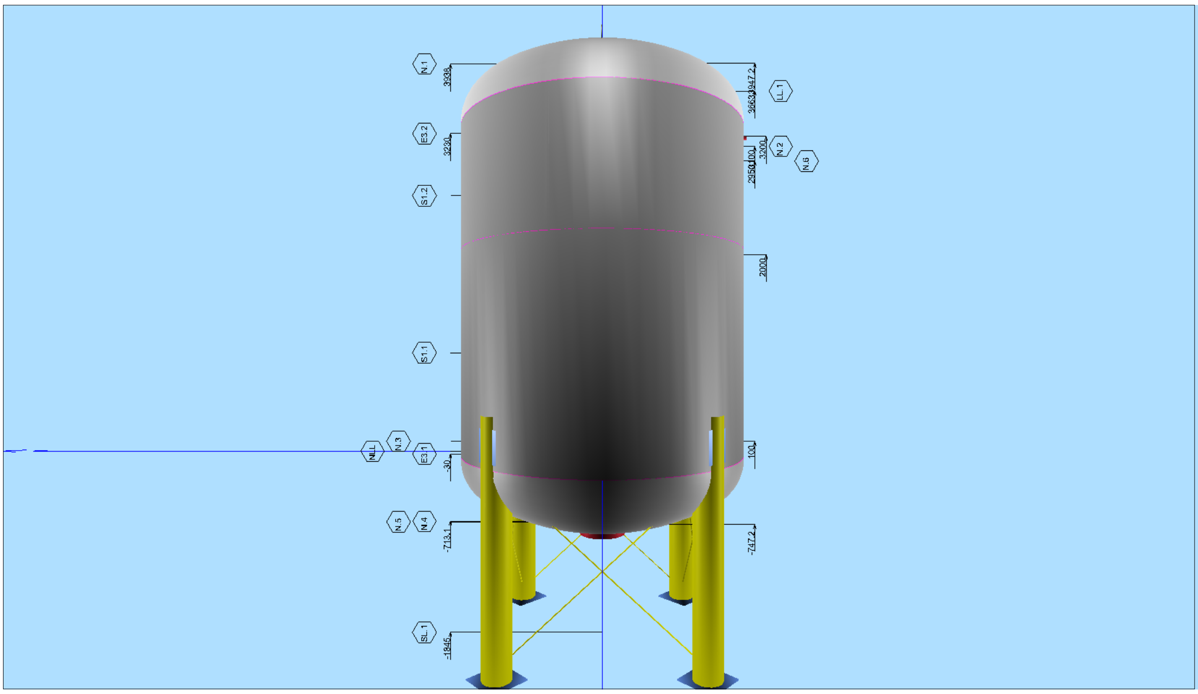
Company Name -

Client : Vessel Tag No.:BRW.BBT.V.028.002.0.0.P

Visual Vessel Design by Hexagon AB,Ver:19.0 Operator : Rev.:5

(0) Drawing

3D View of Vessel (alter by using the Save User Specified View command)



History of Revisions

Rev	ID	Component Type	Comp. Description	DATE & TIME
5	E3.1	Torispherical End		20 June 2019 12:24
5	E3.2	Torispherical End		20 June 2019 12:24
5	GO.1	Groups of Nozzles/Op		20 June 2019 12:25
5	LL.1	Lifting Lugs		08 July 2019 10:45
5	N.1	Reinforcement Ring	Flange for Instrumental Top Pl	20 June 2019 12:24
5	N.2	Reinforcement Ring	Adaptor for level switch	20 June 2019 12:24
5	N.3	Reinforcement Ring	Sample Valve	20 June 2019 12:24
5	N.4	Nozzle,Seamless Pipe	Outlet	20 June 2019 12:24
5	N.5	Reinforcement Ring	Adaptor for level transmitter	20 June 2019 12:24
5	N.6	Nozzle,Seamless Pipe	Side outlet	20 June 2019 12:24
5	S1.1	Cylindrical Shell	Main Shell	20 June 2019 12:24
5	S1.2	Cylindrical Shell	Main Shell	20 June 2019 12:24
5	SL.1	Leg Support	Support	20 June 2019 12:24

5 First Issue 21 Mar. 2019 10:50

Design Data & Process Information

Description	Units	Design Data
Process Card		General Design Data
Design Code & Specifications		EN13445 TG = 3b
Internal Design Pressure (MPa)	MPa	0.2
External Design Pressure (MPa)	MPa	0.002
Hydrotest Pressure (MPa)	MPa	0.31
Maximum Design Temperature ('C)	'C	90
Minimum Design Temperature ('C)	'C	0
Operating Temperature ('C)	'C	85
Corrosion Allowance (mm)	mm	
Content of Vessel		

Description	Units	Design Data
Specific Density of Oper.Liq		1
Normal Liquid Level NLL (mm)	mm	

Weight & Volume of Vessel

ID	No.	Wt-UnFinish.	Wt-Finished	Tot.Volume	Test.Liq.Wt	Oper.Liq.Wt
E3.1	1	351.0 kg	344.3 kg	3.069 m3	3069.0 kg	3069.3 kg
E3.2	1	351.0 kg	341.5 kg	3.069 m3	3069.0 kg	0.0 kg
LL.1	1	2.0 kg	2.0 kg	0.000 m3	0.0 kg	0.0 kg
N.1	1	16.0 kg	16.0 kg	0.005 m3	5.0 kg	0.0 kg
N.2	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.3	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.4	1	5.0 kg	5.0 kg	0.014 m3	14.0 kg	13.5 kg
N.5	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.6	1	1.0 kg	1.0 kg	0.001 m3	1.0 kg	0.0 kg
S1.1	1	559.0 kg	559.0 kg	12.315 m3	12315.0 kg	0.0 kg
S1.2	1	336.0 kg	335.7 kg	7.389 m3	7389.0 kg	0.0 kg
SL.1	1	163.0 kg	163.0 kg	0.000 m3	0.0 kg	0.0 kg
Total	**12**	**1787.0 kg**	**1770.5 kg**	**25.862 m3**	**25862.0 kg**	**3082.8 kg**

Weight Summary/Condition	Weights
Empty Weight of Vessel incl. 5% Contingency	1859 kg / 1.9 Tons
Total Test Weight of Vessel (Testing with Water)	27721 kg / 27.7 Tons
Total Operating Weight of Vessel	4942 kg / 4.9 Tons

Center of Gravity

ID	X-Empty	Y-Empty	Z-Empty	X-Test	Y-Test	Z-Test	X-Oper	Y-Oper	Z-Oper
E3.1	0	0	-485	0	0	-278	0	0	-278
E3.2	0	0	3653	0	0	3478	0	0	3478
LL.1	0	1100	6613	0	1100	6613	0	1100	6613
N.1	0	0	3961	0	0	3961	0	0	3961
N.2	-1398	247	3100	-1398	247	3100	-1398	247	3100
N.3	0	-1408	100	0	-1408	100	0	-1408	100
N.4	0	0	-783	0	0	-783	0	0	-783
N.5	148	318	-725	148	318	-725	148	318	-725
N.6	-1026	-1026	2950	-1026	-1026	2950	-1026	-1026	2950
S1.1	0	0	1000	0	0	1000	0	0	1000
S1.2	1	1	2598	0	0	2600	0	0	2600
SL.1	0	0	-748	0	0	-748	0	0	-748

CENTER OF GRAVITY AT CONDITIONS BELOW	X	Y	Z
Empty Vessel	-1	0	1394
Test Condition of Vessel (Testing with Water)	0	0	1586
Operating Condition of Vessel	0	0	331

Max. Allowable Pressure MAWP

ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
E3.1	Torispherical End		0.000 MPa	0.410 MPa	0.262 MPa
E3.2	Torispherical End		0.000 MPa	0.410 MPa	0.262 MPa
N.1	Reinforcement Ring	Flange for Instrumental Top PI	0.000 MPa	0.724 MPa	0.593 MPa
N.2	Reinforcement Ring	Adaptor for level switch	0.000 MPa	0.506 MPa	0.420 MPa
N.3	Reinforcement Ring	Sample Valve	0.000 MPa	0.518 MPa	0.432 MPa

ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
N.4	Nozzle,Seamless Pipe	Outlet	0.007 MPa	0.336 MPa	0.278 MPa
N.5	Reinforcement Ring	Adaptor for level transmitter	0.007 MPa	0.674 MPa	0.555 MPa
N.6	Nozzle,Seamless Pipe	Side outlet	0.000 MPa	0.334 MPa	0.275 MPa
S1.1	Cylindrical Shell	Main Shell	0.000 MPa	0.404 MPa	0.331 MPa
S1.2	Cylindrical Shell	Main Shell	0.000 MPa	0.404 MPa	0.331 MPa
	MAWP			**0.334 MPa**	**0.262 MPa**

Note : Other components may limit the MAWP than the ones checked above.
Note : The value for MAWP is at top of vessel, with static liquid head subtracted.

Test Pressure

TEST PRESSURE OF VESSEL - NEW & COLD - VERTICAL

Design Pressure.........................: 0.200 MPa
Specified Test Pressure.................: 0.310 MPa
Design Temperature......................: 90.0 C

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
E3.1	Torispherical End-	0.200	0.585	0.305	0.072	0.305	0.513
E3.2	Torispherical End-	0.200	0.585	0.305	0.034	0.305	0.552
GO.1	Nozzle Group: N.4 - N.5 Located in:E3.1 Torispherical End	0.207	0.447	NA	0.00734	NA	0.440
N.1	Reinforcement Ring-Flange for Instrumental Top Pl	0.200	1.066	NA	0.026	NA	1.040
N.2	Reinforcement Ring-Adaptor for level switch	0.200	0.747	NA	0.021	NA	0.726
N.3	Reinforcement Ring-Sample Valve	0.200	0.766	NA	0.064	NA	0.702
N.4	Nozzle,Seamless Pipe-Outlet	0.207	0.503	NA	0.073	NA	0.429
N.5	Reinforcement Ring-Adaptor for level transmitter	0.207	1.005	NA	0.072	NA	0.933
N.6	Nozzle,Seamless Pipe-Side outlet	0.200	0.491	NA	0.026	NA	0.465
S1.1	Cylindrical Shell-Main Shell	0.200	0.699	0.305	0.065	0.305	0.634
S1.2	Cylindrical Shell-Main Shell	0.200	0.699	0.305	0.045	0.305	0.654

PtReq = MAX(MIN(PtTop), 1.43*p)= 0.3051 MPa (EN13445-5, 10.2.3.3.1-1 & 2)

HYDRO-TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Hydro Test) ......: 0.3051 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Hydro Test) ....: 0.3821 MPa

PNEUMATIC TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..: 0.3132 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...: 0.4470 MPa

TEST PRESSURE OF: 0.310 MPa AT TOP OF VESSEL IS OK FOR ABOVE COMPONENTS.
Note : Other components may limit Ptlim than the ones checked above.

TEST PRESSURE OF VESSEL - NEW & COLD - HORIZONTAL

Design Pressure.........................: 0.200 MPa
Specified Test Pressure.................: 0.310 MPa
Design Temperature......................: 90.0 C

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
E3.1	Torispherical End-	0.200	0.585	0.305	0.014	0.305	0.572
E3.2	Torispherical End-	0.200	0.585	0.305	0.028	0.305	0.558
GO.1	Nozzle Group: N.4 - N.5 Located in:E3.1 Torispherical End	0.207	0.447	NA	0.00734	NA	0.440
N.1	Reinforcement Ring-Flange for Instrumental Top Pl	0.200	1.066	NA	0.016	NA	1.049
N.2	Reinforcement Ring-Adaptor for level switch	0.200	0.747	NA	0.028	NA	0.719
N.3	Reinforcement Ring-Sample Valve	0.200	0.766	NA	0.028	NA	0.739
N.4	Nozzle,Seamless Pipe-Outlet	0.207	0.503	NA	0.014	NA	0.489

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
N.5	Reinforcement Ring-Adaptor for level transmitter	0.207	1.005	NA	0.015	NA	0.990
N.6	Nozzle,Seamless Pipe-Side outlet	0.200	0.491	NA	0.031	NA	0.459
S1.1	Cylindrical Shell-Main Shell	0.200	0.699	0.305	0.028	0.305	0.672
S1.2	Cylindrical Shell-Main Shell	0.200	0.699	0.305	0.028	0.305	0.672

```
PtReq = MAX(MIN(PtTop), 1.43*p)=  0.3051 MPa (EN13445-5, 10.2.3.3.1-1 & 2)
```

HYDRO-TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Hydro Test) ......:     0.3051 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Hydro Test) .......:     0.4194 MPa
```

PNEUMATIC TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..:     0.3132 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...:     0.4470 MPa

TEST PRESSURE OF:   0.310 MPa AT TOP OF VESSEL IS OK FOR ABOVE COMPONENTS.
Note : Other components may limit Ptlim than the ones checked above.
```

NOMENCLATURE:

Pdesign- is the design pressure including liquid head at the part under consideration.

PtMax - is the maximum allowed test pressure determined at the part under consideration.

PtMin - is the required test pressure determined at the part under consideration.

Wat.Head - is the water head during hydrotesting at the part under consideration.

PtBot - is the required test pressure at bottom of the vessel, for the part under consideration.

PtTop - is the required test pressure at top of the vessel, for the part under consideration.

PtTopMax - is the maximum test pressure allowed at top of the vessel, for the part under consideration.

PtReq - is the required minimum test pressure (minimum value of PtTop) at top of vessel for the listed components.

PtLim - is the maximum allowed test pressure (minimum value for PtTopMax) at top of vessel for the listed components.

EN13445-5 10.2.3.3.8 Pressure of vessels under test shall be gradually increased to a value of approximately 50 % of the specified test pressure, thereafter the pressure shall be increased in stages of approximately 10 % of the specified test pressure until this is reached. The required test pressure shall be maintained for not less than 30 min. At no stage shall the vessel be approached for close examination until the pressure has been positively reduced by at least 10 % to a level lower than that previously attained. The pressure shall be maintained at the specified close examination level for a sufficient length of time to permit a visual inspection to be made of all surfaces and joints.

Bill of Materials

ID	No	Description	Component Dimensions	Material Standard
E3.1	1	Torispherical End-	De= 2810, wt= 5, h= 719.73, R= 2248, r= 432.74, Not Applicable	ID 1, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
E3.2	1	Torispherical End-	De= 2810, wt= 5, h= 719.73, R= 2248, r= 432.74, Not Applicable	ID 1, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
LL.1	1	Lifting Lugs-	LUG PL10x100x130,PAD PL5x130x185,FR=10.9kN,dh=40mm	ID 3, EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A
N.1	1	Reinforcement Ring-Flange for Instrumental Top PI	do=550,di=450,thk=25	ID 1, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
N.2	1	Reinforcement Ring-Adaptor for level switch	do=30,di=19,thk=34	ID 6, EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT
N.3	1	Reinforcement Ring-Sample Valve	do=28,di=8,thk=10	ID 7, EN 10222-5:2017, 1.4404 X2CrNiMo17-12-2 forging, HT:AT
N.4	1	Nozzle,Seamless Pipe-Outlet	do=458,wt=4,L=91.7,ho=80	ID 8, EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT
N.5	1	Reinforcement Ring-Adaptor for level transmitter	do=65,di=44,thk=8	ID 6, EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT

ID	No	Description	Component Dimensions	Material Standard
N.6	1	Nozzle,Seamless Pipe-Side outlet	do=104,wt=2,L=105,ho=100	ID 8, EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT
S1.1	1	Cylindrical Shell-Main Shell	De= 2808, en= 4, L= 2000	ID 1, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
S1.2	1	Cylindrical Shell-Main Shell	De= 2808, en= 4, L= 1200	ID 1, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
SL.1	1	Leg Support-Support	4 off Legs;Pipe , H= 2170;, Reinf.Pad PL 300X 250X 4	ID 9, EN 10217-7:2014, 1.4307 X2CrNi18-9 welded tube, HT:AT

Notes, Warning & Error Messages

ID & Comp. Description	Notes/Warnings/Error Messages
S1.1 Cylindrical Shell Main Shell	
-	NOTE: Circularity tolerance limit(in % of radius) =0.016% (based on unsupported length L= 4705 mm
-	NOTE: Maximum unsupported length for given shell thickness Lmax = 14587 mm (en = 4 mm)
-	NOTE: Required minimum shell thickness due to external pressure emin(ext)= 2.63 mm (unsupported length L= 4705 mm)
-	NOTE: EN13445-4 Table 9.4.1 d) for requirement for heat treatment of austenitic steels.
E3.1 Torispherical End	
-	NOTE: Thickness difference between end and adjoining element: 1 mm, please observe weld design details to EN13445-3 Table A-2
S1.2 Cylindrical Shell Main Shell	
-	NOTE: Circularity tolerance limit(in % of radius) =0.016% (based on unsupported length L= 4705 mm
-	NOTE: Maximum unsupported length for given shell thickness Lmax = 14587 mm (en = 4 mm)
-	NOTE: Required minimum shell thickness due to external pressure emin(ext)= 2.63 mm (unsupported length L= 4705 mm)
-	NOTE: EN13445-4 Table 9.4.1 d) for requirement for heat treatment of austenitic steels.
E3.2 Torispherical End	
-	NOTE: Thickness difference between end and adjoining element: 1 mm, please observe weld design details to EN13445-3 Table A-2
SL.1 Leg Support Support	
-	NOTE: The local stresses due to loads from the legs are assumed to be taken by the cylindrical shell only.
-	NOTE: For legs made of pipe it is required to weld the leg into both the head as well as the cylindrical shell.
-	NOTE: APPLICATION OF MORE THAN 3 BRACKETS/LEGS REQUIRES SPECIAL CARE DURING ASSEMBLY TO ENSURE NEARLY EQUAL LOAD DISTRIBUTION.
-	NOTE: The maximum force(in tension and compression) in the cross bracing is FbraceMax=1.3 kN
-	NOTE: The cross bracing strength has not been checked.
LL.1 Lifting Lugs	
-	$S220:1$DNV Cert.Notes 2.7-1 Annex D
-	NOTE: The minimum shackle pin/bolt diameter shall be dpmin= 37.74mm based on a bolt hole diameter of dh= 40mm

TOTAL No. OF ERRORS/WARNINGS : 0

Nozzle List

ID	Service	SIZE	STANDARD/CLASS	ID	Standout	X	Y	Z	Rot.	Orient.
N.1	Flange for Instrumental Top PI	DN450		450	25	0	0	3947.2	0	Radial
N.2	Adaptor for level switch			19	34	-1380.7	243.5	3100	170	Radial
N.3	Sample Valve			8	10	0	-1402	100	270	Radial
N.4	Outlet			450.8	80	0	0	-747.2	0	Radial
N.5	Adaptor for level transmitter			44	8	147.9	317.2	-719.8	65	Radial
N.6	Side outlet			100.5	100	-991.4	-991.4	2950	225	Radial

Maximum Component Utilization - Umax

ID	Comp.Type	Umax(%)	Limited by
E3.1	Torispherical End	84.2%	Internal Pressure
E3.2	Torispherical End	84.2%	Internal Pressure
GO.1	Groups of Nozzles/Op	81.5%	Nozzle Reinforcement N.4 - N.5
LL.1	Lifting Lugs	99.8%	Local Force on Lifting Lug(Lon
N.1	Reinforcement Ring	33.6%	Nozzle Reinforcement
N.2	Reinforcement Ring	47.6%	Nozzle Reinforcement
N.3	Reinforcement Ring	46.2%	Nozzle Reinforcement
N.4	Nozzle,Seamless Pipe	72.7%	Nozzle Reinforcement
N.5	Reinforcement Ring	36.7%	Nozzle Reinforcement
N.6	Nozzle,Seamless Pipe	72.6%	Nozzle Reinforcement
S1.1	Cylindrical Shell	63.3%	Internal Pressure
S1.2	Cylindrical Shell	63.3%	Internal Pressure
SL.1	Leg Support	53.1%	Combined Stress in Welds betw.

```
Component with highest utilization    Umax = 99.8% LL.1

Average utilization of all components Umean= 64.5%
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Material Data/Mechanical Properties

ID	Material Name	Temp	Rm	Rp	Rpt	f_d	f20	ftest	E-mod	Note
1	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, TG3, SS, Mat.Group:8.1, , Max.T= 8mm, SG=7.93	90	530	270	207.9	147.5	180	265	194028	
2	EN 10216-5:2013, 1.4307 X2CrNi18-9 seamless tube, HT:AT TG3, SS, Mat.Group:8.1, , Max.T= 60mm, SG=7.93	90	460	215	184	122.7	153.3	230	194028	
3	EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A TG3, SS, Mat.Group:8.1, , Max.T= 8mm, SG=7.93	90	520	250	189.6	141.3	173.3	260	194028	
4	EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT TG3, SS, Mat.Group:8.1, , Max.T= 60mm, SG=7.93	90	490	225	203.4	135.6	150	214.3	194028	
5	EN 10272:2016, 1.4435 X2CrNiMo18-14-3 bar, HT:AT TG3, SS, Mat.Group:8.1, , Max.T= 160mm, SG=7.93	90	500	235	204.4	143.3	166.7	250	194028	
6	EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT TG3, SS, Mat.Group:8.1, , Max.T= 160mm, SG=7.93	90	500	235	204.4	146.3	166.7	250	194028	
7	EN 10222-5:2017, 1.4404 X2CrNiMo17-12-2 forging, HT:AT TG3, SS, Mat.Group:8.1, , Max.T= 250mm, SG=7.93	90	490	225	202.3	145.8	163.3	245	194028	
8	EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT TG3, SS, Mat.Group:8.1, , Max.T= 60mm, SG=7.93	90	490	225	202.6	135.1	150	214.3	194028	
9	EN 10217-7:2014, 1.4307 X2CrNi18-9 welded tube, HT:AT TG3, SS, Mat.Group:8.1, , Max.T= 60mm, SG=7.93	90	470	215	184.8	123.2	156.7	235	194028	

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Notation:
Thickness in mm, stress in N/mm2, temperature in deg.C
TG   : Test Group 1 to 4
Max.T: Maximum thickness for this stress set, 0 or 999 = No limit specified
S/C  : CS = Carbon Steel, SS = Stainless Steel
SG   : SG = Specific Gravity (Water = 1.0)
Rm   : MIN.TENSILE STRENGTH at ambient temp.
Rp   : MIN. PROOF STRENGTH at ambient temp.
Rpt  : MIN. PROOF STRENGTH at calc.temp.
f_d  : DESIGN STRESS at calc.temp.
f20  : DESIGN STRESS at ambient temp.
GRP  : 8.1 = Austenitic stainless steels with Cr <= 19 %
GRP  : 8.0 = Austenitic steels
HT   : AT = solution annealed
HT   : A = annealed
HT   : AT = solution annealed
HT   : AT = solution annealed
HT   : AT = solution annealed
HT   : AT = solution annealed
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HT   : AT = solution annealed
HT   : AT = solution annealed
```

Comp.Location in Global Coord.System

ID	Comp. Type	X	Y	Z	Teta	Phi	ConnID
E3.1	Torispherical End	0	0	0	0.0	0.0	S1.1
E3.2	Torispherical End	0	0	3200	0.0	0.0	S1.2
LL.1	Lifting Lugs	0	1100	3663	0.0	0.0	E3.2
N.1	Reinforcement Ring	0	0	3947	0.0	0.0	E3.2
N.2	Reinforcement Ring	-1381	243	3100	90.0	170.0	S1.2
N.3	Reinforcement Ring	0	-1402	100	90.0	270.0	S1.1
N.4	Nozzle,Seamless Pipe	0	0	-747	0.0	0.0	E3.1
N.5	Reinforcement Ring	148	317	-720	-9.0	65.0	E3.1
N.6	Nozzle,Seamless Pipe	-991	-991	2950	90.0	225.0	S1.2
S1.1	Cylindrical Shell	0	0	0	0.0	0.0	
S1.2	Cylindrical Shell	0	0	2000	0.0	0.0	S1.1
SL.1	Leg Support	0	0	0	0.0	0.0	S1.1

The report above shows the location of the connecting point (x, y and z) for each component referenced to the coordinate system of the connecting component (ConnID). The connecting point (x, y and z) is always on the center axis of rotational symmetry for the component under consideration, i.e. the connecting point for a nozzle connected to a cylindrical shell will be at the intersection of the nozzle center axis and the mid thickness of the shell referenced to the shell s coordinate system. In addition the orientation of the the center axis of the component is given by the two angles Teta and Phi, where Teta is the angle between the center axis of the two components and Phi is the orientation in the x-y plane
The basis for the coordinate system used by the software is a right handed coordinate system with the z-axis as the center axis of rotational geometry for the components, and Teta as the Polar Angle and Phi as the Azimuthal Angle

Impact Test Requirements

Table :

ID-Description	Material Name	en(mm)	eB(mm)	Re(N/mm2)	f/fd
E3.1 - End	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	5.0	5.0	270.0	0.84
E3.2 - End	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	5.0	5.0	270.0	0.84
N.1 Flange for Instrumental Top Pl - Ring	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	50.0	50.0	270.0	0.34
N.2 Adaptor for level switch - Ring	EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT	5.5	5.5	235.0	0.48
N.3 Sample Valve - Ring	EN 10222-5:2017, 1.4404 X2CrNiMo17-12-2 forging, HT:AT	10.0	10.0	225.0	0.46
N.4 Outlet - Nozzle	EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT	4.0	4.0	225.0	0.73
N.5 Adaptor for level transmitter - Ring	EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT	10.5	10.5	235.0	0.37
N.6 Side outlet - Nozzle	EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT	2.0	2.0	225.0	0.73
S1.1 Main Shell - Shell	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	4.0	4.0	270.0	0.63
S1.2 Main Shell - Shell	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	4.0	4.0	270.0	0.63

Table Continued

ID-Description	Ts(C)	TR(C)	TR+Ts	TKVPWHT	TKVAW	Comments
E3.1 - End	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C
E3.2 - End	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C
N.1 Flange for Instrumental Top Pl - Ring	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C
N.2 Adaptor for level switch - Ring	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C
N.3 Sample Valve - Ring	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C

ID-Description	Ts(C)	TR(C)	TR+Ts	TKVPWHT	TKVAW	Comments
N.4 Outlet - Nozzle	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C
N.5 Adaptor for level transmitter - Ring	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C
N.6 Side outlet - Nozzle	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C
S1.1 Main Shell - Shell	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C
S1.2 Main Shell - Shell	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C

```
EN13445-2 Annex B, Requirements for Prevention of Brittle Fracture
B.2.3 Method 2 - Code of practice developed from fracture mechanics

NOMENCLATURE:
  en      - Nominal thickness of component under consideration(including corr.
allow.).
  eB      - Reference thickness of component under consideration from Table B.4-1.
  Re      - Minimum specified yield strength at room temperature.
  AW      - As Welded condition.
  PWHT    - Post Weld Heat Treatment.
  f/fd    - Ratio in Table B.2-12, f=membrane stress, fd=allowable stress.
  TR      - Design Reference Temperature.
  Ts      - Temperature adjustment according to Table B.2-12.
  NOTE:   - Ts, the temperature adjustment according to Table B.2-12 has been based
on the design conditions. If a reduced pressure exist at low temperature further
adjustment may be possible.
  KV&TKV - Parent material, welds and HAZs shall meet the impact energy KV at the
impact temperature TKV.
  TKVPWHT- Material impact test temperature for PWHT condition from Figure B.2-1,
3, 5 or 7, and required impact energy 27J, 40J or 60J.
  TKVAW   - Material impact test temperature for AW condition from Figure B.2-2, 4,
6, 8, 9, 10 or 11, and required impact energy 27J or 40J.
  NOTE 1:- Steel designation unknown, this method is only applicable for ferritic
steels(C, CMn and fine grain) and 1.5% to 5% Ni-alloy steels.
```

NDT - Requirements for Test Group :3b

Table EN13445-5, 6.6.2-1:

Weld ID	Weld Category	Weld Type	RT or UT	MT or PT
1	Full Penetration butt weld	Longitudinal joints	10%	0
2a	Full Penetration butt weld	Circumferential joints on a shell	5%(c	0
2b	Full Penetration butt weld	Circumferential joints on a shell with backing strip (k)	NA	100%
2c	Full Penetration butt weld	Circumferential joggle joint (k)	NA	100%
3a	Full Penetration butt weld	Circumferential joints on a nozzle di > 150 mm and e > 16 mm	5%(c	10%(d)
3b	Full Penetration butt weld	Circumferential joints on a nozzle di > 150 mm and e > 16 mm with backing strip (k)	NA	100%
4	Full Penetration butt weld	Circumferential joints on a nozzle with di <= 150 mm or e <= 16mm	0	5%
5	Full Penetration butt weld	All welds in spheres, heads and hemispherical heads to shells	10%	0
6	Full Penetration butt weld	Assembly of a conical shell with a cylindrical shell without a knuckle(large end of cone) (q, r)	10%	100%
7	Full Penetration butt weld	Assembly of a conical shell with a cylindrical shell without a knuckle(small end of cone)	10%	10%(d)
8a	Circumferential lapped joints (k)	General application shell to head	NA	NA
8b	Circumferential lapped joints (k)	Bellows to shell e <= 8 mm	0 %	10%
9	Assembly of a flat head or a tubesheet, with a cylindrical shell Assembly of a flange or a collar with a shell	With full penetration	5%	10%(d)
10	Assembly of a flat head or a tubesheet, with a cylindrical shell Assembly of a flange or a collar with a shell	With partial penetration if a>16 mm (a as defined in figure 6.6.2-1)(j)	NA	10%

Weld ID	Weld Category	Weld Type	RT or UT	MT or PT
11	Assembly of a flat head or a tubesheet, with a cylindrical shell Assembly of a flange or a collar with a shell	With partial penetration if a<=16 mm (a as defined in figure 6.6.2-1) (j)	NA	10%
12	Assembly of a flange or a collar with a nozzle	With full penetration	5%	10%(d)
13	Assembly of a flange or a collar with a nozzle	With partial penetration (j)	NA	10%
14	Assembly of a flange or a collar with a nozzle	With full or partial penetration di <= 150 mm and e <= 16 mm j	0	10%
15	Nozzle or branch (e)	With full penetration di > 150 mm and e > 16 mm	5%	10%(d)
16	Nozzle or branch (e)	With full penetration di <= 150 mm or e <= 16 mm	0	10%
17	Nozzle or branch (e)	With partial penetration for any di a > 16 mm (see figure 6.6.2-2)	NA	10%(d)
18	Nozzle or branch (e)	With partial penetration di > 150 mm a <= 16 mm (see figure 6.6.2-2)	0	10%
19	Nozzle or branch (e)	With partial penetration di <= 150 mm a <= 16 mm (see figure 6.6.2-2)	0	10%
20	Tube ends into tubesheet	-	-	10%
21	Permanent attachments (f)	With full penetration or partial penetration	10%(d)	10%(d)
22	Pressure retaining areas after removal of temporary attachments	-	-	100%
23	Cladding by welding	-	-	100%
24	Repairs	-	100 %	100%
19i	Nozzle or branch (e)	With reinforcing plate	0	5%
19j	Nozzle or branch (e)	Weld joint in reinforcing plate (s)	10%	0

The above requirements are for test group TG:3b
Notes:
(a): See figure 6.6.2-3 for an explanation on Weld ID.
(b): RT=Radiographic Testing, UT=Ultrasonic Testing, MT=Magnetic Particle Testing, PT=Penetrant Testing.
(c): 2 % if e <= 30mm and same WPS as longitudinal, for steel groups 1.1 and 8.1
(d): 10 % if e > 30 mm, 0 % if e <= 30 mm
(e): Percentage in the table refers to the aggregate weld length of all the nozzles see 6.6.2.5 b).
(f): No RT or UT for weld throat thickness <= 16 mm
(g): 10 % for steel groups 8.2, 9.1, 9.2, 9.3 and 10
(h): Volumetric testing if risks of cracks due to parent material or heat treatment
(i): For explanation of the reduction in NDT in testing group 2, see 6.6.1.2
(j): In exceptional cases or where the design or load bearing on the joint is critical, it may be necessary to employ both techniques (i.e. RT & UT, MT & PT). See table 6.6.3-1 for other circumstances for use of both techniques.
(k): For limitations of application see EN 13445-3, 5.7.3.2
(l): The percentage of surface examination refers to the percentage of length of the welds both on the inside and the outside.
(m): RT and UT are volumetric while MT and PT are surface testing. When referenced in this table both volumetric and surface are necessary to the extent shown.
(n): NA means 'Not Applicable'.
(o): In case of cyclic loading refer to Annex G.2.
(p): Annex A of EN 13445-3 gives design limitations on welds.
(q): Unless the design is such that the thickness at the weld exceeds 1.4*ej (see 7.6.6 of EN13445-3). In which case, use NDT of line 2a.
(r): For connections with knuckle, line 2a applies.
(s): Only MT or PT are applicable if the shell itself is used as backing.
NOTE: All testing groups require 100% visual inspection.
NOTE: G.2 In addition to the requirements of 6.6.2, all locations where the cumulative fatigue index D is greater than 0.8, the surfaces shall be 100% inspected.

