses (Flag)	N	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Consider Vortex Shedding	N	

Shop Pressure Test:

Pressure Test Position	Horizontal
Test Performed in Corroded Condition	No

Load Case 1	0
Load Case 2	1
Load Case 3	0
Load Case 4	0.
Load Case 5	0.
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
Load Case 20	BL+IP+OW

Wind Design Code	European Code
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Input Echo: Step: 1 10:41am Jul 22,2026

Design Wind Speed	86 km/hr
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

Configuration Directives:

g0 is taken as min(g0, attached shell thk)	Yes
Design Lifetime in Hours	100000
Is the vessel monitored over its lifetime	No

Complete Listing of Vessel Elements and Details:

Element#	1/3
Element From Node	20
Element To Node	30
Element Type	Cylinder
Description	
Distance "FROM" to "TO"	7950 mm
Inside Diameter	9000 mm
Element Thickness	22 mm
Internal Corrosion Allowance	1 mm
Nominal Thickness	22 mm
External Corrosion Allowance	0 mm
Design Internal Pressure	0.35 MPa
Design Temperature Internal Pressure	300 °C
Design External Pressure	0 MPa
Design Temperature External Pressure	0 °C
Effective Diameter Multiplier	1.2
Material Name	P355NH, EN 10028-3:2017
Allowable Stress, Ambient	204.17 MPa
Allowable Stress, Operating	150.01 MPa
Material Density	0.00785 kg/cm³
Efficiency, Longitudinal Seam	1.0
Efficiency, Circumferential Seam	1.0
Weld is pre-Heated	N/A
Element From Node	20
Detail Type	Nozzle
Detail ID	Nozzle L
Dist. from "FROM" Node / Offset dist	1200 mm
Nozzle Diameter	355.6 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	
Nozzle Matl	A-106 B
Element From Node	20
Detail Type	Nozzle

Detail ID	Nozzle F	
Dist. from "FROM" Node / Offset dist	1200	mm
Nozzle Diameter	84	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	278.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange		
Nozzle Matl	A-105	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	Nozzle T12	
Dist. from "FROM" Node / Offset dist	5175	mm
Nozzle Diameter	84	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	230.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange		
Nozzle Matl	A-105	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	Nozzle T17	
Dist. from "FROM" Node / Offset dist	2075	mm
Nozzle Diameter	84	mm
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	285.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange		
Nozzle Matl	A-105	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	Nozzle K6	
Dist. from "FROM" Node / Offset dist	1200	mm
Nozzle Diameter	114.3	mm
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	294.14899	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange		
Nozzle Matl	A-106 B	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	Manhole Z5	
Dist. from "FROM" Node / Offset dist	1015	mm
Nozzle Diameter	900	mm
Nozzle Schedule	None	
Nozzle Class	16	
Layout Angle	90.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	0	N
Grade of Attached Flange	3E0 50<vR<=150	

Nozzle Matl	P355NH
Element From Node	20
Detail Type	Nozzle
Detail ID	Manhole Z4
Dist. from "FROM" Node / Offset dist	5775 mm
Nozzle Diameter	900 mm
Nozzle Schedule	None
Nozzle Class	16
Layout Angle	90.0
Blind Flange (Y/N)	Y
Weight of Nozzle (Used if > 0)	0 N
Grade of Attached Flange	3E0 50<vR<=150
Nozzle Matl	P355NH

Element#	2/3
Element From Node	30
Element To Node	40
Element Type	Conical
Description	
Distance "FROM" to "TO"	2750 mm
Inside Diameter	9000 mm
Element Thickness	25 mm
Internal Corrosion Allowance	1 mm
Nominal Thickness	25 mm
External Corrosion Allowance	0 mm
Design Internal Pressure	0.35 MPa
Design Temperature Internal Pressure	300 °C
Design External Pressure	0 MPa
Design Temperature External Pressure	0 °C
Effective Diameter Multiplier	1.2
Material Name	P355NH, EN 10028-3:2017
Efficiency, Longitudinal Seam	1.0
Efficiency, Circumferential Seam	1.0
Cone Diameter at "To" End	11000 mm
Design Length of Cone	2750 mm
Half Apex Angle of Cone	19.983101 degrees
Toriconical (Y/N)	N
Weld is pre-Heated	N/A

Element#	3/3
Element From Node	40
Element To Node	50
Element Type	Cylinder
Description	
Distance "FROM" to "TO"	6250 mm
Inside Diameter	11000 mm
Element Thickness	22 mm
Internal Corrosion Allowance	1 mm
Nominal Thickness	22 mm
External Corrosion Allowance	0 mm
Design Internal Pressure	0.35 MPa
Design Temperature Internal Pressure	300 °C
Design External Pressure	0 MPa
Design Temperature External Pressure	0 °C
Effective Diameter Multiplier	1.2
Material Name	09G2S, GOST 5520-79 92

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Allowable Stress, Ambient	195.84	MPa
Allowable Stress, Operating	151.01	MPa
Material Density	0.00785	kg/cm ³
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	N/A	

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 Internal Pressure Calculations: Step: 3 10:41am Jul 22,2026

Internal Pressure Results Summary:

Element Properties:

From	To	Int. Press + Liq. Hd MPa	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) MPa	Element#
20	30	0.35	22	1	9000	150.01	1
30	40	0.35	25	1	11000	150	2
40	50	0.35	22	1	11000	151.01	3

Calculation Results:

From	To	Design Pressure MPa	M.A.W.P. Corroded MPa	M.A.P. New & Cold MPa	Minimum Thickness mm	Required Thickness mm	Element#
20	30	0.35	0.69827	0.99575	22	11.5138	1
30	40	0.35	0.61376	0.86959	25	14.6741	2
40	50	0.35	0.57538	0.7818	22	13.7645	3
Minimum			0	1			

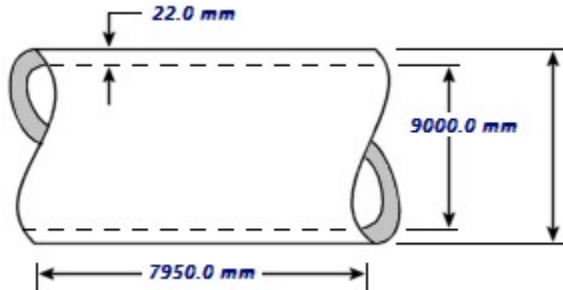
MAWP: 0 MPa, limited by: Nozzle Reinforcement.

Elements Suitable for Design Internal Pressure.

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Internal Pressure Calculation Results:

European Std: EN 13445-3:2021



Internal Pressure Results for: Element # 1

Cylindrical Shell Design Information:

Design Pressure	P	0.350 MPa	Int. Design Temperature	300 °C
Material		P355NH	Ext. Design Temperature	0 °C
Length		7950.000 mm		
Int. Corr. All.	c	1.0000 mm	Allowable Stress (ope)	f 150.0 MPa
Ext. Corr. All.	ce	0.0000 mm	Allowable Stress (amb)	fa 204.2 MPa
Inside Diameter	Di	9000.000 mm	Actual Stress	75.2 MPa
Spec. Min. Thk	t or e	22.0000 mm	Spec. Nominal Thk.	22.000 mm
Surface Area		225879856.0 mm ²	SG of Contents	0.000
Element Volume		505847.8 ltr	Weight of Contents	0.0 N
Empty Weight		381598.6 N	Operating Weight	381598.6 N

Thickness due to internal pressure [e]:

$$\begin{aligned}
 &= P * Di / (2 * f * z - P) \text{ EN 13445 Equation: 7.4.2:} \\
 &= 0.35 * 9002.0 / (2 * 150.012 * 1.0 - 0.35) + c + c_{ext} \\
 &= 10.5138 + 1.0 + 0.0 = 11.5138 \text{ mm}
 \end{aligned}$$

The shell is suitable for the design pressure.

Maximum Working Pressure Hot and Corroded [MAWP]:

$$\begin{aligned}
 &= (2 * f * e_{cor} * z) / (Di + e_{cor}) - P_{head} \\
 &= (2 * 150.01 * 21.0 * 1.0) / (9002.0 + 21.0) - 0.0 \\
 &= 0.698 \text{ MPa}
 \end{aligned}$$

Maximum Pressure New and Cold [MAPNC]:

$$\begin{aligned}
 &= (2 * f_a * e * z) / (D + e) \\
 &= (2 * 204.17 * 22.0 * 1.0) / (9000.0 + 22.0) \\
 &= 0.996 \text{ MPa}
 \end{aligned}$$

Stress at Design Pressure [Stres]:

$$\begin{aligned}
 &= P (Di + e_{cor}) / (2 * e_{cor} * z) \\
 &= 0.35 (9002.0 + 21.0) / (2 * 21.0 * 1.0) \\
 &= 75.192 \text{ MPa}
 \end{aligned}$$

Uncorrected (for liquid) Hydrotest Pressure per 6.2.2 stress limitation:

$$\begin{aligned}
 &= (2 * F_{test} * e * z) / (Di + e) \\
 &= (2 * 328.58 * 22.0 * 1.0) / (9000.0 + 22.0) \\
 &= 1.599 \text{ MPa}
 \end{aligned}$$

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Element: # 1 Step: 4 10:41am Jul 22,2026

Ratio e/De , per 7.4.1 [e/De]:

= e/De

= 10.514/9044.0

= 0.001 should be ≤ 0.16

Elongation of the Extreme Fiber per EN 13445-4 Para 10.2.2 [F]:

= $50 * \max(e, e_{nom}) / R_m$

= $50 * \max(22.0, 22.0) / 4511.0$

= 0.244 %

Impact Test Requirements per EN 13445 Part 2 Annex B

Min. Des. Temp. [TR] per EN 13445 Part 2: Thickness 22.0 mm at -40 °C:

Temperature Adjustment per Table B.2-12 [T_s]:= 30.0 °C

Adjusted Temperature [$TR + T_s$]:= -10.0 °C

Note: The Component is Post Weld Heat Treated.

Material Yield Stress 345.0 MPa

Selected Graph: B.2-3 per EN 13445-2

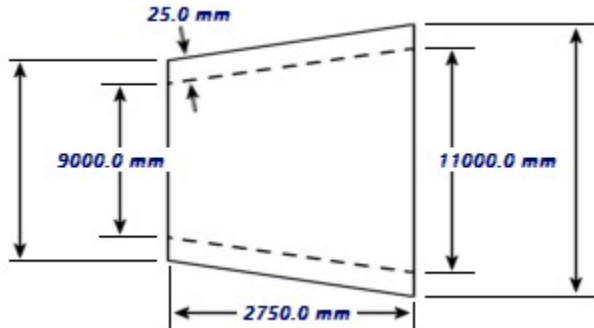
Note: Computed Impact Test Temp. T_{kv} : 41 °C.

*Impact Temperature (41°C) Exceeds 20°C, Impact Testing Not Required
However, this must be confirmed as meeting the Code Requirements.*

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Internal Pressure Calculation Results:

European Std: EN 13445-3:2021



Internal Pressure Results for: Element # 2

Conical Head/Section Design Information:			
Design Pressure P	0.350 MPa	Int. Design Temperature	300 °C
Material	P355NH	Ext. Design Temperature	0 °C
Length	2750.000 mm	Allowable Stress (ope) f	150.0 MPa
Int. Corr. All. c	1.0000 mm	Allowable Stress (amb) fa	204.0 MPa
Ext. Corr. All. ce	0.0000 mm	Actual Stress	85.4 MPa
Inside Diameter Di	11000.000 mm	Spec. Nominal Thk.	25.000 mm
Spec. Min. Thk t or e	25.0000 mm	SG of Contents	0.000
Surface Area	92417592.0 mm ²	Weight of Contents	0.0 N
Element Volume	216743.3 ltr	Operating Weight	177381.9 N
Empty Weight	177381.9 N	To End Diameter	9000.000 mm

Note: Junction analysis is included in full Cone Analysis where thickness e2 is the final thickness is based on Dk, Dc, L1, L2 and other factors.

Thickness Due to Design Internal Pressure: e - para 7.5.2

$$= ((P * Dica) / (2 * f * z - P)) * (1/Cosa) \text{ Eqn 7.6-2}$$

$$= ((0.35 * 11002.13) / (2 * 150.0 * 1.0 - 0.35)) * (1/0.94)$$

$$= 13.6741 + 1.0000 + 0.0000 = 14.6741 \text{ mm}$$

The cone is suitable for the design pressure

Maximum Allowable Working Pressure at Given Thickness [Pmax]:

$$= (2 * f * z * ecor * Cosa) / (Dica + (ecor * Cosa)) \text{ [MAWP]}$$

$$= (2 * 150.0 * 1.0 * 24.0) / (0.94 + (11002.13 * 24.0)) - Phead$$

$$= 0.61 \text{ MPa}$$

Maximum Allowable Pressure, New and Cold [PmaxNC]:

$$= (2 * fa * z * e * Cosa) / (D + (e * Cosa)) \text{ [MAPNC]}$$

$$= (2 * 204.0 * 1.0 * 25.0 * 0.94) / (11000.0 + (25.0 * 0.94))$$

$$= 0.87 \text{ MPa}$$

Actual Stress at Given Thickness [Stres]:

$$= (P * Dica / (2 * ecor * z * \cos(\text{angle}))) \text{ [Stres]}$$

$$= (0.35 * 11002.13) / (2 * 24.0 * 1.0 * 0.9398)$$

$$= 85.36 \text{ MPa}$$

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FileName : R-202-NOZZLES-----

Element: # 2 Step: 5 10:41am Jul 22,2026

Hydrotest pressure no liquid pressure [Phyd]:

$$\begin{aligned} &= 2 * f_{test} * e * z * \cos(a) / (D + e * \cos(a)) \\ &= 2 * 328.583 * 25.0 * 1.0 * 0.94 / (11000.0 + 25.0 * 0.94) \\ &= 1.3977 \text{ MPa} \end{aligned}$$

Elongation of the Extreme Fiber per EN 13445-4 Para 10.2.2 [F]:

$$\begin{aligned} &= 50 * \max(e, e_{nom}) / R_m \\ &= 50 * \max(25.0, 25.0) / 4513.301 \\ &= 0.277 \% \end{aligned}$$

Impact Test Requirements per EN 13445 Part 2 Annex B

Min. Des. Temp. [TR] per EN 13445 Part 2: Thickness 25.0 mm at -40 °C:

Temperature Adjustment per Table B.2-12 [Ts]:= 24.0 °C

Adjusted Temperature [TR + Ts]:= -16.0 °C

Note: The Component is Post Weld Heat Treated.

