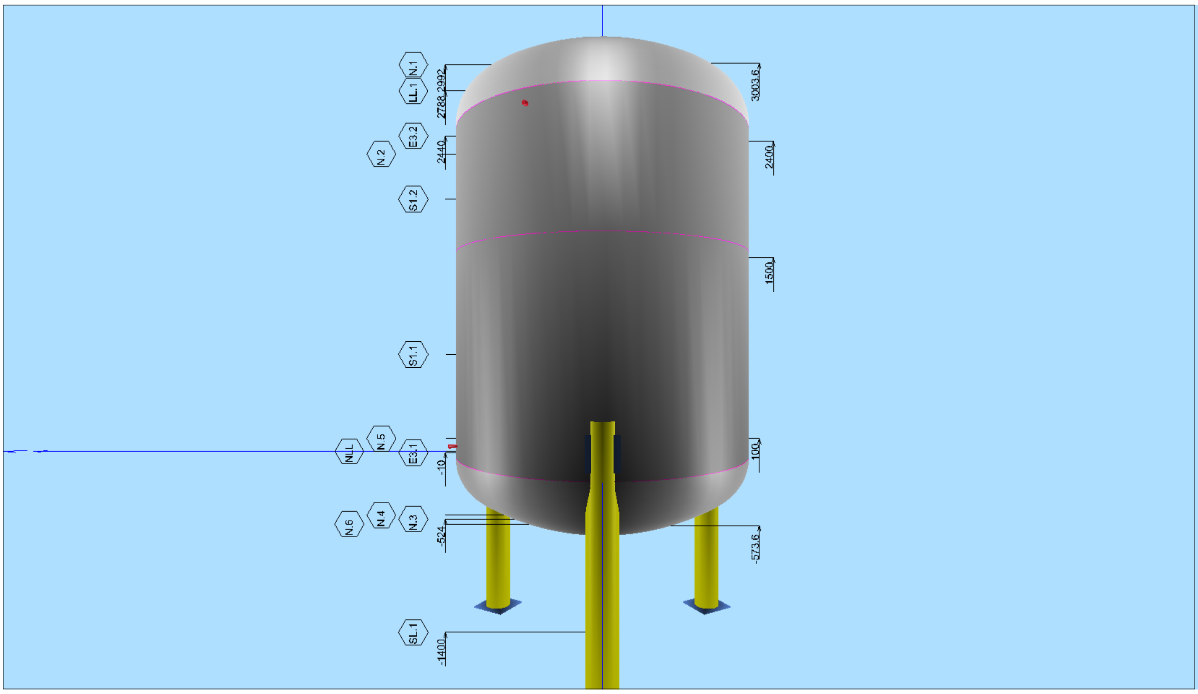
(0) Drawing

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



History of Revisions

Rev	ID	Component Type	Comp. Description	DATE & TIME
6	E3.1	Torispherical End		20 June 2019 12:02
6	E3.2	Torispherical End		20 June 2019 12:02
6	GO.1	Groups of Nozzles/Op		20 June 2019 12:02
6	LL.1	Lifting Lugs		20 June 2019 12:02
6	N.1	Reinforcement Ring	Flange for Instrumental Top Pl	20 June 2019 12:02
6	N.2	Reinforcement Ring	Adaptor for level switch	20 June 2019 12:02
6	N.3	Nozzle,Seamless Pipe	Outlet	20 June 2019 12:02
6	N.4	Nozzle,Seamless Pipe	Outlet	20 June 2019 12:02
6	N.5	Reinforcement Ring	Sample Valve	20 June 2019 12:02
6	N.6	Reinforcement Ring	Adaptor for level transmitter	20 June 2019 12:02
6	S1.1	Cylindrical Shell	Main Shell	20 June 2019 12:02
6	S1.2	Cylindrical Shell		20 June 2019 12:02
6	SL.1	Leg Support		20 June 2019 12:02

6 First Issue 20 Mar. 2019 13:02

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	

Description	Units	Design Data
Content of Vessel		
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	171.0 kg	170.4 kg	1.437 m3	1437.0 kg	1437.3 kg
E3.2	1	177.0 kg	169.4 kg	1.551 m3	1551.0 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	0.001 m3	1.0 kg	0.8 kg
N.4	1	1.0 kg	1.0 kg	0.001 m3	1.0 kg	0.9 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	0.000 m3	0.0 kg	0.0 kg
S1.1	1	330.0 kg	330.0 kg	5.702 m3	5702.0 kg	0.0 kg
S1.2	1	198.0 kg	198.0 kg	3.421 m3	3421.0 kg	0.0 kg
SL.1	1	49.0 kg	49.0 kg	0.000 m3	0.0 kg	0.0 kg
Total	**12**	**948.0 kg**	**939.7 kg**	**12.118 m3**	**12118.0 kg**	**1439.0 kg**