EN13445-5, Table 6.6.2-3, Map of Weld Types/Weld ID.

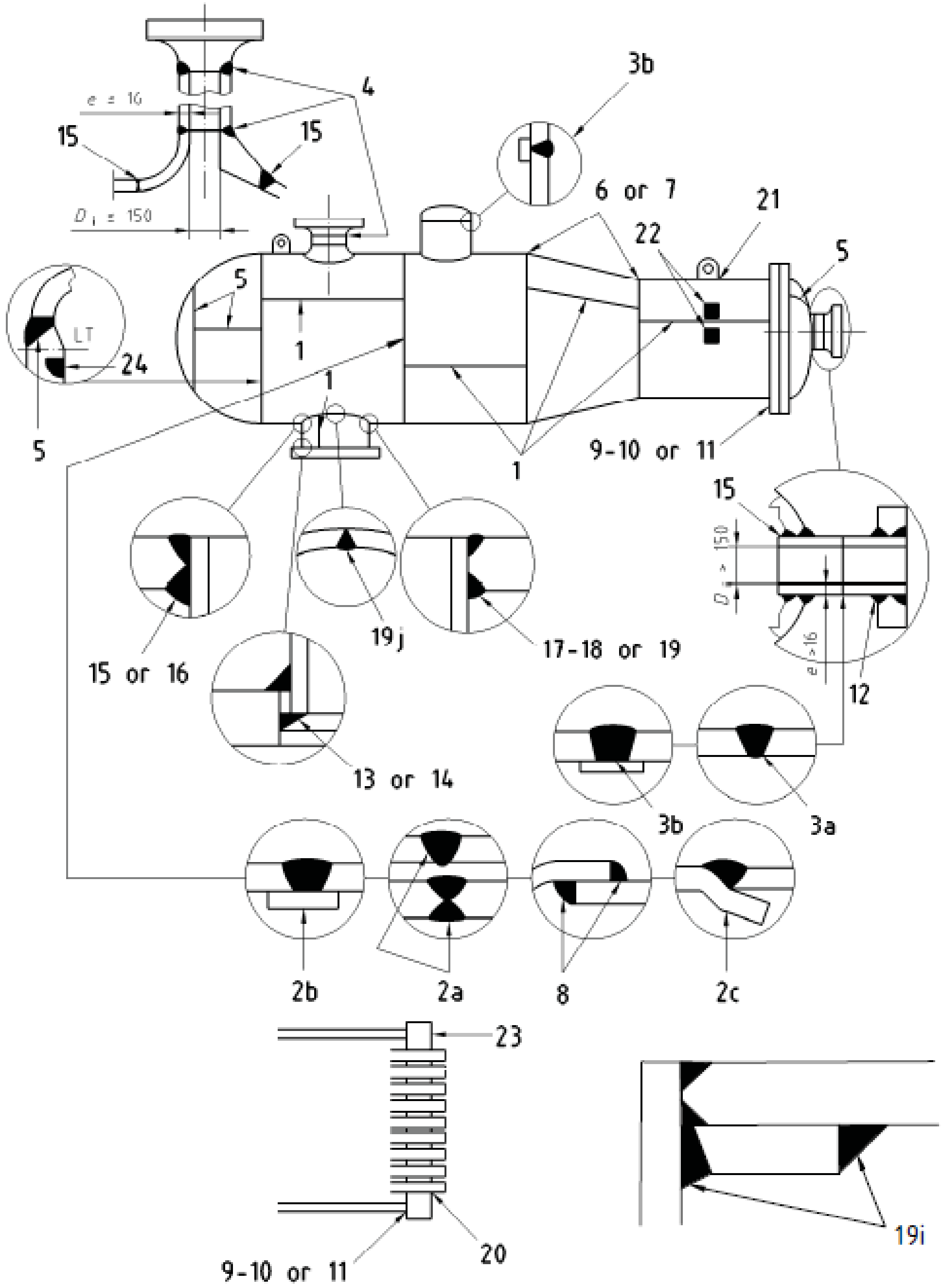
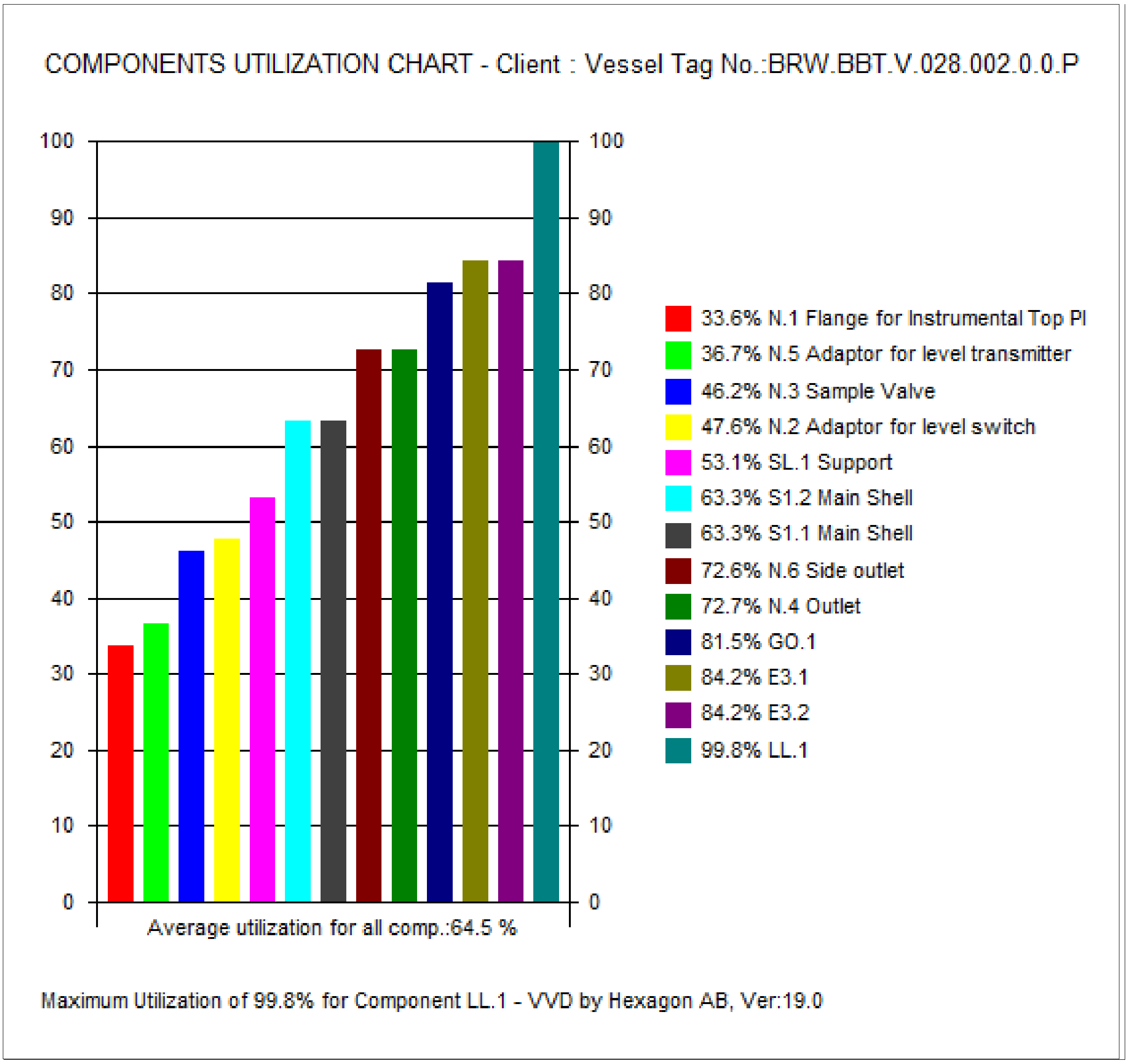


Figure 6.6.2-3 — Type of welds

Utilization Chart

Utilization Chart



Surface Area

ID	No.	Description	Area Outside(m2)	Area Inside(m2)
E3.1	1	Torispherical End,	8.861	8.830
E3.2	1	Torispherical End,	8.861	8.830
LL.1	1	Lifting Lugs,	0.000	0.000
N.1	1	Reinforcement Ring, Flange for Instrumental Top PI	0.043	0.035
N.2	1	Reinforcement Ring, Adaptor for level switch	0.003	0.002
N.3	1	Reinforcement Ring, Sample Valve	0.001	0.000
N.4	1	Nozzle,Seamless Pipe, Outlet	0.115	0.113
N.5	1	Reinforcement Ring, Adaptor for level transmitter	0.002	0.001
N.6	1	Nozzle,Seamless Pipe, Side outlet	0.033	0.031
S1.1	1	Cylindrical Shell, Main Shell	17.643	17.593
S1.2	1	Cylindrical Shell, Main Shell	10.586	10.556
SL.1	1	Leg Support, Support	7.444	0.000
Total	**12**		**53.592**	**45.991**

Foundation Loading

No	Load Case	Fx(kN)	Fy(kN)	Fz(kN)	Mx(kNm)	My(kNm)	Mz(kNm)
1	SL.1-LC9 HYDROTEST	0.00	0.00	-270.95	0.00	0.04	0.00
2	SL.1-LC4 SHUT DOWN	0.01	0.00	-15.87	0.00	0.04	0.00
3	SL.1-LC5 INSTALLATION	0.00	0.00	-15.87	0.00	0.04	0.00
4	SL.1-LC1&2&3 OPER.WIND	0.01	0.00	-46.78	0.00	0.04	0.00
5	SL.1-OPER.SEISMIC	5.43	0.00	-46.78	0.00	15.37	0.01

NOMENCLATURE:
Fx(kN) - Force in horizontal plane x-direction
Fy(kN) - Force in horizontal plane y-direction
Fz(kN) - Force in vertical direction (positive upward)
Mx(kNm)- Moment around x-axis
My(kNm)- Moment around y-axis
Mz(kNm)- Torsional moment around z-axis
Note: All forces and moments are considered to be acting at the elevation at bottom of support, at the interface between the support and the foundation.
Note: The moments above are the global moments considered to be acting at the elevation at the centre of the vessel at the elevation of the support.
Note: VVD applies the primary loading from wind and seismic in the x-direction, the foundation however needs to be able to withstand the same loads from any direction.

Welding Information

EN1708-1 Welding Requirements for Pressurized Components

S1.1 Cylindrical Shell Main Shell
Comment:

E3.1 Torispherical End
Comment:

S1.2 Cylindrical Shell Main Shell
Comment:

E3.2 Torispherical End
Comment:

N.1 Reinforcement Ring Flange for Instrumental Top Pl
Comment:

N.2 Reinforcement Ring Adaptor for level switch
Comment:

N.3 Reinforcement Ring Sample Valve
Comment:

N.4 Nozzle,Seamless Pipe Outlet

Comment:

N.5 Reinforcement Ring Adaptor for level transmitter
Comment:

SL.1 Leg Support Support
Comment:

N.6 Nozzle,Seamless Pipe Side outlet
Comment:

LL.1 Lifting Lugs
Comment:

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          0.00 mm
```

SHELL DATA

```
CYLINDER FABRICATION: Plate Material
WELD JOINT COEFFICIENT: Testing Group  3   (z=0.85)
DIAMETER INPUT: Base Design on Shell Inside Diameter
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 f=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
INSIDE SHELL DIAMETER (corroded)....................:Di       2800.00 mm
LENGTH OF CYLINDRICAL PART OF SHELL.................:Lcyl     2000.00 mm
SAFETY FACTOR (1.0 carbon and 1.25 austenitic steels):s        1.2500
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
Split shell into several shell courses and include welding information: NO
```

DATA FOR STIFFENER RINGS

```
SHELL STIFFENER RINGS: Shell without stiffening rings
UNSUPPORTED LENGTH OF SHELL (Fig. 8.5-2)............:L       4705.00 mm
```

WELDING REQUIREMENTS TO EN 1708-1:2010

```
Comment(Optional):
Type of welded connection: Not Applicable
```

CALCULATION DATA

7.4.2 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

```
Required Minimum Shell Thickness Excl.Allow. emin :
emin = Di * P / (2 * f * z - P)                                    (7.4-1)
=2800*0.2/(2*147.5*0.85-0.2)=                              2.2351 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =2.24+0+0.3=                       2.5351 mm

Analysis Thickness
ea = en - c - NegDev =4-0-0.3=                               3.7000 mm
```

»7.4.1 Cond.of Applicabilty emin/De=7.9597E-04 <= 0.16« » OK«

Internal Pressure emina=2.54 <= en=4[mm]	63.3%	OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

```
Outside Diameter of Shell
De = Di + 2 * (ea + NegDev) =2800+2*(3.7+0.3)=               2808.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2808+2800)/2=                           2804.00 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
MAWPHC = 2 * f * z * ea / Dm =2*147.5*0.85*3.7/2804=          0.3309 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)
MAWPNC = 2 * f20 * z * (ea + c) / Dm
=2*180*0.85*(3.7+0)/2804=                                   0.4038 MPa
```

MAX TEST PRESSURE (Uncorroded cond.at ambient temp.)

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/2804=                                      0.6994 MPa
```

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

```
NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.2*180/147.5=              0.3051 MPa
Ptmin = 1.43 * Pd =1.43*0.2=                                  0.2860 MPa
```

Test Pressure Ptmin=0.3051 <= Ptmax=0.6994[MPa]	43.6%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

```
Inside Radius of Shell
ris = Di / 2 (9.5-3) =2800/2=                                1400.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*1400+3.7)*3.7)=   101.85 mm
Maximum Diameter of Unreinforced Opening in Shell Checked to Rules in Section 9
dmax1 = MIN(0.5*Di,(ea*Is*(f-0.5*P)/P-ris*Is)/(0.5*ris+0.5*ea))    (9.5-7,22,23)
=MIN(0.5*2800,(3.7*101.85*(147.5-0.5*0.2)/0.2-1400*101.85)/(0.5*1400+0.5*3.
7))=                                                         =   192.56 mm
Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                          (9.5-18)
=0.15*Sqr((2*1400+3.7)*3.7)=                                 15.28 mm
Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(192.56,15.28)=                 192.56 mm
```

8.5 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

8.5.1.1 Circularity Limits

»The requirements of 8.5.2 and 8.5.3 apply to cylinders that are circular to within 0.5% on radius (i.e. 0.005R) measured from the true centre. The tolerance shall appear on the vessel drawing.

8.4.3 Nominal Elastic Limit Sige:

```
Sige = Rpt02 / s (8.4.3-1) =172.75/1.25=                      138.20 N/mm2
```

Preliminary Calculations

```
R = Dm / 2 =2804/2=                                          1402.00 mm
Z = PI * R / L (8.5.2-7) =3.14*1402/4705=                     0.9361
Delta = 1.28 / Sqr( R * ea) (8.5.3-20) =1.28/Sqr(1402*3.7)=    0.0178
gamma = 0 for No Stiffeners
```

DETERMINATION OF eps FROM FIGURE 8.5-3 :

```
eps is a minimum when n= 7
eps (from fig. 8.5-3) = 0.000038
```

MEMBRANE YIELD py

```
py = Sige * ea / (R * (1 - gamma * G ))                          (8.5.3-15)
=138.2*3.7/(1402*(1-0*0))=                                  0.3647 MPa
```

ELASTIC INSTABILITY pe

```
pm = E * ea * eps / R (8.5.2-5) =194028*3.7*3.7829E-05/1402=    0.0194 MPa
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
Value pr/py From Figure 8.5-5 Curve    1
Value1 =  ==                                                  0.0264
pr = Value1 * py =0.0264*0.3647=                              0.0096 MPa
Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.0096/1.5=                          0.0064 MPa
```

External Pressure Pmax=0.0064 >= Pext=0.002[MPa]	31.1%	OK

8.5.1.2 Circularity tolerance for cylinders with excess thickness.

```
Limit on circularity tolerance (in % of radius)
Tolerance = 0.005 * Pmax / Pext (8.5.1-1) =0.005*0.0064/0.002=   0.0160 %
Maximum unsupported length for given shell thickness Lmax =   14587 mm (en = 4 mm)
```

EN13445-4 Sect. 9.2 Ratio of Deformation

```
F = en / Dm * 100 (9.2-2) =4/2804*100=                          0.1427 %
NOTE: EN13445-4, 5.4.2 Maximum out of roundness for vessels subjected to internal
pressure: 1.5% for the ratio of emin/Dm > 0.01
```

CALCULATION SUMMARY

7.4.2 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

```
Required Minimum Shell Thickness Excl.Allow. emin :
emin = Di * P / (2 * f * z - P)                                      (7.4-1)
=2800*0.2/(2*147.5*0.85-0.2)=                                2.2351 mm
Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =2.24+0+0.3=                         2.5351 mm
```

Internal Pressure emina=2.54 <= en=4[mm]	63.3%	OK

MAX TEST PRESSURE (Uncorroded cond.at ambient temp.)

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/2804=                                       0.6994 MPa
```

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

```
NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.2*180/147.5=               0.3051 MPa
Ptmin = 1.43 * Pd =1.43*0.2=                                     0.2860 MPa
```

Test Pressure Ptmin=0.3051 <= Ptmax=0.6994[MPa]	43.6%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

```
Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(192.56,15.28)=                  192.56 mm
```

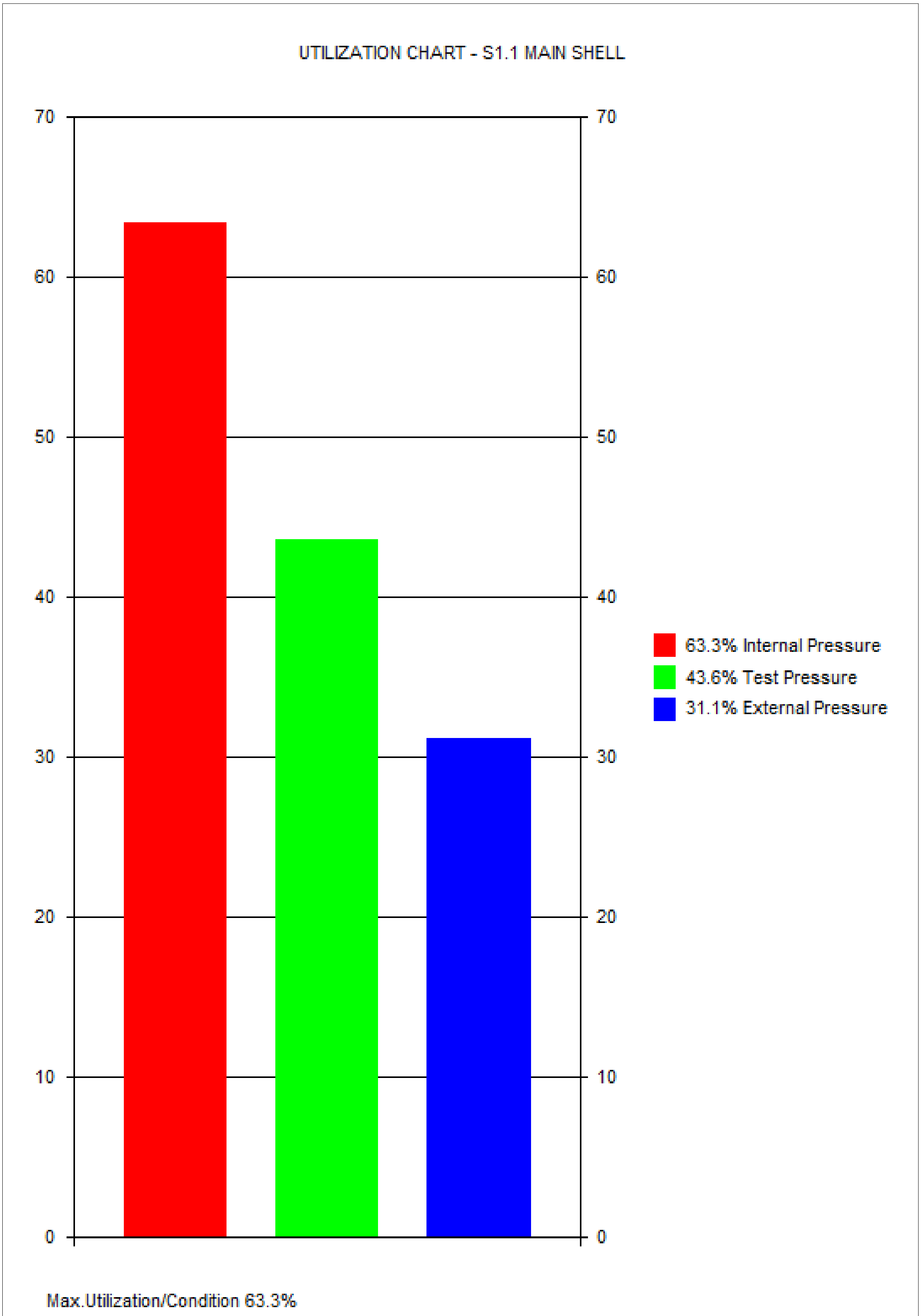
8.5 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

```
Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.0096/1.5=                            0.0064 MPa
```

External Pressure Pmax=0.0064 >= Pext=0.002[MPa]	31.1%	OK

```
Maximum unsupported length for given shell thickness Lmax =   14587 mm (en = 4 mm)
```

Volume:12.32 m3 Weight:558.8 kg (SG= 7.93)


UTILIZATION CHART - S1.1 MAIN SHELL
70
60
50
40
30
20
10
0
63.3% Internal Pressure
43.6% Test Pressure
31.1% External Pressure
Max.Utilization/Condition 63.3%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    Main Shell
Location: Along z-axis z1=  2000
```

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          0.00 mm
```

SHELL DATA

```
CYLINDER FABRICATION: Plate Material
WELD JOINT COEFFICIENT: Testing Group  3   (z=0.85)
DIAMETER INPUT: Base Design on Shell Inside Diameter
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 f=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
INSIDE SHELL DIAMETER (corroded)...................:Di       2800.00 mm
LENGTH OF CYLINDRICAL PART OF SHELL.................:Lcyl     1200.00 mm
SAFETY FACTOR (1.0 carbon and 1.25 austenitic steels):s        1.2500
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
Split shell into several shell courses and include welding information: NO
```

DATA FOR STIFFENER RINGS

```
SHELL STIFFENER RINGS: Shell without stiffening rings
UNSUPPORTED LENGTH OF SHELL (Fig. 8.5-2)............:L        4705.00 mm
```

WELDING REQUIREMENTS TO EN 1708-1:2010

```
Comment(Optional):
Type of welded connection: Not Applicable
```

CALCULATION DATA

7.4.2 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

```
Required Minimum Shell Thickness Excl.Allow. emin :
emin = Di * P / (2 * f * z - P)                                     (7.4-1)
=2800*0.2/(2*147.5*0.85-0.2)=                                 2.2351 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =2.24+0+0.3=                          2.5351 mm

Analysis Thickness
ea = en - c - NegDev =4-0-0.3=                                  3.7000 mm
```

»7.4.1 Cond.of Applicabilty emin/De=7.9597E-04 <= 0.16« » OK«

Internal Pressure emina=2.54 <= en=4[mm]	63.3%	OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

```
Outside Diameter of Shell
De = Di + 2 * (ea + NegDev) =2800+2*(3.7+0.3)=                 2808.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2808+2800)/2=                             2804.00 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
MAWPHC = 2 * f * z * ea / Dm =2*147.5*0.85*3.7/2804=             0.3309 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)
MAWPNC = 2 * f20 * z * (ea + c) / Dm
=2*180*0.85*(3.7+0)/2804=                                      0.4038 MPa
```

MAX TEST PRESSURE (Uncorroded cond.at ambient temp.)

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/2804=                                  0.6994 MPa
```

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

```
NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.2*180/147.5=          0.3051 MPa
Ptmin = 1.43 * Pd =1.43*0.2=                              0.2860 MPa
```

Test Pressure Ptmin=0.3051 <= Ptmax=0.6994[MPa]	43.6%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

```
Inside Radius of Shell
ris = Di / 2 (9.5-3) =2800/2=                            1400.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*1400+3.7)*3.7)=   101.85 mm
Maximum Diameter of Unreinforced Opening in Shell Checked to Rules in Section 9
dmax1 = MIN(0.5*Di,(ea*Is*(f-0.5*P)/P-ris*Is)/(0.5*ris+0.5*ea))    (9.5-7,22,23)
=MIN(0.5*2800,(3.7*101.85*(147.5-0.5*0.2)/0.2-1400*101.85)/(0.5*1400+0.5*3.
7))=                                                     =    192.56 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                          (9.5-18)
=0.15*Sqr((2*1400+3.7)*3.7)=                             15.28 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(192.56,15.28)=             192.56 mm
```

8.5 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

8.5.1.1 Circularity Limits

»The requirements of 8.5.2 and 8.5.3 apply to cylinders that are circular to within 0.5% on radius (i.e. 0.005R) measured from the true centre. The tolerance shall appear on the vessel drawing.