Material Yield Stress 345.0 MPa

Selected Graph: B.2-3 per EN 13445-2

Note: Computed Impact Test Temp. T_{kv}: 32 °C.

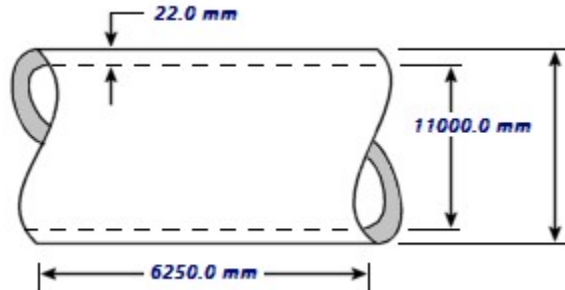
*Impact Temperature (32°C) Exceeds 20°C, Impact Testing Not Required
However, this must be confirmed as meeting the Code Requirements.*

Note: The Pressure at the Large Diameter is used in the TR calculation.

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Internal Pressure Calculation Results:

European Std: EN 13445-3:2021



Internal Pressure Results for: Element # 3

Cylindrical Shell Design Information:					
Design Pressure	P	0.350 MPa	Int. Design Temperature	300 °C	
Material		09G2S	Ext. Design Temperature	0 °C	
Length		6250.000 mm			
Int. Corr. All.	c	1.0000 mm	Allowable Stress (ope)	f	151.0 MPa
Ext. Corr. All.	ce	0.0000 mm	Allowable Stress (amb)	fa	195.8 MPa
Inside Diameter	Di	11000.000 mm	Actual Stress		91.9 MPa
Spec. Min. Thk	t or e	22.0000 mm	Spec. Nominal Thk.		22.000 mm
Surface Area		216848448.0 mm²	SG of Contents		0.000
Element Volume		594063.8 ltr	Weight of Contents		0.0 N
Empty Weight		366506.6 N	Operating Weight		366506.6 N

Thickness due to internal pressure [e]:

$$\begin{aligned}
 &= P * Di / (2 * f * z - P) \text{ EN 13445 Equation: 7.4.2:} \\
 &= 0.35 * 11002.0 / (2 * 151.011 * 1.0 - 0.35) + c + c_{ext} \\
 &= 12.7645 + 1.0 + 0.0 = 13.7645 \text{ mm}
 \end{aligned}$$

The shell is suitable for the design pressure.

Maximum Working Pressure Hot and Corroded [MAWP]:

$$\begin{aligned}
 &= (2 * f * e_{cor} * z) / (Di + e_{cor}) - P_{head} \\
 &= (2 * 151.01 * 21.0 * 1.0) / (11002.0 + 21.0) - 0.0 \\
 &= 0.575 \text{ MPa}
 \end{aligned}$$

Maximum Pressure New and Cold [MAPNC]:

$$\begin{aligned}
 &= (2 * f_a * e * z) / (D + e) \\
 &= (2 * 195.84 * 22.0 * 1.0) / (11000.0 + 22.0) \\
 &= 0.782 \text{ MPa}
 \end{aligned}$$

Stress at Design Pressure [Stres]:

$$\begin{aligned}
 &= P (Di + e_{cor}) / (2 * e_{cor} * z) \\
 &= 0.35 (11002.0 + 21.0) / (2 * 21.0 * 1.0) \\
 &= 91.858 \text{ MPa}
 \end{aligned}$$

Uncorrected (for liquid) Hydrotest Pressure per 6.2.2 stress limitation:

$$\begin{aligned}
 &= (2 * F_{test} * e * z) / (Di + e) \\
 &= (2 * 285.72 * 22.0 * 1.0) / (11000.0 + 22.0) \\
 &= 1.138 \text{ MPa}
 \end{aligned}$$

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Element: # 3 Step: 6 10:41am Jul 22,2026

Ratio e/De , per 7.4.1 [e/De]:

= e/De

= 12.765/11044.0

= 0.001 should be ≤ 0.16

Elongation of the Extreme Fiber per EN 13445-4 Para 10.2.2 [F]:

= $50 * \max(e, e_{nom}) / R_m$

= $50 * \max(22.0, 22.0) / 5511.0$

= 0.200 %

Impact Test Requirements per EN 13445 Part 2 Annex B

Min. Des. Temp. [TR] per EN 13445 Part 2: Thickness 22.0 mm at -40 °C:

Temperature Adjustment per Table B.2-12 [T_s]:= 21.0 °C

Adjusted Temperature [$TR + T_s$]:= -19.0 °C

Note: The Component is Post Weld Heat Treated.

Material Yield Stress 300.0 MPa

Selected Graph: B.2-3 per EN 13445-2

Note: Computed Impact Test Temp. T_{kv} : 33 °C.

*Impact Temperature (33°C) Exceeds 20°C, Impact Testing Not Required
However, this must be confirmed as meeting the Code Requirements.*

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PV Elite 26 Licensee: Unknown Company
 FileName : R-202-NOZZLES-----
 Element and Detail Weights: Step: 9 10:41am Jul 22,2026

Element and Detail Weights:

From	To	Element Metal Wgt. kg	Element ID Volume ltr	Corroded Metal Wgt. kg	Corroded ID Volume ltr	Extra due Misc % kg
20	30	38914.8	505848	37150.1	506073	...
30	40	18089.1	216743	17367.5	216835	...
40	50	37375.8	594064	35679.8	594280	...
Total		94379	1316654.88	90197	1317187.75	0

Weight of Details:

From	Type	Weight of Detail kg	X Offset, Dtl. Cent. mm	Y Offset, Dtl. Cent. mm	Z Offset Dtl. Cent. mm	Description
20	Noz1	75.4793	...	1200	4559.99	Nozzle L
20	Noz1	16.5739	642.98	1200	4575.04	Nozzle F
20	Noz1	19.7474	-2988.96	5175	3562.11	Nozzle T12
20	Noz1	19.7474	1203.51	2075	4491.55	Nozzle T17
20	Noz1	13.4584	1850.78	1200	4127.99	Nozzle K6
20	Noz1	357.083	...	1015	-4625.01	Manhole Z5
20	Noz1	209.729	...	5775	-4625.01	Manhole Z4
40	Noz1	209.729	...	950	-5625.01	Manhole Z3

Total Weight of Each Detail Type:

Nozzles	921.5
Sum of the Detail Weights	921.5 kg

Weight Summation Results: (kg)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	94379.7	94379.7	94379.7	94379.7	94379.7	94379.7
Nozzles	921.5	921.5	921.5	921.5	921.5	921.5
Test Liquid	...	1315851.1	...	...	...	...
Totals	95301.3	1411152.4	95301.3	95301.3	95301.3	95301.3

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	95301.3 kg
Shop Test Wt.	- Fabricated Weight + Water (Full)	1411152.4 kg
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	95301.3 kg
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	95301.3 kg
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	95301.3 kg
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	95301.3 kg
Field Test Wt.	- Empty Weight + Water (Full)	1411152.4 kg

Weights used in Vortex Shedding Calculations:

Mass of the Upper 1/3 of the Vertical Vessel (operating)	32464.2 kg
Mass of the Upper 1/3 of the Vertical Vessel (filled w/water)	537094.3 kg
Mass of the Upper 1/3 of the Vertical Vessel (empty)	33997.4 kg

Surface Areas of Elements:

From	To	Outside Surface Area mm ²	Inside Surface Area mm ²
20	30	225879856	224780976
30	40	92417592	91928504
40	50	216848448	215984496
Total		535145920.0	532693984.0 mm ²
Total		535.1	532.7 m ²

Element and Detail Weights:

From	To	Total Ele. Empty Wgt. kg	Total. Ele. Oper. Wgt. kg	Total. Ele. Hydro. Wgt. kg	Total Dtl. Offset Mom. N-mm	Oper. Wgt. No Liquid kg
20	30	39626.6	39626.6	545166	19491500	39626.6
30	40	18089.1	18089.1	234700	...	18089.1
40	50	37585.5	37585.5	631287	11573110	37585.5

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kg	Cumulative Oper. Wgt. kg	Cumulative Hydro. Wgt. kg
20	30	95301.2	95301.2	1411152
30	40	55674.6	55674.6	865987
40	50	37585.5	37585.5	631287

The cumulative operating weights no liquid in the column above are the cumulative operating weights minus the operating liquid weight minus any weights absent in the empty condition.

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. N-mm	Cumulative Oper. Mom. N-mm	Cumulative Hydro. Mom. N-mm
20	30	31064608	31064608	31064608
30	40	11573110	11573110	11573110
40	50	11573110	11573110	11573110

Conical Reinforcement Calculations, EN 13445**Input Values:****Conical Section From 30 To 40**

Design Internal Pressure, Small End	0.350	MPa
Design Internal Pressure, Large End	0.350	MPa
Temperature for Internal Pressure	300.0	°C
Design External Pressure	0.000	MPa
Temperature for External Pressure	0.0	°C

Cone Material		P355NH
Cone Allowable Stress at Temperature	Ss	150.00 MPa
Cone Allowable Stress At Ambient		204.00 MPa
Longitudinal Joint Efficiency of Cone		1.00
Circumferential Joint Efficiency of Cone		1.00
Actual Thickness of Cone	Tc	25.0000 mm
Corrosion Allowance for Cone	Cac	1.0000 mm

Diameter Basis for Cone and Cylinders		ID
Diameter of Small End of Cone	Ds	9000.000 mm
Diameter of Large End of Cone	DI	11000.000 mm
Half Apex Angle for Cone		19.98
Axial Length of Cone	Lc	2750.000 mm

SMALL-END Properties:

Attached Small End Material Specification		P355NH
Operating Allowable Stress	Ss	150.01 MPa
Ambient Allowable Stress		204.17 MPa
Joint Efficiency	Es	1.0000
Actual Thickness	Ts	22.0000 mm
Corrosion Allowance	Cas	1.0000 mm
Axial Length of Attached Element	Ls	16950.000 mm

LARGE-END Properties:

Attached Large End Material Specification		09G2S
Operating Allowable Stress	Sl	151.01 MPa
Ambient Allowable Stress		195.84 MPa
Joint Efficiency	El	1.0000
Actual Thickness	Tl	22.0000 mm
Corrosion Allowance	Cal	1.0000 mm
Axial Length of Attached Element	Ll	16950.000 mm

Calculated Values:**Large End Cone Calculations:**

Without a knuckle radius in accordance with:EN 13445 Equations 7.6.6.

Cone Geometry and Geometry Factors:

Mean Large End Diameter [Dc]:

$$\begin{aligned}
 &= D_i + e_j + c_i \\
 &= 11000.0 + 17.383 + 1.0 \\
 &= 11018.382 \text{ mm}
 \end{aligned}$$

Note: Analysis based on constant cone thickness and iterating on the large end cylinder thickness.

Final required thickness of the Cone [e]:

$$\begin{aligned}
 &= \max(e_j, e_{cyl}, e_{con}) + c_i + c_o \\
 &= \max(17.383, 12.851, 13.674) + 1.0 + 0.0 \\
 &= 18.3827 \text{ mm}
 \end{aligned}$$

The detailed calculation follows:

Iterated intermediate value [Beta]:

$$\begin{aligned}
 &= (1/3) * \sqrt{D_c/e_j} * \tan(a) / (1 + 1/\sqrt{\cos(a)}) - 0.15 \\
 &= (1/3) * \sqrt{11018.382/17.383} * \tan(20) / (1 + 1/\sqrt{\cos(20)}) - 0.15 \\
 &= 1.3522
 \end{aligned}$$

Required Thickness [e_j]:

$$\begin{aligned}
 &= P * D_c * \text{Beta} / (2 * f) + c_i + c_{ext} \\
 &= 0.35 * 11018.382 * 1.3522 / (2 * 150.0) + 1.0 + 0.0 \\
 &= 18.382 \text{ mm}
 \end{aligned}$$

Required thickness of the cylinder [e_cyl]:

$$\begin{aligned}
 &= p * D_i / (2 * f - p) \\
 &= 0.35 * 11002.0 / (2 * 150.0 - 0.35) \\
 &= 12.8507 \text{ mm}
 \end{aligned}$$

Required thickness of the cone [e_con]:

$$\begin{aligned}
 &= p * D_i / \cos(a) * (2 * f * z - p) \\
 &= 0.35 * 11002.0 / (\cos(19.98) * (2 * 150.0 * 1.0 - 0.35)) \\
 &= 13.6741 \text{ mm}
 \end{aligned}$$

Required Large End Thickness [e1]:

$$\begin{aligned}
 &= \max(e_{cyl}, e_j, e_{con}) + c_i + c_o \\
 &= \max(12.8507, 17.3827, 13.6741) + 1.0 + 0.0 \\
 &= 18.383 \text{ mm}
 \end{aligned}$$

Distance [1.4 * L1]:

$$\begin{aligned}
 &= 1.4 * \sqrt{D_c * (e_1 - c_i - c_{ext})} \\
 &= 1.4 * \sqrt{11018.382 * (18.383 - 1.0 - 0.0)} \\
 &= 612.696 \text{ mm}
 \end{aligned}$$

Junction MAWP based upon corroded thickness:

$$= 0.579 \text{ MPa}$$

Junction MAPnc based upon new thickness:

$$= 0.804 \text{ MPa}$$

Actual Stress at Design Conditions:

$$= 89.928 \text{ MPa}$$

Uncorrected hydrotest pressure (liquid ignored):

$$= 1.349 \text{ MPa}$$

Allowable Stress used to determine hydrotest pressure:

$$= 204.0 \text{ MPa}$$

Small End Cone Calculations:

Note: Analysis based on constant cone thickness and iterating on the small end cylinder thickness.