Weight Summary/Condition	Weights
Empty Weight of Vessel incl. 5% Contingency	987 kg / 1.0 Tons
Total Test Weight of Vessel (Testing with Water)	13105 kg / 13.1 Tons
Total Operating Weight of Vessel	2426 kg / 2.4 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	-357	0	0	-212	0	0	-212
E3.2	0	0	2761	0	0	2626	0	0	2626
LL.1	850	0	2788	850	0	2788	850	0	2788
N.1	0	0	3017	0	0	3017	0	0	3017
N.2	473	1015	2300	473	1015	2300	473	1015	2300
N.3	0	0	-622	0	0	-622	0	0	-622
N.4	0	-330	-584	0	-330	-584	0	-330	-584
N.5	1067	388	100	1067	388	100	1067	388	100
N.6	85	182	-567	85	182	-567	85	182	-567
S1.1	0	0	749	0	0	750	0	0	750
S1.2	0	0	1949	0	0	1950	0	0	1950
SL.1	0	0	-548	0	0	-548	0	0	-548

CENTER OF GRAVITY AT CONDITIONS BELOW	X	Y	Z
Empty Vessel	3	1	1136
Test Condition of Vessel (Testing with Water)	0	0	1210
Operating Condition of Vessel	1	0	320

Max. Allowable Pressure MAWP

ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
E3.1	Torispherical End		0.000 MPa	0.411 MPa	0.263 MPa
E3.2	Torispherical End		0.000 MPa	0.411 MPa	0.263 MPa
N.1	Reinforcement Ring	Flange for Instrumental Top PI	0.000 MPa	0.856 MPa	0.701 MPa
N.2	Reinforcement Ring	Adaptor for level switch	0.000 MPa	0.647 MPa	0.536 MPa

ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
N.3	Nozzle,Seamless Pipe	Outlet	0.006 MPa	0.541 MPa	0.445 MPa
N.4	Nozzle,Seamless Pipe	Outlet	0.005 MPa	0.538 MPa	0.442 MPa
N.5	Reinforcement Ring	Sample Valve	0.000 MPa	0.947 MPa	0.807 MPa
N.6	Reinforcement Ring	Adaptor for level transmitter	0.006 MPa	0.686 MPa	0.567 MPa
S1.1	Cylindrical Shell	Main Shell	0.000 MPa	0.514 MPa	0.421 MPa
S1.2	Cylindrical Shell		0.000 MPa	0.514 MPa	0.421 MPa
	MAWP			**0.411 MPa**	**0.263 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	0.587	0.305	0.035	0.305	0.552
E3.2	Torispherical End-	0.200	0.587	0.305	0.006	0.305	0.581
GO.1	Nozzle Group: N.3 - N.4 Located in:E3.1 Torispherical End	0.206	0.802	NA	0.00552	NA	0.796
N.1	Reinforcement Ring-Flange for Instrumental Top Pl	0.200	1.260	NA	0.000	NA	1.259
N.2	Reinforcement Ring-Adaptor for level switch	0.200	0.957	NA	0.012	NA	0.945
N.3	Nozzle,Seamless Pipe-Outlet	0.206	0.803	NA	0.036	NA	0.767
N.4	Nozzle,Seamless Pipe-Outlet	0.205	0.799	NA	0.036	NA	0.763
N.5	Reinforcement Ring-Sample Valve	0.200	1.406	NA	0.039	NA	1.367
N.6	Reinforcement Ring-Adaptor for level transmitter	0.206	1.021	NA	0.036	NA	0.985
S1.1	Cylindrical Shell-Main Shell	0.200	0.890	0.305	0.030	0.305	0.860
S1.2	Cylindrical Shell-	0.200	0.890	0.305	0.015	0.305	0.875

```
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) .......:     0.5518 MPa
```

PNEUMATIC TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..:     0.3143 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...:     0.5872 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	0.587	0.305	0.028	0.305	0.560
E3.2	Torispherical End-	0.200	0.587	0.305	0.038	0.305	0.549
GO.1	Nozzle Group: N.3 - N.4 Located in:E3.1 Torispherical End	0.206	0.802	NA	0.00552	NA	0.796
N.1	Reinforcement Ring-Flange for Instrumental Top Pl	0.200	1.260	NA	0.030	NA	1.229
N.2	Reinforcement Ring-Adaptor for level switch	0.200	0.957	NA	0.032	NA	0.925
N.3	Nozzle,Seamless Pipe-Outlet	0.206	0.803	NA	0.028	NA	0.776