8.4.3 Nominal Elastic Limit Sige:

```
Sige = Rpt02 / s (8.4.3-1) =172.75/1.25=                  138.20 N/mm2
```

Preliminary Calculations

```
R = Dm / 2 =2804/2=                                      1402.00 mm
Z = PI * R / L (8.5.2-7) =3.14*1402/4705=                 0.9361
Delta = 1.28 / Sqr( R * ea) (8.5.3-20) =1.28/Sqr(1402*3.7)=   0.0178
gamma = 0 for No Stiffeners
```

DETERMINATION OF eps FROM FIGURE 8.5-3 :

```
eps is a minimum when n= 7
eps (from fig. 8.5-3) = 0.000038
```

MEMBRANE YIELD py

```
py = Sige * ea / (R * (1 - gamma * G ))                           (8.5.3-15)
=138.2*3.7/(1402*(1-0*0))=                              0.3647 MPa
```

ELASTIC INSTABILITY pe

```
pm = E * ea * eps / R (8.5.2-5) =194028*3.7*3.7829E-05/1402=   0.0194 MPa
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
Value pr/py From Figure 8.5-5 Curve   1
Value1 =  ==                                              0.0264
pr = Value1 * py =0.0264*0.3647=                          0.0096 MPa
Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.0096/1.5=                      0.0064 MPa
```

External Pressure Pmax=0.0064 >= Pext=0.002[MPa]	31.1%	OK

8.5.1.2 Circularity tolerance for cylinders with excess thickness.

```
Limit on circularity tolerance (in % of radius)
Tolerance = 0.005 * Pmax / Pext (8.5.1-1) =0.005*0.0064/0.002=   0.0160 %
Maximum unsupported length for given shell thickness Lmax =   14587 mm (en = 4 mm)
```

EN13445-4 Sect. 9.2 Ratio of Deformation

```
F = en / Dm * 100 (9.2-2) =4/2804*100=                          0.1427 %
NOTE: EN13445-4, 5.4.2 Maximum out of roundness for vessels subjected to internal
pressure: 1.5% for the ratio of emin/Dm > 0.01
```

CALCULATION SUMMARY

7.4.2 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

```
Required Minimum Shell Thickness Excl.Allow. emin :
emin = Di * P / (2 * f * z - P)                                      (7.4-1)
=2800*0.2/(2*147.5*0.85-0.2)=                                  2.2351 mm
Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =2.24+0+0.3=                           2.5351 mm
```

Internal Pressure emina=2.54 <= en=4[mm]	63.3%	OK

MAX TEST PRESSURE (Uncorroded cond.at ambient temp.)

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/2804=                                         0.6994 MPa
```

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

```
NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.2*180/147.5=                 0.3051 MPa
Ptmin = 1.43 * Pd =1.43*0.2=                                     0.2860 MPa
```

Test Pressure Ptmin=0.3051 <= Ptmax=0.6994[MPa]	43.6%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

```
Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(192.56,15.28)=                    192.56 mm
```

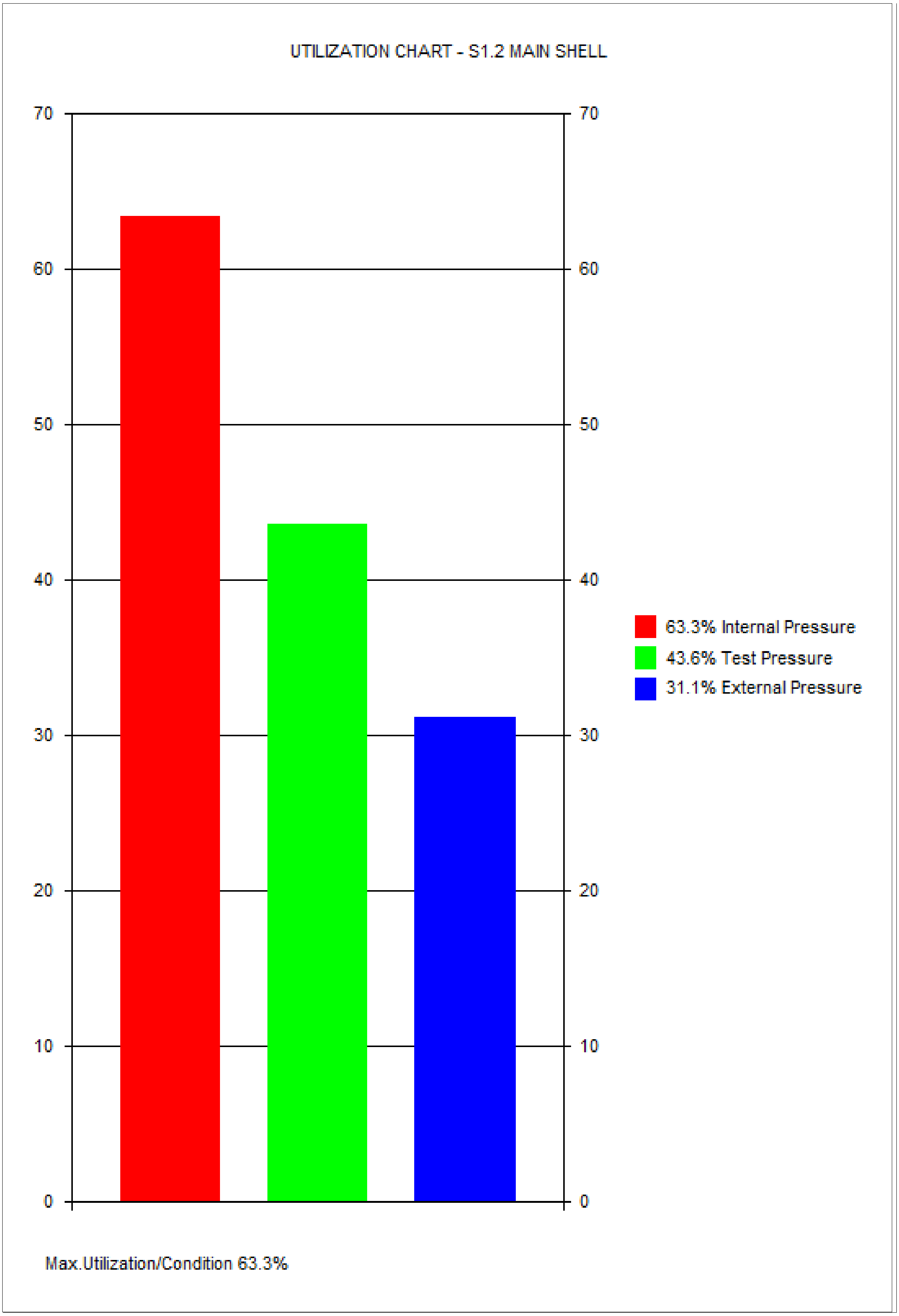
8.5 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

```
Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.0096/1.5=                             0.0064 MPa
```

External Pressure Pmax=0.0064 >= Pext=0.002[MPa]	31.1%	OK

```
Maximum unsupported length for given shell thickness Lmax =   14587 mm (en = 4 mm)
```

Volume:7.39 m3 Weight:335.3 kg (SG= 7.93)


UTILIZATION CHART - S1.2 MAIN SHELL
70
60
50
40
30
20
10
0
63.3% Internal Pressure
43.6% Test Pressure
31.1% External Pressure
Max.Utilization/Condition 63.3%

INPUT DATA

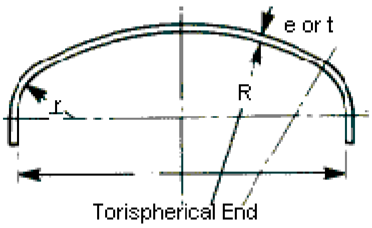
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    Main Shell
Location: Along z-axis zo=  0
```

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          0.00 mm
```

DIMENSIONS OF END




```
Type of Torispherical End: Dished End KORBBOGEN DIN 28013-28014/SMS 482
WELD JOINT COEFFICIENT: Testing Group  3   (z=0.85)
OUTSIDE DIAMETER OF CYLINDRICAL FLANGE OF END.......:De       2810.00 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl       30.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en        5.0000 mm
Include calculation of forming during fabrication to EN13445-4 Section 9.: NO
```

MATERIAL DATA FOR END

```
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 f=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
SAFETY FACTOR (1.0 carbon and 1.25 austenitic steels):s        1.2500
Material & Delivery Form: NOT Cold Spun Seamless Austenitic Stainless Steel
```

NOZZLES IN KNUCKLE REGION TO SECTION 7.7

```
Nozzles In Knuckle Region: NO
```

WELDING REQUIREMENTS TO EN 1708-1:2010

```
Comment(Optional):
Type of welded connection: Not Applicable
```

CALCULATION DATA

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

```
Required Thickness of End to Limit Membrane Stress in Central Part
es = P * R / (2 * f * z - 0.5 * P)                               (7.5-1)
=0.2*2248/(2*147.5*0.85-0.5*0.2)=                        1.7937 mm

fb = Rpt02 / 1.5 (7.5-4) =172.75/1.5=                     115.17 N/mm2
Required Thickness of Knuckle to Avoid Plastic Buckling
eb = (0.75*R+0.2*Di)*((P/(111*fb)*(Di/r)^0.825)^(0.667)          (7.5-3)
=(0.75*2248+0.2*2800)*((0.2/(111*115.17)*(2800/432.74)^0.825)^(0.667)
=   3.9111 mm

7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(2.47/2248,0.04)=      0.0011
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0011)=                    2.9592
```

```
X = r / Di (7.5-11) =432.74/2805.06=                          0.1543
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                                (7.5-12)
=1.006-1/(6.2+(90*0.0011)^4)=                               0.8447
Beta01 = N*(-0.1833*Z^3+1.0383*Z^2-1.2943*Z+0.837)                  (7.5-15)
=0.8447*(-0.1833*2.96^3+1.0383*2.96^2-1.2943*2.96+0.837)=    1.1397
Beta02 = MAX( 0.5, 0.95 * (0.56 - 1.94 * Y - 82.5 * Y ^ 2))         (7.5-17)
=MAX(0.5,0.95*(0.56-1.94*0.0011-82.5*0.0011^2))=            0.5299
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)               (7.5-16)
=10*((0.2-0.1543)*1.14+(0.1543-0.1)*0.5299)=                0.8088
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * P * (0.75 * R + 0.2 * Di) / f                           (7.5-2)
=0.8088*0.2*(0.75*2248+0.2*2805.06)/147.5=                  2.4641 mm

Required Minimum End Thickness Excl.Allow. emin :
emin = emin =3.91=                                            3.9111 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =3.91+0+0.3=                            4.2100 mm
```

Internal Pressure emina=4.21 <= en=5[mm]	84.2%	OK

```
Analysis Thickness
ea = en - c - th =5-0-0.3=                                    4.7000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =2810-2*(5-0)=                        2800.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2810+2800)/2=                           2805.00 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(2800*3.91)=               20.93 mm
Since Lcyl > Llim, Required Thickness of Straight Cylindrical Flange to 7.4.2
Minimum Thickness of Straight Flange Excl. Allow.
ecyl = P * Di / (2 * f * z - P)                                     (7.4-1)
=0.2*2800/(2*147.5*0.85-0.2)=                               2.2351 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =2.24+0=                                     2.2400 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=432.74 <= 0.2 * Di=560[mm] « » OK«
»Geometry Check r=432.74 >= 0.06 * Di=168[mm] « » OK«
»Geometry Check r=432.74 >= 2*e[mm] « » OK«
»Geometry Check e=3.91 <= 0.08*De=224.8[mm] « » OK«
»Geometry Check ea=4.7 >= 0.001*De=2.81[mm] « » OK«
»Geometry Check R=2248 <= De=2810[mm] « » OK«

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                (7.5-6)
=2*180*0.85*4.7/(2248+0.5*4.7)=                             0.6391 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                      (7.5-7)
=180*4.7/(0.786*(0.75*2248+0.2*2800))=                      0.4792 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                   (7.5-8)
=111*180*(4.7/(0.75*2248+0.2*2800))^1.5*(432.74/2800)^0.825=   0.4098 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*4.7*180*0.85/(2800+4.7)=                                 0.5128 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.4098=                                                    0.4098 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                (7.5-6)
=2*147.5*0.85*4.7/(2248+0.5*4.7)=                           0.5237 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                      (7.5-7)
=147.5*4.7/(0.786*(0.75*2248+0.2*2800))=                    0.3927 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                   (7.5-8)
```

```
=111*115.17*(4.7/(0.75*2248+0.2*2800))^1.5*(432.74/2800)^0.825=   0.2622 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*4.7*147.5*0.85/(2800+4.7)=                                0.4202 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.2622=                                                     0.2622 MPa
```

MAX TEST PRESSURE (Uncorroded cond.at ambient temp.)

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                 (7.5-6)
=2*265*1*4.7/(2248+0.5*4.7)=                                 1.1069 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                       (7.5-7)
=265*4.7/(0.786*(0.75*2248+0.2*2800))=                       0.7055 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                    (7.5-8)
=111*257.14*(4.7/(0.75*2248+0.2*2800))^1.5*(432.74/2800)^0.825=   0.5855 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*4.7*265*1/(2800+4.7)=                                     0.8882 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.5855=                                                     0.5855 MPa
```

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

```
NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.2*180/147.5=               0.3051 MPa

Ptmin = 1.43 * Pd =1.43*0.2=                                   0.2860 MPa
```

Test Pressure Ptmin=0.3051 <= Ptmax=0.5855[MPa]	52.1%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =2248=                                        2248.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*2248+4.7)*4.7)=   145.44 mm
Maximum Diameter of Unreinforced Opening in Shell Checked to Rules in Section 9
dmax1 = (ea*Is*(f-0.5*P)/P-ris*Is)/(0.5*ris+0.5*ea)                  (9.5-7,22,23)
=(4.7*145.44*(147.5-0.5*0.2)/0.2-2248*145.44)/(0.5*2248+0.5*4.7)=   157.00 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                             (9.5-18)
=0.15*Sqr((2*2248+4.7)*4.7)=                                  21.82 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(157.,21.82)=                     157.00 mm
```

8.7 - SPHERICAL SHELL UNDER EXTERNAL PRESSURE

8.4.3 Nominal Elastic Limit Sige:

```
Sige = Rpt02 / s (8.4.3-1) =172.75/1.25=                        138.20 N/mm2
Mean Radius R:
Rmean = R + ea / 2 =2248+4.7/2=                               2250.35 mm
MEMBRANE YIELD py
py = 2 * Sige * ea / Rmean (8.7.1-1) =2*138.2*4.7/2250.35=     0.5773 MPa

ELASTIC INSTABILITY pm
pm = 1.21 * E * ea ^ 2 / Rmean ^ 2                                   (8.7.1-2)
=1.21*194028*4.7^2/2250.35^2=                                1.0241 MPa

Value pr/py From Figure 8.5-5 Curve   2
Value1 =  ==                                                   0.2933
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
pr = Value1 * py =0.2933*0.5773=                               0.1693 MPa
Pmax = pr / S =0.1693/1.5=                                     0.1129 MPa
```

External Pressure Pmax=0.1129 >= Pext=0.002[MPa]	1.7%	OK

8.7.2 - Permissible Shape Deviations

»The method of 8.7.1 applies to dished ends that are spherical to within 1% on radius and in which the radius of curvature based on an arc length of 2.4*Sqr(ea*Rmax) does not exceed the nominal value by more than 30%.

CALCULATION SUMMARY

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

Required Minimum End Thickness Excl.Allow. emin :
emin = emin =3.91= 3.9111 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =3.91+0+0.3= 4.2100 mm

Internal Pressure emina=4.21 <= en=5[mm]	84.2%	OK

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =2.24+0= 2.2400 mm

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.4098= 0.4098 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.2622= 0.2622 MPa

MAX TEST PRESSURE (Uncorroded cond.at ambient temp.)

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.5855= 0.5855 MPa

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.2*180/147.5= 0.3051 MPa

Ptmin = 1.43 * Pd =1.43*0.2= 0.2860 MPa

Test Pressure Ptmin=0.3051 <= Ptmax=0.5855[MPa]	52.1%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

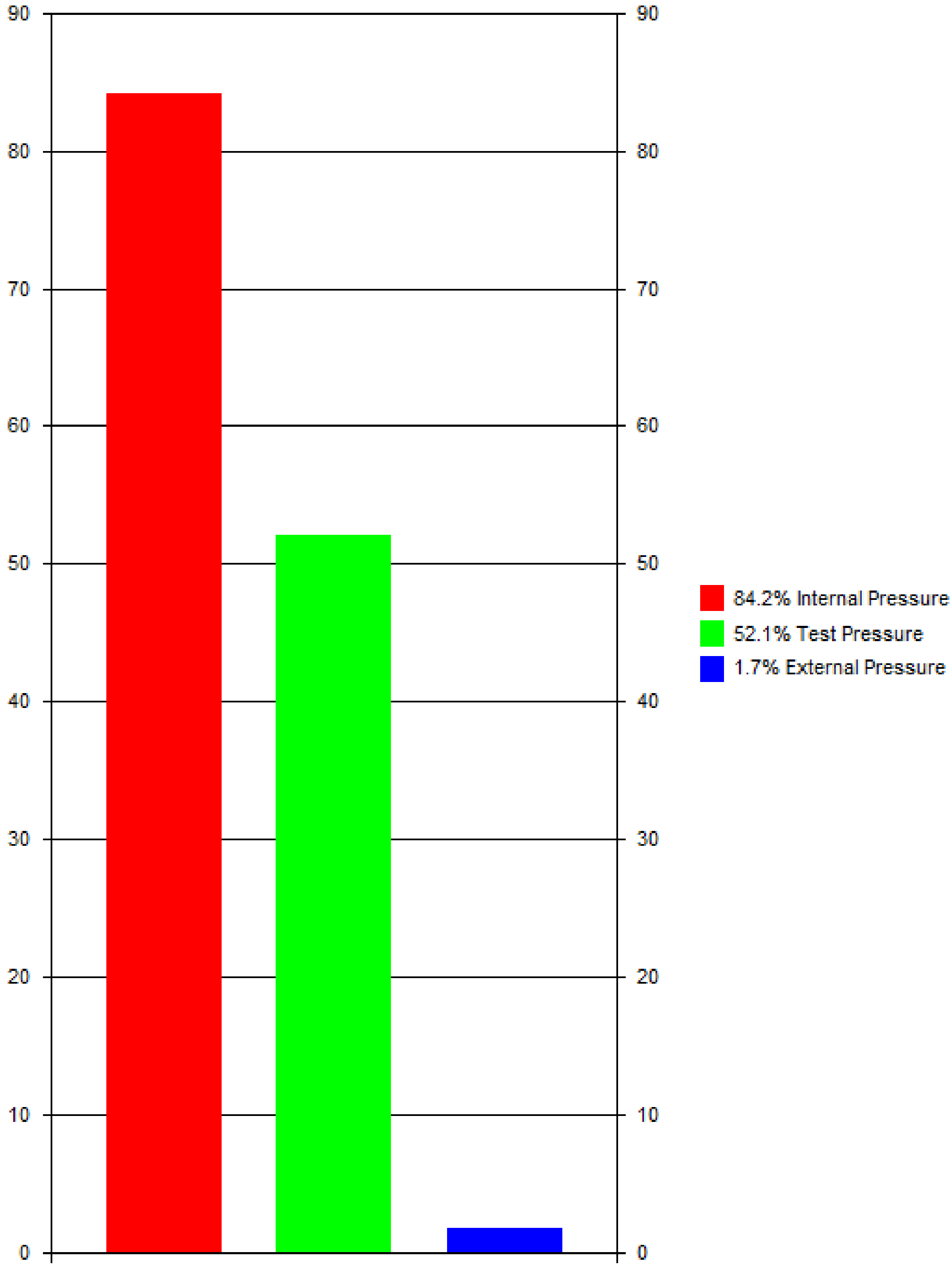
Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(157.,21.82)= 157.00 mm

8.7 - SPHERICAL SHELL UNDER EXTERNAL PRESSURE

External Pressure Pmax=0.1129 >= Pext=0.002[MPa]	1.7%	OK

Volume:3.07 m3 Weight:350.7 kg (SG= 7.93)

UTILIZATION CHART - E3.1



Max.Utilization/Condition 84.2%

INPUT DATA

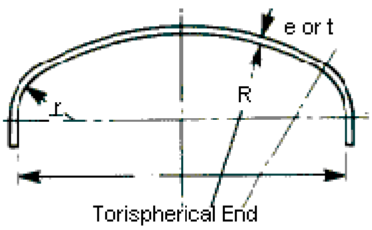
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.2    Cylindrical Shell    Main Shell                         S1.1
Location: Along z-axis z1=  3200
```

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          0.00 mm
```

DIMENSIONS OF END




```
Type of Torispherical End: Dished End KORBBOGEN DIN 28013-28014/SMS 482
WELD JOINT COEFFICIENT: Testing Group  3   (z=0.85)
OUTSIDE DIAMETER OF CYLINDRICAL FLANGE OF END.......:De       2810.00 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl       30.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en        5.0000 mm
Include calculation of forming during fabrication to EN13445-4 Section 9.: NO
```

MATERIAL DATA FOR END

```
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 f=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
SAFETY FACTOR (1.0 carbon and 1.25 austenitic steels):s        1.2500
Material & Delivery Form: NOT Cold Spun Seamless Austenitic Stainless Steel
```

NOZZLES IN KNUCKLE REGION TO SECTION 7.7

```
Nozzles In Knuckle Region: NO
```

WELDING REQUIREMENTS TO EN 1708-1:2010

```
Comment(Optional):
Type of welded connection: Not Applicable
```

CALCULATION DATA

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

```
Required Thickness of End to Limit Membrane Stress in Central Part
es = P * R / (2 * f * z - 0.5 * P)                                  (7.5-1)
=0.2*2248/(2*147.5*0.85-0.5*0.2)=                           1.7937 mm

fb = Rpt02 / 1.5 (7.5-4) =172.75/1.5=                         115.17 N/mm2
Required Thickness of Knuckle to Avoid Plastic Buckling
eb = (0.75*R+0.2*Di)*((P/(111*fb)*(Di/r)^0.825)^(0.667)             (7.5-3)
=(0.75*2248+0.2*2800)*((0.2/(111*115.17)*(2800/432.74)^0.825)^(0.667)
=   3.9111 mm

7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(2.47/2248,0.04)=        0.0011
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0011)=                      2.9592
```

```
X = r / Di (7.5-11) =432.74/2805.06=                      0.1543
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                             (7.5-12)
=1.006-1/(6.2+(90*0.0011)^4)=                           0.8447
Beta01 = N*(-0.1833*Z^3+1.0383*Z^2-1.2943*Z+0.837)               (7.5-15)
=0.8447*(-0.1833*2.96^3+1.0383*2.96^2-1.2943*2.96+0.837)=  1.1397
Beta02 = MAX( 0.5, 0.95 * (0.56 - 1.94 * Y - 82.5 * Y ^ 2))      (7.5-17)
=MAX(0.5,0.95*(0.56-1.94*0.0011-82.5*0.0011^2))=        0.5299
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)            (7.5-16)
=10*((0.2-0.1543)*1.14+(0.1543-0.1)*0.5299)=            0.8088
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * P * (0.75 * R + 0.2 * Di) / f                        (7.5-2)
=0.8088*0.2*(0.75*2248+0.2*2805.06)/147.5=              2.4641 mm

Required Minimum End Thickness Excl.Allow. emin :
emin = emin =3.91=                                        3.9111 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =3.91+0+0.3=                        4.2100 mm
```

Internal Pressure emina=4.21 <= en=5[mm]	84.2%	OK

```
Analysis Thickness
ea = en - c - th =5-0-0.3=                                4.7000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =2810-2*(5-0)=                    2800.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2810+2800)/2=                       2805.00 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(2800*3.91)=          20.93 mm
Since Lcyl > Llim, Required Thickness of Straight Cylindrical Flange to 7.4.2
Minimum Thickness of Straight Flange Excl. Allow.
ecyl = P * Di / (2 * f * z - P)                                  (7.4-1)
=0.2*2800/(2*147.5*0.85-0.2)=                           2.2351 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =2.24+0=                                 2.2400 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=432.74 <= 0.2 * Di=560[mm] « » OK«
»Geometry Check r=432.74 >= 0.06 * Di=168[mm] « » OK«
»Geometry Check r=432.74 >= 2*e[mm] « » OK«
»Geometry Check e=3.91 <= 0.08*De=224.8[mm] « » OK«
»Geometry Check ea=4.7 >= 0.001*De=2.81[mm] « » OK«
»Geometry Check R=2248 <= De=2810[mm] « » OK«

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                             (7.5-6)
=2*180*0.85*4.7/(2248+0.5*4.7)=                         0.6391 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                   (7.5-7)
=180*4.7/(0.786*(0.75*2248+0.2*2800))=                  0.4792 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                (7.5-8)
=111*180*(4.7/(0.75*2248+0.2*2800))^1.5*(432.74/2800)^0.825=   0.4098 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*4.7*180*0.85/(2800+4.7)=                             0.5128 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.4098=                                                0.4098 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                             (7.5-6)
=2*147.5*0.85*4.7/(2248+0.5*4.7)=                       0.5237 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                   (7.5-7)
=147.5*4.7/(0.786*(0.75*2248+0.2*2800))=                0.3927 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                (7.5-8)
```

```
=111*115.17*(4.7/(0.75*2248+0.2*2800))^1.5*(432.74/2800)^0.825=   0.2622 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*4.7*147.5*0.85/(2800+4.7)=                                   0.4202 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.2622=                                                        0.2622 MPa
```

MAX TEST PRESSURE (Uncorroded cond.at ambient temp.)

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                    (7.5-6)
=2*265*1*4.7/(2248+0.5*4.7)=                                    1.1069 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                          (7.5-7)
=265*4.7/(0.786*(0.75*2248+0.2*2800))=                          0.7055 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                       (7.5-8)
=111*257.14*(4.7/(0.75*2248+0.2*2800))^1.5*(432.74/2800)^0.825=   0.5855 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*4.7*265*1/(2800+4.7)=                                        0.8882 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.5855=                                                        0.5855 MPa
```

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

```
NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.2*180/147.5=                  0.3051 MPa

Ptmin = 1.43 * Pd =1.43*0.2=                                      0.2860 MPa
```

Test Pressure Ptmin=0.3051 <= Ptmax=0.5855[MPa]	52.1%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =2248=                                            2248.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*2248+4.7)*4.7)=   145.44 mm
Maximum Diameter of Unreinforced Opening in Shell Checked to Rules in Section 9
dmax1 = (ea*Is*(f-0.5*P)/P-ris*Is)/(0.5*ris+0.5*ea)                    (9.5-7,22,23)
=(4.7*145.44*(147.5-0.5*0.2)/0.2-2248*145.44)/(0.5*2248+0.5*4.7)=   157.00 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                                (9.5-18)
=0.15*Sqr((2*2248+4.7)*4.7)=                                      21.82 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(157.,21.82)=                        157.00 mm
```

8.7 - SPHERICAL SHELL UNDER EXTERNAL PRESSURE

8.4.3 Nominal Elastic Limit Sige:

```
Sige = Rpt02 / s (8.4.3-1) =172.75/1.25=                           138.20 N/mm2
Mean Radius R:
Rmean = R + ea / 2 =2248+4.7/2=                                   2250.35 mm
MEMBRANE YIELD py
py = 2 * Sige * ea / Rmean (8.7.1-1) =2*138.2*4.7/2250.35=        0.5773 MPa

ELASTIC INSTABILITY pm
pm = 1.21 * E * ea ^ 2 / Rmean ^ 2                                      (8.7.1-2)
=1.21*194028*4.7^2/2250.35^2=                                   1.0241 MPa