Iterated Mean Diameter of the Cylinder at the Cone Small End [Dc]:

$$\begin{aligned}
 &= D_i + e + c_i \\
 &= 9000.0 + 19.7011 + 1.0 \\
 &= 9021.706 \text{ mm}
 \end{aligned}$$

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FileName : R-202-NOZZLES-----

Conical Section: Cone: 5 10:41am Jul 22,2026

Thickness ratio based on final iterated Small End Thickness [s]:

$$= e2/e1 = 24.0/19.701$$

$$= 1.218$$

Intermediate value [tau]:

$$= 1 + \sqrt{s(1 + s^2) / (2 * \cos(\alpha))}$$

$$= 1 + \sqrt{1.218(1 + 1.218^2) / (2 * \cos(19.983))}$$

$$= 2.269$$

Iterated intermediate value [betaH]:

$$= 0.4 * \sqrt{Dc / e1} * \tan(\alpha) / \tau + 0.5$$

$$= 0.4 * \sqrt{9021.706/19.701} * \tan(19.983) / 2.269 + 0.5$$

$$= 1.8719$$

Small End Cylinder Required Thickness [e1]:

$$= \max(P * Dc * \beta H / (2 * f * Z) + ca + cext, e)$$

$$= \max(0.35 * 9021.7 * 1.87 / (2 * 150.0 * 1.0) + 1.0, 11.514)$$

$$= \max(20.701, 11.514)$$

$$= 20.701 \text{ mm}$$

Required Length along the Small End Cylinder [L1]:

$$= \sqrt{Dc(e1 - ci - cext)}$$

$$= \sqrt{9021.706(20.701 - 1.0 - 0.0)}$$

$$= 421.590 \text{ mm}$$

Elongation of the Extreme Fiber per EN 13445-4 Para 10.2.2 [F]:

$$= 50 * \max(e, enom) / Rm$$

$$= 50 * \max(25.0, 25.0) / 4513.301$$

$$= 0.277 \%$$

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 FileName : R-202-NOZZLES-----
 Nozzle Calcs.: Nozzle L Nozl: 33 10:41am Jul 22,2026

Input, Nozzle Desc: Nozzle L

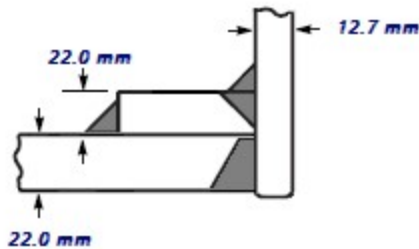
From: 20

Pressure for Reinforcement Calculations	P	0.3500	MPa
Temperature for Internal Pressure	Temp	300	°C
Shell Material	P355NH, EN 10028-3:2017		
Parent Allowable Stress at Temperature	f	150.01	MPa
Parent Allowable Stress At Ambient	fa	204.17	MPa
Inside Diameter of Cylindrical Shell	Di	9000.00	mm
Shell Finished (Minimum) Thickness	ea	22.0000	mm
Shell Internal Corrosion Allowance	c	1.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		1200.00	mm

Type of Element Connected to the Parent : Nozzle

Nozzle Material	A-106 B, ASTM Not Normative		
Allowable Stress at Temperature	fn	125.34	MPa
Allowable Stress At Ambient	fna	160.01	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter	deb	355.6000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.7000	mm
Corrosion Allowance	can	3.0000	mm
Outside Projection	ho	120.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	22.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material	P355NH, EN 10028-3:2017		
Pad Allowable Stress at Temperature	f2	150.01	MPa
Pad Allowable Stress At Ambient	f2a	204.17	MPa
Diameter of Pad along vessel surface	d2	640.0000	mm
Thickness of Pad	e2	22.0000	mm
Weld leg size between Pad and Shell	Wp	18.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	22.0000	mm
Reinforcing Pad Width		142.2000	mm
Flange Class		0	
Flange Grade			

The Pressure Design option was Design Pressure + static head.

**Isolated Nozzle Calculation per EN 13445, Description: Nozzle L**

Actual Outside Diameter Used in Calculation 355.600 mm.
 Actual Thickness Used in Calculation 12.700 mm

Required Thickness of Nozzle Neck due to Internal Pressure:

$$\begin{aligned}
 &= P * D_i / (2 * f * z - P) + c \quad \text{EN 13445 Equation: 7.4.2:} \\
 &= 0.35 * 336.2 / (2 * 125.341 * 1.0 - 0.35) + 3.0 \\
 &= 3.470 \text{ mm}
 \end{aligned}$$

EN 13445 Section 9 - Pressure Area Design Method:

Dist from Center of Nozzle to Nearest Circ. Seam: 1200.000 mm

Credit Distance along the Shell per 9.5.1 [Iso, l's]:

$$\begin{aligned}
 &= \sqrt{(2 * r_{is} + e_{c,s}) e_{c,s} } \\
 &= \sqrt{(2 * 4501.0 + 21.0) 21.0 } \quad (\text{where } e_{c,s} \text{ is } e_{a,s}) \\
 &= 435.30 \text{ mm}
 \end{aligned}$$

Note: l's equals Iso if no physical diameter limit value is entered. Otherwise l's considers the physical diameter limit entry.

Inside Radius per paragraph 9.5-3 [ris]:

$$\begin{aligned}
 &= (D_i + 2 * c) / 2 \\
 &= (9000.0 + 2 * 1.0) / 2 \\
 &= 4501.00 \text{ mm}
 \end{aligned}$$

Credit Distance Along the Nozzle per 9.5-76 [Ibo]:

$$\begin{aligned}
 &= \min(\sqrt{(d_{eb} - 2 * c_{ext} - e_{ab}) e_{ab} }, h_o) \\
 &= \min(\sqrt{(355.6 - 2 * 0.0 - 9.7) 9.7 }, 120.0) \\
 &= 57.92 \text{ mm}
 \end{aligned}$$

Credit Distance Along the Nozzle per 9.5-77 [Ibi]:

$$\begin{aligned}
 &= \min(h_i, 0.5 * I_{bo}) \\
 &= \min(0.0, 0.5 * 57.92) \\
 &= 0.00 \text{ mm}
 \end{aligned}$$

Compute area in the re-pad [Afp]:

$$\begin{aligned}
 &= I_p * \min(e_{a,p} ; e_{c,s}) \\
 &= 142.2 * 21.0 \\
 &= 2986.2 \text{ mm}^2
 \end{aligned}$$

Calculate the Pressure Area per 9.5-60 [Aps]:

Note: a (nozzle OD/2) taken as the diameter of the hole in the shell.

$$\begin{aligned}
 &= r_{is} (l's + a) \\
 &= 4501.0 (435.296 + 177.8) \\
 &= 2759.5471 \times 10^3 \text{ mm}^2
 \end{aligned}$$

Pressure Area of Nozzle using dib and Ibo [Apb]:

$$\begin{aligned}
 &= 0.5 * dib(I'b + ea,s) \\
 &= 0.5 * 336.2(57.92 + 21.0) \\
 &= 13.2672 \times 10^3 \text{ mm}^2
 \end{aligned}$$

Note: Pad Width assumed to be constant around the Nozzle perimeter.

Available Metal Areas per 9.5-78 to 9.5-81 [Afs, Afb, Afp, Afw]:

Area [Afs]:

$$\begin{aligned}
 &= l's * ea,s \\
 &= 435.3 * 21.0 \\
 &= 9141.226 \text{ mm}^2
 \end{aligned}$$

Area [Afb]:

$$\begin{aligned}
 &= eb(l'b + l'bi + e's) \\
 &= 9.7(57.92 + 0.0 + 21.0) \\
 &= 765.566 \text{ mm}^2
 \end{aligned}$$

Area [Afp]:

$$\begin{aligned}
 &= Ip * \min(ea,p; ec,s) \\
 &= 142.2 * 21.0 \\
 &= 2986.200 \text{ mm}^2
 \end{aligned}$$

Area [Afw]:

$$\begin{aligned}
 &= (wshell^2 + wpad^2 + winside^2) / 2 \\
 &= (10.0^2 + 18.0^2 + 0.0^2)/2 \\
 &= 212.000 \text{ mm}^2
 \end{aligned}$$

Note: The welds are considered to be corroded.

Calculation per paragraph 9.5.2.1.1 [fob, fop]:

$$\begin{aligned}
 fob &= \min(fs, fb) = \min(150.01, 125.34) = 125.34 \text{ MPa} \\
 fop &= \min(fs, fp) = \min(150.01, 150.01) = 150.01 \text{ MPa}
 \end{aligned}$$

Force Term per 9.5.2.1.1 [Pa]:

$$\begin{aligned}
 &= P(Aps + Apb + 0.5 * Appsi) \\
 &= 0.35(2759547 + 13267.18 + 0.5*0.0) \\
 &= 970.4 \times 10^3 \text{ N}
 \end{aligned}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$\begin{aligned}
 &= (Afs+Afw)(fs-0.5P) + Afp(\min(fs,fp) - 0.5P) + Afb(\min(fs,fb) - 0.5P) \\
 &= (9141.2 + 212.0)(150.01 - 0.5 * 0.35) + \\
 &\quad 2986.2(\min(150.01, 150.01) - 0.50 * 0.35) + \\
 &\quad 765.6(\min(150.01, 125.34) - 0.50 * 0.35) \\
 &= 1944.56 \times 10^3 \text{ N}
 \end{aligned}$$

Since Fa >= Pa, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:

$$\begin{aligned}
 &= ((Afs + Afw)fs + Afb * fob + Afp * fop) / \\
 &\quad ((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp)) \\
 &= ((9141.23+212.0)150.01+765.57*125.34+2986.2*150.01)/ \\
 &\quad ((2759547+13267.18+0.5*0.0)+0.5(63.02+212.0+765.57+20.59)) \\
 &= 0.701 \text{ MPa}
 \end{aligned}$$

Nozzle Pmax including Liquid Pressure: 0.701 = 0.701 - 0.0 MPa

Checking the Nozzle Reinforcement in the Transverse direction:

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FileName : R-202-NOZZLES-----

Nozzle Calcs.: Nozzle L Noz1: 33 10:41am Jul 22,2026

Determine Shell/Head mean Radius [rms]:

$$\begin{aligned} &= ris + 0.5 * ea,s \\ &= 4501.0 + 0.5 * 21.0 \\ &= 4511.50 \text{ mm} \end{aligned}$$

Determine intermediate Angle [delta]:

$$\begin{aligned} &= deb / (2 * rms) \\ &= 355.6 / (2 * 4511.5) \\ &= 0.0394 \text{ radians} \end{aligned}$$

Determine Opening Length [a]:

$$\begin{aligned} &= rms * \text{asin}(\min(1, \text{delta})) \\ &= 4511.5 * \text{asin}(1, 0.0394) \\ &= 177.85 \text{ mm} \end{aligned}$$

Determine Pressure Loaded Area [Aps]:

$$\begin{aligned} &= 0.5 * ris^2(1's + a) / (0.5 * ea,s + ris) \\ &= 0.5 * 4501.0^2(435.3 + 177.85) / (0.5 * 21.0 + 4501.0) \\ &= 1376665.75 \text{ mm}^2 \end{aligned}$$

Force Term per 9.5.2.1.1 [Pa]:

$$\begin{aligned} &= P(Aps + Apb + 0.5 * Appsi) \\ &= 0.35(1376666 + 13267.18 + 0.5*0.0) \\ &= 486.44 \times 10^3 \text{ N} \end{aligned}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$\begin{aligned} &= (Afs+Afw)(fs-0.5P) + Afp(\min(fs,fp) - 0.5P) + Afb(\min(fs,fb) - 0.5P) \\ &= (9141.2 + 212.0)(150.01 - 0.5 * 0.35) + \\ &\quad 2986.2(\min(150.01, 150.01) - 0.50 * 0.35) + \\ &\quad 765.6(\min(150.01, 125.34) - 0.50 * 0.35) \\ &= 1944.56 \times 10^3 \text{ N} \end{aligned}$$

Since $F_a \geq P_a$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:

$$\begin{aligned} &= ((Afs + Afw)fs + Afb * fob + Afp * fop) / \\ &\quad ((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp)) \\ &= ((9141.23+212.0)150.01+765.57*125.34+2986.2*150.01)/ \\ &\quad ((1376666+13267.18+0.5*0.0)+0.5(63.02+212.0+765.57+20.59)) \\ &= 1.394 \text{ MPa} \end{aligned}$$

Nozzle Pmax including Liquid Pressure: $1.394 = 1.394 - 0.0 \text{ MPa}$

The Drop for this Nozzle is : 3.5137 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 145.5136 mm

For possible nozzle interference - See Nozzle Summary

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Input, Nozzle Desc: Nozzle F

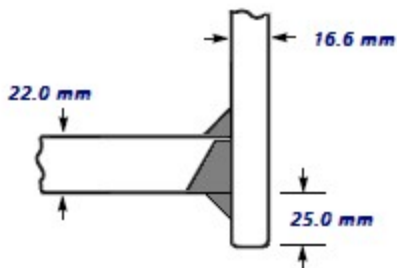
From: 20

Pressure for Reinforcement Calculations	P	0.3500	MPa
Temperature for Internal Pressure	Temp	300	°C
Shell Material	P355NH, EN 10028-3:2017		
Parent Allowable Stress at Temperature	f	150.01	MPa
Parent Allowable Stress At Ambient	fa	204.17	MPa
Inside Diameter of Cylindrical Shell	Di	9000.00	mm
Shell Finished (Minimum) Thickness	ea	22.0000	mm
Shell Internal Corrosion Allowance	c	1.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		1200.00	mm

Type of Element Connected to the Parent : Nozzle

Nozzle Material	A-105, ASTM Not Normative		
Allowable Stress at Temperature	fn	129.34	MPa
Allowable Stress At Ambient	fna	166.67	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		278.00	deg
Diameter	deb	84.0000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm
Flange Material	A-105		
Flange Type	Long Weld Neck		
Corrosion Allowance	can	3.0000	mm
Outside Projection	ho	240.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel Wgnv		22.0000	mm
Inside Projection	h	25.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		300	
Flange Grade			

The Pressure Design option was Design Pressure + static head.