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
N.4	Nozzle,Seamless Pipe-Outlet	0.205	0.799	NA	0.031	NA	0.768
N.5	Reinforcement Ring-Sample Valve	0.200	1.406	NA	0.019	NA	1.388
N.6	Reinforcement Ring-Adaptor for level transmitter	0.206	1.021	NA	0.028	NA	0.993
S1.1	Cylindrical Shell-Main Shell	0.200	0.890	0.305	0.038	0.305	0.851
S1.2	Cylindrical Shell-	0.200	0.890	0.305	0.038	0.305	0.851

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) ....:   0.5488 MPa

PNEUMATIC TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..:   0.3143 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...:   0.5872 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= 2208, wt= 4, h= 565.58, R= 1766.4, r= 340.032, Not Applicable	ID 2, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
E3.2	1	Torispherical End-	De= 2208, wt= 4, h= 565.58, R= 1766.4, r= 340.032, Not Applicable	ID 2, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
LL.1	1	Lifting Lugs-	LUG PL10x100x130,PAD PL5x120x180,FR=6.5kN,dh=40mm	ID 1, EN 10028-7:2016, 1.4301 X5CrNi18-10 C=Cold Rolled Strip, HT:
N.1	1	Reinforcement Ring-Flange for Instrumental Top Pl	do=550,di=450,thk=25	ID 2, 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 10, EN 10272:2016, 1.4435 X2CrNiMo18-14-3 bar, HT:AT
N.3	1	Nozzle,Seamless Pipe-Outlet	do=104,wt=2,L=104.8,ho=100	ID 6, EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT
N.4	1	Nozzle,Seamless Pipe-Outlet	do=104,wt=2,L=119.8,ho=100	ID 6, EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT

ID	No	Description	Component Dimensions	Material Standard
N.5	1	Reinforcement Ring-Sample Valve	do=28,di=8,thk=65	ID 7, EN 10222-5:2017, 1.4404 X2CrNiMo17-12-2 forging, HT:AT
N.6	1	Reinforcement Ring-Adaptor for level transmitter	do=65,di=44,thk=8	ID 9, EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT
S1.1	1	Cylindrical Shell-Main Shell	De= 2208, en= 4, L= 1500	ID 2, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
S1.2	1	Cylindrical Shell-	De= 2208, en= 4, L= 900	ID 2, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
SL.1	1	Leg Support-	3 off Legs;Pipe , H= 1660;, Reinf.Pad PL 230X 220X 4	ID 8, 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) =0.030% (based on unsupported length L= 3580 mm
-	NOTE: Maximum unsupported length for given shell thickness Lmax = 21856 mm (en = 4 mm)
-	NOTE: Required minimum shell thickness due to external pressure emin(ext)= 2.11 mm (unsupported length L= 3580 mm)
-	NOTE: EN13445-4 Table 9.4.1 d) for requirement for heat treatment of austenitic steels.
S1.2 Cylindrical Shell	
-	NOTE: Circularity tolerance limit(in % of radius) =0.030% (based on unsupported length L= 3580 mm
-	NOTE: Maximum unsupported length for given shell thickness Lmax = 21856 mm (en = 4 mm)
-	NOTE: Required minimum shell thickness due to external pressure emin(ext)= 2.11 mm (unsupported length L= 3580 mm)
-	NOTE: EN13445-4 Table 9.4.1 d) for requirement for heat treatment of austenitic steels.
SL.1 Leg 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.
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 Pl	DN450		450	25	0	0	3003.6	0	Radial
N.2	Adaptor for level switch			19	34	465.7	998.8	2300	65	Radial
N.3	Outlet			100.4	100	0	0	-573.6	0	Radial
N.4	Outlet			100.4	100	0	-330	-542.5	270	Non Rad.
N.5	Sample Valve			8	65	1035.5	376.9	100	20	Radial
N.6	Adaptor for level transmitter			44	8	84.5	181.3	-562.2	65	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	45.6%	Nozzle Reinforcement N.3 - N.4