Value pr/py From Figure 8.5-5 Curve   2
Value1 =  ==                                                      0.2933
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
pr = Value1 * py =0.2933*0.5773=                                   0.1693 MPa
Pmax = pr / S =0.1693/1.5=                                         0.1129 MPa
```

External Pressure Pmax=0.1129 >= Pext=0.002[MPa]	1.7%	OK

8.7.2 - Permissible Shape Deviations

»The method of 8.7.1 applies to dished ends that are spherical to within 1% on radius and in which the radius of curvature based on an arc length of 2.4*Sqr(ea*Rmax) does not exceed the nominal value by more than 30%.

CALCULATION SUMMARY

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

Required Minimum End Thickness Excl.Allow. emin :
emin = emin =3.91= 3.9111 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =3.91+0+0.3= 4.2100 mm

Internal Pressure emina=4.21 <= en=5[mm]	84.2%	OK

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =2.24+0= 2.2400 mm

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.4098= 0.4098 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.2622= 0.2622 MPa

MAX TEST PRESSURE (Uncorroded cond.at ambient temp.)

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.5855= 0.5855 MPa

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.2*180/147.5= 0.3051 MPa

Ptmin = 1.43 * Pd =1.43*0.2= 0.2860 MPa

Test Pressure Ptmin=0.3051 <= Ptmax=0.5855[MPa]	52.1%	OK

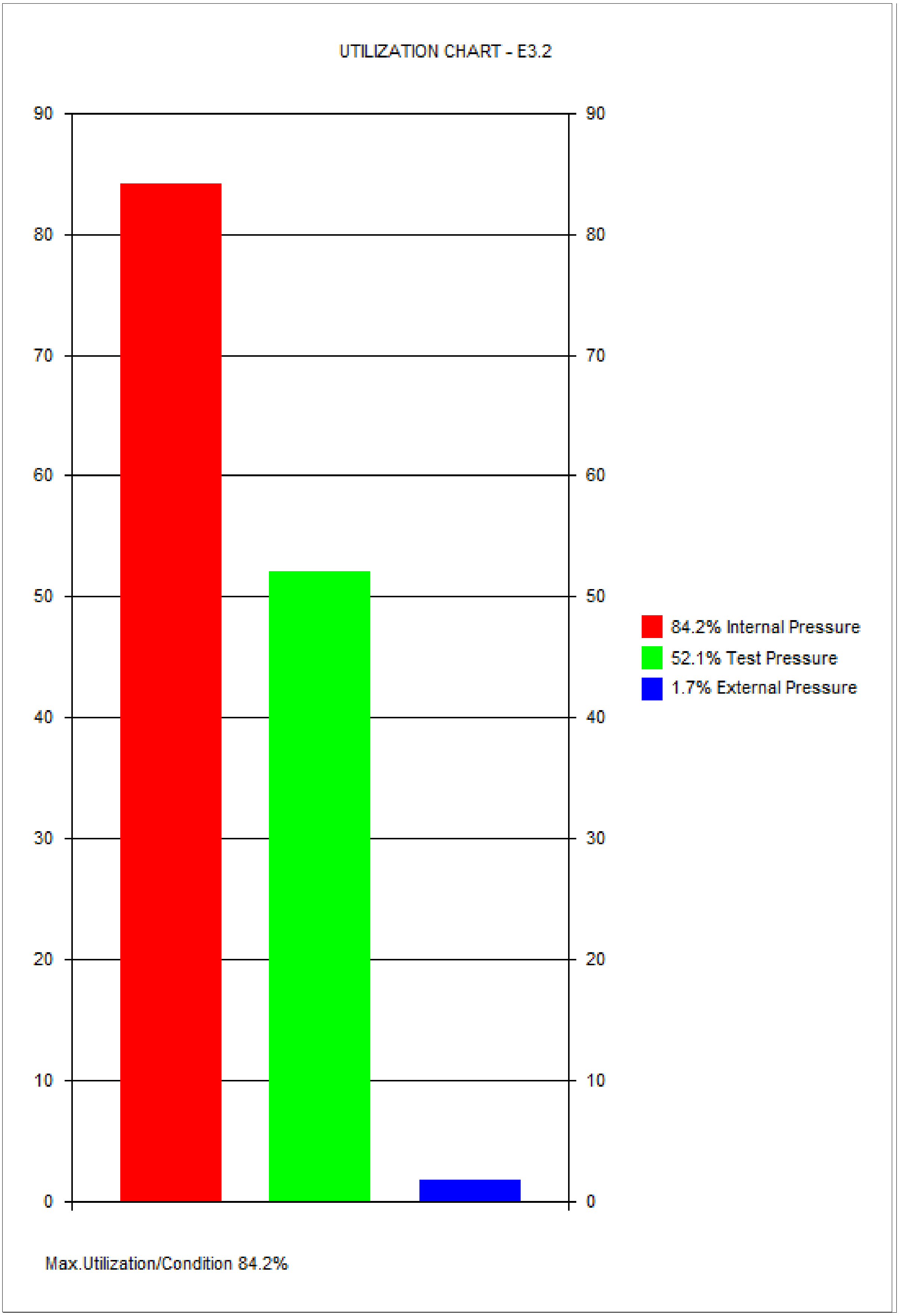
Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(157.,21.82)= 157.00 mm

8.7 - SPHERICAL SHELL UNDER EXTERNAL PRESSURE

External Pressure Pmax=0.1129 >= Pext=0.002[MPa]	1.7%	OK

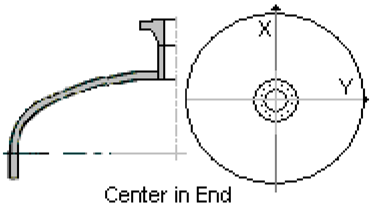
Volume:3.07 m3 Weight:350.7 kg (SG= 7.93)


UTILIZATION CHART - E3.2
90
80
70
60
50
40
30
20
10
0
84.2% Internal Pressure
52.1% Test Pressure
1.7% External Pressure
Max.Utilization/Condition 84.2%

INPUT DATA

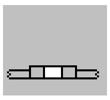
COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End S1.2
Connect this nozzle to the nozzle neck of another nozzle: NO



Orientation & Location of Nozzle: Center in End

GENERAL DESIGN DATA



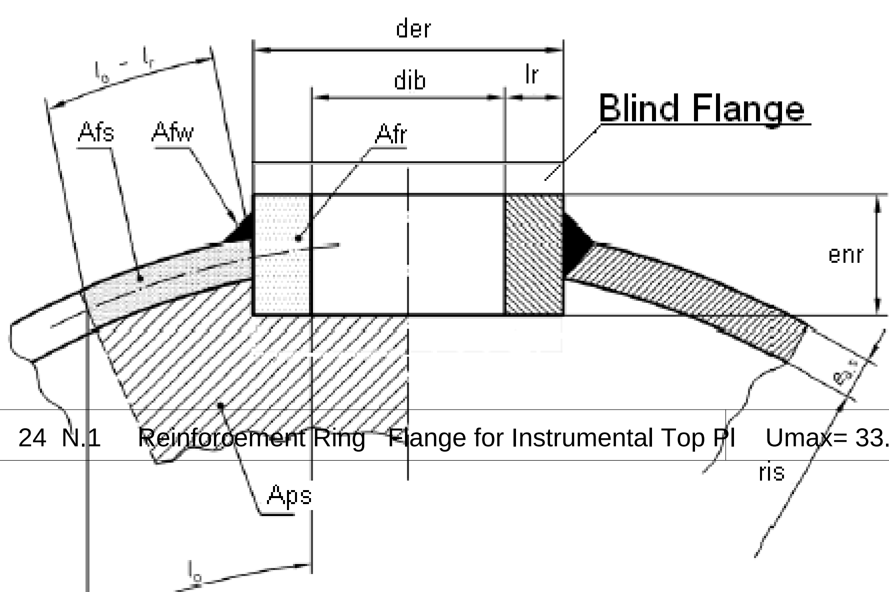
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG 1.0000
LIQUID HEAD...:LH 0.00 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
Include Nozzle Load Calculation: NO

SHELL DATA (E3.2)

Shell Type: Torispherical End
OUTSIDE DIAMETER OF SHELL...........................:De 2810.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en 5.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th 0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R 2248.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fs=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93

RING DATA

Location of closure opening: Outside the shell
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fr=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
WIDTH OF RING (uncorroded)..........................:lr 50.00 mm
THICKNESS/HEIGTH OF RING............................:enr 25.00 mm
INSIDE DIAMETER OF RING (corroded)..................:dib 450.00 mm
Size of Flange and Nozzle: DN450
Comment (Optional):



WELDING DATA

Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld

WELDING REQUIREMENTS TO EN 1708-1:2010

Comment(Optional):
Type of welded connection: Not Applicable

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness eas
eas = en - c - th =5-0-0.3=                                      4.7000 mm
Ring Analysis Thickness ear
ear = enr - c =25-0=                                              25.00 mm
ris = R (9.5-4) =2248=                                          2248.00 mm
Allowable Stresses
for/fob = Min( fs, fb) (9.5-8) =Min(147.5,147.5)=                147.50 N/mm2
```

»Location in End to Fig.9.5-4 L=1130 >= De/10=281[mm] « » OK«

9.5.2.4.3 Shells with openings without nozzle, reinforced by reiforcement rings.

Calculation of Stress Loaded Areas Effective as Reinforcement

Reinforcement Ring

```
Effective Thickness of Reinforcement Ring for Reinforcement Calculations
er = MIN( ear, MAX( 3 * eas, 3 * Ir))                                (9.5-45)
=MIN(25,MAX(3*4.7,3*50))=                                       25.00 mm
Limit of Reinforcement Along Shell and Ring Io
Io = Sqr(( 2 * ris + eam) * eam)                                     (9.5-46)
=Sqr((2*2248+9.58)*9.58)=                                      208.05 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io                                     (9.5-48)
=4.7+(25-4.7)*50/208.05=                                       9.5787 mm
Area of Ring Afr/Afb
Afr/Afb = er * Ir (9.5-55) =25*50=                              1250.00 mm2

Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*2248+4.7)*4.7)=                                        145.44 mm
Is = MIN( Iso , Io - Ir) (9.5-50) =MIN(145.44,208.05-50)=        145.44 mm
Area of Shell
Afs = eas * Is (9.5-54) =4.7*145.44=                             683.58 mm2
```

Calculation of Pressure Loaded Areas

```
Apr/Apb = 0.5 * dib * er =0.5*450*25=                           5625.00 mm2

Spherical Shell/End on any Section Aps
Aps = 0.5*ris^2*(Is+a)/(0.5*eas+ris)+a*(eas+ep)                      (9.5-72)
=0.5*2248^2*(145.44+275.69)/(0.5*4.7+2248)+275.69*(4.7+0)=4,7415E05 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apr + 0.5 * Apphi)                                (9.5-7)
=0.2*(4.7415E05+5625+0.5*0)=                                    95.96 kN
```

Pressure Area Available pA(aval.)

```
pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P)                    (9.5-16)
=(683.58+0+0+1250)*(147.5-0.5*0.2)=                            285.01 kN
```

Nozzle Reinforcement pAAval=285.01 >= pAReq=95.96[kN]	33.6%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw+Afr)*fs/((Aps+Apr+0.5*Apphi)+0.5*(Afs+Afw+Afr+Afp)) (9.5-17)
=(683.58+0+1250)*147.5/((4.7415E05+5625+0.5*0)+0.5*(683.58+0+1250+0))
=   0.5933 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                1.0658 MPa
```

Weight of Nozzle: 15.6kg

CALCULATION SUMMARY

9.5.2.4.3 Shells with openings without nozzle, reinforced by reiforcement rings.

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apr + 0.5 * Apphi)                              (9.5-7)
=0.2*(4.7415E05+5625+0.5*0)=                                     95.96 kN
```

Pressure Area Available pA(aval.)

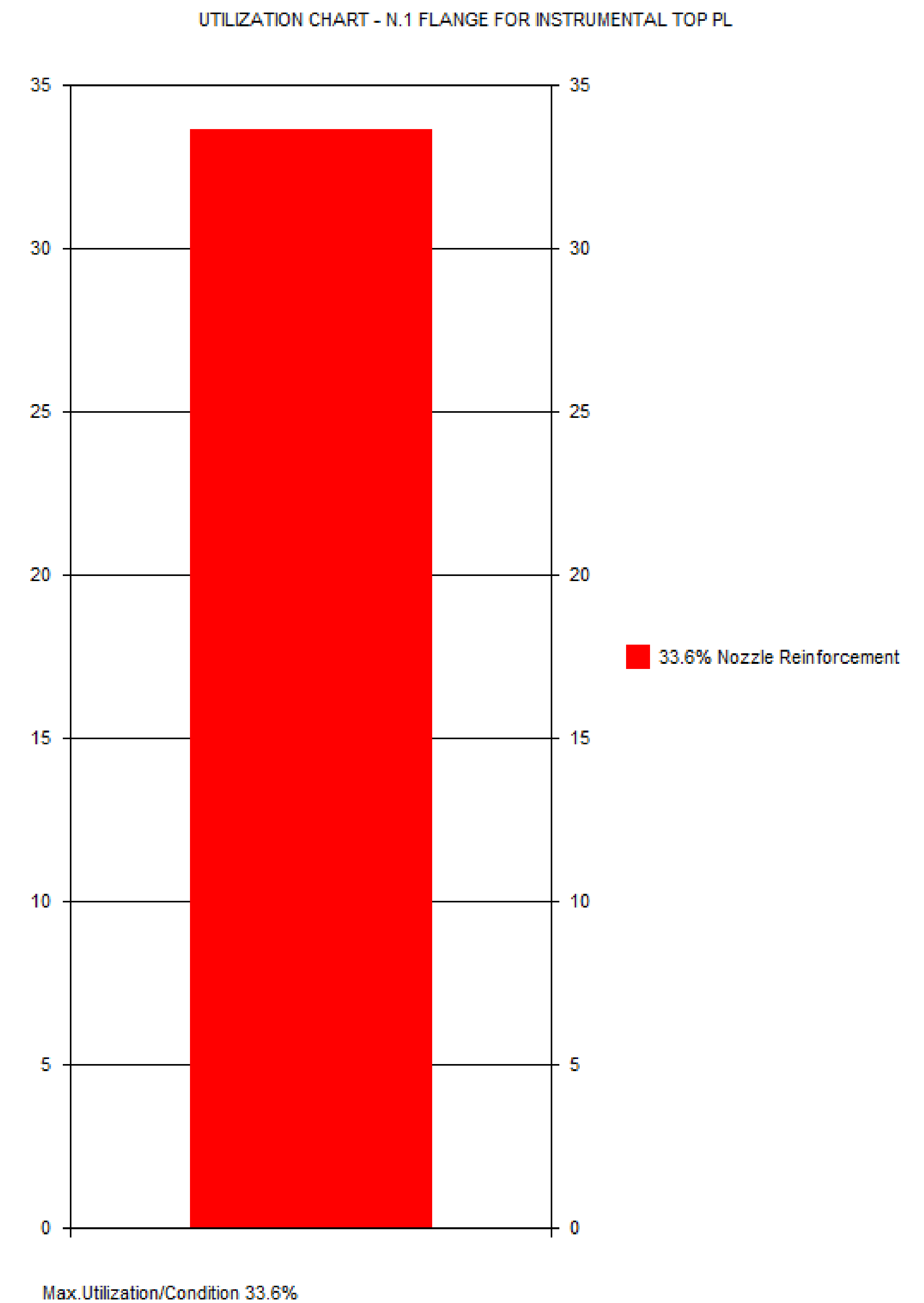
```
pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P)                  (9.5-16)
=(683.58+0+0+1250)*(147.5-0.5*0.2)=                             285.01 kN
```

Nozzle Reinforcement pAAval=285.01 >= pAReq=95.96[kN]	33.6%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw+Afr)*fs/((Aps+Apr+0.5*Apphi)+0.5*(Afs+Afw+Afr+Afp)) (9.5-17)
=(683.58+0+1250)*147.5/((4.7415E05+5625+0.5*0)+0.5*(683.58+0+1250+0))
=   0.5933 MPa
```

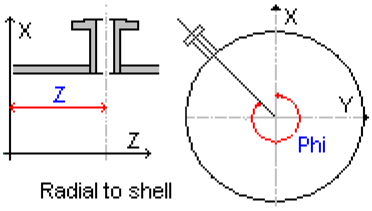
Volume:0.0048 m3 Weight:15.6 kg (SG= 7.93)


UTILIZATION CHART - N.1 FLANGE FOR INSTRUMENTAL TOP PL
35
30
25
20
15
10
5
0
33.6% Nozzle Reinforcement
Max.Utilization/Condition 33.6%

INPUT DATA

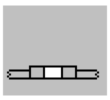
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.2    Cylindrical Shell    Main Shell                        S1.1
Connect this nozzle to the nozzle neck of another nozzle: NO
```




```
Orientation & Location of Nozzle: Radial to Shell
z-location of nozzle along axis of attacment........:z        3100.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi   170.00 Degr.
```

GENERAL DESIGN DATA



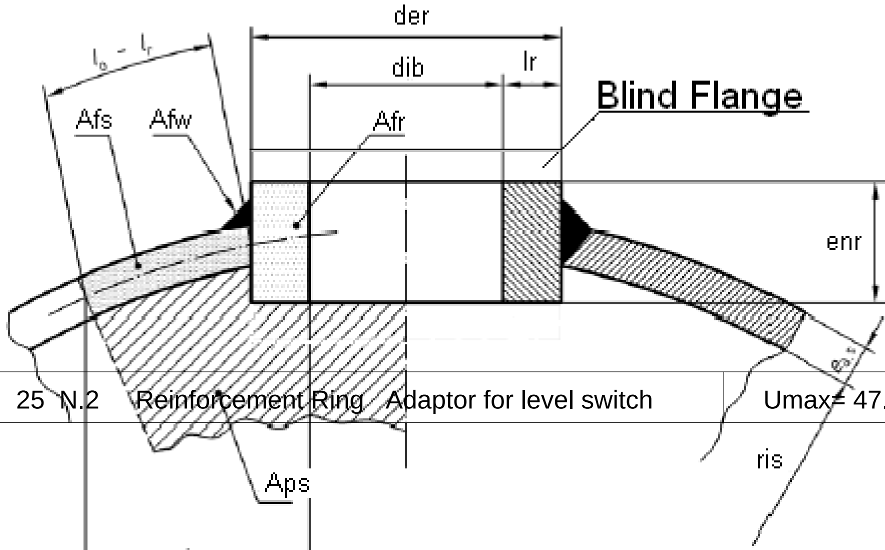
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          0.00 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
Include Nozzle Load Calculation: NO
```

SHELL DATA (S1.2)

```
Shell Type: Cylindrical Shell
OUTSIDE DIAMETER OF SHELL...........................:De       2808.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fs=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

RING DATA

```
Location of closure opening: Outside the shell
EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT THK<=160mm 90'C,A>=35%
Rm=500 Rp=235 Rpt=204.38 fr=146.25 f20=166.67 ftest=250 E=194028(N/mm2) ro=7.93
WIDTH OF RING (uncorroded)..........................:lr        5.5000 mm
THICKNESS/HEIGTH OF RING............................:enr        34.00 mm
INSIDE DIAMETER OF RING (corroded)..................:dib        19.00 mm
Size of Flange and Nozzle:
Comment (Optional):
```



WELDING DATA
Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld

WELDING REQUIREMENTS TO EN 1708-1:2010
Comment(Optional):
Type of welded connection: Not Applicable

CALCULATION DATA

PRELIMINARY CALCULATIONS
Shell Analysis Thickness eas
eas = en - c - th =4-0-0.3= 3.7000 mm
Ring Analysis Thickness ear
ear = enr - c =34-0= 34.00 mm
Inside Radius of Curvature
ris = De / 2 - eas (9.5-3) =2808/2-3.7= 1400.30 mm
Allowable Stresses
for/fob = Min(fs, fb) (9.5-8) =Min(147.5,146.25)= 146.25 N/mm2

9.5.2.4.3 Shells with openings without nozzle, reinforced by reiforcement rings.

Calculation of Stress Loaded Areas Effective as Reinforcement

Reinforcement Ring
Effective Thickness of Reinforcement Ring for Reinforcement Calculations
er = MIN(ear, MAX(3 * eas, 3 * Ir)) (9.5-45)
=MIN(34,MAX(3*3.7,3*5.5))= 16.50 mm
Limit of Reinforcement Along Shell and Ring Io
Io = Sqr((2 * ris + eam) * eam) (9.5-46)
=Sqr((2*1400.3+4.33)*4.33)= 111.12 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io (9.5-48)
=3.7+(16.5-3.7)*5.5/111.12= 4.3335 mm
Area of Ring Afr/Afb
Afr/Afb = er * Ir (9.5-55) =16.5*5.5= 90.75 mm2

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas)
=Sqr((2*1400.3+3.7)*3.7)= 101.86 mm
Is = MIN(Iso , Io - Ir) (9.5-50) =MIN(101.86,111.12-5.5)= 101.86 mm
Area of Shell
Afs = eas * Is (9.5-54) =3.7*101.86= 376.89 mm2

Calculation of Pressure Loaded Areas
Apr/Apb = 0.5 * dib * er =0.5*19*16.5= 156.75 mm2

Cyl.Shell in the Longitudinal Section Aps
ApsL = ris * (Is + Ir + a) + a * (eas + ep) (9.5-56)
=1400.3*(101.86+5.5+9.5)+9.5*(3.7+0)= 1,6368E05 mm2

Cyl.Shell in the Transverse Cross Section Aps
ApsT = 0.5*ris^2*(Is+ar)/(0.5*eas+ris)+a*(eas+ep) (9.5-72)
=0.5*1400.3^2*(101.86+15.)/(0.5*3.7+1400.3)+9.5*(3.7+0)= 81748.48 mm2

Aps = MAX(ApsL ApsT) =MAX(1.6368E05,81748.48)= 1,6368E05 mm2

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)
pAReqL = P * (ApsL + Apr) (9.5-7) =0.2*(1.6368E05+156.75)= 32.77 kN

pAReqT = P * (ApsT + Apr + 0.5 * Apphi) (9.5-7)
=0.2*(81748.48+156.75+0.5*0)= 16.38 kN

pAReq = MAX(pAReqL, pAReqT) =MAX(32766.81,16381.05)= 32.77 kN

Pressure Area Available pA(aval.)

```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afr*(fob-0.5*P)       (9.5-13)
=(376.89+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+90.75*(146.25-0.5*0.2)=    68.82 kN
```

Nozzle Reinforcement pAAval=68.82 >= pAReq=32.77[kN]	47.6%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(376.89+0)*147.5+90.75*146.25/((1.6368E05+156.75)+0.5*(376.89+0+90.75+0))
=   0.4197 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =   ==                                                   0.7470 MPa
Weight of Nozzle: .1141kg
```

CALCULATION SUMMARY

9.5.2.4.3 Shells with openings without nozzle, reinforced by reiforcement rings.

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apr) (9.5-7) =0.2*(1.6368E05+156.75)=    32.77 kN
pAReqT = P * (ApsT + Apr + 0.5 * Apphi)                          (9.5-7)
=0.2*(81748.48+156.75+0.5*0)=                                16.38 kN
pAReq = MAX( pAReqL, pAReqT) =MAX(32766.81,16381.05)=          32.77 kN
```

Pressure Area Available pA(aval.)

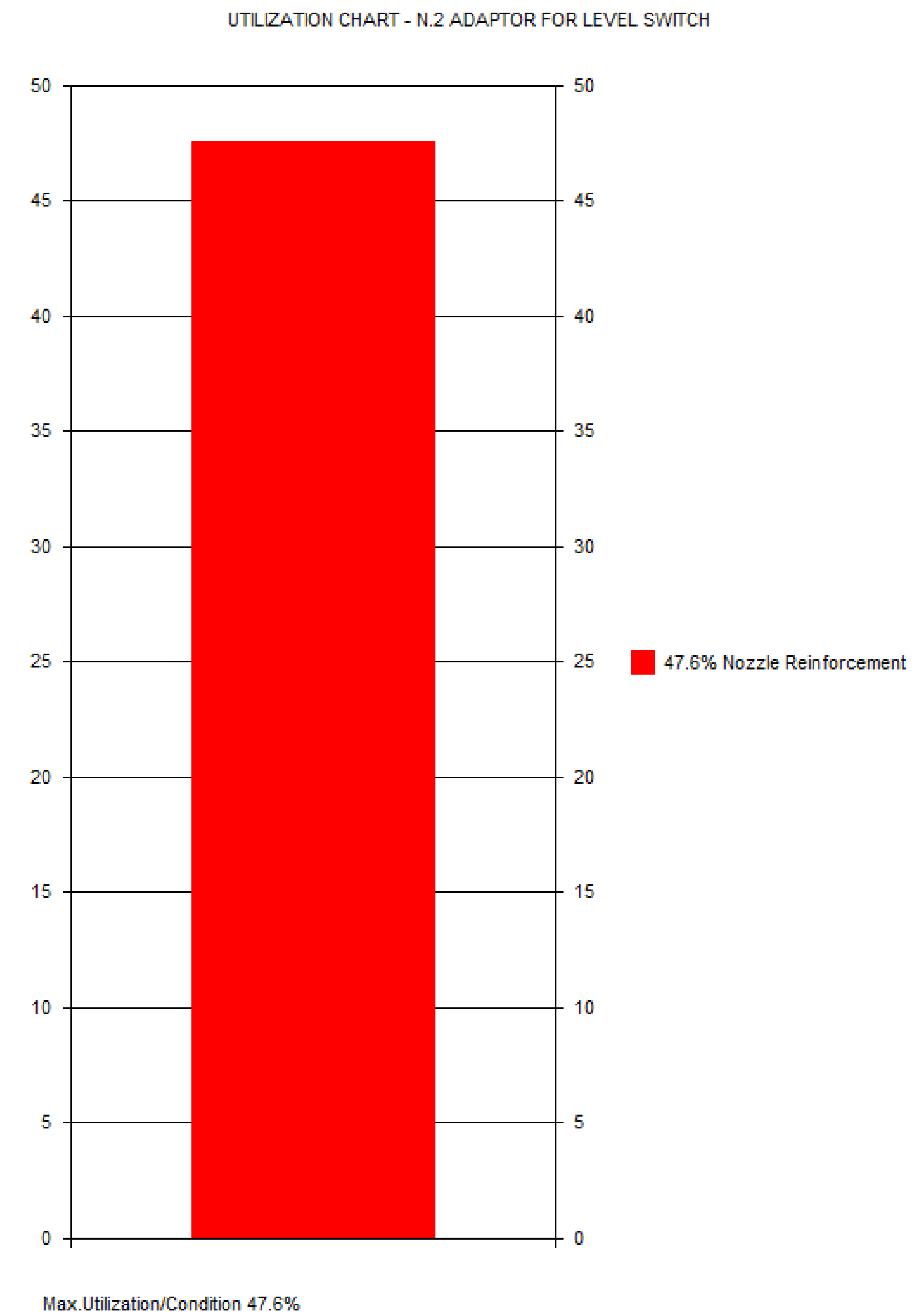
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afr*(fob-0.5*P)       (9.5-13)
=(376.89+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+90.75*(146.25-0.5*0.2)=    68.82 kN
```

Nozzle Reinforcement pAAval=68.82 >= pAReq=32.77[kN]	47.6%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(376.89+0)*147.5+90.75*146.25/((1.6368E05+156.75)+0.5*(376.89+0+90.75+0))
=   0.4197 MPa
```

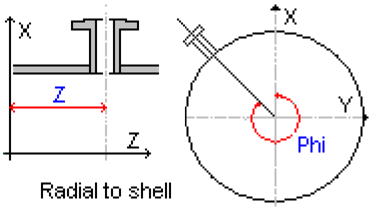
Volume:0.00 m3 Weight:0.1 kg (SG= 7.93)


UTILIZATION CHART - N.2 ADAPTOR FOR LEVEL SWITCH
50
45
40
35
30
25
20
15
10
5
0
47.6% Nozzle Reinforcement
Max.Utilization/Condition 47.6%

INPUT DATA

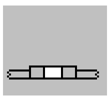
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    Main Shell
Connect this nozzle to the nozzle neck of another nozzle: NO
```




```
Orientation & Location of Nozzle: Radial to Shell
z-location of nozzle along axis of attacment........:z         100.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi   270.00 Degr.
```

GENERAL DESIGN DATA



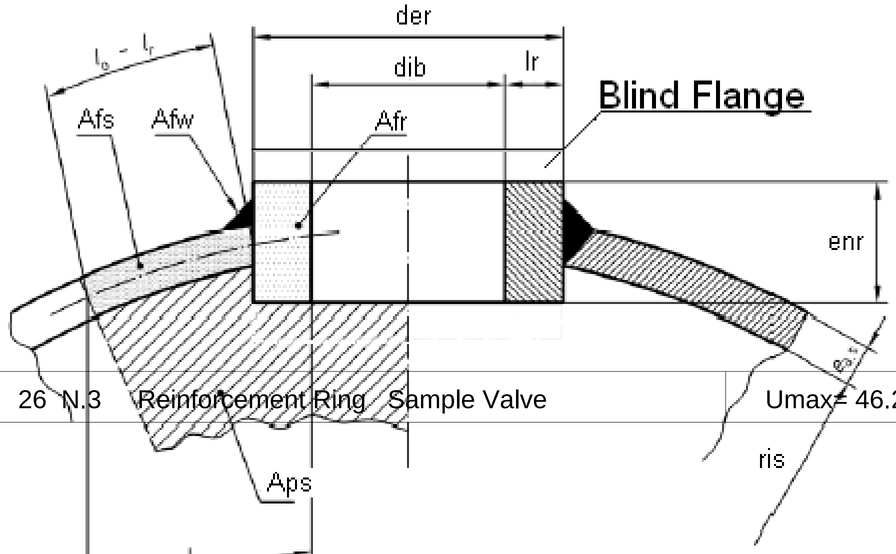
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          0.00 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
Include Nozzle Load Calculation: NO
```

SHELL DATA (S1.1)

```
Shell Type: Cylindrical Shell
OUTSIDE DIAMETER OF SHELL...........................:De       2808.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fs=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

RING DATA

```
Location of closure opening: Outside the shell
EN 10222-5:2017, 1.4404 X2CrNiMo17-12-2 forging, HT:AT THK<=250mm 90'C,A>=35%
Rm=490 Rp=225 Rpt=202.25 fr=145.83 f20=163.33 ftest=245 E=194028(N/mm2) ro=7.93
WIDTH OF RING (uncorroded)..........................:Ir          10.00 mm
THICKNESS/HEIGTH OF RING............................:enr         10.00 mm
INSIDE DIAMETER OF RING (corroded)..................:dib        8.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
```



WELDING DATA
Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld

WELDING REQUIREMENTS TO EN 1708-1:2010
Comment(Optional):
Type of welded connection: Not Applicable

CALCULATION DATA

PRELIMINARY CALCULATIONS
Shell Analysis Thickness eas
eas = en - c - th =4-0-0.3= 3.7000 mm
Ring Analysis Thickness ear
ear = enr - c =10-0= 10.00 mm
Inside Radius of Curvature
ris = De / 2 - eas (9.5-3) =2808/2-3.7= 1400.30 mm
Allowable Stresses
for/fob = Min(fs, fb) (9.5-8) =Min(147.5,145.83)= 145.83 N/mm2

9.5.2.4.3 Shells with openings without nozzle, reinforced by reiforcement rings.

Calculation of Stress Loaded Areas Effective as Reinforcement

Reinforcement Ring
Effective Thickness of Reinforcement Ring for Reinforcement Calculations
er = MIN(ear, MAX(3 * eas, 3 * Ir)) (9.5-45)
=MIN(10,MAX(3*3.7,3*10))= 10.00 mm
Limit of Reinforcement Along Shell and Ring Io
Io = Sqr((2 * ris + eam) * eam) (9.5-46)
=Sqr((2*1400.3+4.27)*4.27)= 110.32 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io (9.5-48)
=3.7+(10-3.7)*10/110.32= 4.2710 mm
Area of Ring Afr/Afb
Afr/Afb = er * Ir (9.5-55) =10*10= 100.00 mm2

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas)
=Sqr((2*1400.3+3.7)*3.7)= 101.86 mm
Is = MIN(Iso , Io - Ir) (9.5-50) =MIN(101.86,110.32-10)= 100.32 mm
Area of Shell
Afs = eas * Is (9.5-54) =3.7*100.32= 371.20 mm2

Calculation of Pressure Loaded Areas
Apr/Apb = 0.5 * dib * er =0.5*8*10= 40.00 mm2

Cyl.Shell in the Longitudinal Section Aps
ApsL = ris * (Is + Ir + a) + a * (eas + ep) (9.5-56)
=1400.3*(100.32+10+4)+4*(3.7+0)= 1,601E05 mm2

Cyl.Shell in the Transverse Cross Section Aps
ApsT = 0.5*ris^2*(Is+ar)/(0.5*eas+ris)+a*(eas+ep) (9.5-72)
=0.5*1400.3^2*(100.32+14.)/(0.5*3.7+1400.3)+4.*(3.7+0)= 79952.84 mm2

Aps = MAX(ApsL ApsT) =MAX(1.601E05,79952.84)= 1,601E05 mm2

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)
pAReqL = P * (ApsL + Apr) (9.5-7) =0.2*(1.601E05+40)= 32.03 kN

pAReqT = P * (ApsT + Apr + 0.5 * Apphi) (9.5-7)
=0.2*(79952.84+40+0.5*0)= 16.00 kN

pAReq = MAX(pAReqL, pAReqT) =MAX(32028.35,15998.57)= 32.03 kN

Pressure Area Available pA(aval.)