Isolated Nozzle Calculation per EN 13445, Description: Nozzle F

Actual Outside Diameter Used in Calculation	84.000	mm.
---	--------	-----

Actual Thickness Used in Calculation 16.600 mm

Required Thickness of Nozzle Neck due to Internal Pressure:

$$\begin{aligned}
 &= P * Di / (2 * f * z - P) + c \quad \text{EN 13445 Equation: 7.4.2:} \\
 &= 0.35 * 56.8 / (2 * 129.341 * 1.0 - 0.35) + 3.0 \\
 &= 3.077 \text{ mm}
 \end{aligned}$$

EN 13445 Section 9 - Pressure Area Design Method:

Dist from Center of Nozzle to Nearest Circ. Seam: 1200.000 mm

Credit Distance along the Shell per 9.5.1 [Iso, l's]:

$$\begin{aligned}
 &= \sqrt{(2 * ris + ec,s) ec,s } \\
 &= \sqrt{(2 * 4501.0 + 21.0) 21.0 } \quad (\text{where } ec,s \text{ is } ea,s) \\
 &= 435.30 \text{ mm}
 \end{aligned}$$

Note: l's equals Iso if no physical diameter limit value is entered. Otherwise l's considers the physical diameter limit entry.

Inside Radius per paragraph 9.5-3 [ris]:

$$\begin{aligned}
 &= (Di + 2 * c) / 2 \\
 &= (9000.0 + 2 * 1.0) / 2 \\
 &= 4501.00 \text{ mm}
 \end{aligned}$$

Credit Distance Along the Nozzle per 9.5-76 [Ibo]:

$$\begin{aligned}
 &= \min(\sqrt{(deb - 2 * cext - eab) eab }, ho) \\
 &= \min(\sqrt{(84.0 - 2 * 0.0 - 13.6) 13.6 }, 240.0) \\
 &= 30.94 \text{ mm}
 \end{aligned}$$

Credit Distance Along the Nozzle per 9.5-77 [Ibi]:

$$\begin{aligned}
 &= \min(hi, 0.5 * Ibo) \\
 &= \min(25.0, 0.5 * 30.94) \\
 &= 15.47 \text{ mm}
 \end{aligned}$$

Compute area in the re-pad [Afp]:

$$\begin{aligned}
 &= Ip * \min(ea,p ; ec,s) \\
 &= 0.0 * 0.0 \\
 &= 0.0 \text{ mm}^2
 \end{aligned}$$

Calculate the Pressure Area per 9.5-60 [Aps]:

Note: a (nozzle OD/2) taken as the diameter of the hole in the shell.

$$\begin{aligned}
 &= ris(l's + a) \\
 &= 4501.0(435.296 + 42.0) \\
 &= 2148.3113 \times 10^3 \text{ mm}^2
 \end{aligned}$$

Pressure Area of Nozzle using dib and Ibo [Apb]:

$$\begin{aligned}
 &= 0.5 * dib(I'b + ea,s) \\
 &= 0.5 * 56.8(30.94 + 21.0) \\
 &= 1.4752 \times 10^3 \text{ mm}^2
 \end{aligned}$$

Available Metal Areas per 9.5-78 to 9.5-81 [Afs, Afb, Afp, Afw]:

Area [Afs]:

$$\begin{aligned}
 &= l's * ea,s \\
 &= 435.3 * 21.0 \\
 &= 9141.226 \text{ mm}^2
 \end{aligned}$$

Area [Afb]:

$$\begin{aligned}
 &= eb(l'b + l'bi + e's) \\
 &= 13.6(30.94 + 15.47 + 21.0) \\
 &= 916.828 \text{ mm}^2
 \end{aligned}$$

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 FileName : R-202-NOZZLES-----
 Nozzle Calcs.: Nozzle F Noz1: 34 10:41am Jul 22,2026

Area [Afp]:
 = $I_p * \min(ea, p; ec, s)$
 = $0.0 * 0.0$
 = 0.000 mm^2

Area [Afw]:
 = $(wshell^2 + wpad^2 + winside^2) / 2$
 = $(10.0^2 + 0.0^2 + 0.0^2) / 2$
 = 50.000 mm^2

Note: The welds are considered to be corroded.

Note: There is No Reinforcing Pad.

Calculation per paragraph 9.5.2.1.1 [fob, fop]:
 $fob = \min(fs, fb) = \min(150.01, 129.34) = 129.34 \text{ MPa}$
 $fop = \min(fs, fp) = \min(150.01, 0.00) = 0.00 \text{ MPa}$

Force Term per 9.5.2.1.1 [Pa]:
 = $P(Aps + Apb + 0.5 * Appsi)$
 = $0.35(2148311 + 1475.17 + 0.5*0.0)$
 = $752.36 \times 10^3 \text{ N}$

Force requirement per paragraph 9.5.2.1.1 [Fa]:
 = $(Afs + Afw)(fs - 0.5P) + Afp(\min(fs, fp) - 0.5P) + Afb(\min(fs, fb) - 0.5P)$
 = $(9141.2 + 50.0)(150.01 - 0.5 * 0.35) +$
 $0.0(\min(150.01, 0.0) - 0.50 * 0.35) +$
 $916.8(\min(150.01, 129.34) - 0.50 * 0.35)$
 = $1495.48 \times 10^3 \text{ N}$

Since $Fa \geq Pa$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:
 = $((Afs + Afw)fs + Afb * fob + Afp * fop) /$
 $((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp))$
 = $((9141.23 + 50.0)150.01 + 916.83 * 129.34 + 0.0 * 0.0) /$
 $((2148311 + 1475.17 + 0.5 * 0.0) + 0.5(63.02 + 50.0 + 916.83 + 0.0))$
 = 0.695 MPa

Nozzle Pmax including Liquid Pressure: $0.695 = 0.695 - 0.0 \text{ MPa}$

Checking the Nozzle Reinforcement in the Transverse direction:

Determine Shell/Head mean Radius [rms]:
 = $ris + 0.5 * ea, s$
 = $4501.0 + 0.5 * 21.0$
 = 4511.50 mm

Determine intermediate Angle [delta]:
 = $deb / (2 * rms)$
 = $84.0 / (2 * 4511.5)$
 = 0.0093 radians

Determine Opening Length [a]:
 = $rms * \text{asin}(\min(1, \text{delta}))$
 = $4511.5 * \text{asin}(1, 0.0093)$
 = 42.00 mm

Determine Pressure Loaded Area [Aps]:

$$= 0.5 * ris^2(l's + a) / (0.5 * ea,s + ris)$$

$$= 0.5 * 4501.0^2(435.3 + 42.0) / (0.5 * 21.0 + 4501.0)$$

$$= 1071656.88 \text{ mm}^2$$

Force Term per 9.5.2.1.1 [Pa]:

$$= P(Aps + Apb + 0.5 * Appsi)$$

$$= 0.35(1071657 + 1475.17 + 0.5*0.0)$$

$$= 375.56 \times 10^3 \text{ N}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$= (Afs+Afw)(fs-0.5P) + Afp(\min(fs,fp) - 0.5P) + Afb(\min(fs,fb) - 0.5P)$$

$$= (9141.2 + 50.0)(150.01 - 0.5 * 0.35) +$$

$$0.0(\min(150.01, 0.0) - 0.50 * 0.35) +$$

$$916.8(\min(150.01, 129.34) - 0.50 * 0.35)$$

$$= 1495.48 \times 10^3 \text{ N}$$

Since $F_a \geq P_a$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:

$$= ((Afs + Afw) fs + Afb * fob + Afp * fop) /$$

$$((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp))$$

$$= ((9141.23+50.0)150.01+916.83*129.34+0.0*0.0) /$$

$$((1071657+1475.17+0.5*0.0)+0.5(63.02+50.0+916.83+0.0))$$

$$= 1.389 \text{ MPa}$$

Nozzle Pmax including Liquid Pressure: $1.389 = 1.389 - 0.0 \text{ MPa}$

The Drop for this Nozzle is : 0.1961 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 287.1959 mm

For possible nozzle interference - See Nozzle Summary

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Input, Nozzle Desc: Nozzle T12

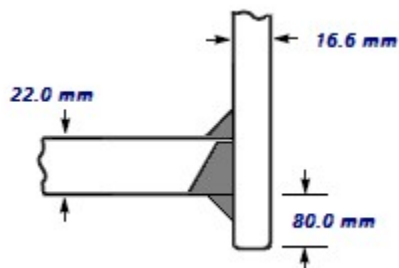
From: 20

Pressure for Reinforcement Calculations	P	0.3500	MPa
Temperature for Internal Pressure	Temp	300	°C
Shell Material	P355NH, EN 10028-3:2017		
Parent Allowable Stress at Temperature	f	150.01	MPa
Parent Allowable Stress At Ambient	fa	204.17	MPa
Inside Diameter of Cylindrical Shell	Di	9000.00	mm
Shell Finished (Minimum) Thickness	ea	22.0000	mm
Shell Internal Corrosion Allowance	c	1.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		5175.00	mm

Type of Element Connected to the Parent : Nozzle

Nozzle Material	A-105, ASTM Not Normative		
Allowable Stress at Temperature	fn	129.34	MPa
Allowable Stress At Ambient	fna	166.67	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		230.00	deg
Diameter	deb	84.0000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm
Flange Material	A-105		
Flange Type	Long Weld Neck		
Corrosion Allowance	can	3.0000	mm
Outside Projection	ho	300.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel Wgnv		22.0000	mm
Inside Projection	h	80.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
User Defined Nozzle/Shell Centerline Angle		45.0000	deg.
Flange Class		300	
Flange Grade			

The Pressure Design option was Design Pressure + static head.



Isolated Nozzle Calculation per EN 13445, Description: Nozzle T12

Area [Afs]:
 $= l's * ea,s$
 $= 435.3 * 21.0$
 $= 9141.226 \text{ mm}^2$

Area [Afb]:
 $= eb(l'b + l'bi + e's/\cos(\psi))$
 $= 13.6(30.94 + 15.47 + 29.7)$
 $= 1035.127 \text{ mm}^2$

Area [Afp]:
 $= Ip * \min(ea,p; ec,s)$
 $= 0.0 * 0.0$
 $= 0.000 \text{ mm}^2$

Area [Afw]:
 $= (wshell^2 + wpad^2 + winside^2) / 2$
 $= (10.0^2 + 0.0^2 + 0.0^2)/2$
 $= 50.000 \text{ mm}^2$

Note: The welds are considered to be corroded.

Note: There is No Reinforcing Pad.

Calculation per paragraph 9.5.2.1.1 [fob, fop]:
 $fob = \min(fs, fb) = \min(150.01, 129.34) = 129.34 \text{ MPa}$
 $fop = \min(fs, fp) = \min(150.01, 0.00) = 0.00 \text{ MPa}$

Force Term per 9.5.2.1.1 [Pa]:
 $= P(Aps + Apb + 0.5 * Appsi)$
 $= 0.35(2226615 + 1722.2 + 0.5*1613.12)$
 $= 780.13 \times 10^3 \text{ N}$

Force requirement per paragraph 9.5.2.1.1 [Fa]:
 $= (Afs+Afw)(fs-0.5P) + Afp(\min(fs,fp) - 0.5P) + Afb(\min(fs,fb) - 0.5P)$
 $= (9141.2 + 50.0)(150.01 - 0.5 * 0.35) +$
 $0.0(\min(150.01, 0.0) - 0.50 * 0.35) +$
 $1035.1(\min(150.01, 129.34) - 0.50 * 0.35)$
 $= 1510.76 \times 10^3 \text{ N}$

Since $Fa \geq Pa$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:
 $= ((Afs + Afw)fs + Afb * fob + Afp * fop) /$
 $((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp))$
 $= ((9141.23+50.0)150.01+1035.13*129.34+0.0*0.0)/$
 $((2226615+1722.2+0.5*1613.12)+0.5(63.02+50.0+1035.13+0.0))$
 $= 0.677 \text{ MPa}$

Nozzle Pmax including Liquid Pressure: $0.677 = 0.677 - 0.0 \text{ MPa}$

Checking the Nozzle Reinforcement in the Transverse direction:

Determine Shell/Head mean Radius [rms]:
 $= ris + 0.5 * ea,s$
 $= 4501.0 + 0.5 * 21.0$
 $= 4511.50 \text{ mm}$