ID	Comp.Type	Umax(%)	Limited by
LL.1	Lifting Lugs	93.2%	Local Force on Lifting Lug(Lon
N.1	Reinforcement Ring	28.4%	Nozzle Reinforcement
N.2	Reinforcement Ring	37.2%	Nozzle Reinforcement
N.3	Nozzle,Seamless Pipe	45.6%	Nozzle Reinforcement
N.4	Nozzle,Seamless Pipe	45.8%	Nozzle Reinforcement
N.5	Reinforcement Ring	24.7%	Nozzle Reinforcement
N.6	Reinforcement Ring	35.8%	Nozzle Reinforcement
S1.1	Cylindrical Shell	51.4%	Internal Pressure
S1.2	Cylindrical Shell	51.4%	Internal Pressure
SL.1	Leg Support	98.6%	Loads in Cyl.Shell

Component with highest utilization Umax = 98.6% SL.1

Average utilization of all components Umean= 55.9%

Material Data/Mechanical Properties

ID	Material Name	Temp	Rm	Rp	Rpt	f_d	f20	ftest	E-mod	Note
1	EN 10028-7:2016, 1.4301 X5CrNi18-10 C=Cold Rolled Strip, HT: TG3, SS, Mat.Group:8.1, , Max.T= 8mm, SG=7.93	90	540	260	199.6	153.8	180	270	194028	
2	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, HT: TG3, SS, Mat.Group:8.1, , Max.T= 8mm, SG=7.93	90	530	270	207.9	147.5	180	265	194028	
3	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	
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 10028-2:2017, 1.0425 P265GH plate and strip, HT:N TG3, CS, Mat.Group:1.1, , Max.T= 16mm, SG=7.85	90	410	265	244	162.7	170.8	252.4	206793	
6	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	
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, 1.4307 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	
9	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	
10	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	