```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afr*(fob-0.5*P)       (9.5-13)
=(371.2+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+100*(145.83-0.5*0.2)=     69.29 kN
```

Nozzle Reinforcement pAAval=69.29 >= pAReq=32.03[kN]	46.2%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))      (9.5-14)
=(371.2+0)*147.5+100*145.83/((1.601E05+40)+0.5*(371.2+0+100+0))=   0.4323 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                      0.7661 MPa
Weight of Nozzle: .0448kg
```

CALCULATION SUMMARY

9.5.2.4.3 Shells with openings without nozzle, reinforced by reiforcement rings.

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apr) (9.5-7) =0.2*(1.601E05+40)=              32.03 kN
pAReqT = P * (ApsT + Apr + 0.5 * Apphi)                                (9.5-7)
=0.2*(79952.84+40+0.5*0)=                                         16.00 kN
pAReq = MAX( pAReqL, pAReqT) =MAX(32028.35,15998.57)=              32.03 kN
```

Pressure Area Available pA(aval.)

```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afr*(fob-0.5*P)       (9.5-13)
=(371.2+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+100*(145.83-0.5*0.2)=     69.29 kN
```

Nozzle Reinforcement pAAval=69.29 >= pAReq=32.03[kN]	46.2%	OK

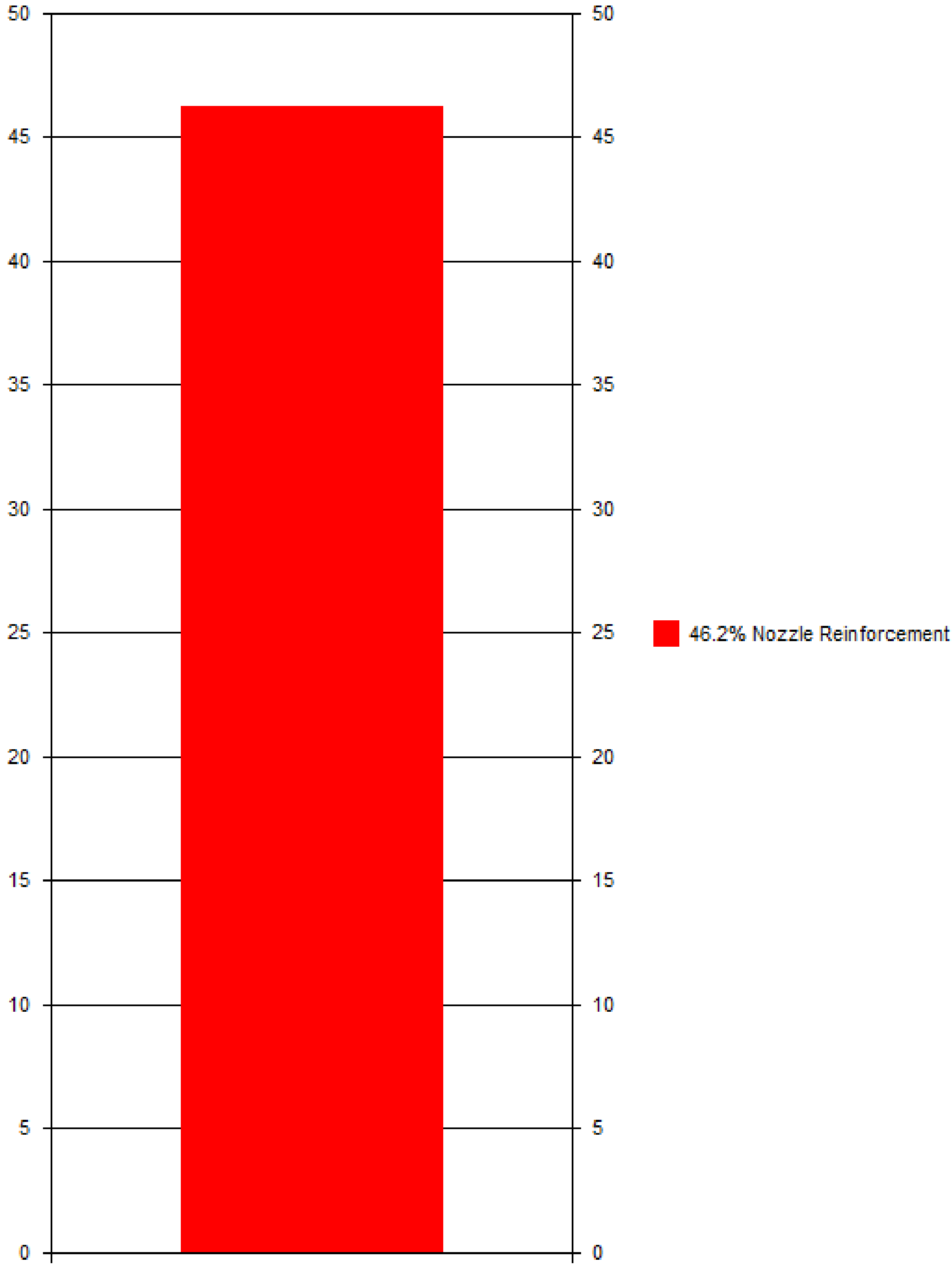
Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))      (9.5-14)
=(371.2+0)*147.5+100*145.83/((1.601E05+40)+0.5*(371.2+0+100+0))=   0.4323 MPa
```

Volume:0.00 m3 Weight:0 kg (SG= 7.93)

EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.3 Sample Valve 20 June 2019 12:24 ConnID:S1.1

UTILIZATION CHART - N.3 SAMPLE VALVE



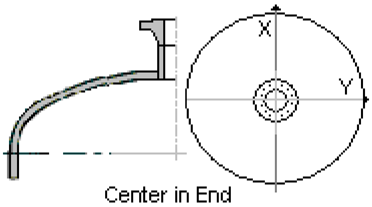
Max.Utilization/Condition 46.2%

20 June 2019 12:24 ConnID:E3.1

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

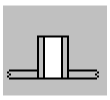
```
Attachment: E3.1    Torispherical End                                  S1.1
Connect this nozzle to the nozzle neck of another nozzle: NO
```



Center in End

```
Orientation & Location of Nozzle: Center in End
```

GENERAL DESIGN DATA

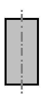


```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH        747.23 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
Include Nozzle Load Calculation: NO
```

SHELL DATA (E3.1)

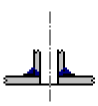
```
Shell Type: Torispherical End
OUTSIDE DIAMETER OF SHELL...........................:De       2810.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        5.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R        2248.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fs=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

NOZZLE MATERIAL DATA



```
Delivery Form: Seamless Pipe
EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT THK<=60mm 90'C
Rm=490 Rp=225 Rpt=202.6 fb=135.07 f20=150 ftest=214.29 E=194028(N/mm2) ro=7.93
```

NOZZLE DIMENSIONAL DATA



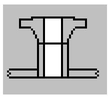
```
Attachment: Set On Nozzle
Shape of Nozzle/Opening: Circular
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER.............................:deb       458.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       4.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:           10.00 %
```

NOZZLE STANDOUT MEASURED FROM VESSEL OD..............:ho 80.00 mm

WELDING DATA

Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE BETWN.BRANCH AXIS AND A LINE NORMAL TO MAIN BODY:Phi 0.00 Degr.

DATA FOR REINFORCEMENT PAD



Type of Pad: No Pad

LIMITS OF REINFORCEMENT

Reduction of Limits of Reinforcement: No Reduction Required

WELDING REQUIREMENTS TO EN 1708-1:2010

Comment(Optional):
Type of welded connection: Not Applicable

CALCULATION DATA

PRELIMINARY CALCULATIONS

Shell Analysis Thickness eas	
eas = en - c - th =5-0-0.3=	4.7000 mm
Nozzle Analysis Thickness eab	
eab = enb - cn - NegDev =4-0-0.4=	3.6000 mm
ris = R (9.5-4) =2248=	2248.00 mm
dib = deb - 2 * eab =458-2*3.6=	450.80 mm
Min.Nozzle Thk.Based on Internal Pressure ebp	
ebp = P * deb / (2 * fb * z + P)	
=0.2073*458/(2*135.07*1+0.2073)=	0.3500 mm
Allowable Stresses	
fob = Min(fs, fb) (9.5-8) =Min(147.5,135.07)=	135.07 N/mm2

GEOMETRIC LIMITATIONS

»Check Max.Diameter of Nozzle dib/De=0.1604 <= 0.60=0.6[mm] (9.4.5.3)«» OK«

Min.Nozzle Thk. ebp=0.35 <= eab=3.6[mm]	9.7%	OK

»Location in End to Fig.9.5-4 L=1176 >= De/10=281[mm] « » OK«

9.5.2.4.4 Nozzles normal to the shell, with or without reinforcement pads.

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell	
Iso = Sqr((2 * ris + eas) * eas)	
=Sqr((2*2248+4.7)*4.7)=	145.44 mm
Set On Nozzle	
Afs = eas * (eb + Is) (9.5-81) =4.7*(3.6+145.44)=	700.50 mm2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)	
Ibo = MIN(Sqr((deb - eb) * eb), ho)	(9.5-76)
=MIN(Sqr((458-3.6)*3.6,)80)=	40.45 mm
Set On Nozzle	
Afb = eb * Ibo (9.5-80) =3.6*40.45=	145.60 mm2

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*450.8*(40.45+4.7)= 10175.80 mm2

Spherical Shell/End on any Section Aps
Aps = 0.5 * ris ^ 2 * (Is + a) / (0.5 * eas + ris)              (9.5-105)
=0.5*2248^2*(145.44+229.4)/(0.5*4.7+2248)=             4,2088E05 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                           (9.5-7)
=0.2073*(4.2088E05+10175.8+0.5*0)=                         89.36 kN
```

Pressure Area Available pA(aval.)

```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)      (9.5-7)
=(700.5+0)*(147.5-0.5*0.2073)+0*(0-0.5*0.2073)+145.6*(135.07-0.5*0.2073)
=   122.90 kN
```

Nozzle Reinforcement pAAval=122.9 >= pAReq=89.36[kN]	72.7%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp)) (9.5-10)
=(700.5+0)*147.5+145.6*135.07/((4.2088E05+10175.8+0.5*0)+0.5*(700.5+0+145.6
+0))=                                                        =   0.2850 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                     0.5025 MPa

Weight of Nozzle: 4.1kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.35 <= eab=3.6[mm]	9.7%	OK

9.5.2.4.4 Nozzles normal to the shell, with or without reinforcement pads.

```
Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*2248+4.7)*4.7)=                                    145.44 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                          (9.5-76)
=MIN(Sqr((458-3.6)*3.6,)80)=                                 40.45 mm
```

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                           (9.5-7)
=0.2073*(4.2088E05+10175.8+0.5*0)=                         89.36 kN
```

Pressure Area Available pA(aval.)

```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)      (9.5-7)
=(700.5+0)*(147.5-0.5*0.2073)+0*(0-0.5*0.2073)+145.6*(135.07-0.5*0.2073)
=   122.90 kN
```

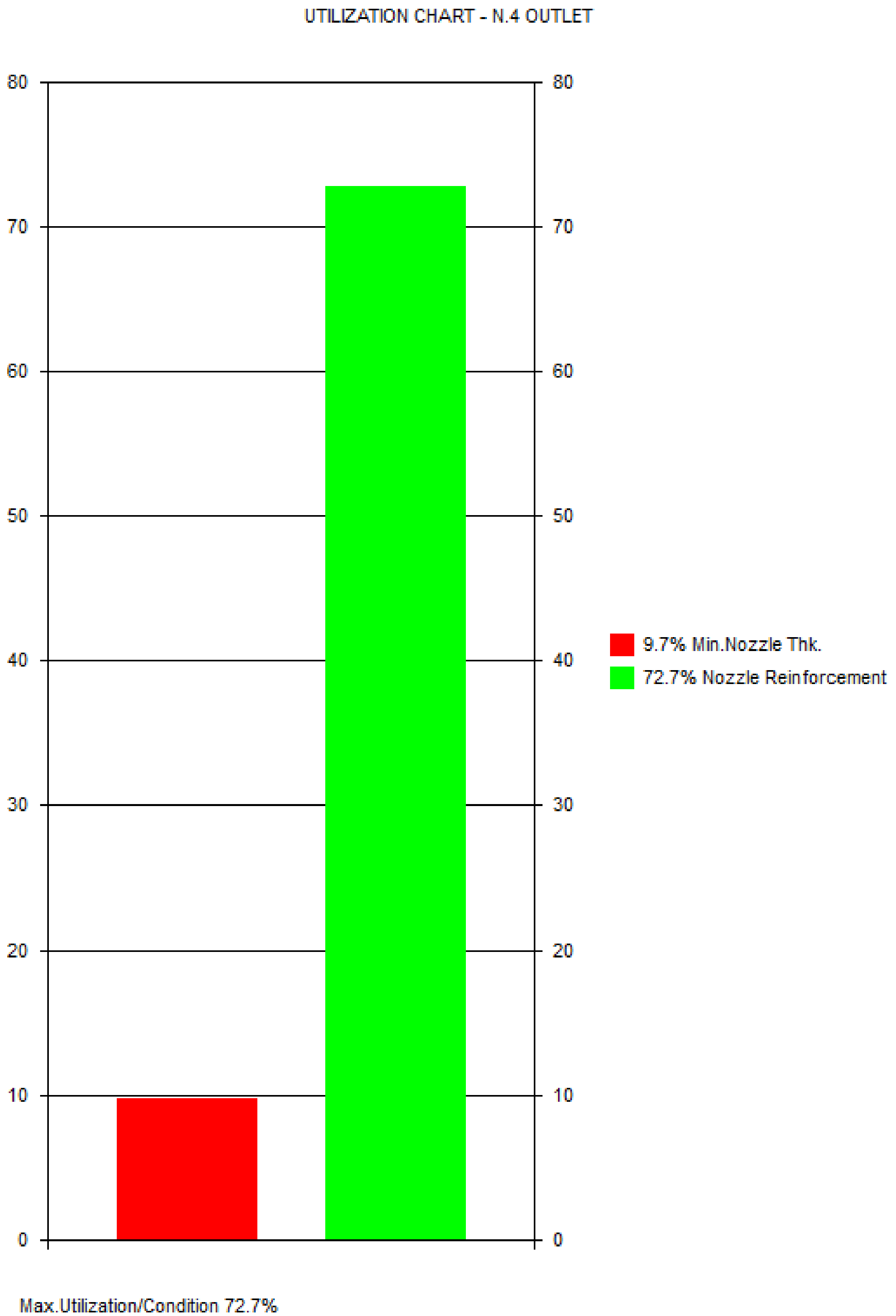
Nozzle Reinforcement pAAval=122.9 >= pAReq=89.36[kN]	72.7%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp)) (9.5-10)
=(700.5+0)*147.5+145.6*135.07/((4.2088E05+10175.8+0.5*0)+0.5*(700.5+0+145.6
+0))=                                                        =   0.2850 MPa
```

EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.4 Outlet
20 June 2019 12:24 ConnID:E3.1
Volume:0.0135 m3 Weight:4.1 kg (SG= 7.93)

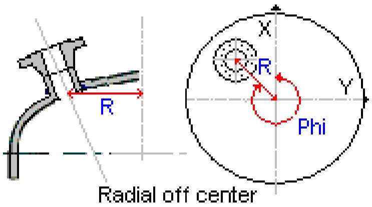
EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.4 Outlet
20 June 2019 12:24 ConnID:E3.1



INPUT DATA

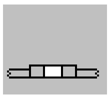
COMPONENT ATTACHMENT/LOCATION

```
Attachment: E3.1    Torispherical End                                    S1.1
Connect this nozzle to the nozzle neck of another nozzle: NO
```




```
Orientation & Location of Nozzle: Radial to End (Off Center)
Angle of Rotation of nozzle axis projected in the x-y plane:Phi    65.00 Degr.
Distance between Center of End and Center of Nozzle.:R         350.00 mm
```

GENERAL DESIGN DATA



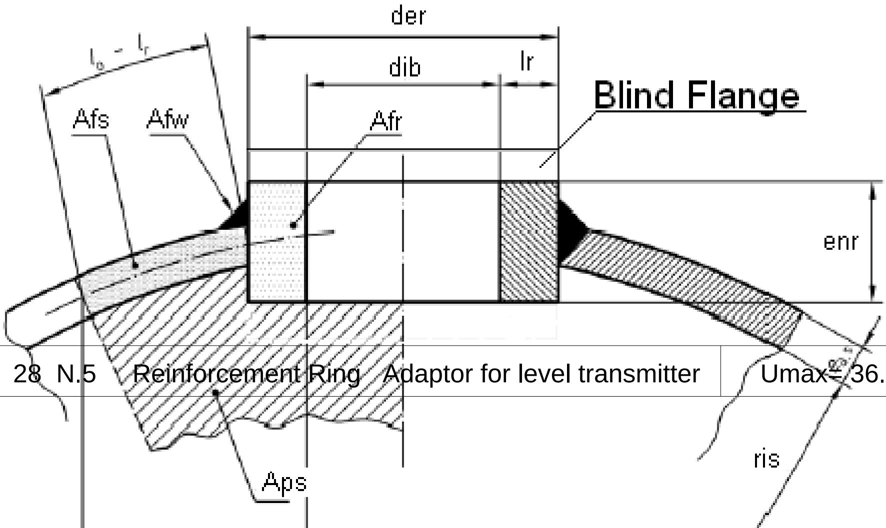
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH        719.85 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
Include Nozzle Load Calculation: NO
```

SHELL DATA (E3.1)

```
Shell Type: Torispherical End
OUTSIDE DIAMETER OF SHELL...........................:De       2810.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        5.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R        2248.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fs=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

RING DATA

```
Location of closure opening: Outside the shell
EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT THK<=160mm 90'C,A>=35%
Rm=500 Rp=235 Rpt=204.38 fr=146.25 f20=166.67 ftest=250 E=194028(N/mm2) ro=7.93
WIDTH OF RING (uncorroded)..........................:lr         10.50 mm
THICKNESS/HEIGTH OF RING............................:enr       8.0000 mm
INSIDE DIAMETER OF RING (corroded)..................:dib        44.00 mm
Size of Flange and Nozzle:
Comment (Optional):
```



WELDING DATA

Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld

WELDING REQUIREMENTS TO EN 1708-1:2010

Comment(Optional):
Type of welded connection: Not Applicable

CALCULATION DATA

PRELIMINARY CALCULATIONS

Shell Analysis Thickness eas
eas = en - c - th =5-0-0.3= 4.7000 mm
Ring Analysis Thickness ear
ear = enr - c =8-0= 8.0000 mm
ris = R (9.5-4) =350= 2248.00 mm
Allowable Stresses
for/fob = Min(fs, fb) (9.5-8) =Min(147.5,146.25)= 146.25 N/mm2

»Location in End to Fig.9.5-4 L=1022.57 >= De/10=281[mm] « » OK«

9.5.2.4.3 Shells with openings without nozzle, reinforced by reiforcement rings.

Calculation of Stress Loaded Areas Effective as Reinforcement

Reinforcement Ring

Effective Thickness of Reinforcement Ring for Reinforcement Calculations
er = MIN(ear, MAX(3 * eas, 3 * Ir)) (9.5-45)
=MIN(8,MAX(3*4.7,3*10.5))= 8.0000 mm
Limit of Reinforcement Along Shell and Ring Io
Io = Sqr((2 * ris + eam) * eam) (9.5-46)
=Sqr((2*2248+4.93)*4.93)= 150.30 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io (9.5-48)
=4.7+(8-4.7)*10.5/150.3= 4.9305 mm
Area of Ring Afr/Afb
Afr/Afb = er * Ir (9.5-55) =8*10.5= 84.00 mm2

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas)
=Sqr((2*2248+4.7)*4.7)= 145.44 mm
Is = MIN(Iso , Io - Ir) (9.5-50) =MIN(145.44,150.3-10.5)= 139.80 mm
Area of Shell
Afs = eas * Is (9.5-54) =4.7*139.8= 657.07 mm2

Calculation of Pressure Loaded Areas

Apr/Apb = 0.5 * dib * er =0.5*44*8= 176.00 mm2

Spherical Shell/End on any Section Aps
Aps = 0.5*ris^2*(Is+a)/(0.5*eas+ris)+a*(eas+ep) (9.5-72)
=0.5*2248^2*(139.8+32.5)/(0.5*4.7+2248)+32.5*(4.7+0)= 1,9362E05 mm2

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

pAReq = P * (Aps + Apr + 0.5 * Apphi) (9.5-7)
=0.2071*(1.9362E05+176+0.5*0)= 40.13 kN

Pressure Area Available pA(aval.)

pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afr*(fob-0.5*P) (9.5-13)
=(657.07+0)*(147.5-0.5*0.2071)+0*(0-0.5*0.2071)+84*(146.25-0.5*0.2071)
= 109.13 kN

Nozzle Reinforcement pAAval=109.13 >= pAReq=40.13[kN]	36.7%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((Aps+Apr+0.5*Apphi)+0.5*(Afs+Afw+Afr+Afp)) (9.5-14)
=(657.07+0)*147.5+84*146.25/((1.9362E05+176+0.5*0)+0.5*(657.07+0+84+0))
=   0.5624 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                              1.0049 MPa

Weight of Nozzle: .1141kg
```

CALCULATION SUMMARY

9.5.2.4.3 Shells with openings without nozzle, reinforced by reiforcement rings.

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apr + 0.5 * Apphi)                         (9.5-7)
=0.2071*(1.9362E05+176+0.5*0)=                          40.13 kN
```

Pressure Area Available pA(aval.)

```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afr*(fob-0.5*P)      (9.5-13)
=(657.07+0)*(147.5-0.5*0.2071)+0*(0-0.5*0.2071)+84*(146.25-0.5*0.2071)
=   109.13 kN
```

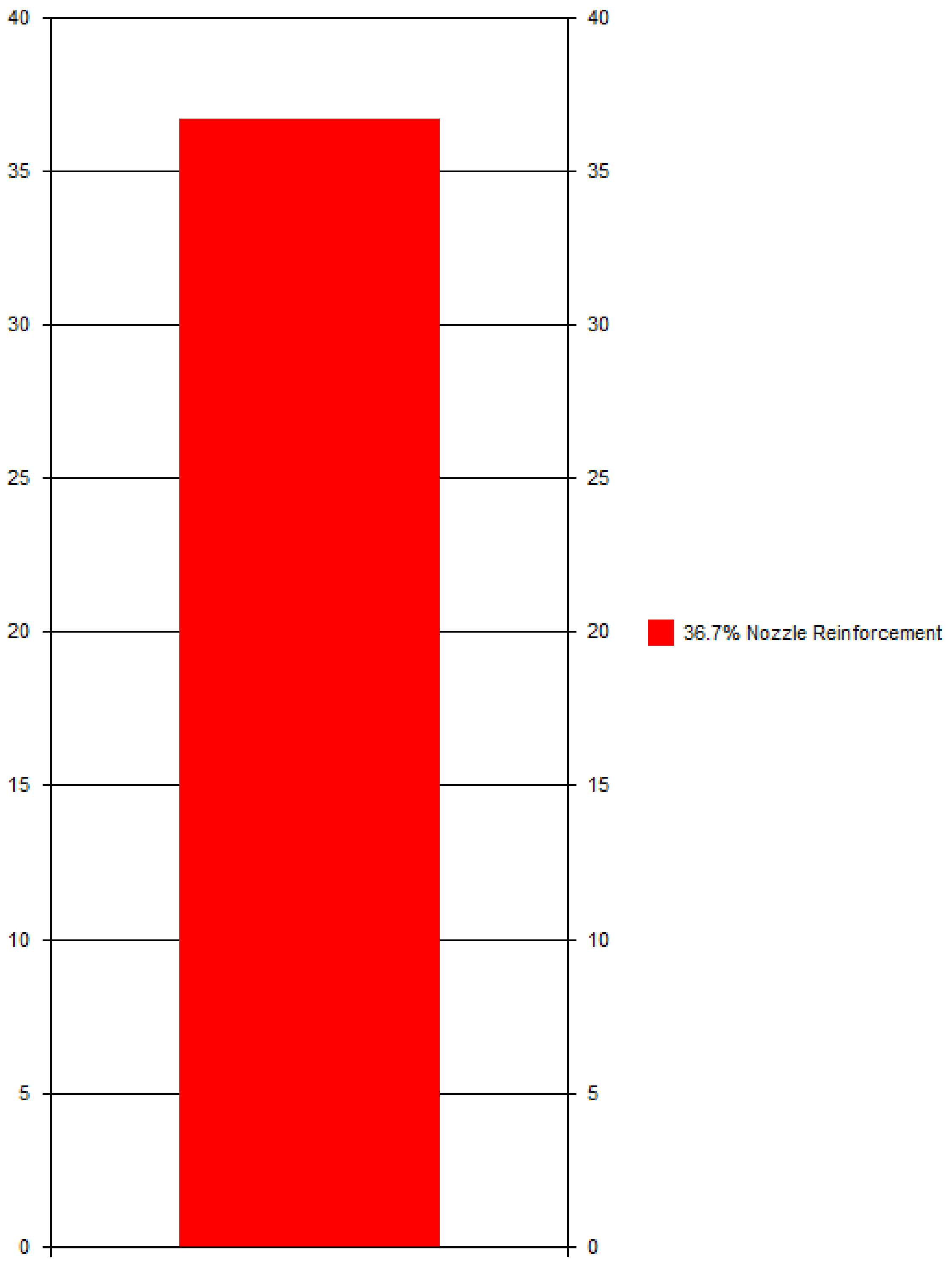
Nozzle Reinforcement pAAval=109.13 >= pAReq=40.13[kN]	36.7%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((Aps+Apr+0.5*Apphi)+0.5*(Afs+Afw+Afr+Afp)) (9.5-14)
=(657.07+0)*147.5+84*146.25/((1.9362E05+176+0.5*0)+0.5*(657.07+0+84+0))
=   0.5624 MPa
```

Volume:0.00 m3 Weight:0.1 kg (SG= 7.93)

UTILIZATION CHART - N.5 ADAPTOR FOR LEVEL TRANSMITTER

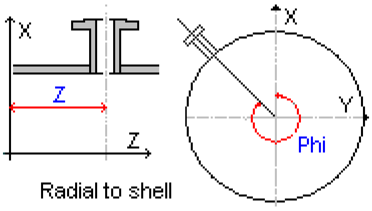


Max.Utilization/Condition 36.7%

INPUT DATA

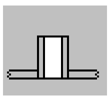
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.2    Cylindrical Shell    Main Shell                     S1.1
Connect this nozzle to the nozzle neck of another nozzle: NO
```




```
Orientation & Location of Nozzle: Radial to Shell
z-location of nozzle along axis of attacment........:z        2950.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi   225.00 Degr.
```

GENERAL DESIGN DATA

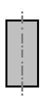


```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          0.00 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
Include Nozzle Load Calculation: NO
```

SHELL DATA (S1.2)

```
Shell Type: Cylindrical Shell
OUTSIDE DIAMETER OF SHELL...........................:De       2808.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fs=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

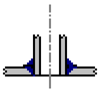
NOZZLE MATERIAL DATA