Determine intermediate Angle [delta]:

$$= deb / (2 * rms)$$

$$= 84.0 / (2 * 4511.5)$$

$$= 0.0093 \text{ radians}$$

Determine Opening Length [a]:

$$= rms * \text{asin}(\min(1, \text{delta}))$$

$$= 4511.5 * \text{asin}(1, 0.0093)$$

$$= 42.00 \text{ mm}$$

Determine Pressure Loaded Area [Aps]:

$$= 0.5 * \text{ris}^2(l's + a) / (0.5 * ea,s + \text{ris})$$

$$= 0.5 * 4501.0^2(435.3 + 42.0) / (0.5 * 21.0 + 4501.0)$$

$$= 1071656.88 \text{ mm}^2$$

Pressure Area of Nozzle per using dib and Ibo, Transverse Plane [Apb]:

$$= 0.5 * \text{dib}(I'b + ea,s)$$

$$= 0.5 * 56.8(30.94 + 21.0)$$

$$= 1475.17 \text{ mm}^2$$

Pressure Loaded Area [Afb]:

$$= eb(l'b + l'bi + e's)$$

$$= 13.6(30.94 + 15.47 + 21.0)$$

$$= 916.83 \text{ mm}^2$$

Force Term per 9.5.2.1.1 [Pa]:

$$= P(Aps + Apb + 0.5 * Appsi)$$

$$= 0.35(1071657 + 1475.17 + 0.5*0.0)$$

$$= 375.56 \times 10^3 \text{ N}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$= (Afs + Afw)(fs - 0.5P) + Afp(\min(fs, fp) - 0.5P) + Afb(\min(fs, fb) - 0.5P)$$

$$= (9141.2 + 50.0)(150.01 - 0.5 * 0.35) +$$

$$0.0(\min(150.01, 0.0) - 0.50 * 0.35) +$$

$$916.8(\min(150.01, 129.34) - 0.50 * 0.35)$$

$$= 1495.48 \times 10^3 \text{ N}$$

Since $F_a \geq P_a$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:

$$= ((Afs + Afw) fs + Afb * fob + Afp * fop) /$$

$$((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp))$$

$$= ((9141.23+50.0)150.01+916.83*129.34+0.0*0.0)/$$

$$((1071657+1475.17+0.5*0.0)+0.5(63.02+50.0+916.83+0.0))$$

$$= 1.389 \text{ MPa}$$

Nozzle Pmax including Liquid Pressure: $1.389 = 1.389 - 0.0 \text{ MPa}$

The Drop for this Nozzle is : 0.1961 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 402.1960 mm

[For possible nozzle interference - See Nozzle Summary](#)

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Input, Nozzle Desc: Nozzle T17

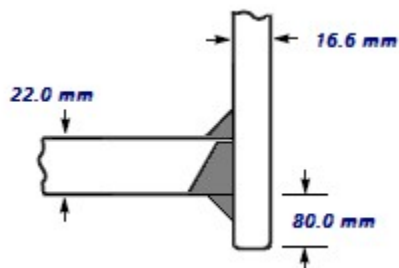
From: 20

Pressure for Reinforcement Calculations	P	0.3500	MPa
Temperature for Internal Pressure	Temp	300	°C
Shell Material	P355NH, EN 10028-3:2017		
Parent Allowable Stress at Temperature	f	150.01	MPa
Parent Allowable Stress At Ambient	fa	204.17	MPa
Inside Diameter of Cylindrical Shell	Di	9000.00	mm
Shell Finished (Minimum) Thickness	ea	22.0000	mm
Shell Internal Corrosion Allowance	c	1.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		2075.00	mm

Type of Element Connected to the Parent : Nozzle

Nozzle Material	A-105, ASTM Not Normative		
Allowable Stress at Temperature	fn	129.34	MPa
Allowable Stress At Ambient	fna	166.67	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		285.00	deg
Diameter	deb	84.0000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.6000	mm
Flange Material	A-105		
Flange Type	Long Weld Neck		
Corrosion Allowance	can	3.0000	mm
Outside Projection	ho	300.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	22.0000	mm
Inside Projection	h	80.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
User Defined Nozzle/Shell Centerline Angle		45.0000	deg.
Flange Class	300		
Flange Grade			

The Pressure Design option was Design Pressure + static head.



Isolated Nozzle Calculation per EN 13445, Description: Nozzle T17

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FileName : R-202-NOZZLES-----

Nozzle Calcs.: Nozzle T17 Noz1: 36 10:41am Jul 22,2026

Actual Outside Diameter Used in Calculation 84.000 mm.
Actual Thickness Used in Calculation 16.600 mm

Required Thickness of Nozzle Neck due to Internal Pressure:

$$\begin{aligned} &= P * Di / (2 * f * z - P) + c \quad \text{EN 13445 Equation: 7.4.2:} \\ &= 0.35 * 56.8 / (2 * 129.341 * 1.0 - 0.35) + 3.0 \\ &= 3.077 \text{ mm} \end{aligned}$$

EN 13445 Section 9 - Pressure Area Design Method:

Dist from Center of Nozzle to Nearest Circ. Seam: 2075.000 mm

Credit Distance along the Shell per 9.5.1 [Iso, l's]:

$$\begin{aligned} &= \text{sqrt}((2 * ris + ec,s)ec,s) \\ &= \text{sqrt}((2 * 4501.0 + 21.0)21.0) \text{ (where } ec,s \text{ is } ea,s) \\ &= 435.30 \text{ mm} \end{aligned}$$

Note: l's equals Iso if no physical diameter limit value is entered. Otherwise l's considers the physical diameter limit entry.

Nozzle Angle from vessel normal to surface used: 45.000 deg.

Inside Radius per paragraph 9.5-3 [ris]:

$$\begin{aligned} &= (Di + 2 * c) / 2 \\ &= (9000.0 + 2 * 1.0) / 2 \\ &= 4501.00 \text{ mm} \end{aligned}$$

Credit Distance Along the Nozzle per 9.5-76 [Ibo]:

$$\begin{aligned} &= \text{min}(\text{sqrt}((deb - 2 * cext - eab)eab), ho) \\ &= \text{min}(\text{sqrt}((84.0-2*0.0-13.6)13.6), 300.0) \\ &= 30.94 \text{ mm} \end{aligned}$$

Credit Distance Along the Nozzle per 9.5-77 [Ibi]:

$$\begin{aligned} &= \text{min}(hi, 0.5 * Ibo) \\ &= \text{min}(80.0, 0.5 * 30.94) \\ &= 15.47 \text{ mm} \end{aligned}$$

Compute area in the re-pad [Afp]:

$$\begin{aligned} &= Ip * \text{min}(ea,p ; ec,s) \\ &= 0.0 * 0.0 \\ &= 0.0 \text{ mm}^2 \end{aligned}$$

Calculate the Pressure Area per 9.5-60 [Aps]:

Note: a (nozzle OD/2) taken as the diameter of the hole in the shell.

$$\begin{aligned} &= ris(l's + a/\cos(psi)) \\ &= 4501.0(l's + 435.3/\cos(84.0)) \\ &= 2226.615 \times 10^3 \text{ mm}^2 \end{aligned}$$

Slant Angle Area per 9.5-112 [Appsi]

$$\begin{aligned} &= di^2/2 * \tan(psi) \\ &= 56.8^2/2 * \tan(45.0) \\ &= 1613.12 \text{ mm}^2 \end{aligned}$$

Pressure Area of Nozzle using dib and Ibo [Apb]:

$$\begin{aligned} &= 0.5 * dib(I'b + ea,s/\cos(psi)) \\ &= 0.5 * 56.8(30.94 + 21.0/\cos(45.0)) \\ &= 1.7222 \times 10^3 \text{ mm}^2 \end{aligned}$$

Available Metal Areas per 9.5-78 to 9.5-81 [Afs, Afb, Afp, Afw]:

$$\begin{aligned}\text{Area [Afs]} &= l's * ea,s \\ &= 435.3 * 21.0 \\ &= 9141.226 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}\text{Area [Afb]} &= eb(l'b + l'bi + e's/\cos(\psi)) \\ &= 13.6(30.94 + 15.47 + 29.7) \\ &= 1035.127 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}\text{Area [Afp]} &= Ip * \min(ea,p; ec,s) \\ &= 0.0 * 0.0 \\ &= 0.000 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}\text{Area [Afw]} &= (wshell^2 + wpad^2 + winside^2) / 2 \\ &= (10.0^2 + 0.0^2 + 0.0^2)/2 \\ &= 50.000 \text{ mm}^2\end{aligned}$$

Note: The welds are considered to be corroded.

Note: There is No Reinforcing Pad.

$$\begin{aligned}\text{Calculation per paragraph 9.5.2.1.1 [fob, fop]} & \\ fob = \min(fs, fb) &= \min(150.01, 129.34) = 129.34 \text{ MPa} \\ fop = \min(fs, fp) &= \min(150.01, 0.00) = 0.00 \text{ MPa}\end{aligned}$$

$$\begin{aligned}\text{Force Term per 9.5.2.1.1 [Pa]} & \\ &= P(Aps + Apb + 0.5 * Appsi) \\ &= 0.35(2226615 + 1722.2 + 0.5*1613.12) \\ &= 780.13 \times 10^3 \text{ N}\end{aligned}$$

$$\begin{aligned}\text{Force requirement per paragraph 9.5.2.1.1 [Fa]} & \\ &= (Afs+Afw)(fs-0.5P) + Afp(\min(fs,fp) - 0.5P) + Afb(\min(fs,fb) - 0.5P) \\ &= (9141.2 + 50.0)(150.01 - 0.5 * 0.35) + \\ &\quad 0.0(\min(150.01, 0.0) - 0.50 * 0.35) + \\ &\quad 1035.1(\min(150.01, 129.34) - 0.50 * 0.35) \\ &= 1510.76 \times 10^3 \text{ N}\end{aligned}$$

Since $F_a \geq P_a$, Code Requirements are satisfied.

$$\begin{aligned}\text{Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]} & \\ &= ((Afs + Afw)fs + Afb * fob + Afp * fop) / \\ &\quad ((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp)) \\ &= ((9141.23+50.0)150.01+1035.13*129.34+0.0*0.0)/ \\ &\quad ((2226615+1722.2+0.5*1613.12)+0.5(63.02+50.0+1035.13+0.0)) \\ &= 0.677 \text{ MPa}\end{aligned}$$

Nozzle Pmax including Liquid Pressure: $0.677 = 0.677 - 0.0 \text{ MPa}$

Checking the Nozzle Reinforcement in the Transverse direction:

$$\begin{aligned}\text{Determine Shell/Head mean Radius [rms]} & \\ &= ris + 0.5 * ea,s \\ &= 4501.0 + 0.5 * 21.0 \\ &= 4511.50 \text{ mm}\end{aligned}$$

Determine intermediate Angle [delta]:

$$= deb / (2 * rms)$$

$$= 84.0 / (2 * 4511.5)$$

$$= 0.0093 \text{ radians}$$

Determine Opening Length [a]:

$$= rms * \text{asin}(\min(1, \text{delta}))$$

$$= 4511.5 * \text{asin}(1, 0.0093)$$

$$= 42.00 \text{ mm}$$

Determine Pressure Loaded Area [Aps]:

$$= 0.5 * ris^2(l's + a) / (0.5 * ea,s + ris)$$

$$= 0.5 * 4501.0^2(435.3 + 42.0) / (0.5 * 21.0 + 4501.0)$$

$$= 1071656.88 \text{ mm}^2$$

Pressure Area of Nozzle per using dib and Ibo, Transverse Plane [Apb]:

$$= 0.5 * dib(l'b + ea,s)$$

$$= 0.5 * 56.8(30.94 + 21.0)$$

$$= 1475.17 \text{ mm}^2$$

Pressure Loaded Area [Afb]:

$$= eb(l'b + l'bi + e's)$$

$$= 13.6(30.94 + 15.47 + 21.0)$$

$$= 916.83 \text{ mm}^2$$

Force Term per 9.5.2.1.1 [Pa]:

$$= P(Aps + Apb + 0.5 * Appsi)$$

$$= 0.35(1071657 + 1475.17 + 0.5*0.0)$$

$$= 375.56 \times 10^3 \text{ N}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$= (Afs + Afw)(fs - 0.5P) + Afp(\min(fs, fp) - 0.5P) + Afb(\min(fs, fb) - 0.5P)$$

$$= (9141.2 + 50.0)(150.01 - 0.5 * 0.35) +$$

$$0.0(\min(150.01, 0.0) - 0.50 * 0.35) +$$

$$916.8(\min(150.01, 129.34) - 0.50 * 0.35)$$

$$= 1495.48 \times 10^3 \text{ N}$$

Since Fa >= Pa, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:

$$= ((Afs + Afw) fs + Afb * fob + Afp * fop) /$$

$$((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp))$$

$$= ((9141.23+50.0)150.01+916.83*129.34+0.0*0.0)/$$

$$((1071657+1475.17+0.5*0.0)+0.5(63.02+50.0+916.83+0.0))$$

$$= 1.389 \text{ MPa}$$

Nozzle Pmax including Liquid Pressure: 1.389 = 1.389 - 0.0 MPa

The Drop for this Nozzle is : 0.1961 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 402.1960 mm

[For possible nozzle interference - See Nozzle Summary](#)

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Input, Nozzle Desc: Nozzle K6

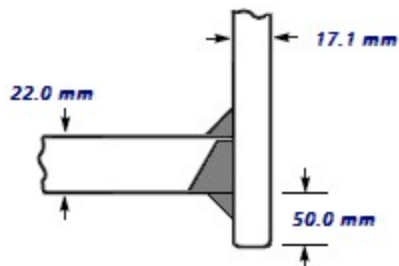
From: 20

Pressure for Reinforcement Calculations	P	0.3500	MPa
Temperature for Internal Pressure	Temp	300	°C
Shell Material	P355NH, EN 10028-3:2017		
Parent Allowable Stress at Temperature	f	150.01	MPa
Parent Allowable Stress At Ambient	fa	204.17	MPa
Inside Diameter of Cylindrical Shell	Di	9000.00	mm
Shell Finished (Minimum) Thickness	ea	22.0000	mm
Shell Internal Corrosion Allowance	c	1.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Cylinder/Cone Centerline	L1	1850.0000	mm
Distance from Bottom/Left Tangent		1200.00	mm

Type of Element Connected to the Parent : Nozzle

Nozzle Material	A-106 B, ASTM Not Normative		
Allowable Stress at Temperature	fn	125.34	MPa
Allowable Stress At Ambient	fna	160.01	MPa
Diameter Basis (for tr calc only)		Outside	
Layout Angle		294.15	deg
Diameter	deb	114.3000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	17.1200	mm
Flange Material	A-105		
Flange Type	Weld Neck Flange		
Corrosion Allowance	can	3.0000	mm
Outside Projection	ho	47.8000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	22.0000	mm
Inside Projection	h	50.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		150	
Flange Grade			

The Pressure Design option was Design Pressure + static head.