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
GRP : 1.1 = Steels with a specified minimum specified yield strength ReH <= 275 N/mm2
GRP : 1.0 = Steels with a specified minimum yield strength ReH <= 460 N/mm2 a and with analysis in %:C <= 0,25, Si <= 0,60, Mn <= 1,70, Mo <= 0,70b, S <= 0,045, P <= 0,045, Cu <= 0,40b, Ni <= 0,5b, Cr <= 0,3 (0,4 for castings)b, Nb <= 0,05, V <= 0,12b, Ti <= 0,05
HT : AT = solution annealed
HT : AT = solution annealed
HT : N = normalised

```
HT   : AT = solution annealed
HT   : AT = solution annealed
HT   : AT = solution annealed
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	2400	0.0	0.0	S1.2
LL.1	Lifting Lugs	850	0	2788	0.0	0.0	E3.2
N.1	Reinforcement Ring	0	0	3004	0.0	0.0	E3.2
N.2	Reinforcement Ring	466	999	2300	90.0	65.0	S1.2
N.3	Nozzle,Seamless Pipe	0	0	-574	0.0	0.0	E3.1
N.4	Nozzle,Seamless Pipe	0	-330	-543	0.0	270.0	E3.1
N.5	Reinforcement Ring	1036	377	100	90.0	20.0	S1.1
N.6	Reinforcement Ring	85	181	-562	-6.5	65.0	E3.1
S1.1	Cylindrical Shell	0	0	0	0.0	0.0	
S1.2	Cylindrical Shell	0	0	1500	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,	4.0	4.0	270.0	0.84
E3.2 - End	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	4.0	4.0	270.0	0.84
N.1 Flange for Instrumental Top PI - Ring	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	50.0	50.0	270.0	0.28
N.2 Adaptor for level switch - Ring	EN 10272:2016, 1.4435 X2CrNiMo18-14-3 bar, HT:AT	5.5	5.5	235.0	0.37
N.3 Outlet - Nozzle	EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT	2.0	2.0	225.0	0.46
N.4 Outlet - Nozzle	EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT	2.0	2.0	225.0	0.46
N.5 Sample Valve - Ring	EN 10222-5:2017, 1.4404 X2CrNiMo17-12-2 forging, HT:AT	10.0	10.0	225.0	0.25
N.6 Adaptor for level transmitter - Ring	EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT	10.5	10.5	235.0	0.36
S1.1 Main Shell - Shell	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	4.0	4.0	270.0	0.51
S1.2 - Shell	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	4.0	4.0	270.0	0.51

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 PI - 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.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= -273 C
N.3 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.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 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