```
Delivery Form: Seamless Pipe
EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT THK<=60mm 90'C
Rm=490 Rp=225 Rpt=202.6 fb=135.07 f20=150 ftest=214.29 E=194028(N/mm2) ro=7.93
```

NOZZLE DIMENSIONAL DATA

EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.6 Side outlet 20 June 2019 12:24 ConnID:S1.2



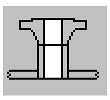
```
Attachment: Set In Flush Nozzle
Shape of Nozzle/Opening: Circular
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER.............................:deb       104.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       2.0000 mm
Size of Flange and Nozzle:
Comment (Optional): Side outlet

NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:           12.50 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.............:ho        100.00 mm
```

WELDING DATA

```
Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE PhiC(OBLIQUE IN TRANSVERSE.CROSS SECT.)Fig.9.5-2:PhiC      0.00 Degr.
ANGLE PhiL(OBLIQUE IN LONG.CROSS SECT.)Fig.9.5-1....:PhiL        0.00 Degr.
```

DATA FOR REINFORCEMENT PAD



```
Type of Pad: No Pad
```

LIMITS OF REINFORCEMENT

```
Reduction of Limits of Reinforcement: No Reduction Required
```

WELDING REQUIREMENTS TO EN 1708-1:2010

```
Comment(Optional):
Type of welded connection: Not Applicable
```

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness eas
eas = en - c - th =4-0-0.3=                                    3.7000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =2-0-0.25=                             1.7500 mm
Inside Radius of Curvature
ris = De / 2 - eas (9.5-3) =2808/2-3.7=                       1400.30 mm
dib = deb - 2 * eab =104-2*1.75=                               100.50 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=0.2*104/(2*135.07*1+0.2)=                                   0.0800 mm
Allowable Stresses
fob = Min( fs, fb) (9.5-8) =Min(147.5,135.07)=                 135.07 N/mm2
```

GEOMETRIC LIMITATIONS

»Check Max.Diameter of Nozzle dib/(2*ris)=0.0359 <= 1.00=1[mm] «» OK«

Min.Nozzle Thk. ebp=0.08 <= eab=1.75[mm]	4.5%	OK

9.5.2.4.4 Nozzles normal to the shell, with or without reinforcement pads.

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

```
Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*1400.3+3.7)*3.7)=                                  101.86 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =3.7*101.86=                        376.89 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((104-1.75)*1.75,)100)=                             13.38 mm
Set In Nozzle
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =1.75*(13.38+0+3.7)=   29.88 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*100.5*(13.38+3.7)=   858.11 mm2

Cyl.Shell in the Longitudinal Section Aps
ApsL = ris * (Is + a) (9.5-94) =1400.3*(101.86+52)=       2,1545E05 mm2

Cyl.Shell in the Transverse Cross Section Aps
ApsT = 0.5 * ris ^ 2 * (Is + a ) / (0.5 * eas + ris)              (9.5-105)
=0.5*1400.3^2*(101.86+52.01)/(0.5*3.7+1400.3)=          1,0759E05 mm2

Aps = MAX( ApsL ApsT) =MAX(2.1545E05,1.0759E05)=         2,1545E05 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =0.2*(2.1545E05+858.11)=   43.26 kN

pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                         (9.5-7)
=0.2*(1.0759E05+858.11+0.5*0)=                             21.69 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(43262.27,21690.19)=        43.26 kN
```

Pressure Area Available pA(aval.)

```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)     (9.5-7)
=(376.89+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+29.88*(135.07-0.5*0.2)=    59.59 kN
```

Nozzle Reinforcement pAAval=59.59 >= pAReq=43.26[kN]	72.6%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))     (9.5-10)
=(376.89+0)*147.5+29.88*135.07/((2.1545E05+858.11)+0.5*(376.89+0+29.88+0))
=   0.2754 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                 0.4909 MPa

Weight of Nozzle: .5335kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.08 <= eab=1.75[mm]	4.5%	OK

9.5.2.4.4 Nozzles normal to the shell, with or without reinforcement pads.

```
Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*1400.3+3.7)*3.7)=                                  101.86 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((104-1.75)*1.75,)100)=                             13.38 mm
```

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =0.2*(2.1545E05+858.11)=      43.26 kN
pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                          (9.5-7)
=0.2*(1.0759E05+858.11+0.5*0)=                               21.69 kN
pAReq = MAX( pAReqL, pAReqT) =MAX(43262.27,21690.19)=           43.26 kN
```

Pressure Area Available pA(aval.)

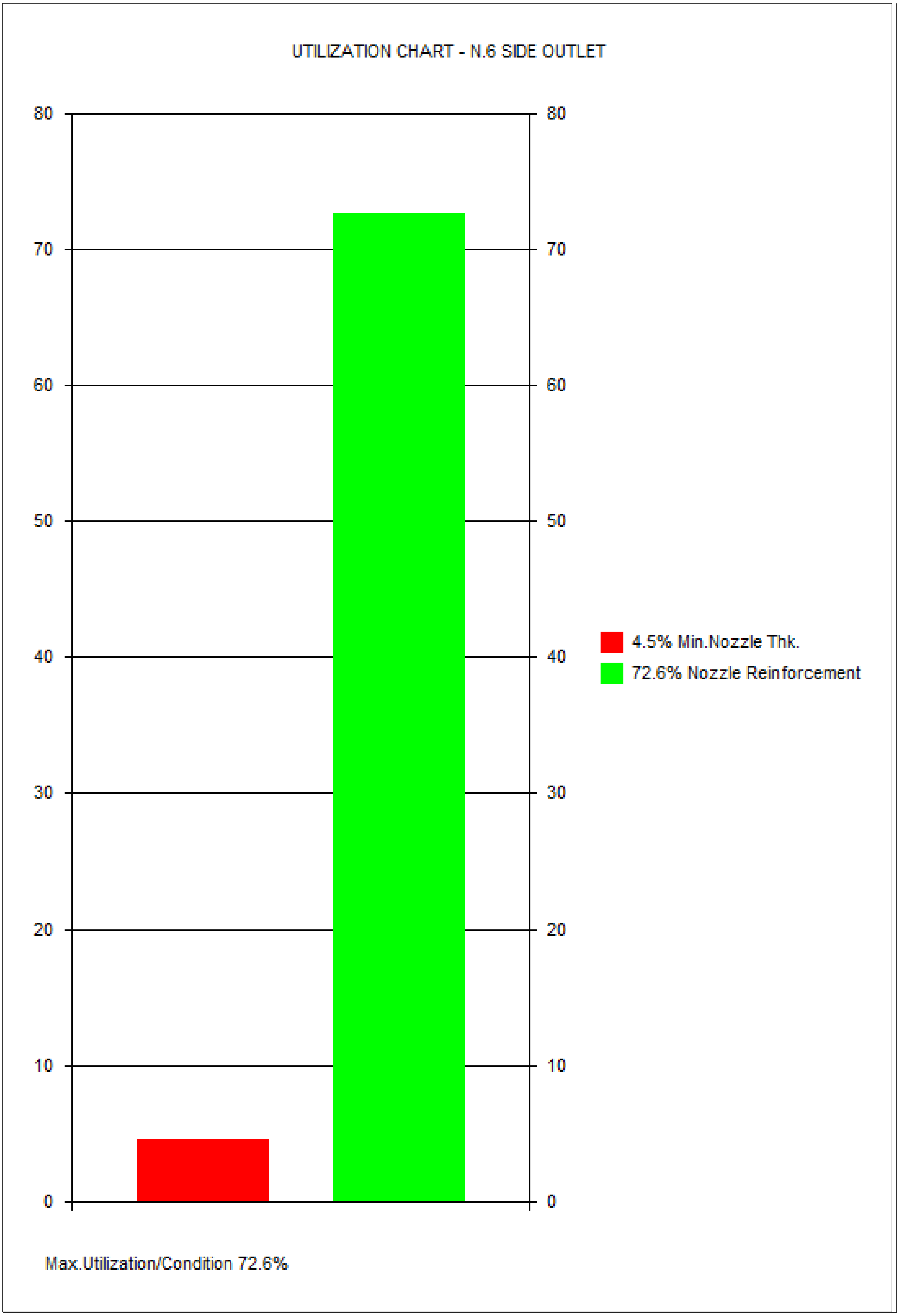
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)      (9.5-7)
=(376.89+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+29.88*(135.07-0.5*0.2)=     59.59 kN
```

Nozzle Reinforcement pAAval=59.59 >= pAReq=43.26[kN]	72.6%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))     (9.5-10)
=(376.89+0)*147.5+29.88*135.07/((2.1545E05+858.11)+0.5*(376.89+0+29.88+0))
=   0.2754 MPa
```

Volume:0.0008000 m3   Weight:0.5 kg (SG= 7.93)


UTILIZATION CHART - N.6 SIDE OUTLET
80
70
60
50
40
30
20
10
0
4.5% Min.Nozzle Thk.
72.6% Nozzle Reinforcement
Max.Utilization/Condition 72.6%

INPUT DATA

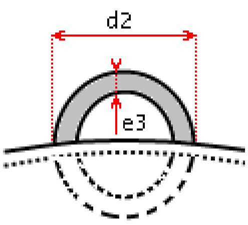
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    Main Shell
z-location of Bottom of Base Plate/Bottom Leg.......:z       -1845.00 mm
Angular Location....................................:phi        45.00 degr.
Load Analysis: Detailed Load Analysis Included(wind, seismic, blast etc.)
```

SHELL DATA

```
Shell Type: Cylindrical Shell
OUTSIDE DIAMETER OF SHELL...........................:De       2808.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fs=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

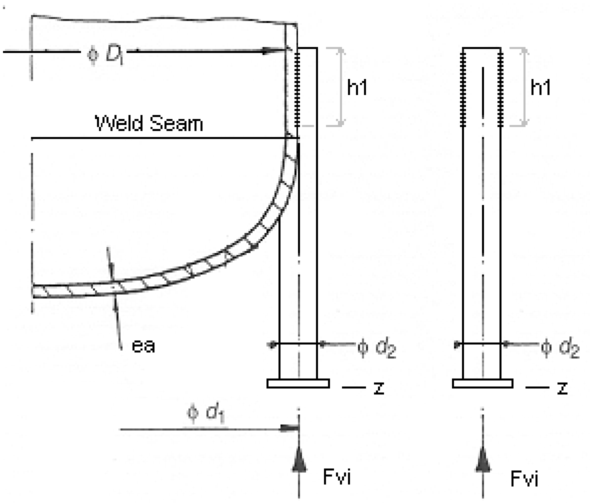
LEG DATA




```
Leg Geometry: Pipe
Legs are Cross Braced: YES
Comment (Optional):
OUTSIDE DIAMETER OF SUPPORTING LEG PIPE.............:d2        273.00 mm
WALL THICKNESS OF SUPPORTING LEG PIPE...............:e3        3.0000 mm
LEG CENTERLINE DIAMETER.............................:d1       2600.00 mm
NUMBER OF LEGS......................................:n         4.0000
LEG END CONNECTION COEFFICIENT FOR BUCKLING(1.5-2.0):K1        1.5000
```

LEG MATERIAL AND WELDING DATA

```
EN 10217-7:2014, 1.4307 X2CrNi18-9 welded tube, HT:AT THK<=60mm 90'C,A>=35%
Rm=470 Rp=215 Rpt=184.8 fl=123.2 f20=156.67 ftest=235 E=194028(N/mm2) ro=7.93
MATERIAL FORMING: Cold Formed
WELD BETWEEN LEG AND PAD/SHELL/END, THROAT DIMENSION:aw        2.0000 mm
LENGTH OF FILLET WELD ON LEG IN CYLINDRICAL SHELL...:h1        275.00 mm
WELD JOINT COEFFICIENT..............................:z         0.8500
```



DATA FOR REINFORCEMENT PAD

```
Reinforcement Pad: Included
WIDTH OF REINFORCEMENT PAD..........................:b2        250.00 mm
HEIGHT OF REINFORCEMENT PAD.........................:b3        300.00 mm
THICKNESS OF REINFORCEMENT PAD......................:e2        4.0000 mm
WELD BETWEEN SHELL AND PAD, THROAT DIMENSION........:apad      2.0000 mm
```

ANCHOR BOLT DATA

```
Perform Calculation of Anchor Bolts and base plate: NO
```

GENERAL LOAD DATA

```
Wind Load: YES
Type of Wind Load: User Defined - Wind Velocity
Wind Load Distribution: Evenly Wind Load Distribution
MAXIMUM/PEAK WIND VELOCITY..........................:Lw        1.0000 m/s
WIND FORCE/VESSEL SHAPE/DRAG COEFFICIENT............:Cf        0.7000
Check the possibility of wind induced vibration to RKF Part 3 BR-K1 Sect.5.2: YES
Seismic Load: YES
Type of Seismic Load: Uniform Building Code UBC 1997
Seismic Zone Factor (Table 16-I): Zone 3,  Z=0.3
Site Coefficient for Soil Profile (Table 16-Q): SA Hard Rock
Nonbuilding Factor R (Table 16-P): Vertical Vessels on Legs, R=2.2
OCCUPANCY IMPORTANCE COEFFICIENT (1.0 for vessels)..:I         1.0000
VERTICAL SPECTRAL RESPONSE IN PERCENT OF HORIZONTAL.:vs          0.00 %
Acceleration Loads: NO
Blast Pressure Load: NO
```

EXTERNAL LOAD BEARING COMPONENTS

Table COMPONENTS:

Description	ID	Do1(mm)	Do2(mm)	L(mm)	Thk(mm)	z1(mm)	z2(mm)	A(m2)	Sp.Dens.
Outlet	N.4	458	458	80	4	-828	-747.2	0.04	7.93
	E3.1	2810	-1	30	5	-747.2	0	0.04	7.93
Main Shell	S1.1	2808	2808	2000	4	0	2000	5.62	7.93
Main Shell	S1.2	2808	2808	1200	4	2000	3200	3.37	7.93
	E3.2	2810	1	30	5	3200	3949.7	0.04	7.93
Flange forInstrumental Top Pl	N.1	550	550	25	50	3949.7	3972	0.01	7.93

Table COMPONENTS Continued

Description	Weight(kg)	Vol(m3)	Material Name	fd	fa	fcd	fca	E-Module
Outlet	4.1	0.014	EN 10217-7:2014, 1.4404 X2CrNi	135.1	150	95.6	105.3	194028
	350.7	3.069	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	66	75.8	194028
Main Shell	558.8	12.315	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	56.1	60.9	194028
Main Shell	335.3	7.389	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	56.1	60.9	194028
	350.7	3.069	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	66	75.8	194028
Flange forInstrumental Top Pl	15.6	0.005	EN 10028-7:2016,1.4404 X2CrNi	147.5	180	108	139.7	194028

Table COMPONENTS Continued

Description	S	Thinning(mm)	E20-Module	Pemax
Outlet	1.25	0	199964	0
	1.25	0.3	199964	0
Main Shell	1.25	0.3	199964	0.00642
Main Shell	1.25	0.3	199964	0.00642
	1.25	0.3	199964	0
Flange forInstrumental Top Pl	1.25	0	199964	0

DESIGN LOADS

Table DESIGN LOADS:

Load Description	ID	Fx-kN	Fy-kN	Fz-kN	x(mm)	y(mm)	z(mm)

LOAD CASES/COMBINATION

Table LOAD CASES:

Description	ID	LC9 Hydrotest	LC4 Shut Down	LC5 Installation	LC1&2&3 Oper.Wind
Wind Load	W	0.6	1.1	0.7	1.1
Seismic	S	0	0	0	0
Blast Load	B	0	0	0	0
Acceleration	A	0	0	0	0

Table LOAD CASES Continued

Description	Oper.Seismic
Wind Load	
Seismic	1.0
Blast Load	
Acceleration	

LOAD CASE FACTORS

Table LOAD CASE FACTORS:

Description	ID	LC9 Hydrotest	LC4 Shut Down	LC5 Installation	LC1&2&3 Oper.Wind
Int.Pressure(MPa)	P	0.3	0	0	0.1800
Ext.Pressure(MPa)	Pe	0	0	0	0.002
Temperature D/A	T	A	A	A	D
Corrosion (mm)	c	0	0	0	0
Stress M-Factor :	mf	1.425	1.0	1.0	1.0
Liquid Level (mm)	LL	FULL	EMPTY	EMPTY	0
Sp.Gravity (Liq.)	SG	1.0	0	0	1
Max.Deflection d/200	d	1	1	1	1

Table LOAD CASE FACTORS Continued

Description	Oper.Seismic
Int.Pressure(MPa)	0.1800
Ext.Pressure(MPa)	0.002
Temperature D/A	D
Corrosion (mm)	0
Stress M-Factor :	1.425
Liquid Level (mm)	0
Sp.Gravity (Liq.)	1
Max.Deflection d/200	1

WELDING REQUIREMENTS TO EN 1708-1:2010

```
Comment(Optional):
Type of welded connection: Not Applicable
```

CALCULATION DATA

```
Total Height of Unit
Height = ABS( zmax - zmin) =ABS(3972--1845)=              5817.00 mm
```

Uniform Building Code 1997

```
Ca (from UBC Table 16Q) = ==                               0.2400
Cv (from UBC Table 16R) = ==                               0.2400
Fundamental period of vibration TRay calculated using the Rayleigh method:
TRay = 2*pi*SQR( SUM(Wi*yi^2)/(g*SUM(Wi*yi))) where
Wi is the element weight, yi is the element deflection
```

SEISMIC LOAD CASE NO: 5 - OPER.SEISMIC

```
The total design base shear is given by the following formulas(rigid vessel
T<0.06):
V = 0.7 * Ca * I * W (34-1) =0.7*0.24*1*4706.57=           790.70 kg
Shear force at bottom of vessel V
V = V * 9.81 / 1.4 =790.7*9.81/1.4=                        5.5406 kN
```

Natural Frequency of Vessel

```
The natural frequency of vibration is based on Rayleighs method of approximation:
T = 2*pi*Sqr(Sum(Wi*yi^2)/(g*Sum(Wi*yi))); where
Wi is the weight of the i th. element and yi is the deflection of this element.
```

LOAD CASE	Fundamental Period(s)	Natural Frequency(Hz)
LOAD CASE NO: 1 - LC9 HYDROTEST	0.0244 s	40.97 Hz
LOAD CASE NO: 2 - LC4 SHUT DOWN	0.0062 s	160.54 Hz
LOAD CASE NO: 3 - LC5 INSTALLATION	0.0062 s	160.54 Hz
LOAD CASE NO: 4 - LC1&2&3 OPER.WIND	0.0062 s	162.05 Hz
LOAD CASE NO: 5 - OPER.SEISMIC	0.0062 s	162.05 Hz

LOADS AT ELEVATION OF SUPPORT/SHELL INTERACTION

Table SUPPORT LOADS:

LOAD CASE	Fx(kN)	Fy(kN)	Fz(kN)	Mx(kNm)	My(kNm)	Mz(kNm)
LC9 HYDROTEST	0.00	0.00	-269.42	0.00	0.04	0.00
LC4 SHUT DOWN	0.01	0.00	-14.34	0.00	0.03	0.00
LC5 INSTALLATION	0.00	0.00	-14.34	0.00	0.03	0.00
LC1&2&3 OPER.WIND	0.01	0.00	-45.25	0.00	0.03	0.00
OPER.SEISMIC	5.43	0.00	-45.25	0.00	5.35	0.01

FOUNDATION LOADS AT ELEVATION AT BOTTOM OF SUPPORT

Table FOUNDATION LOADS:

LOAD CASE	Fx(kN)	Fy(kN)	Fz(kN)	Mx(kNm)	My(kNm)	Mz(kNm)
LC9 HYDROTEST	0.00	0.00	-270.95	0.00	0.04	0.00
LC4 SHUT DOWN	0.01	0.00	-15.87	0.00	0.04	0.00
LC5 INSTALLATION	0.00	0.00	-15.87	0.00	0.04	0.00
LC1&2&3 OPER.WIND	0.01	0.00	-46.78	0.00	0.04	0.00
OPER.SEISMIC	5.43	0.00	-46.78	0.00	15.37	0.01

LOAD CASE NO: 1 - LC9 HYDROTEST

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness ea
ea = en - c - th =4-0-0.3=                                   3.7000 mm
```

LOADS AND STRESSES IN THE LEGS

```
Maximum Eccentric Load F1 (compression side)
F1 = FV / n - 4 * MA / (n * d1)
=2.6942E05/4-4*35900.81/(4*2600)=                          -67.37 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=2.6942E05/4+4*35900.81/(4*2600)=                          -67.34 kN
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	0	2037.65	0.00	0.00	0.00	-67.35	30.2	0.0	30.2
2	90	2037.65	0.00	0.00	0.00	-67.36	30.2	0.0	30.2
3	180	2037.65	0.00	0.00	0.00	-67.35	30.2	0.0	30.2
4	270	2037.65	0.00	0.00	0.00	-67.36	30.2	0.0	30.2

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	45	2037.65	0.00	0.00	0.00	-67.36	30.2	0.0	30.2
2	135	2037.65	0.00	0.00	0.00	-67.36	30.2	0.0	30.2
3	225	2037.65	0.00	0.00	0.00	-67.36	30.2	0.0	30.2
4	315	2037.65	0.00	0.00	0.00	-67.36	30.2	0.0	30.2

```
Maximum Additional Force in Leg due to Bracing , FLegBrace= 3.02 N
Maximum Force in Cross-Bracing , Fbrace= .78 N
Horizontal force at each leg  Fhi = FH/n*Sin(Phin + 0.5 * DeltaPhin)
Moment at top of leg  Mi = F1*a1
Axial stress in leg  Siga = Fvi / A
Bending stress in leg Sigb  = Mi * (b/Ixx*Cos(Phi) + a/Iyy*Sin(Phi))
Maximum combined stresses in leg  Sigc=Siga(axial)+Sigb(bending)= 30.21 N/mm2
```

Axial Stresses in the Leg Siga=30.21 <= fl=235[N/mm2]	12.8%	OK
Combined Stresses in the Leg Sigc=30.21 <= 1.5*fl=352.5[N/mm2]	8.5%	OK

BUCKLING CHECK OF LEG TO EN1993-1-1 Section 6.3

```
Lambda1 = PI * Sqr( El / fY) =3.14*Sqr(194028/156.67)=      110.56
Non dimensional slenderness ratio.
Lambdam = K1 * L / (r * Lambda1)
=1.5*1895/(95.6*110.56)=                                  0.2689
From table 6.2: Selection of buckling curve : c
Imperfection factor alfa from Table  6.1: alfa= .49
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.49*(0.2689-0.2)+0.2689^2)=                      0.5531
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5531+Sqr(0.5531^2-0.2689^2,))1)=                0.9650
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-67.36,-67370)=                 67.37 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.965*2229.7*156.67/1=                                   337.08 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(2.0377E07/136.5*Cos(0)^2+2.0377E07/136.5*Sin(0)^2)=    23.39 kNm
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	0	67.35	337.08	0.00	23.39	0.1998
2	90	67.36	337.08	0.00	23.39	0.1998
3	180	67.35	337.08	0.00	23.39	0.1998
4	270	67.36	337.08	0.00	23.39	0.1998

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	45	67.36	337.08	0.00	23.39	0.1998
2	135	67.36	337.08	0.00	23.39	0.1998
3	225	67.36	337.08	0.00	23.39	0.1998
4	315	67.36	337.08	0.00	23.39	0.1998

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(67355.63/3.3708E05+1.5*0/2.3387E07,-67370/3.3708E05)=   0.1999
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.1999 <= 1.0=1	19.9%	OK

NOTE: In EUROCODE EN 1993-1 fY is the yield point, however in these calculationsfY is taken as the nominal design stress since no partial load factor has been included.

STRESSES IN WELDS

```
Section Modulus of Weld, Zw
Zw = h1 ^ 2 * aw / 3 =275^2*2/3=                          50416.67 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =0/50416.67=                               0.00 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-67370/(2*275*2)=                 61.24 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(0^2+3*61.24^2)=                                      106.08 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=106.08 <= z*fld=199.75[N/mm2]	53.1%	OK

EN13445 SECTION 16.10 - LOCAL LOADS AND STRESSES IN THE CYLINDRICAL SHELL

```
Shell Inside Diameter
Di = De - 2 * (en - c) =2808-2*(4-0)=                      2800.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2800=                                            2800.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0014« » OK«
»a) en/Deq=0.0014 <= 0.05« » OK«
»b) g/h1=0.9832 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=300 <= 1.5*h1=412.5[mm] « » OK«
»d) b2=250 >= 0.6*b3=180[mm] « » OK«

```
»e) The bracket/leg is connected to a cylindrical or a conical shell.
»f) The bracket force Fi acts parallel to the shell axis.
```

16.10.4 APPLIED FORCES

```
Vertical Force Fvi on Each Bracket/Leg, Fvi:
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(2.6942E05+4*35900.81/(2800+2*(0+3.7+4)))/4+3.02=        67.37 kN
Moment due to Horizontal Force Fhi*h is equal to zero for crossed braced legs.
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =300/Sqr(2800*3.7)=   2.9474
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)            (16.10-12)
=1/Sqr(0.36+0.5*2.95+0.5*2.95^2)=                         0.4023
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.95,0.4)=   0.2358
Sigm = P * Deq / (2 * ea) (16.6-11) =0.3*2800/(2*3.7)=       113.51 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =113.51/(1.05*265)=          0.4080
Sigball = K1 * K2 * fs (16.6-6) =0.916*1.05*265=             254.89 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi (16.10-14) =0+4+0*2032.5/67369.9=   4.0000 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                  (16.10-15)
=(254.89*3.7^2*300/(0.4023*4))=                           650.45 kN
```

Loads in Cyl.Shell Fvi=67.37 <= Fimax=650.45[kN]	10.3%	OK

```
NOTE: The calculation model assumes that all loads are taken by the cylindrical
shell.
```

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(250+300)=               2200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
```

```
=2*300^2/6*(3*250+300)=                                3,15E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*250^2/6*(3*300+250)=                                2,3958E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(250+300)^3/6=      5,5458E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =67369.9/2200=                         30.62 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(67369.9*0+0*2032.5)*0.5*300/3.15E07=                     0.00 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0^2+3*30.62^2)=                                     53.04 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=53.04 <= z*fs=225.25[N/mm2]	23.5%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0/2200)=                   0.00 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=67369.9*0*0.5*300/3.15E07=                                0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0*0*0.5*250/2.3958E07=                                    0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0*2032.5*0.5*300/5.5458E07=                               0.00 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0*2032.5*0.5*250/5.5458E07=                               0.00 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((30.62+0)^2+(30.62+0)^2)=                           43.31 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*43.31^2)=                                 75.01 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=75.01 <= z*fs=225.25[N/mm2]	33.3%	OK

LOAD CASE NO: 2 - LC4 SHUT DOWN

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness ea
ea = en - c - th =4-0-0.3=                                 3.7000 mm
```

LOADS AND STRESSES IN THE LEGS

```
Maximum Eccentric Load F1 (compression side)
F1 = FV / n - 4 * MA / (n * d1)
=14343.94/4-4*32021.51/(4*2600)=                        -3.6 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=14343.94/4+4*32021.51/(4*2600)=                        -3.57 kN
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	0	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
2	90	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
3	180	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
4	270	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	45	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
2	135	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
3	225	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
4	315	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6

```
Maximum Additional Force in Leg due to Bracing , FLegBrace= 5.54 N
Maximum Force in Cross-Bracing , Fbrace= 1.43 N
Horizontal force at each leg  Fhi = FH/n*Sin(Phin + 0.5 * DeltaPhin)
Moment at top of leg  Mi = F1*a1
Axial stress in leg  Siga = Fvi / A
Bending stress in leg Sigb  = Mi * (b/Ixx*Cos(Phi) + a/Iyy*Sin(Phi))
Maximum combined stresses in leg  Sigc=Siga(axial)+Sigb(bending)= 1.61 N/mm2
```

Axial Stresses in the Leg Siga=1.61 <= fl=156.67[N/mm2]	1.0%	OK
Combined Stresses in the Leg Sigc=1.61 <= 1.5*fl=235.[N/mm2]	0.6%	OK

BUCKLING CHECK OF LEG TO EN1993-1-1 Section 6.3

```
Lambda1 = PI * Sqr( El / fY) =3.14*Sqr(194028/156.67)=       110.56
Non dimensional slenderness ratio.
Lambdam = K1 * L / (r * Lambda1)
=1.5*1895/(95.6*110.56)=                                   0.2689
From table 6.2: Selection of buckling curve : c
Imperfection factor alfa from Table  6.1: alfa= .49
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.49*(0.2689-0.2)+0.2689^2)=                       0.5531
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5531+Sqr(0.5531^2-0.2689^2,))1)=                 0.9650
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-3.59,-3600)=                    3.5983 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.965*2229.7*156.67/1=                                    337.08 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(2.0377E07/136.5*Cos(0)^2+2.0377E07/136.5*Sin(0)^2)=     23.39 kNm
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	0	3.59	337.08	0.00	23.39	0.0106
2	90	3.59	337.08	0.00	23.39	0.0106
3	180	3.59	337.08	0.00	23.39	0.0106
4	270	3.59	337.08	0.00	23.39	0.0106

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	45	3.59	337.08	0.00	23.39	0.0106
2	135	3.59	337.08	0.00	23.39	0.0106
3	225	3.59	337.08	0.00	23.39	0.0106
4	315	3.59	337.08	0.00	23.39	0.0106

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(3588.76/3.3708E05+1.5*0/2.3387E07,-3600/3.3708E05)=   0.0107
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0107 <= 1.0=1	1.0%	OK

NOTE: In EUROCODE EN 1993-1 fY is the yield point, however in these calculationsfY is taken as the nominal design stress since no partial load factor has been included.

STRESSES IN WELDS