Isolated Nozzle Calculation per EN 13445, Description: Nozzle K6

Actual Outside Diameter Used in Calculation 114.300 mm.
Actual Thickness Used in Calculation 17.120 mm

Required Thickness of Nozzle Neck due to Internal Pressure:

$$= P * Di / (2 * f * z - P) + c \quad \text{EN 13445 Equation: 7.4.2:}$$

$$= 0.35 * 86.06 / (2 * 125.341 * 1.0 - 0.35) + 3.0$$

$$= 3.120 \text{ mm}$$

EN 13445 Section 9 - Pressure Area Design Method:

Dist from Center of Nozzle to Nearest Circ. Seam: 1200.000 mm

Credit Distance along the Shell per 9.5.1 [Iso, l's]:

$$= \sqrt{(2 * ris + ec,s) ec,s }$$

$$= \sqrt{(2 * 4501.0 + 21.0) 21.0 } \quad (\text{where } ec,s \text{ is } ea,s)$$

$$= 435.30 \text{ mm}$$

Note: l's equals Iso if no physical diameter limit value is entered. Otherwise l's considers the physical diameter limit entry.

Inside Radius per paragraph 9.5-3 [ris]:

$$= (Di + 2 * c) / 2$$

$$= (9000.0 + 2 * 1.0) / 2$$

$$= 4501.00 \text{ mm}$$

Credit Distance Along the Nozzle per 9.5-76 [Ibo]:

$$= \min(\sqrt{(deb - 2 * c_{ext} - eab) eab }, ho)$$

$$= \min(\sqrt{(114.3 - 2 * 0.0 - 14.12) 14.12 }, 47.8)$$

$$= 37.61 \text{ mm}$$

Credit Distance Along the Nozzle per 9.5-77 [Ibi]:

$$= \min(hi, 0.5 * Ibo)$$

$$= \min(50.0, 0.5 * 37.61)$$

$$= 18.81 \text{ mm}$$

Compute area in the re-pad [Afp]:

$$= Ip * \min(ea,p ; ec,s)$$

$$= 0.0 * 0.0$$

$$= 0.0 \text{ mm}^2$$

Calculate the Pressure Area per 9.5-60 [Aps]:

Note: a (nozzle OD/2) taken as the diameter of the hole in the shell.

$$= ris(l's + a)$$

$$= 4501.0(435.296 + 57.15)$$

$$= 2216.5015 \times 10^3 \text{ mm}^2$$

Pressure Area of Nozzle using dib and Ibo [Apb]:

$$= 0.5 * dib(I'b + ea,s)$$

$$= 0.5 * 86.06(37.61 + 21.0)$$

$$= 2.522 \times 10^3 \text{ mm}^2$$

Available Metal Areas per 9.5-78 to 9.5-81 [Afs, Afb, Afp, Afw]:

Area [Afs]:

$$= l's * ea,s$$

$$= 435.3 * 21.0$$

$$= 9141.226 \text{ mm}^2$$

Area [Afb]:

$$= eb(l'b + l'bi + e's)$$

$$= 14.12(37.61 + 18.81 + 21.0)$$

$$= 1093.108 \text{ mm}^2$$

Area [Afp]:

$$= Ip * \min(ea,p; ec,s)$$

$$= 0.0 * 0.0$$

$$= 0.000 \text{ mm}^2$$

Area [Afw]:

$$= (wshell^2 + wpad^2 + winside^2) / 2$$

$$= (10.0^2 + 0.0^2 + 0.0^2)/2$$

$$= 50.000 \text{ mm}^2$$

Note: The welds are considered to be corroded.

Note: There is No Reinforcing Pad.

Calculation per paragraph 9.5.2.1.1 [fob, fop]:

$$fob = \min(fs, fb) = \min(150.01, 125.34) = 125.34 \text{ MPa}$$

$$fop = \min(fs, fp) = \min(150.01, 0.00) = 0.00 \text{ MPa}$$

Force Term per 9.5.2.1.1 [Pa]:

$$= P(Aps + Apb + 0.5 * Appsi)$$

$$= 0.35(2216502 + 2522.01 + 0.5*0.0)$$

$$= 776.59 \times 10^3 \text{ N}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$= (Afs+Afw)(fs-0.5P) + Afp(\min(fs,fp) - 0.5P) + Afb(\min(fs,fb) - 0.5P)$$

$$= (9141.2 + 50.0)(150.01 - 0.5 * 0.35) +$$

$$0.0(\min(150.01, 0.0) - 0.50 * 0.35) +$$

$$1093.1(\min(150.01, 125.34) - 0.50 * 0.35)$$

$$= 1513.88 \times 10^3 \text{ N}$$

Since $Fa \geq Pa$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:

$$= ((Afs + Afw)fs + Afb * fob + Afp * fop) /$$

$$((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp))$$

$$= ((9141.23+50.0)150.01+1093.11*125.34+0.0*0.0)/$$

$$((2216502+2522.01+0.5*0.0)+0.5(63.02+50.0+1093.11+0.0))$$

$$= 0.682 \text{ MPa}$$

Nozzle Pmax including Liquid Pressure: $0.682 = 0.682 - 0.0 \text{ MPa}$

Checking the Nozzle in the Transverse plane:

Determine Angle [delta]:

$$= deb / (2 * rms)$$

$$= 114.3 / (2 * 4511.5)$$

$$= 0.0127 \text{ radians}$$

The distance as depicted in figure 9.5-3 [a]:

$$= 0.5 * rms(\sin(delta + \sin(psi)) + \sin(delta - \sin(psi)))$$

$$= 0.5 * 4511.5(\sin(0.013 + \sin(0.423)) + \sin(0.013 - \sin(0.423)))$$

$$= 62.66 \text{ mm}$$

Angle between nozzle centerline and head centerline [psi]:

$$\begin{aligned}
 &= \text{asin}(\text{Offset} / \text{rms}) \\
 &= \text{asin}(1850.0/4511.5) \\
 &= 0.4225 \text{ radians } (24.209 \text{ degrees})
 \end{aligned}$$

Area due to Nozzle Obliquity [Apsi]:

$$\begin{aligned}
 &= 0.5 * \text{dib}^2 * \tan(\text{psi}) \\
 &= 0.5 * 86.06^2 * \tan(0.423) \\
 &= 1664.95 \text{ mm}^2
 \end{aligned}$$

Pressure area inside shell/head per 9.5-56 [Aps]:

$$\begin{aligned}
 &= 0.5 * \text{ris}^2(1's + a) / (0.5 * \text{ea},s + \text{ris}) \\
 &= 0.5 * 4501.0^2(435.296+62.664) / (0.5 * 21.0 + 4501.0) \\
 &= 1118051.25 \text{ mm}^2
 \end{aligned}$$

Available Metal Area [Afb]:

$$\begin{aligned}
 &= \text{eb}(1'b + 1'bi + e's/\cos(\text{psi})) \\
 &= 14.12(37.61 + 18.81 + 21.0/\cos(0.4225)) \\
 &= 1121.70 \text{ mm}^2
 \end{aligned}$$

Pressure Area of Nozzle [Apb]:

$$\begin{aligned}
 &= 0.5 * \text{dib}(1'b + \text{ea},s/\cos(\text{psi})) \\
 &= 0.5 * 86.06(37.61 + 21.0/\cos(0.423)) \\
 &= 2609.14 \text{ mm}^2
 \end{aligned}$$

Force Term per 9.5.2.1.1 [Pa]:

$$\begin{aligned}
 &= P(\text{Aps} + \text{Apb} + 0.5 * \text{Apsi}) \\
 &= 0.35(1118051 + 2609.14 + 0.5*1664.95) \\
 &= 392.49 \times 10^3 \text{ N}
 \end{aligned}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$\begin{aligned}
 &= (\text{Afs}+\text{Afw})(\text{fs}-0.5P) + \text{Afp}(\min(\text{fs},\text{fp}) - 0.5P) + \text{Afb}(\min(\text{fs},\text{fb}) - 0.5P) \\
 &= (9141.2 + 50.0)(150.01 - 0.5 * 0.35) + \\
 &\quad 0.0(\min(150.01, 0.0) - 0.50 * 0.35) + \\
 &\quad 1121.7(\min(150.01, 125.34) - 0.50 * 0.35) \\
 &= 1517.46 \times 10^3 \text{ N}
 \end{aligned}$$

Since $F_a \geq P_a$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:

$$\begin{aligned}
 &= ((\text{Afs} + \text{Afw})\text{fs} + \text{Afb} * \text{fob} + \text{Afp} * \text{fop}) / \\
 &\quad ((\text{Aps} + \text{Apb} + 0.5 * \text{Apsi}) + 0.5(\text{Afs} + \text{Afw} + \text{Afb} + \text{Afp})) \\
 &= ((9141.23+50.0)150.01+1121.7*125.34+0.0*0.0)/ \\
 &\quad ((1118051+2609.14+0.5*1664.95)+0.5(63.02+50.0+1121.7+0.0)) \\
 &= 1.349 \text{ MPa}
 \end{aligned}$$

Nozzle Pmax including Liquid Pressure: $1.349 = 1.349 - 0.0 \text{ MPa}$

The Drop for this Nozzle is : 26.2561 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 148.1779 mm

For possible nozzle interference - See Nozzle Summary

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PV Elite 26 Licensee: Unknown Company
 FileName : R-202-NOZZLES-----
 Nozzle Calcs.: Manhole Z5 Nozl: 38 10:41am Jul 22,2026

Input, Nozzle Desc: Manhole Z5

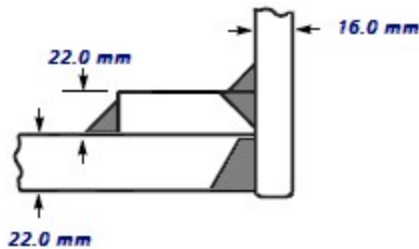
From: 20

Pressure for Reinforcement Calculations	P	0.3500	MPa
Temperature for Internal Pressure	Temp	300	°C
Shell Material	P355NH, EN 10028-3:2017		
Parent Allowable Stress at Temperature	f	150.01	MPa
Parent Allowable Stress At Ambient	fa	204.17	MPa
Inside Diameter of Cylindrical Shell	Di	9000.00	mm
Shell Finished (Minimum) Thickness	ea	22.0000	mm
Shell Internal Corrosion Allowance	c	1.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		1015.00	mm

Type of Element Connected to the Parent : Nozzle

Nozzle Material	P355NH, EN 10028-3:2017		
Allowable Stress at Temperature	fn	154.68	MPa
Allowable Stress At Ambient	fna	204.17	MPa
Diameter Basis (for tr calc only)		Inside	
Layout Angle		90.00	deg
Diameter	deb	900.0000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.0000	mm
Flange Material	P355NH		
Flange Type	Socket Weld		
Corrosion Allowance	can	3.0000	mm
Outside Projection	ho	250.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	22.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material	P355NH, EN 10028-3:2017		
Pad Allowable Stress at Temperature	f2	150.01	MPa
Pad Allowable Stress At Ambient	f2a	204.17	MPa
Diameter of Pad along vessel surface	d2	1300.0000	mm
Thickness of Pad	e2	22.0000	mm
Weld leg size between Pad and Shell	Wp	18.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	22.0000	mm
Reinforcing Pad Width		184.0000	mm
Flange Class		PN16	
Flange Grade		3E0 50<vR<=150	

The Pressure Design option was Design Pressure + static head.

**Isolated Nozzle Calculation per EN 13445, Description: Manhole Z5**

Actual Inside Diameter Used in Calculation 900.000 mm.
 Actual Thickness Used in Calculation 16.000 mm

Required Thickness of Nozzle Neck due to Internal Pressure:

$$= P * D_i / (2 * f * z - P) + c \quad \text{EN 13445 Equation: 7.4.2:}$$

$$= 0.35 * 906.0 / (2 * 154.679 * 1.0 - 0.35) + 3.0$$

$$= 4.026 \text{ mm}$$

EN 13445 Section 9 - Pressure Area Design Method:

Dist from Center of Nozzle to Nearest Circ. Seam: 1015.000 mm

Credit Distance along the Shell per 9.5.1 [Iso, l's]:

$$= \sqrt{(2 * r_{is} + e_{c,s}) e_{c,s} }$$

$$= \sqrt{(2 * 4501.0 + 21.0) 21.0 } \quad (\text{where } e_{c,s} \text{ is } e_{a,s})$$

$$= 435.30 \text{ mm}$$

Note: l's equals Iso if no physical diameter limit value is entered. Otherwise l's considers the physical diameter limit entry.