N.6 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
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 - 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)

Weld ID	Weld Category	Weld Type	RT or UT	MT or PT
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%
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.

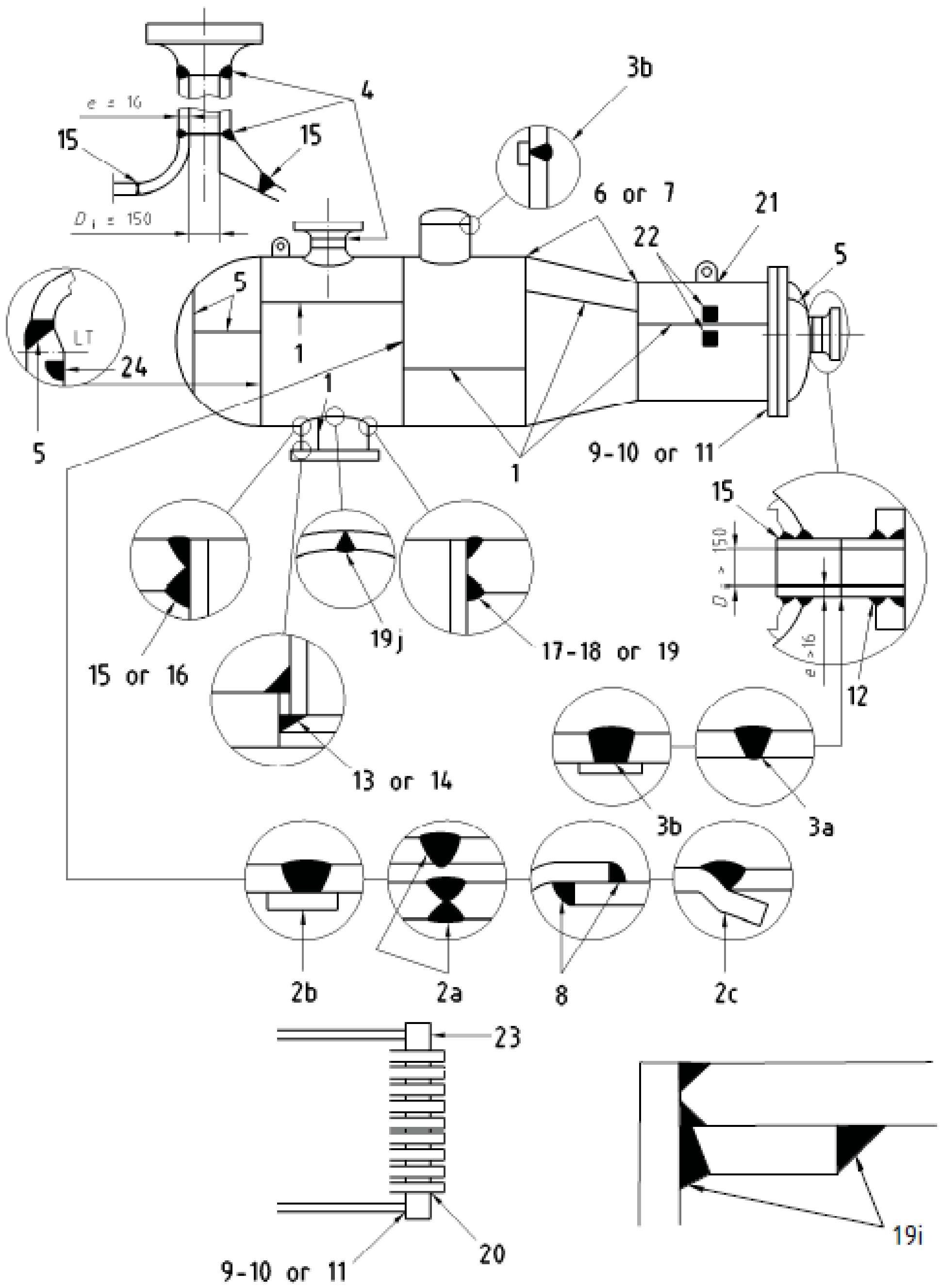
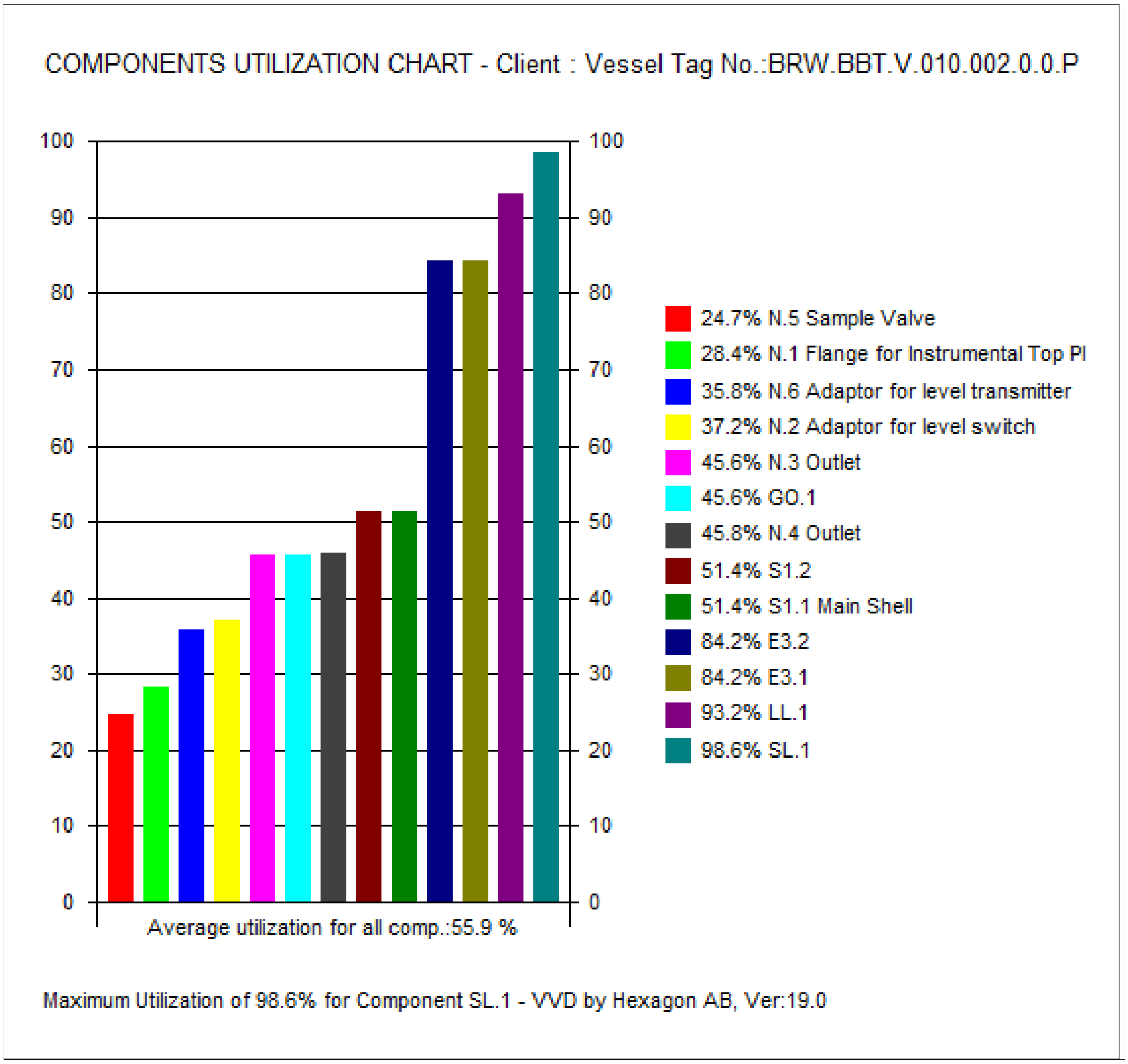


Figure 6.6.2-3 — Type of welds

Utilization Chart

Utilization Chart



Surface Area

ID	No.	Description	Area Outside(m2)	Area Inside(m2)
E3.1	1	Torispherical End,	5.377	5.358
E3.2	1	Torispherical End,	5.585	5.565
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	Nozzle,Seamless Pipe, Outlet	0.033	0.031
N.4	1	Nozzle,Seamless Pipe, Outlet	0.033	0.031
N.5	1	Reinforcement Ring, Sample Valve	0.006	0.002
N.6	1	Reinforcement Ring, Adaptor for level transmitter	0.002	0.001
S1.1	1	Cylindrical Shell, Main Shell	10.405	10.367
S1.2	1	Cylindrical Shell,	6.243	6.220
SL.1	1	Leg Support,	3.192	0.000
Total	**12**		**30.922**	**27.612**

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	-128.08	0.01	0.04	0.00
2	SL.1-LC4 SHUT DOWN	0.00	0.00	-8.48	0.01	0.04	0.00
3	SL.1-LC5 INSTALLATION	0.00	0.00	-8.48	0.01	0.04	0.00
4	SL.1-LC1&2&3 OPER.WIND	0.00	0.00	-22.97	0.01	0.04	0.00
5	SL.1-OPER.SEISMIC	4.39	0.00	-22.97	0.01	9.82	0.00

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
Comment:

E3.2 Torispherical End
Comment:

SL.1 Leg Support
Comment:

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

N.2 Reinforcement Ring Adaptor for level switch
Comment:

N.3 Nozzle,Seamless Pipe Outlet

Comment:

N.4 Nozzle,Seamless Pipe Outlet

Comment:

N.5 Reinforcement Ring Sample Valve
Comment:

N.6 Reinforcement Ring Adaptor for level transmitter
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       2200.00 mm
LENGTH OF CYLINDRICAL PART OF SHELL.................:Lcyl     1500.00 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        3580.00 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)
=2200*0.2/(2*147.5*0.85-0.2)=                            1.7561 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =1.76+0+0.3=                     2.0561 mm

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

»7.4.1 Cond.of Applicabilty emin/De=7.9535E-04 <= 0.16« » OK«

Internal Pressure emina=2.06 <= en=4[mm]	51.4%	OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