```
Section Modulus of Weld, Zw
Zw = h1 ^ 2 * aw / 3 =275^2*2/3=                        50416.67 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =0/50416.67=                             0.00 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-3600/(2*275*2)=               3.2712 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(0^2+3*3.27^2)=                                     5.6659 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=5.67 <= z*fld=133.17[N/mm2]	4.2%	OK

EN13445 SECTION 16.10 - LOCAL LOADS AND STRESSES IN THE CYLINDRICAL SHELL

```
Shell Inside Diameter
Di = De - 2 * (en - c) =2808-2*(4-0)=                    2800.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2800=                                          2800.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0014« » OK«
»a) en/Deq=0.0014 <= 0.05« » OK«
»b) g/h1=0.9832 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=300 <= 1.5*h1=412.5[mm] « » OK«
»d) b2=250 >= 0.6*b3=180[mm] « » OK«

```
»e) The bracket/leg is connected to a cylindrical or a conical shell.
»f) The bracket force Fi acts parallel to the shell axis.
```

16.10.4 APPLIED FORCES

```
Vertical Force Fvi on Each Bracket/Leg, Fvi:
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(14343.94+4*32021.51/(2800+2*(0+3.7+4)))/4+5.54=       3.6029 kN
Moment due to Horizontal Force Fhi*h is equal to zero for crossed braced legs.
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =300/Sqr(2800*3.7)=   2.9474
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)          (16.10-12)
=1/Sqr(0.36+0.5*2.95+0.5*2.95^2)=                       0.4023
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.95,0.4)=   0.2358
Sigm = P * Deq / (2 * ea) (16.6-11) =0*2800/(2*3.7)=        0.00 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =0/(1.25*180)=              0.00
Sigball = K1 * K2 * fs (16.6-6) =1.35*1.25*180=           303.38 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi (16.10-14) =0+4+0*2032.5/3602.9=   4.0000 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                (16.10-15)
=(303.38*3.7^2*300/(0.4023*4))=                         774.21 kN
```

Loads in Cyl.Shell Fvi=3.6 <= Fimax=774.21[kN]	0.4%	OK

```
NOTE: The calculation model assumes that all loads are taken by the cylindrical
shell.
```

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(250+300)=              2200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=2*300^2/6*(3*250+300)=                                 3,15E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*250^2/6*(3*300+250)=                                 2,3958E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(250+300)^3/6=       5,5458E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =3602.9/2200=                         1.6377 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(3602.9*0+0*2032.5)*0.5*300/3.15E07=                       0.00 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0^2+3*1.64^2)=                                       2.8365 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=2.84 <= z*fs=153.[N/mm2]	1.8%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0/2200)=                    0.00 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=3602.9*0*0.5*300/3.15E07=                                  0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0*0*0.5*250/2.3958E07=                                     0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0*2032.5*0.5*300/5.5458E07=                                0.00 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0*2032.5*0.5*250/5.5458E07=                                0.00 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((1.64+0)^2+(1.64+0)^2)=                              2.3160 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*2.32^2)=                                   4.0115 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=4.01 <= z*fs=153.[N/mm2]	2.6%	OK

LOAD CASE NO: 3 - LC5 INSTALLATION

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness ea
ea = en - c - th =4-0-0.3=                                  3.7000 mm
```

LOADS AND STRESSES IN THE LEGS

```
Maximum Eccentric Load F1 (compression side)
F1 = FV / n - 4 * MA / (n * d1)
=14343.94/4-4*28576.87/(4*2600)=                          -3.6 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=14343.94/4+4*28576.87/(4*2600)=                          -3.57 kN
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	0	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
2	90	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
3	180	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
4	270	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	45	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
2	135	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
3	225	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6
4	315	2037.65	0.00	0.00	0.00	-3.59	1.6	0.0	1.6

```
Maximum Additional Force in Leg due to Bracing , FLegBrace= 3.53 N
Maximum Force in Cross-Bracing , Fbrace= .91 N
Horizontal force at each leg  Fhi = FH/n*Sin(Phin + 0.5 * DeltaPhin)
Moment at top of leg  Mi = F1*a1
Axial stress in leg  Siga = Fvi / A
Bending stress in leg Sigb  = Mi * (b/Ixx*Cos(Phi) + a/Iyy*Sin(Phi))
Maximum combined stresses in leg  Sigc=Siga(axial)+Sigb(bending)= 1.61 N/mm2
```

Axial Stresses in the Leg Siga=1.61 <= fl=156.67[N/mm2]	1.0%	OK
Combined Stresses in the Leg Sigc=1.61 <= 1.5*fl=235.[N/mm2]	0.6%	OK

BUCKLING CHECK OF LEG TO EN1993-1-1 Section 6.3

```
Lambda1 = PI * Sqr( El / fY) =3.14*Sqr(194028/156.67)=      110.56
Non dimensional slenderness ratio.
Lambdam = K1 * L / (r * Lambda1)
=1.5*1895/(95.6*110.56)=                                 0.2689
From table 6.2: Selection of buckling curve : c
Imperfection factor alfa from Table  6.1: alfa= .49
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.49*(0.2689-0.2)+0.2689^2)=                     0.5531
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5531+Sqr(0.5531^2-0.2689^2,))1)=               0.9650
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-3.59,-3600)=                  3.5970 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.965*2229.7*156.67/1=                                  337.08 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(2.0377E07/136.5*Cos(0)^2+2.0377E07/136.5*Sin(0)^2)=    23.39 kNm
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	0	3.59	337.08	0.00	23.39	0.0106
2	90	3.59	337.08	0.00	23.39	0.0106
3	180	3.59	337.08	0.00	23.39	0.0106
4	270	3.59	337.08	0.00	23.39	0.0106

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	45	3.59	337.08	0.00	23.39	0.0106
2	135	3.59	337.08	0.00	23.39	0.0106
3	225	3.59	337.08	0.00	23.39	0.0106
4	315	3.59	337.08	0.00	23.39	0.0106

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(3587.75/3.3708E05+1.5*0/2.3387E07,-3600/3.3708E05)=   0.0107
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0107 <= 1.0=1	1.0%	OK

NOTE: In EUROCODE EN 1993-1 fY is the yield point, however in these calculationsfY is taken as the nominal design stress since no partial load factor has been included.

STRESSES IN WELDS

```
Section Modulus of Weld, Zw
Zw = h1 ^ 2 * aw / 3 =275^2*2/3=                        50416.67 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =0/50416.67=                             0.00 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-3600/(2*275*2)=               3.2700 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(0^2+3*3.27^2)=                                     5.6638 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=5.66 <= z*fld=133.17[N/mm2]	4.2%	OK

EN13445 SECTION 16.10 - LOCAL LOADS AND STRESSES IN THE CYLINDRICAL SHELL

```
Shell Inside Diameter
Di = De - 2 * (en - c) =2808-2*(4-0)=                    2800.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2800=                                          2800.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0014« » OK«
»a) en/Deq=0.0014 <= 0.05« » OK«
»b) g/h1=0.9832 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=300 <= 1.5*h1=412.5[mm] « » OK«
»d) b2=250 >= 0.6*b3=180[mm] « » OK«
»e) The bracket/leg is connected to a cylindrical or a conical shell.
»f) The bracket force Fi acts parallel to the shell axis.

16.10.4 APPLIED FORCES

```
Vertical Force Fvi on Each Bracket/Leg, Fvi:
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(14343.94+4*28576.87/(2800+2*(0+3.7+4)))/4+3.53=        3.5997 kN
```

Moment due to Horizontal Force Fhi*h is equal to zero for crossed braced legs.

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =300/Sqr(2800*3.7)=   2.9474
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)           (16.10-12)
=1/Sqr(0.36+0.5*2.95+0.5*2.95^2)=                        0.4023
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.95,0.4)=   0.2358
Sigm = P * Deq / (2 * ea) (16.6-11) =0*2800/(2*3.7)=         0.00 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =0/(1.25*180)=               0.00
Sigball = K1 * K2 * fs (16.6-6) =1.35*1.25*180=            303.38 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi (16.10-14) =0+4+0*2032.5/3599.66=   4.0000 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                 (16.10-15)
=(303.38*3.7^2*300/(0.4023*4))=                          774.21 kN
```

Loads in Cyl.Shell Fvi=3.6 <= Fimax=774.21[kN]	0.4%	OK

NOTE: The calculation model assumes that all loads are taken by the cylindrical shell.

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(250+300)=                2200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=2*300^2/6*(3*250+300)=                                   3,15E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*250^2/6*(3*300+250)=                                   2,3958E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(250+300)^3/6=         5,5458E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =3599.66/2200=                         1.6362 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(3599.66*0+0*2032.5)*0.5*300/3.15E07=                       0.00 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0^2+3*1.64^2)=                                        2.8340 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=2.83 <= z*fs=153.[N/mm2]	1.8%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0/2200)=                     0.00 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=3599.66*0*0.5*300/3.15E07=                                  0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0*0*0.5*250/2.3958E07=                                      0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0*2032.5*0.5*300/5.5458E07=                                 0.00 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0*2032.5*0.5*250/5.5458E07=                                 0.00 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((1.64+0)^2+(1.64+0)^2)=                               2.3139 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*2.31^2)=                                    4.0079 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=4.01 <= z*fs=153.[N/mm2]	2.6%	OK

LOAD CASE NO: 4 - LC1&2&3 OPER.WIND

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness ea
ea = en - c - th =4-0-0.3=                                   3.7000 mm
```

LOADS AND STRESSES IN THE LEGS

```
Maximum Eccentric Load F1 (compression side)
F1 = FV / n - 4 * MA / (n * d1)
=45250.27/4-4*32021.51/(4*2600)=                           -11.32 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=45250.27/4+4*32021.51/(4*2600)=                           -11.30 kN
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	0	2037.65	0.00	0.00	0.00	-11.31	5.1	0.0	5.1
2	90	2037.65	0.00	0.00	0.00	-11.32	5.1	0.0	5.1
3	180	2037.65	0.00	0.00	0.00	-11.31	5.1	0.0	5.1
4	270	2037.65	0.00	0.00	0.00	-11.32	5.1	0.0	5.1

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	45	2037.65	0.00	0.00	0.00	-11.31	5.1	0.0	5.1
2	135	2037.65	0.00	0.00	0.00	-11.31	5.1	0.0	5.1
3	225	2037.65	0.00	0.00	0.00	-11.31	5.1	0.0	5.1
4	315	2037.65	0.00	0.00	0.00	-11.31	5.1	0.0	5.1

```
Maximum Additional Force in Leg due to Bracing , FLegBrace= 5.54 N
Maximum Force in Cross-Bracing , Fbrace= 1.43 N
Horizontal force at each leg  Fhi = FH/n*Sin(Phin + 0.5 * DeltaPhin)
Moment at top of leg  Mi = F1*a1
Axial stress in leg  Siga = Fvi / A
Bending stress in leg Sigb  = Mi * (b/Ixx*Cos(Phi) + a/Iyy*Sin(Phi))
Maximum combined stresses in leg  Sigc=Siga(axial)+Sigb(bending)= 5.07 N/mm2
```

Axial Stresses in the Leg Siga=5.07 <= fl=123.2[N/mm2]	4.1%	OK
Combined Stresses in the Leg Sigc=5.07 <= 1.5*fl=184.8[N/mm2]	2.7%	OK

BUCKLING CHECK OF LEG TO EN1993-1-1 Section 6.3

```
Lambda1 = PI * Sqr( El / fY) =3.14*Sqr(194028/156.67)=      110.56
Non dimensional slenderness ratio.
Lambdam = K1 * L / (r * Lambda1)
=1.5*1895/(95.6*110.56)=                                  0.2689
From table 6.2: Selection of buckling curve : c
Imperfection factor alfa from Table  6.1: alfa= .49
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.49*(0.2689-0.2)+0.2689^2)=                      0.5531
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5531+Sqr(0.5531^2-0.2689^2,))1)=                0.9650
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-11.32,-11320)=                 11.32 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.965*2229.7*156.67/1=                                   337.08 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(2.0377E07/136.5*Cos(0)^2+2.0377E07/136.5*Sin(0)^2)=  23.39 kNm
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	0	11.31	337.08	0.00	23.39	0.0336
2	90	11.32	337.08	0.00	23.39	0.0336
3	180	11.31	337.08	0.00	23.39	0.0336
4	270	11.32	337.08	0.00	23.39	0.0336

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	45	11.31	337.08	0.00	23.39	0.0336
2	135	11.31	337.08	0.00	23.39	0.0336
3	225	11.31	337.08	0.00	23.39	0.0336
4	315	11.31	337.08	0.00	23.39	0.0336

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
```

```
=MAX(11315.34/3.3708E05+1.5*0/2.3387E07,-11320/3.3708E05)=   0.0336
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0336 <= 1.0=1	3.3%	OK

```
NOTE: In EUROCODE EN 1993-1 fY is the yield point, however in these calculationsfY
is taken as the nominal design stress since no partial load factor has been
included.
```

STRESSES IN WELDS

```
Section Modulus of Weld, Zw
Zw = h1 ^ 2 * aw / 3 =275^2*2/3=                           50416.67 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =0/50416.67=                                0.00 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-11320/(2*275*2)=                  10.30 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(0^2+3*10.3^2)=                                         17.83 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=17.83 <= z*fld=104.72[N/mm2]	17.0%	OK

EN13445 SECTION 16.10 - LOCAL LOADS AND STRESSES IN THE CYLINDRICAL SHELL

```
Shell Inside Diameter
Di = De - 2 * (en - c) =2808-2*(4-0)=                       2800.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2800=                                             2800.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0014« » OK«
»a) en/Deq=0.0014 <= 0.05« » OK«
»b) g/h1=0.9832 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=300 <= 1.5*h1=412.5[mm] « » OK«
»d) b2=250 >= 0.6*b3=180[mm] « » OK«

```
»e) The bracket/leg is connected to a cylindrical or a conical shell.
»f) The bracket force Fi acts parallel to the shell axis.
```

16.10.4 APPLIED FORCES

```
Vertical Force Fvi on Each Bracket/Leg, Fvi:
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(45250.27+4*32021.51/(2800+2*(0+3.7+4)))/4+5.54=           11.33 kN
Moment due to Horizontal Force Fhi*h is equal to zero for crossed braced legs.
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =300/Sqr(2800*3.7)=   2.9474
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)             (16.10-12)
=1/Sqr(0.36+0.5*2.95+0.5*2.95^2)=                          0.4023
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.95,0.4)=   0.2358
Sigm = P * Deq / (2 * ea) (16.6-11) =0.18*2800/(2*3.7)=       68.11 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =68.11/(1.25*147.5)=         0.3694
Sigball = K1 * K2 * fs (16.6-6) =0.9653*1.25*147.5=          177.99 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi (16.10-14) =0+4+0*2032.5/11329.48=   4.0000 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                   (16.10-15)
=(177.99*3.7^2*300/(0.4023*4))=                            454.20 kN
```

Loads in Cyl.Shell Fvi=11.33 <= Fimax=454.2[kN]	2.4%	OK

```
NOTE: The calculation model assumes that all loads are taken by the cylindrical
shell.
```

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(250+300)=              2200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=2*300^2/6*(3*250+300)=                                 3,15E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*250^2/6*(3*300+250)=                                 2,3958E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(250+300)^3/6=       5,5458E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =11329.48/2200=                      5.1498 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(11329.48*0+0*2032.5)*0.5*300/3.15E07=                    0.00 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0^2+3*5.15^2)=                                      8.9197 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=8.92 <= z*fs=125.38[N/mm2]	7.1%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0/2200)=                   0.00 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=11329.48*0*0.5*300/3.15E07=                               0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0*0*0.5*250/2.3958E07=                                    0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0*2032.5*0.5*300/5.5458E07=                               0.00 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0*2032.5*0.5*250/5.5458E07=                               0.00 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((5.15+0)^2+(5.15+0)^2)=                             7.2829 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*7.28^2)=                                   12.61 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=12.61 <= z*fs=125.38[N/mm2]	10.0%	OK

LOAD CASE NO: 5 - OPER.SEISMIC

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness ea
ea = en - c - th =4-0-0.3=                                 3.7000 mm
```

LOADS AND STRESSES IN THE LEGS

```
Maximum Eccentric Load F1 (compression side)
F1 = FV / n - 4 * MA / (n * d1)
=45250.27/4-4*5.3546E06/(4*2600)=                        -13.37 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=45250.27/4+4*5.3546E06/(4*2600)=                        -9.25 kN
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	0	2037.65	0.90	0.00	0.00	-12.57	5.6	0.0	5.6
2	90	2037.65	1.81	0.00	0.00	-13.83	6.2	0.0	6.2
3	180	2037.65	0.90	0.00	0.00	-12.57	5.6	0.0	5.6
4	270	2037.65	1.81	0.00	0.00	-13.83	6.2	0.0	6.2

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	45	2037.65	1.36	0.00	0.00	-13.20	5.9	0.0	5.9
2	135	2037.65	1.36	0.00	0.00	-13.20	5.9	0.0	5.9
3	225	2037.65	1.36	0.00	0.00	-13.20	5.9	0.0	5.9
4	315	2037.65	1.36	0.00	0.00	-13.20	5.9	0.0	5.9

```
Maximum Additional Force in Leg due to Bracing , FLegBrace= 5041.88 N
Maximum Force in Cross-Bracing , Fbrace= 1299.22 N
Horizontal force at each leg  Fhi = FH/n*Sin(Phin + 0.5 * DeltaPhin)
Moment at top of leg  Mi = F1*a1
Axial stress in leg  Siga = Fvi / A
Bending stress in leg Sigb  = Mi * (b/Ixx*Cos(Phi) + a/Iyy*Sin(Phi))
Maximum combined stresses in leg  Sigc=Siga(axial)+Sigb(bending)= 6.2 N/mm2
```

Axial Stresses in the Leg Siga=6.2 <= fl=235[N/mm2]	2.6%	OK
Combined Stresses in the Leg Sigc=6.2 <= 1.5*fl=352.5[N/mm2]	1.7%	OK

BUCKLING CHECK OF LEG TO EN1993-1-1 Section 6.3

```
Lambda1 = PI * Sqr( El / fY) =3.14*Sqr(194028/156.67)=       110.56
Non dimensional slenderness ratio.
Lambdam = K1 * L / (r * Lambda1)
=1.5*1895/(95.6*110.56)=                                   0.2689
From table 6.2: Selection of buckling curve : c
Imperfection factor alfa from Table  6.1: alfa= .49
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.49*(0.2689-0.2)+0.2689^2)=                       0.5531
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5531+Sqr(0.5531^2-0.2689^2,))1)=                 0.9650
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-13.83,-13370)=                  13.83 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.965*2229.7*156.67/1=                                    337.08 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(2.0377E07/136.5*Cos(0)^2+2.0377E07/136.5*Sin(0)^2)=    23.39 kNm
```

CASE 1 (first leg at angle Phi = 0 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	0	12.57	337.08	0.00	23.39	0.0373
2	90	13.83	337.08	0.00	23.39	0.0410
3	180	12.57	337.08	0.00	23.39	0.0373
4	270	13.83	337.08	0.00	23.39	0.0410

CASE 2 (first leg at angle Phi = 45 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	45	13.20	337.08	0.00	23.39	0.0392
2	135	13.20	337.08	0.00	23.39	0.0392
3	225	13.20	337.08	0.00	23.39	0.0392
4	315	13.20	337.08	0.00	23.39	0.0392

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(13833.51/3.3708E05+1.5*0/2.3387E07,-13370/3.3708E05)=   0.0410
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.041 <= 1.0=1	4.1%	OK

NOTE: In EUROCODE EN 1993-1 fY is the yield point, however in these calculationsfY is taken as the nominal design stress since no partial load factor has been included.

STRESSES IN WELDS

```
Section Modulus of Weld, Zw
Zw = h1 ^ 2 * aw / 3 =275^2*2/3=                          50416.67 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =0/50416.67=                               0.00 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-13370/(2*275*2)=                 12.16 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(0^2+3*12.16^2)=                                       21.06 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=21.06 <= z*fld=199.75[N/mm2]	10.5%	OK

EN13445 SECTION 16.10 - LOCAL LOADS AND STRESSES IN THE CYLINDRICAL SHELL

```
Shell Inside Diameter
Di = De - 2 * (en - c) =2808-2*(4-0)=                      2800.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2800=                                            2800.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0014« » OK«
»a) en/Deq=0.0014 <= 0.05« » OK«
»b) g/h1=0.9832 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=300 <= 1.5*h1=412.5[mm] « » OK«
»d) b2=250 >= 0.6*b3=180[mm] « » OK«
»e) The bracket/leg is connected to a cylindrical or a conical shell.
»f) The bracket force Fi acts parallel to the shell axis.

16.10.4 APPLIED FORCES

```
Vertical Force Fvi on Each Bracket/Leg, Fvi:
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(45250.27+4*5.3546E06/(2800+2*(0+3.7+4)))/4+5041.88=      18.26 kN
```

Moment due to Horizontal Force Fhi*h is equal to zero for crossed braced legs.

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =300/Sqr(2800*3.7)=   2.9474
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)            (16.10-12)
=1/Sqr(0.36+0.5*2.95+0.5*2.95^2)=                         0.4023
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.95,0.4)=   0.2358
Sigm = P * Deq / (2 * ea) (16.6-11) =0.18*2800/(2*3.7)=      68.11 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =68.11/(1.05*265)=          0.2448
Sigball = K1 * K2 * fs (16.6-6) =1.11*1.05*265=             309.92 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi (16.10-14) =0+4+0*2032.5/18256.36=   4.0000 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                  (16.10-15)
=(309.92*3.7^2*300/(0.4023*4))=                           790.88 kN
```

Loads in Cyl.Shell Fvi=18.26 <= Fimax=790.88[kN]	2.3%	OK

NOTE: The calculation model assumes that all loads are taken by the cylindrical shell.

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(250+300)=              2200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=2*300^2/6*(3*250+300)=                                 3,15E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*250^2/6*(3*300+250)=                                 2,3958E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(250+300)^3/6=       5,5458E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =18256.36/2200=                      8.2983 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(18256.36*0+0*2032.5)*0.5*300/3.15E07=                    0.00 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0^2+3*8.3^2)=                                       14.37 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=14.37 <= z*fs=225.25[N/mm2]	6.3%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0/2200)=                   0.00 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=18256.36*0*0.5*300/3.15E07=                               0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0*0*0.5*250/2.3958E07=                                    0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0*2032.5*0.5*300/5.5458E07=                               0.00 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0*2032.5*0.5*250/5.5458E07=                               0.00 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((8.3+0)^2+(8.3+0)^2)=                                11.74 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*11.74^2)=                                  20.33 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=20.33 <= z*fs=225.25[N/mm2]	9.0%	OK

CALCULATION SUMMARY

LOADS AT ELEVATION OF SUPPORT/SHELL INTERACTION

Table SUPPORT LOADS:

LOAD CASE	Fx(kN)	Fy(kN)	Fz(kN)	Mx(kNm)	My(kNm)	Mz(kNm)
LC9 HYDROTEST	0.00	0.00	-269.42	0.00	0.04	0.00
LC4 SHUT DOWN	0.01	0.00	-14.34	0.00	0.03	0.00
LC5 INSTALLATION	0.00	0.00	-14.34	0.00	0.03	0.00
LC1&2&3 OPER.WIND	0.01	0.00	-45.25	0.00	0.03	0.00
OPER.SEISMIC	5.43	0.00	-45.25	0.00	5.35	0.01

FOUNDATION LOADS AT ELEVATION AT BOTTOM OF SUPPORT

Table FOUNDATION LOADS:

LOAD CASE	Fx(kN)	Fy(kN)	Fz(kN)	Mx(kNm)	My(kNm)	Mz(kNm)
LC9 HYDROTEST	0.00	0.00	-270.95	0.00	0.04	0.00
LC4 SHUT DOWN	0.01	0.00	-15.87	0.00	0.04	0.00
LC5 INSTALLATION	0.00	0.00	-15.87	0.00	0.04	0.00
LC1&2&3 OPER.WIND	0.01	0.00	-46.78	0.00	0.04	0.00
OPER.SEISMIC	5.43	0.00	-46.78	0.00	15.37	0.01

LOAD CASE NO: 1 - LC9 HYDROTEST

Axial Stresses in the Leg Siga=30.21 <= fl=235[N/mm2]	12.8%	OK
Combined Stresses in the Leg Sigc=30.21 <= 1.5*fl=352.5[N/mm2]	8.5%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.1999 <= 1.0=1	19.9%	OK
Combined Stress in Welds betw.Leg and Pad Tauw=106.08 <= z*fld=199.75[N/mm2]	53.1%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(2.6942E05+4*35900.81/(2800+2*(0+3.7+4)))/4+3.02=          67.37 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                   (16.10-15)
=(254.89*3.7^2*300/(0.4023*4))=                         650.45 kN
```

Loads in Cyl.Shell Fvi=67.37 <= Fimax=650.45[kN]	10.3%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=53.04 <= z*fs=225.25[N/mm2]	23.5%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=75.01 <= z*fs=225.25[N/mm2]	33.3%	OK

LOAD CASE NO: 2 - LC4 SHUT DOWN

Axial Stresses in the Leg Siga=1.61 <= fl=156.67[N/mm2]	1.0%	OK
Combined Stresses in the Leg Sigc=1.61 <= 1.5*fl=235.[N/mm2]	0.6%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0107 <= 1.0=1	1.0%	OK
Combined Stress in Welds betw.Leg and Pad Tauw=5.67 <= z*fld=133.17[N/mm2]	4.2%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(14343.94+4*32021.51/(2800+2*(0+3.7+4)))/4+5.54=         3.6029 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                   (16.10-15)
=(303.38*3.7^2*300/(0.4023*4))=                         774.21 kN
```

Loads in Cyl.Shell Fvi=3.6 <= Fimax=774.21[kN]	0.4%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=2.84 <= z*fs=153.[N/mm2]	1.8%	OK

Total Stresses in Pad Weld Case B SigwTotPadB=4.01 <= z*fs=153.[N/mm2]	2.6%	OK

LOAD CASE NO: 3 - LC5 INSTALLATION

Axial Stresses in the Leg Siga=1.61 <= fl=156.67[N/mm2]	1.0%	OK
Combined Stresses in the Leg Sigc=1.61 <= 1.5*fl=235.[N/mm2]	0.6%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0107 <= 1.0=1	1.0%	OK
Combined Stress in Welds betw.Leg and Pad Tauw=5.66 <= z*fld=133.17[N/mm2]	4.2%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(14343.94+4*28576.87/(2800+2*(0+3.7+4)))/4+3.53=          3.5997 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                   (16.10-15)
=(303.38*3.7^2*300/(0.4023*4))=                           774.21 kN
```

Loads in Cyl.Shell Fvi=3.6 <= Fimax=774.21[kN]	0.4%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=2.83 <= z*fs=153.[N/mm2]	1.8%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=4.01 <= z*fs=153.[N/mm2]	2.6%	OK

LOAD CASE NO: 4 - LC1&2&3 OPER.WIND

Axial Stresses in the Leg Siga=5.07 <= fl=123.2[N/mm2]	4.1%	OK
Combined Stresses in the Leg Sigc=5.07 <= 1.5*fl=184.8[N/mm2]	2.7%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0336 <= 1.0=1	3.3%	OK
Combined Stress in Welds betw.Leg and Pad Tauw=17.83 <= z*fld=104.72[N/mm2]	17.0%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(45250.27+4*32021.51/(2800+2*(0+3.7+4)))/4+5.54=           11.33 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                   (16.10-15)
=(177.99*3.7^2*300/(0.4023*4))=                           454.20 kN
```

Loads in Cyl.Shell Fvi=11.33 <= Fimax=454.2[kN]	2.4%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=8.92 <= z*fs=125.38[N/mm2]	7.1%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=12.61 <= z*fs=125.38[N/mm2]	10.0%	OK

LOAD CASE NO: 5 - OPER.SEISMIC

Axial Stresses in the Leg Siga=6.2 <= fl=235[N/mm2]	2.6%	OK
Combined Stresses in the Leg Sigc=6.2 <= 1.5*fl=352.5[N/mm2]	1.7%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.041 <= 1.0=1	4.1%	OK

Combined Stress in Welds betw.Leg and Pad Tauw=21.06 <= z*fld=199.75[N/mm2]	10.5%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV+4*MA/(Di+2*(a1+ea+e2)))/n+FLegBrace
=(45250.27+4*5.3546E06/(2800+2*(0+3.7+4)))/4+5041.88=        18.26 kN
```