Inside Radius per paragraph 9.5-3 [ris]:

$$= (D_i + 2 * c) / 2$$

$$= (900.0 + 2 * 1.0) / 2$$

$$= 4501.00 \text{ mm}$$

Credit Distance Along the Nozzle per 9.5-76 [Ibo]:

$$= \min(\sqrt{(d_{eb} - 2 * c_{ext} - e_{ab}) e_{ab} }, h_o)$$

$$= \min(\sqrt{(932.0 - 2 * 0.0 - 13.0) 13.0 }, 250.0)$$

$$= 109.30 \text{ mm}$$

Credit Distance Along the Nozzle per 9.5-77 [Ibi]:

$$= \min(h_i, 0.5 * I_{bo})$$

$$= \min(0.0, 0.5 * 109.3)$$

$$= 0.00 \text{ mm}$$

Compute area in the re-pad [Afp]:

$$= I_p * \min(e_{a,p} ; e_{c,s})$$

$$= 184.0 * 21.0$$

$$= 3864.0 \text{ mm}^2$$

Calculate the Pressure Area per 9.5-60 [Aps]:

Note: a (nozzle OD/2) taken as the diameter of the hole in the shell.

$$= r_{is} (l's + a)$$

$$= 4501.0 (435.296 + 466.0)$$

$$= 4056.7351 \times 10^3 \text{ mm}^2$$

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FileName : R-202-NOZZLES-----

Nozzle Calcs.: Manhole Z5 Noz1: 38 10:41am Jul 22,2026

Pressure Area of Nozzle using dib and Ibo [Apb]:

$$\begin{aligned} &= 0.5 * dib(I'b + ea,s) \\ &= 0.5 * 906.0(109.3 + 21.0) \\ &= 59.027 \times 10^3 \text{ mm}^2 \end{aligned}$$

Note: Pad Width assumed to be constant around the Nozzle perimeter.

Available Metal Areas per 9.5-78 to 9.5-81 [Afs, Afb, Afp, Afw]:

Area [Afs]:

$$\begin{aligned} &= l's * ea,s \\ &= 435.3 * 21.0 \\ &= 9141.226 \text{ mm}^2 \end{aligned}$$

Area [Afb]:

$$\begin{aligned} &= eb(l'b + l'bi + e's) \\ &= 13.0(109.3 + 0.0 + 21.0) \\ &= 1693.930 \text{ mm}^2 \end{aligned}$$

Area [Afp]:

$$\begin{aligned} &= Ip * \min(ea,p; ec,s) \\ &= 184.0 * 21.0 \\ &= 3864.000 \text{ mm}^2 \end{aligned}$$

Area [Afw]:

$$\begin{aligned} &= (wshell^2 + wpad^2 + winside^2) / 2 \\ &= (10.0^2 + 18.0^2 + 0.0^2)/2 \\ &= 212.000 \text{ mm}^2 \end{aligned}$$

Note: The welds are considered to be corroded.

Calculation per paragraph 9.5.2.1.1 [fob, fop]:

$$\begin{aligned} fob &= \min(fs, fb) = \min(150.01, 154.68) = 150.01 \text{ MPa} \\ fop &= \min(fs, fp) = \min(150.01, 150.01) = 150.01 \text{ MPa} \end{aligned}$$

Force Term per 9.5.2.1.1 [Pa]:

$$\begin{aligned} &= P(Aps + Apb + 0.5 * Appsi) \\ &= 0.35(4056735 + 59026.95 + 0.5*0.0) \\ &= 1440.39 \times 10^3 \text{ N} \end{aligned}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$\begin{aligned} &= (Afs + Afw + Afb + Afp)(fs - 0.5P) \\ &= (9141.23 + 212.0 + 1693.93 + 3864.0)(150.01 - 0.5* 0.35) \\ &= 2234.05 \times 10^3 \text{ N} \end{aligned}$$

Since Fa >= Pa, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-12) [Pmax]:

$$\begin{aligned} &= ((Afs + Afw + Afb + Afp)fs) / \\ &\quad ((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp)) \\ &= ((9141.23+212.0+1693.93+3864.0)150.01)/ \\ &\quad ((4056735+59026.95+0.5*0.0)+0.5(63.02+212.0+1693.93+26.64)) \\ &= 0.543 \text{ MPa} \end{aligned}$$

Nozzle Pmax including Liquid Pressure: 0.543 = 0.543 - 0.0 MPa

Checking the Nozzle Reinforcement in the Transverse direction:

Determine Shell/Head mean Radius [rms]:

$$\begin{aligned}
 &= ris + 0.5 * ea,s \\
 &= 4501.0 + 0.5 * 21.0 \\
 &= 4511.50 \text{ mm}
 \end{aligned}$$

Determine intermediate Angle [delta]:

$$\begin{aligned}
 &= deb / (2 * rms) \\
 &= 932.0 / (2 * 4511.5) \\
 &= 0.1033 \text{ radians}
 \end{aligned}$$

Determine Opening Length [a]:

$$\begin{aligned}
 &= rms * \text{asin}(\min(1, \text{delta})) \\
 &= 4511.5 * \text{asin}(1, 0.1033) \\
 &= 466.83 \text{ mm}
 \end{aligned}$$

Determine Pressure Loaded Area [Aps]:

$$\begin{aligned}
 &= 0.5 * ris^2(l's + a) / (0.5 * ea,s + ris) \\
 &= 0.5 * 4501.0^2(435.3 + 466.83) / (0.5 * 21.0 + 4501.0) \\
 &= 2025516.25 \text{ mm}^2
 \end{aligned}$$

Force Term per 9.5.2.1.1 [Pa]:

$$\begin{aligned}
 &= P(Aps + Apb + 0.5 * Appsi) \\
 &= 0.35(2025516 + 59026.95 + 0.5*0.0) \\
 &= 729.53 \times 10^3 \text{ N}
 \end{aligned}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$\begin{aligned}
 &= (Afs + Afw + Afb + Afp)(fs - 0.5P) \\
 &= (9141.23 + 212.0 + 1693.93 + 3864.0)(150.01 - 0.5* 0.35) \\
 &= 2234.05 \times 10^3 \text{ N}
 \end{aligned}$$

Since $F_a \geq P_a$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-12) [Pmax]:

$$\begin{aligned}
 &= ((Afs + Afw + Afb + Afp)fs) / \\
 &\quad ((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp)) \\
 &= ((9141.23+212.0+1693.93+3864.0)150.01)/ \\
 &\quad ((2025516+59026.95+0.5*0.0)+0.5(63.02+212.0+1693.93+26.64)) \\
 &= 1.069 \text{ MPa}
 \end{aligned}$$

Nozzle Pmax including Liquid Pressure: $1.069 = 1.069 - 0.0 \text{ MPa}$

The Drop for this Nozzle is : 24.1935 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 296.1933 mm

For possible nozzle interference - See Nozzle Summary

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PV Elite 26 Licensee: Unknown Company
 FileName : R-202-NOZZLES-----
 Nozzle Calcs.: Manhole Z4 Nozl: 39 10:41am Jul 22,2026

Input, Nozzle Desc: Manhole Z4

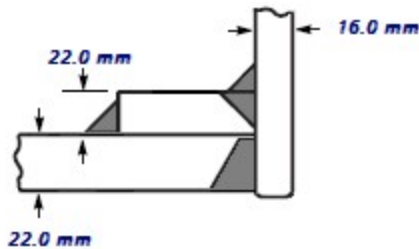
From: 20

Pressure for Reinforcement Calculations	P	0.3500	MPa
Temperature for Internal Pressure	Temp	300	°C
Shell Material	P355NH, EN 10028-3:2017		
Parent Allowable Stress at Temperature	f	150.01	MPa
Parent Allowable Stress At Ambient	fa	204.17	MPa
Inside Diameter of Cylindrical Shell	Di	9000.00	mm
Shell Finished (Minimum) Thickness	ea	22.0000	mm
Shell Internal Corrosion Allowance	c	1.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		5775.00	mm

Type of Element Connected to the Parent : Nozzle

Nozzle Material	P355NH, EN 10028-3:2017		
Allowable Stress at Temperature	fn	154.68	MPa
Allowable Stress At Ambient	fna	204.17	MPa
Diameter Basis (for tr calc only)		Inside	
Layout Angle		90.00	deg
Diameter	deb	900.0000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.0000	mm
Flange Material	P355NH		
Flange Type	Socket Weld		
Corrosion Allowance	can	3.0000	mm
Outside Projection	ho	250.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	22.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material	P355NH, EN 10028-3:2017		
Pad Allowable Stress at Temperature	f2	150.01	MPa
Pad Allowable Stress At Ambient	f2a	204.17	MPa
Diameter of Pad along vessel surface	d2	1300.0000	mm
Thickness of Pad	e2	22.0000	mm
Weld leg size between Pad and Shell	Wp	18.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	22.0000	mm
Reinforcing Pad Width		184.0000	mm
Flange Class		PN16	
Flange Grade		3E0 50<vR<=150	

The Pressure Design option was Design Pressure + static head.



Isolated Nozzle Calculation per EN 13445, Description: Manhole Z4

Actual Inside Diameter Used in Calculation 900.000 mm.
Actual Thickness Used in Calculation 16.000 mm

Required Thickness of Nozzle Neck due to Internal Pressure:

$$= P * D_i / (2 * f * z - P) + c \quad \text{EN 13445 Equation: 7.4.2:}$$

$$= 0.35 * 906.0 / (2 * 154.679 * 1.0 - 0.35) + 3.0$$

$$= 4.026 \text{ mm}$$

EN 13445 Section 9 - Pressure Area Design Method:

Dist from Center of Nozzle to Nearest Circ. Seam: 2175.000 mm

Credit Distance along the Shell per 9.5.1 [Iso, l's]:

$$= \sqrt{(2 * r_{is} + e_{c,s}) e_{c,s} }$$

$$= \sqrt{(2 * 4501.0 + 21.0) 21.0 } \quad (\text{where } e_{c,s} \text{ is } e_{a,s})$$

$$= 435.30 \text{ mm}$$

Note: l's equals Iso if no physical diameter limit value is entered. Otherwise l's considers the physical diameter limit entry.

Inside Radius per paragraph 9.5-3 [ris]:

$$= (D_i + 2 * c) / 2$$

$$= (900.0 + 2 * 1.0) / 2$$

$$= 4501.00 \text{ mm}$$

Credit Distance Along the Nozzle per 9.5-76 [Ibo]:

$$= \min(\sqrt{(d_{eb} - 2 * c_{ext} - e_{ab}) e_{ab} }, h_o)$$

$$= \min(\sqrt{(932.0 - 2 * 0.0 - 13.0) 13.0 }, 250.0)$$

$$= 109.30 \text{ mm}$$

Credit Distance Along the Nozzle per 9.5-77 [Ibi]:

$$= \min(h_i, 0.5 * I_{bo})$$

$$= \min(0.0, 0.5 * 109.3)$$

$$= 0.00 \text{ mm}$$

Compute area in the re-pad [Afp]:

$$= I_p * \min(e_{a,p} ; e_{c,s})$$

$$= 184.0 * 21.0$$

$$= 3864.0 \text{ mm}^2$$

Calculate the Pressure Area per 9.5-60 [Aps]:

Note: a (nozzle OD/2) taken as the diameter of the hole in the shell.

$$= r_{is} (l's + a)$$

$$= 4501.0 (435.296 + 466.0)$$

$$= 4056.7351 \times 10^3 \text{ mm}^2$$

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FileName : R-202-NOZZLES-----

Nozzle Calcs.: Manhole Z4 Noz1: 39 10:41am Jul 22,2026

Pressure Area of Nozzle using dib and Ibo [Apb]:

$$\begin{aligned} &= 0.5 * dib(I'b + ea,s) \\ &= 0.5 * 906.0(109.3 + 21.0) \\ &= 59.027 \times 10^3 \text{ mm}^2 \end{aligned}$$

Note: Pad Width assumed to be constant around the Nozzle perimeter.

Available Metal Areas per 9.5-78 to 9.5-81 [Afs, Afb, Afp, Afw]:

Area [Afs]:

$$\begin{aligned} &= l's * ea,s \\ &= 435.3 * 21.0 \\ &= 9141.226 \text{ mm}^2 \end{aligned}$$

Area [Afb]:

$$\begin{aligned} &= eb(l'b + l'bi + e's) \\ &= 13.0(109.3 + 0.0 + 21.0) \\ &= 1693.930 \text{ mm}^2 \end{aligned}$$

Area [Afp]:

$$\begin{aligned} &= Ip * \min(ea,p; ec,s) \\ &= 184.0 * 21.0 \\ &= 3864.000 \text{ mm}^2 \end{aligned}$$

Area [Afw]:

$$\begin{aligned} &= (wshell^2 + wpad^2 + winside^2) / 2 \\ &= (10.0^2 + 18.0^2 + 0.0^2)/2 \\ &= 212.000 \text{ mm}^2 \end{aligned}$$

Note: The welds are considered to be corroded.