```
Outside Diameter of Shell
De = Di + 2 * (ea + NegDev) =2200+2*(3.7+0.3)=            2208.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2208+2200)/2=                         2204.00 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
MAWPHC = 2 * f * z * ea / Dm =2*147.5*0.85*3.7/2204=        0.4210 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)
MAWPNC = 2 * f20 * z * (ea + c) / Dm
=2*180*0.85*(3.7+0)/2204=                                 0.5137 MPa
```

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

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/2204=                                    0.8897 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=0.8897[MPa]	34.2%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

```
Inside Radius of Shell
ris = Di / 2 (9.5-3) =2200/2=                                1100.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*1100+3.7)*3.7)=    90.30 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*2200,(3.7*90.3*(147.5-0.5*0.2)/0.2-1100*90.3)/(0.5*1100+0.5*3.7))
=   266.21 mm
Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                            (9.5-18)
=0.15*Sqr((2*1100+3.7)*3.7)=                                 13.54 mm
Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(266.21,13.54)=                  266.21 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 =2204/2=                                          1102.00 mm
Z = PI * R / L (8.5.2-7) =3.14*1102/3580=                     0.9670
Delta = 1.28 / Sqr( R * ea) (8.5.3-20) =1.28/Sqr(1102*3.7)=    0.0200
gamma = 0 for No Stiffeners
```

DETERMINATION OF eps FROM FIGURE 8.5-3 :

```
eps is a minimum when n= 6
eps (from fig. 8.5-3) = 0.000056
```

MEMBRANE YIELD py

```
py = Sige * ea / (R * (1 - gamma * G ))                        (8.5.3-15)
=138.2*3.7/(1102*(1-0*0))=                                  0.4640 MPa
```

ELASTIC INSTABILITY pe

```
pm = E * ea * eps / R (8.5.2-5) =194028*3.7*5.5661E-05/1102=    0.0363 MPa
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
Value pr/py From Figure 8.5-5 Curve   1
Value1 =  ==                                                  0.0389
pr = Value1 * py =0.0389*0.464=                               0.0180 MPa
Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.018/1.5=                           0.0120 MPa
```

External Pressure Pmax=0.012 >= Pext=0.002[MPa]	16.6%	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*0.012/0.002=   0.0300 %
Maximum unsupported length for given shell thickness Lmax =   21856 mm (en = 4 mm)
```

EN13445-4 Sect. 9.2 Ratio of Deformation

```
F = en / Dm * 100 (9.2-2) =4/2204*100=                          0.1815 %
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)
=2200*0.2/(2*147.5*0.85-0.2)=                          1.7561 mm
Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =1.76+0+0.3=                    2.0561 mm
```

Internal Pressure emina=2.06 <= en=4[mm]	51.4%	OK

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

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/2204=                                 0.8897 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=0.8897[MPa]	34.2%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

```
Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(266.21,13.54)=             266.21 mm
```