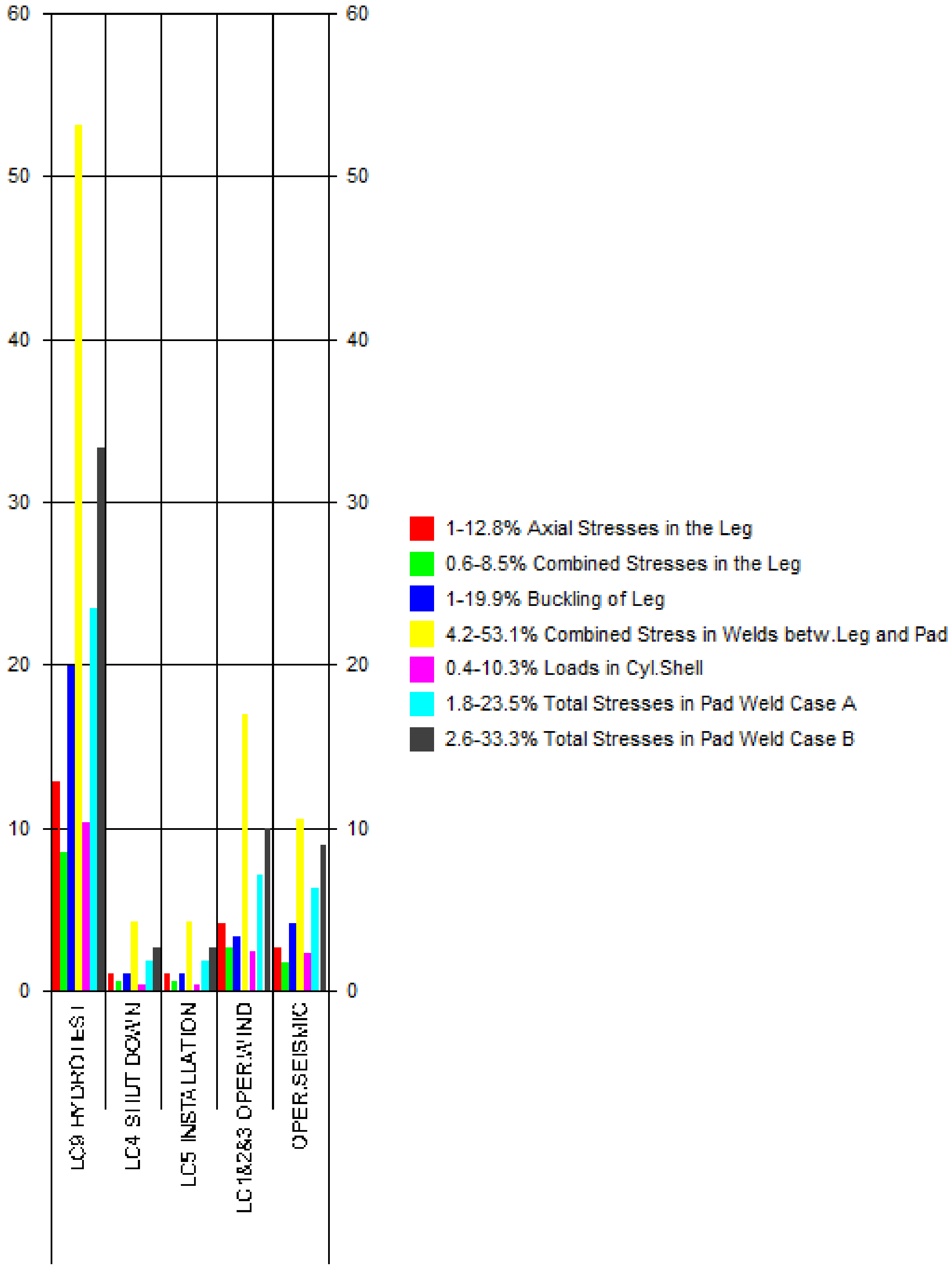
16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                (16.10-15)
=(309.92*3.7^2*300/(0.4023*4))=                        790.88 kN
```

Loads in Cyl.Shell Fvi=18.26 <= Fimax=790.88[kN]	2.3%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=14.37 <= z*fs=225.25[N/mm2]	6.3%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=20.33 <= z*fs=225.25[N/mm2]	9.0%	OK

Volume:0.00 m3 Weight:163 kg (SG= 7.93)

UTILIZATION CHART - SL.1 SUPPORT



Max.Utilization/Condition 53.1% CASE:LC9 HYDROTEST

```
EN13445 - 9.6 MULTIPLE OPENINGS
GO.1                                      20 June 2019 12:25

SUMMARY OF CALCULATION RESULTS :
No. of Nozzles Considered :  4
No. of Permutations ......:  2
No. of Nozzle Pairs Classified as Groups ...............: 1
No. of Nozzle Groups Requiring Additional Reinforcement : 0

Nozzles on Component :S1.2   Cylindrical Shell   Main Shell
NOMENCLATURE :
Distance(mm); Lb = Center Dist.between the pair of Nozzles
Distance(mm); s = Dist.between OD of Nozzles = Lb-a1-a2 ; Iso = Iso1+Iso2
Pres.Area(N); pAreq.= Pressure Area Required, pAaval = Pressure Area Available
Status (---); N/A = Not a Group, OK = Sufficient Reinf., ADD = Add reinf.

No.  Nozz1  Nozz2  ---s--- --Iso-- ---Lb-- Grp.-pAreq.-- -pAaval-- -U- -STS-
1 N.2    N.6       1287     204     1354 No  ---N/A--- ---N/A---  N/A  N/A

EN13445 - 9.6 MULTIPLE OPENINGS
GO.1                                      20 June 2019 12:25

Nozzles on Component :E3.1   Torispherical End
NOMENCLATURE :
Distance(mm); Lb = Center Dist.between the pair of Nozzles
Distance(mm); s = Dist.between OD of Nozzles = Lb-a1-a2 ; Iso = Iso1+Iso2
Pres.Area(N); pAreq.= Pressure Area Required, pAaval = Pressure Area Available
Status (---); N/A = Not a Group, OK = Sufficient Reinf., ADD = Add reinf.

No.  Nozz1  Nozz2  ---s--- --Iso-- ---Lb-- Grp.-pAreq.-- -pAaval-- -U- -STS-
2 N.4    N.5         90     291      351 Yes     83945    102993  81%  OK
Max.test pressure Ptmax= .447 for Nozzle Group: N.4 - N.5 Located in:E3.1   To
```

INPUT DATA

Extent of Nozzle Interaction Check

```
Select Extent of Nozzle Interaction Check:
Check All Components. ==> No. of Nozzles/Permutations : 4/ 2
```

GENERAL DESIGN DATA

```
CALCULATION TEMPERATURE.............................:Temp       90.00 °C
DESIGN PRESSURE.....................................:P         0.2073 MPa
INTERNAL CORROSION ALLOWANCE........................:c           0.00 mm
```

SHELL DATA

```
Nozzles on Component :E3.1   Torispherical End
OUTSIDE DIAMETER OF SHELL...........................:De       2810.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        5.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 f=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

DATA FOR NOZZLE: N.4 Outlet

```
NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.............................:deb       458.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:          0.4000 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded).:epb       0.3500 mm
EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT THK<=60mm 90'C
Rm=490 Rp=225 Rpt=202.6 f=135.07 f20=150 ftest=214.29 E=194028(N/mm2) ro=7.93
```

```
OUTWARD NOZZLE WELD, THROAT DIMENSION...............:mo          0.00 mm
```

DATA FOR NOZZLE: N.5 Adaptor for level transmitter

```
NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.............................:deb        65.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb        10.50 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:          1.0500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded).:epb         0.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 f=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION...............:mo          0.00 mm
```

CALCULATION DATA

Nozzle Group: N.4 - N.5 Located in:E3.1 Torispherical End

Preliminary Calculations

```
Center Distance Between Nozzles Lb = ==                     351.43 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 =351.43-229.4-32.5=                         89.53 mm
ApLs = 0.5 * ris ^ 2 * Lb / (ris + 0.5 * eas)                    (9.6-5)
=0.5*2248^2*351.43/(2248+0.5*3.7)=                   3,9459E05 mm2

AfLs = (Lb-a1-a2+tn1-c-dev1+tn2-c-dev2)*eas                      (9.6-7)
=(351.43-229.4-32.5+4-0-0.4+10.5-0-1.05)*3.7=           482.13 mm2
```

Pressure Area Required pA(req.)

```
pAReq = P*(ApLs+Apb1+0.5*Apphi1+Apb2+0.5*Apphi2)                 (9.6-4)
=0.2073*(3.9459E05+10175.8+0.5*0+176+0.5*0)=             83.95 kN
```

Pressure Area Available pA(aval.)

```
pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)
=0*(0-0.5*0.2073)+145.6*(135.07-0.5*0.2073)=             19.65 kN
pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)
=0*(0-0.5*0.2073)+84*(146.25-0.5*0.2073)=                12.28 kN
pAAval = (AfLs+Afw1+Afw2)*(fs-0.5*P)+pANozz1+pANozz2             (9.6-4)
=(482.13+0+0)*(147.5-0.5*0.2073)+19651.62+12276.29=     102.99 kN
```

Nozzle Reinforcement N.4 - N.5 pAAval=102.99 >= pAReq=83.95[kN]	81.5%	OK

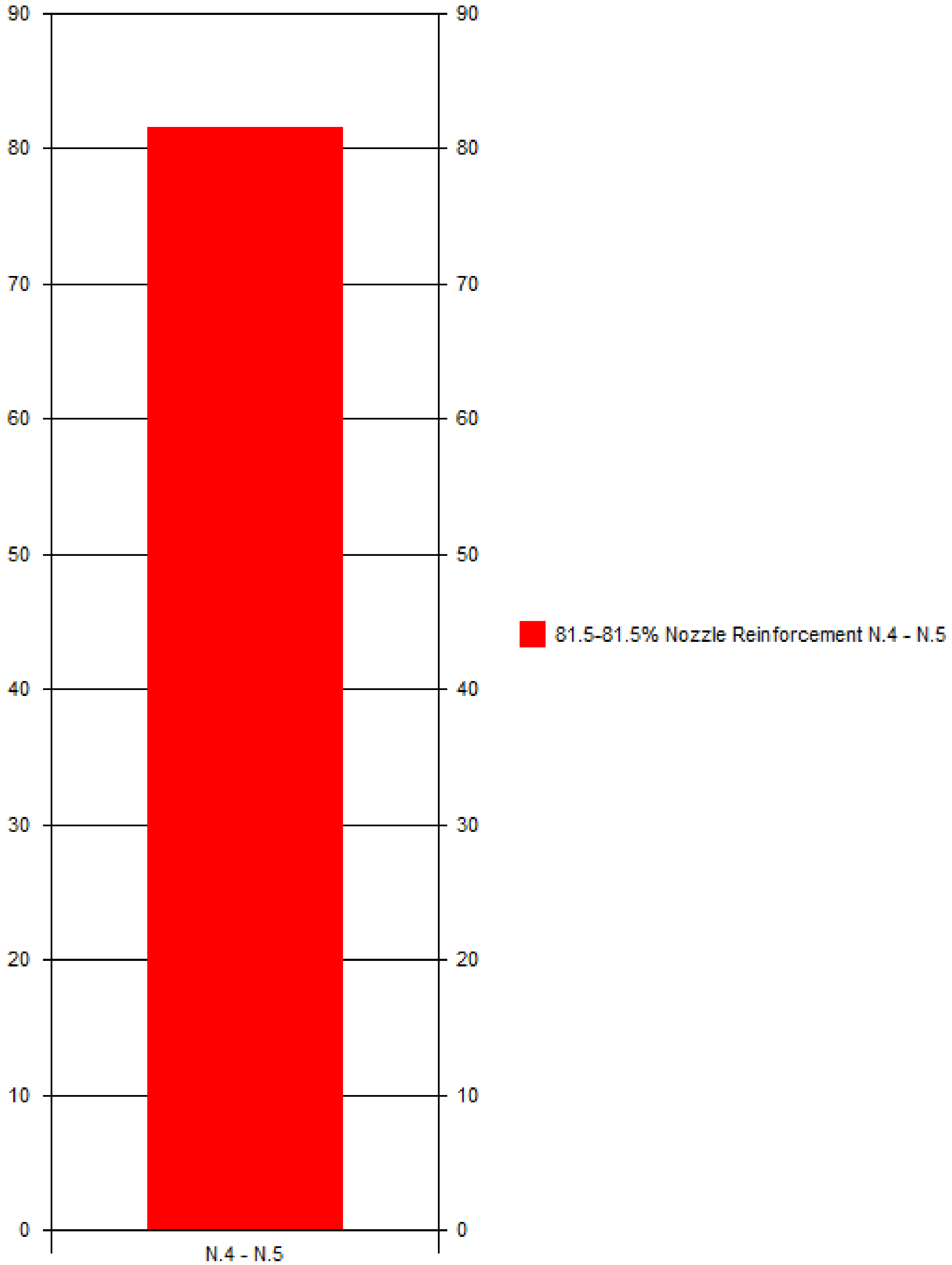
```
Max.test pressure Ptmax= .447 for Nozzle Group: N.4 - N.5 Located in:E3.1
Torispherical End
==                                                       0.4470 MPa
```

CALCULATION SUMMARY

Nozzle Group: N.4 - N.5 Located in:E3.1 Torispherical End

Nozzle Reinforcement N.4 - N.5 pAAval=102.99 >= pAReq=83.95[kN]	81.5%	OK

UTILIZATION CHART - GO.1



Max.Utilization/Condition 81.5% CASE:N.4 - N.5

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

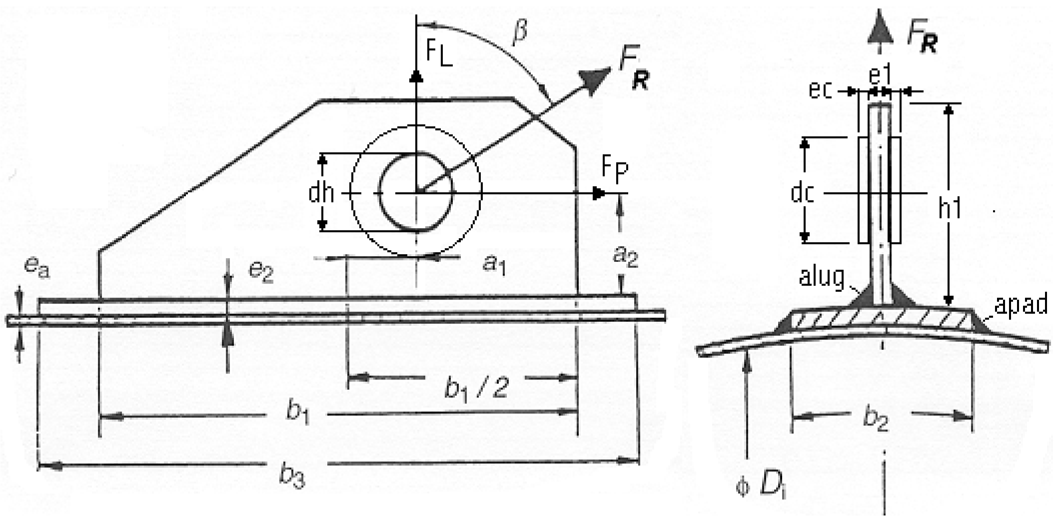
```
Attachment: E3.2    Torispherical End                                  S1.2
Off center radius of lug............................:R         1100.00 mm
Angular rotation of lug.............................:angle       90.00 degr.
Extent of Analysis: Check Lug and Loads in Shell
Type of Lifting Lug:
Symmetric lug with hole in center(a1=0), lift angle -90 to +90 degr.
Design Standard: DNV Cert.Notes 2.7-1 Annex D
```

SHELL DATA (E3.2)

```
Shell Type: Torispherical End
INSIDE SPHERICAL RADIUS (corroded)..................:R         2248.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en          5.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th          0.3000 mm
INTERNAL CORROSION ALLOWANCE........................:c            0.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 f=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

DATA FOR LIFTING LUG

```
Cheek Plates/Pad Eyes: Excluded
EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A THK<=8mm 90'C,A>=35%
Rm=520 Rp=250 Rpt=189.63 f=141.25 f20=173.33 ftest=260 E=194028(N/mm2) ro=7.93
Comment:
LENGTH OF LIFTING LUG AT SHELL/PAD JUNCTION.........:b1          130.00 mm
HEIGHT OF LIFTING LUG...............................:h1          100.00 mm
THICKNESS OF LIFTING LUG............................:e1           10.00 mm
DIAMETER OF HOLE IN LIFTING LUG.....................:dh           40.00 mm
DISTANCE FROM LOAD TO SHELL OR REINFORCEMENT PAD....:a2           60.00 mm
```



DATA FOR REINFORCEMENT PAD

```
Reinforcement Pad: Included
WIDTH OF REINFORCEMENT PAD..........................:b2          130.00 mm
LENGTH OF REINFORCEMENT PAD.........................:b3          185.00 mm
THICKNESS OF REINFORCEMENT PAD......................:e2          5.0000 mm
```

WELDING DATA

```
Type of Weld - Lug to Pad/Shell: Full Penetration Weld
WELD JOINT COEFFICIENT..............................:z           0.8500
WELD BETWEEN SHELL AND PAD, THROAT DIMENSION........:apad        2.0000 mm
```

LOAD DATA

Load Description	ID	Units	Load Case 1
Pressure	P	MPa	0
Not Applicable			0
Test Condition (Yes/No)			No
Temp.D=Design/A=Ambient	Temp		A
Maximum Force on Lug (at angle Beta)	FR	kN	10.92
Angle of Sling Leg From Vertical	Beta	degr.	30
Load Safety Factor	SL		2
Percentage Skew/Side Load	PS	%	0

Analyse Lifting Loads for Horizontal to Vertical Rotational Lift.: NO

WELDING REQUIREMENTS TO EN 1708-1:2010

Comment(Optional):
Type of welded connection: Not Applicable

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness ea
ea = en - c - th =5-0-0.3=                                    4.7000 mm
16.6.3 Equivalent Shell Diameter
Deq = R (16.6-3) =1100=                                      2248.00 mm
Lambda = b / SQR( Deq * ea) (16.6-13/17) =185/SQR(2248*4.7)=    1.7998
```

16.7.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0022« » OK«
»a) en/Deq=0.0022 <= 0.05« » OK«
»16.7.3 b) e2=5 >= en=5[mm] « » OK«
»16.7.3 b) b3=185 <= 1.5*b1=195[mm] « » OK«

LOAD CASE NO: 1 - LOAD CASE 1

```
K2 (design condition) = ==                                    1.2500
Normal Force Component
FL = SL * FR * Cos( beta) =2*10920*Cos(30)=                     18.91 kN

Parallel Force Component
FP = SL * FR * Sin( beta) =2*10920*Sin(30)=                     10.92 kN

Side/Skew Load -  0% Lateral Load
Fside = PS / 100 * SL * FR =0/100*2*10920=                       0.00 kN

External Moment Along Load Direction
ML = SL * FR * ((a2 + e2) * Sin( beta) - a1 * Cos( beta))
=2*10920*((60+5)*Sin(30)-0*Cos(30))=                         0.7098 kNm

External Moment in Transverse Load Direction
MT = Fside * (a2 + e2) =0*(60+5)=                                0.00 kNm
```

Stresses in the Lug Foot/Across Baseline and at Weld

```
Tensional Stress in the Lug Foot
SigTension = FL / (e1 * b1) =18913.99/(10*130)=               14.55 N/mm2
Bending Stress due to FP
SigBendL = 6 * FP * a2 / (e1 * b1 ^ 2)
=6*10920.*60/(10*130^2)=                                     23.26 N/mm2
Bending Stress in Lug Plate due to Moment in Transverse Load Direction
SigBendT = 6 * Fside * a2 / (b1 * e1 ^ 2)
=6*0*60/(130*10^2)=                                            0.00 N/mm2
Shear Stress due to FP
TauL = FP / (b1 * e1) =10920./(130*10)=                        8.4000 N/mm2
Shear Stress in Transverse Load Direction
TauT = Fside / (b1 * e1) =0/(130*10)=                            0.00 N/mm2
Effective Stress
Sige = SQR((SigTension+SigBendL+SigBendT)^2+3*(TauL^2+TauT^2))
```

```
=SQR((14.55+23.26+0)^2+3*(8.4^2+0^2))=                          40.51 N/mm2
```

Effective Stress in the Lug Foot Sige=40.51 <= fl=173.33[N/mm2]	23.3%	OK

```
Bending Stress in Pad due to Moment in Transverse Load Direction
SigBendT2 = 6 * Fside * a2 / (b1 * e2 ^ 2)
=6*0*60/(130*5^2)=                                                0.00 N/mm2
```

Bending Stress in Shell/Pad(Transverse Moment) SigBendT2=0 <= 1.5 * fs=270[N/mm2]	0.0%	OK
Effective Stress in Lug Weld Sige=40.51 <= z*MIN(fl,fs)=147.33[N/mm2]	27.4%	OK

Double Fillet Welds on Reinforcement Pad(Bednar Chapter 10.3)

```
Weld Length
Lwpad = 2 * (b2 + b3) =2*(130+185)=                               630.00 mm
Section Modulus(around axis transverse to lug)
Zxpad = b2 * b3 + b3 ^ 2 / 3 =130*185+185^2/3=                  35458.33 mm2
Section Modulus(around axis along lug)
Zypad = b3 * b2 + b2 ^ 2 / 3 =185*130+130^2/3=                  29683.33 mm2
Unit force due to FL
f1p = FL / Lwpad =18913.99/630=                                    30.02 N/mm
Unit force due to FP and Fside
f2p = SQR( FP ^ 2 + Fside ^ 2) / Lwpad
=SQR(10920.^2+0^2)/630=                                          17.33 N/mm
Bending
f3p = MAX((FP*a2-FL*a1)/Zxpad,Fside*a2/Zypad)
=MAX((10920.*60-18913.99*0)/35458.33,0*60/29683.33)=             18.48 N/mm
Resultant Load
ftot = SQR(( f1p + f3p) ^ 2 + f2p ^ 2)
=SQR((30.02+18.48)^2+17.33^2)=                                   51.50 N/mm
Required Weld Size, Throat Dimension
apadmin = fptot / (z * fs) =51.5/(0.85*180)=                      0.3366 mm
```

Required Pad Weld Size apadmin=0.3366 <= apad=2[mm]	16.8%	OK

Tear Out Stress , DNV Cert.Notes 2.7-1 Annex D: 2017

```
TauTearOut = 3 * SL * FR / (e1 * 2 * (h1 - a2 - dh / 2))
=3*2*10920/(10*2*(100-60-40/2))=                                163.80 N/mm2
```

Tear Out Stress TauTearOut=163.8 <= Re(lug)=250[N/mm2]	65.5%	OK

Contact/Bearing Stress (Pin in Hole) DNV Cert.Notes 2.7-1 Annex D: 2017

```
Note: Formula for compressive stress assumes a maximum difference in
diameterspin/hole of 6%.
SigBearing = 23.7 * Sqr( SL * FR / (e1 * dh))
=23.7*Sqr(2*10920/(10*40))=                                     175.12 N/mm2
```

Bearing Stress(pin in hole) SigBearing=175.12 <= Re(lug)=250[N/mm2]	70.0%	OK

16.6.7 - Global Circumferential Membrane Stress

```
Sigmy = P * Deq / (2 * ea) (16.6-11/12) =0*2248/(2*4.7)=           0.00 N/mm2
```

16.6.8 - Single Line Loads

```
K13 = 1 / (1.2 * Sqr( 1 + 0.06 * Lambda ^ 2))                   (16.6-15)
=1/(1.2*Sqr(1+0.06*1.8^2))=                             0.7625
K14 = 1 / (0.6 * Sqr( 1 + 0.03 * Lambda ^ 2))                   (16.6-16)
=1/(0.6*Sqr(1+0.03*1.8^2))=                             1.5911
K15 = MIN( 1 + 2.6 * (Deq / ea) ^ (0.3) * (b2 / Deq), 2)        (16.7-2)
=MIN(1+2.6*(2248/4.7)^(0.3)*(130/2248,)2)=              1.9573
```

```
Ny1 = MIN( 0.08 * Lambda , 0.2) (16.6-14) =MIN(0.08*1.8,0.2)=   0.1440
Ny2 = Sigmy / (K2 * fs) (16.6-8) =0/(1.25*180)=               0.00
K1 from figure 16.6-1 =    1.436
Bending Limit Stress Sigball
Sigball = K1 * K2 * fs (16.6-6) =1.44*1.25*180=            323.07 N/mm2

Maximum Allowable Local Force FRmax
FRmax = K15*Sigball*ea^2/(K13*Abs(Cos(beta))+K14*Abs((a2+e2)*Sin(beta)-
a1*Cos(beta))/b3) (16.7-5)
=1.96*323.07*4.7^2/(0.7625*Abs(Cos(0.5236))+1.59*Abs((60+5)*Sin(0.5236)-0*C
os(0.5236))/185)=                                          =    14.86 kN
```

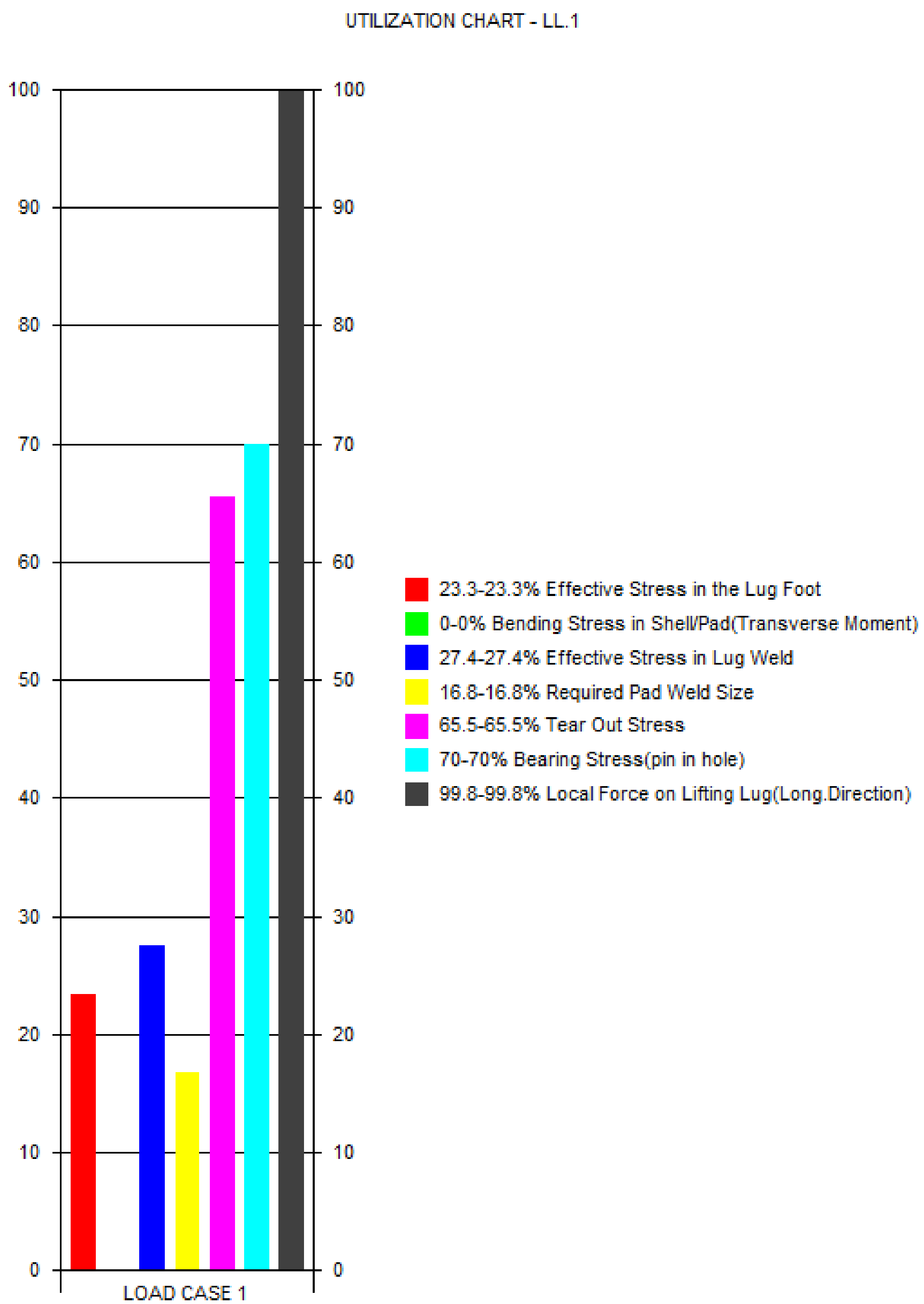
Local Force on Lifting Lug(Long.Direction) SL*FR=21.84 <= FRmax*(Sigballt/Sigball)=21.88[kN]	99.8%	OK

CALCULATION SUMMARY

LOAD CASE NO: 1 - LOAD CASE 1

Effective Stress in the Lug Foot Sige=40.51 <= fl=173.33[N/mm2]	23.3%	OK
Bending Stress in Shell/Pad(Transverse Moment) SigBendT2=0 <= 1.5 * fs=270[N/mm2]	0.0%	OK
Effective Stress in Lug Weld Sige=40.51 <= z*MIN(fl,fs)=147.33[N/mm2]	27.4%	OK
Required Pad Weld Size apadmin=0.3366 <= apad=2[mm]	16.8%	OK
Tear Out Stress TauTearOut=163.8 <= Re(lug)=250[N/mm2]	65.5%	OK
Bearing Stress(pin in hole) SigBearing=175.12 <= Re(lug)=250[N/mm2]	70.0%	OK
Local Force on Lifting Lug(Long.Direction) SL*FR=21.84 <= FRmax*(Sigballt/Sigball)=21.88[kN]	99.8%	OK

Volume:0.00 m3 Weight:1.7 kg (SG= 7.93)



Max.Utilization/Condition 99.8% CASE:LOAD CASE 1