Calculation per paragraph 9.5.2.1.1 [fob, fop]:

$$\begin{aligned} fob &= \min(fs, fb) = \min(150.01, 154.68) = 150.01 \text{ MPa} \\ fop &= \min(fs, fp) = \min(150.01, 150.01) = 150.01 \text{ MPa} \end{aligned}$$

Force Term per 9.5.2.1.1 [Pa]:

$$\begin{aligned} &= P(Aps + Apb + 0.5 * Appsi) \\ &= 0.35(4056735 + 59026.95 + 0.5*0.0) \\ &= 1440.39 \times 10^3 \text{ N} \end{aligned}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$\begin{aligned} &= (Afs + Afw + Afb + Afp)(fs - 0.5P) \\ &= (9141.23 + 212.0 + 1693.93 + 3864.0)(150.01 - 0.5* 0.35) \\ &= 2234.05 \times 10^3 \text{ N} \end{aligned}$$

Since Fa >= Pa, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-12) [Pmax]:

$$\begin{aligned} &= ((Afs + Afw + Afb + Afp)fs) / \\ &\quad ((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp)) \\ &= ((9141.23+212.0+1693.93+3864.0)150.01)/ \\ &\quad ((4056735+59026.95+0.5*0.0)+0.5(63.02+212.0+1693.93+26.64)) \\ &= 0.543 \text{ MPa} \end{aligned}$$

Nozzle Pmax including Liquid Pressure: 0.543 = 0.543 - 0.0 MPa

Checking the Nozzle Reinforcement in the Transverse direction:

Determine Shell/Head mean Radius [rms]:

$$\begin{aligned}
 &= ris + 0.5 * ea,s \\
 &= 4501.0 + 0.5 * 21.0 \\
 &= 4511.50 \text{ mm}
 \end{aligned}$$

Determine intermediate Angle [delta]:

$$\begin{aligned}
 &= deb / (2 * rms) \\
 &= 932.0 / (2 * 4511.5) \\
 &= 0.1033 \text{ radians}
 \end{aligned}$$

Determine Opening Length [a]:

$$\begin{aligned}
 &= rms * \text{asin}(\min(1, \text{delta})) \\
 &= 4511.5 * \text{asin}(1, 0.1033) \\
 &= 466.83 \text{ mm}
 \end{aligned}$$

Determine Pressure Loaded Area [Aps]:

$$\begin{aligned}
 &= 0.5 * ris^2(l's + a) / (0.5 * ea,s + ris) \\
 &= 0.5 * 4501.0^2(435.3 + 466.83) / (0.5 * 21.0 + 4501.0) \\
 &= 2025516.25 \text{ mm}^2
 \end{aligned}$$

Force Term per 9.5.2.1.1 [Pa]:

$$\begin{aligned}
 &= P(Aps + Apb + 0.5 * Appsi) \\
 &= 0.35(2025516 + 59026.95 + 0.5*0.0) \\
 &= 729.53 \times 10^3 \text{ N}
 \end{aligned}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$\begin{aligned}
 &= (Afs + Afw + Afb + Afp)(fs - 0.5P) \\
 &= (9141.23 + 212.0 + 1693.93 + 3864.0)(150.01 - 0.5* 0.35) \\
 &= 2234.05 \times 10^3 \text{ N}
 \end{aligned}$$

Since $F_a \geq P_a$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-12) [Pmax]:

$$\begin{aligned}
 &= ((Afs + Afw + Afb + Afp)fs) / \\
 &\quad ((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp)) \\
 &= ((9141.23+212.0+1693.93+3864.0)150.01)/ \\
 &\quad ((2025516+59026.95+0.5*0.0)+0.5(63.02+212.0+1693.93+26.64)) \\
 &= 1.069 \text{ MPa}
 \end{aligned}$$

Nozzle Pmax including Liquid Pressure: $1.069 = 1.069 - 0.0 \text{ MPa}$

The Drop for this Nozzle is : 24.1935 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 296.1933 mm

For possible nozzle interference - See Nozzle Summary

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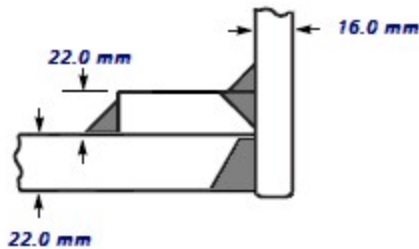
Input, Nozzle Desc: Manhole Z3**From: 40**

Pressure for Reinforcement Calculations	P	0.3500	MPa
Temperature for Internal Pressure	Temp	300	°C
Shell Material 09G2S, GOST 5520-79 92			
Parent Allowable Stress at Temperature	f	151.01	MPa
Parent Allowable Stress At Ambient	fa	195.84	MPa
Inside Diameter of Cylindrical Shell	Di	11000.00	mm
Shell Finished (Minimum) Thickness	ea	22.0000	mm
Shell Internal Corrosion Allowance	c	1.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		11650.00	mm

Type of Element Connected to the Parent : Nozzle

Nozzle Material	P355NH, EN 10028-3:2017		
Allowable Stress at Temperature	fn	154.68	MPa
Allowable Stress At Ambient	fna	204.17	MPa
Diameter Basis (for tr calc only)		Inside	
Layout Angle		90.00	deg
Diameter	deb	900.0000	mm
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.0000	mm
Flange Material	P355NH		
Flange Type	Socket Weld		
Corrosion Allowance	can	3.0000	mm
Outside Projection	ho	250.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	22.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material	P355NH, EN 10028-3:2017		
Pad Allowable Stress at Temperature	f2	150.01	MPa
Pad Allowable Stress At Ambient	f2a	204.17	MPa
Diameter of Pad along vessel surface	d2	1300.0000	mm
Thickness of Pad	e2	22.0000	mm
Weld leg size between Pad and Shell	Wp	18.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	22.0000	mm
Reinforcing Pad Width		184.0000	mm
Flange Class		PN16	
Flange Grade		3E0 50<vR<=150	

The Pressure Design option was Design Pressure + static head.



Isolated Nozzle Calculation per EN 13445, Description: Manhole Z3

Actual Inside Diameter Used in Calculation 900.000 mm.
Actual Thickness Used in Calculation 16.000 mm

Required Thickness of Nozzle Neck due to Internal Pressure:

$$= P * D_i / (2 * f * z - P) + c \quad \text{EN 13445 Equation: 7.4.2:}$$

$$= 0.35 * 906.0 / (2 * 154.679 * 1.0 - 0.35) + 3.0$$

$$= 4.026 \text{ mm}$$

EN 13445 Section 9 - Pressure Area Design Method:

Dist from Center of Nozzle to Nearest Circ. Seam: 950.000 mm

Credit Distance along the Shell per 9.5.1 [Iso, l's]:

$$= \sqrt{(2 * r_{is} + e_{c,s}) e_{c,s} }$$

$$= \sqrt{(2 * 5501.0 + 21.0) 21.0 } \quad (\text{where } e_{c,s} \text{ is } e_{a,s})$$

$$= 481.13 \text{ mm}$$

Note: l's equals Iso if no physical diameter limit value is entered. Otherwise l's considers the physical diameter limit entry.

Inside Radius per paragraph 9.5-3 [ris]:

$$= (D_i + 2 * c) / 2$$

$$= (11000.0 + 2 * 1.0) / 2$$

$$= 5501.00 \text{ mm}$$

Credit Distance Along the Nozzle per 9.5-76 [Ibo]:

$$= \min(\sqrt{(d_{eb} - 2 * c_{ext} - e_{ab}) e_{ab} }, h_o)$$

$$= \min(\sqrt{(932.0 - 2 * 0.0 - 13.0) 13.0 }, 250.0)$$

$$= 109.30 \text{ mm}$$

Credit Distance Along the Nozzle per 9.5-77 [Ibi]:

$$= \min(h_i, 0.5 * I_{bo})$$

$$= \min(0.0, 0.5 * 109.3)$$

$$= 0.00 \text{ mm}$$

Compute area in the re-pad [Afp]:

$$= I_p * \min(e_{a,p} ; e_{c,s})$$

$$= 184.0 * 21.0$$

$$= 3864.0 \text{ mm}^2$$

Calculate the Pressure Area per 9.5-60 [Aps]:

Note: a (nozzle OD/2) taken as the diameter of the hole in the shell.

$$= r_{is} (l's + a)$$

$$= 5501.0 (481.127 + 466.0)$$

$$= 5210.144 \times 10^3 \text{ mm}^2$$

Pressure Area of Nozzle using dib and Ibo [Apb]:

$$\begin{aligned}
 &= 0.5 * dib(I'b + ea,s) \\
 &= 0.5 * 906.0(109.3 + 21.0) \\
 &= 59.027 \times 10^3 \text{ mm}^2
 \end{aligned}$$

Note: Pad Width assumed to be constant around the Nozzle perimeter.

Available Metal Areas per 9.5-78 to 9.5-81 [Afs, Afb, Afp, Afw]:

Area [Afs]:

$$\begin{aligned}
 &= l's * ea,s \\
 &= 481.13 * 21.0 \\
 &= 10103.662 \text{ mm}^2
 \end{aligned}$$

Area [Afb]:

$$\begin{aligned}
 &= eb(l'b + l'bi + e's) \\
 &= 13.0(109.3 + 0.0 + 21.0) \\
 &= 1693.930 \text{ mm}^2
 \end{aligned}$$

Area [Afp]:

$$\begin{aligned}
 &= Ip * \min(ea,p; ec,s) \\
 &= 184.0 * 21.0 \\
 &= 3864.000 \text{ mm}^2
 \end{aligned}$$

Area [Afw]:

$$\begin{aligned}
 &= (wshell^2 + wpad^2 + winside^2) / 2 \\
 &= (10.0^2 + 18.0^2 + 0.0^2)/2 \\
 &= 212.000 \text{ mm}^2
 \end{aligned}$$

Note: The welds are considered to be corroded.

Calculation per paragraph 9.5.2.1.1 [fob, fop]:

$$\begin{aligned}
 fob &= \min(fs, fb) = \min(151.01, 154.68) = 151.01 \text{ MPa} \\
 fop &= \min(fs, fp) = \min(151.01, 150.01) = 150.01 \text{ MPa}
 \end{aligned}$$

Force Term per 9.5.2.1.1 [Pa]:

$$\begin{aligned}
 &= P(Aps + Apb + 0.5 * Appsi) \\
 &= 0.35(5210144 + 59026.95 + 0.5*0.0) \\
 &= 1844.05 \times 10^3 \text{ N}
 \end{aligned}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$\begin{aligned}
 &= (Afs+Afw)(fs-0.5P) + Afp(\min(fs,fp) - 0.5P) + Afb(\min(fs,fb) - 0.5P) \\
 &= (10103.7 + 212.0)(151.01 - 0.5 * 0.35) + \\
 &\quad 3864.0(\min(151.01, 150.01) - 0.50 * 0.35) + \\
 &\quad 1693.9(\min(151.01, 154.68) - 0.50 * 0.35) \\
 &= 2390.25 \times 10^3 \text{ N}
 \end{aligned}$$

Since Fa >= Pa, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:

$$\begin{aligned}
 &= ((Afs + Afw)fs + Afb * fob + Afp * fop) / \\
 &\quad ((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp)) \\
 &= ((10103.66+212.0)151.01+1693.93*151.01+3864.0*150.01)/ \\
 &\quad ((5210144+59026.95+0.5*0.0)+0.5(69.66+212.0+1693.93+26.64)) \\
 &= 0.454 \text{ MPa}
 \end{aligned}$$

Nozzle Pmax including Liquid Pressure: 0.454 = 0.454 - 0.0 MPa

Checking the Nozzle Reinforcement in the Transverse direction:

PV Elite 26 Licensee: Unknown Company
 FileName : R-202-NOZZLES-----
 Nozzle Calcs.: Manhole Z3 Noz1: 40 10:41am Jul 22,2026

Determine Shell/Head mean Radius [rms]:

$$\begin{aligned}
 &= ris + 0.5 * ea,s \\
 &= 5501.0 + 0.5 * 21.0 \\
 &= 5511.50 \text{ mm}
 \end{aligned}$$

Determine intermediate Angle [delta]:

$$\begin{aligned}
 &= deb / (2 * rms) \\
 &= 932.0 / (2 * 5511.5) \\
 &= 0.0846 \text{ radians}
 \end{aligned}$$

Determine Opening Length [a]:

$$\begin{aligned}
 &= rms * \text{asin}(\min(1, \text{delta})) \\
 &= 5511.5 * \text{asin}(1, 0.0846) \\
 &= 466.56 \text{ mm}
 \end{aligned}$$

Determine Pressure Loaded Area [Aps]:

$$\begin{aligned}
 &= 0.5 * ris^2(l's + a) / (0.5 * ea,s + ris) \\
 &= 0.5 * 5501.0^2(481.13 + 466.56) / (0.5 * 21.0 + 5501.0) \\
 &= 2601638.25 \text{ mm}^2
 \end{aligned}$$

Force Term per 9.5.2.1.1 [Pa]:

$$\begin{aligned}
 &= P(Aps + Apb + 0.5 * Appsi) \\
 &= 0.35(2601638 + 59026.95 + 0.5*0.0) \\
 &= 931.15 \times 10^3 \text{ N}
 \end{aligned}$$

Force requirement per paragraph 9.5.2.1.1 [Fa]:

$$\begin{aligned}
 &= (Afs+Afw)(fs-0.5P) + Afp(\min(fs,fp) - 0.5P) + Afb(\min(fs,fb) - 0.5P) \\
 &= (10103.7 + 212.0)(151.01 - 0.5 * 0.35) + \\
 &\quad 3864.0(\min(151.01, 150.01) - 0.50 * 0.35) + \\
 &\quad 1693.9(\min(151.01, 154.68) - 0.50 * 0.35) \\
 &= 2390.25 \times 10^3 \text{ N}
 \end{aligned}$$

Since $F_a \geq P_a$, Code Requirements are satisfied.

Determination of Maximum Pressure in this Plane (9.5-10) [Pmax]:

$$\begin{aligned}
 &= ((Afs + Afw)fs + Afb * fob + Afp * fop) / \\
 &\quad ((Aps + Apb + 0.5 * Appsi) + 0.5(Afs + Afw + Afb + Afp)) \\
 &= ((10103.66+212.0)151.01+1693.93*151.01+3864.0*150.01)/ \\
 &\quad ((2601638+59026.95+0.5*0.0)+0.5(69.66+212.0+1693.93+26.64)) \\
 &= 0.897 \text{ MPa}
 \end{aligned}$$

Nozzle Pmax including Liquid Pressure: $0.897 = 0.897 - 0.0 \text{ MPa}$

The Drop for this Nozzle is : 19.7771 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 291.7769 mm

For possible nozzle interference - See Nozzle Summary

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Išvada:

Atliktas regeneratoriaus R-202 keičiamų elementų stiprumo skaičiavimas rodo, kad leistinos apkrovos nesukelia lestinų metalo įtempimų viršijimo.