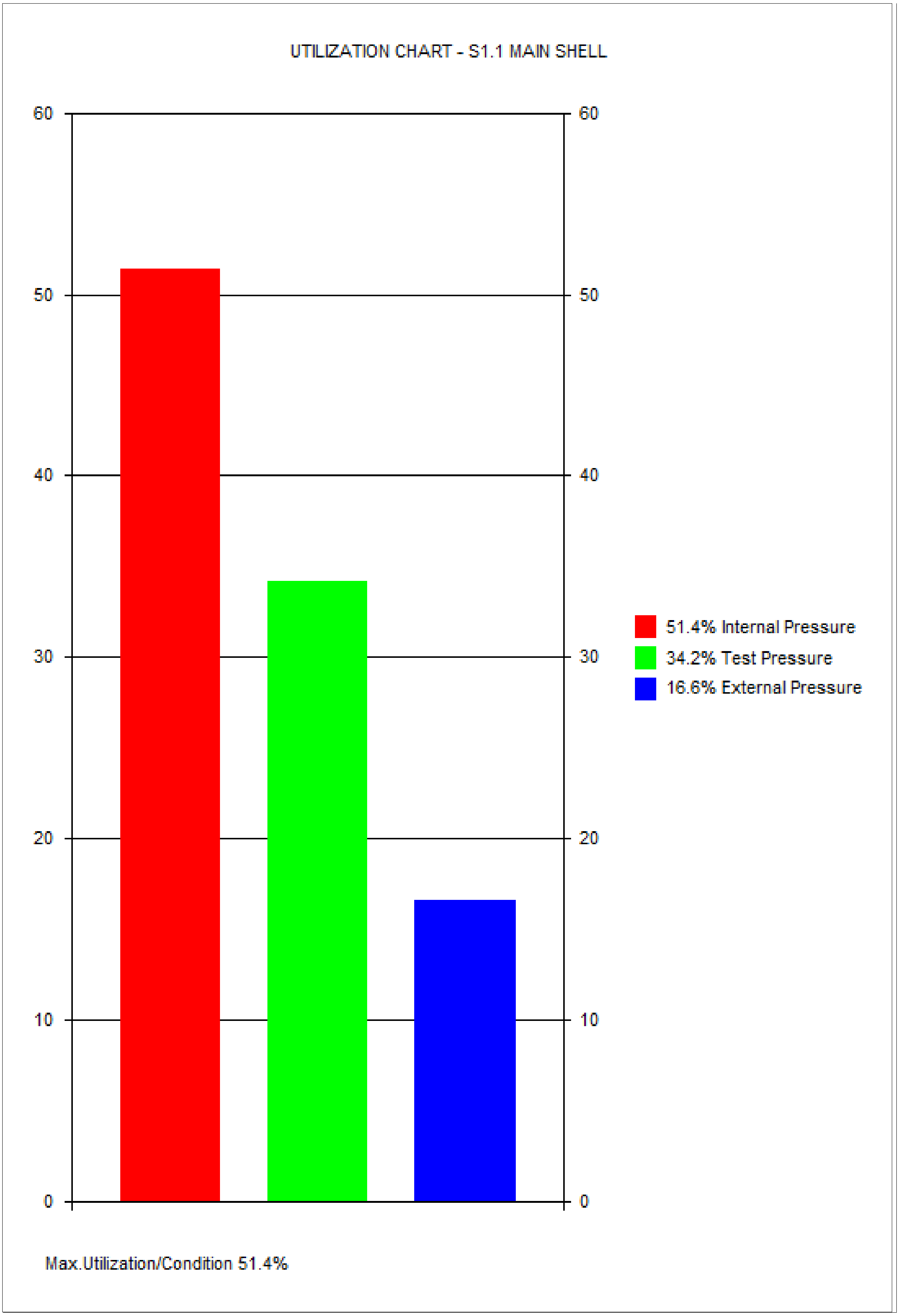
8.5 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

```
Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.018/1.5=                       0.0120 MPa
```

External Pressure Pmax=0.012 >= Pext=0.002[MPa]	16.6%	OK

```
Maximum unsupported length for given shell thickness Lmax =   21856 mm (en = 4 mm)
```

Volume:5.70 m3 Weight:329.4 kg (SG= 7.93)


UTILIZATION CHART - S1.1 MAIN SHELL
60
50
40
30
20
10
0
51.4% Internal Pressure
34.2% Test Pressure
16.6% External Pressure
Max.Utilization/Condition 51.4%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    Main Shell
Location: Along z-axis z1=  1500
```

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       2200.00 mm
LENGTH OF CYLINDRICAL PART OF SHELL.................:Lcyl      900.00 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        3580.00 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)
=2200*0.2/(2*147.5*0.85-0.2)=                             1.7561 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =1.76+0+0.3=                      2.0561 mm

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

»7.4.1 Cond.of Applicabilty emin/De=7.9535E-04 <= 0.16« » OK«

Internal Pressure emina=2.06 <= en=4[mm]	51.4%	OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

```
Outside Diameter of Shell
De = Di + 2 * (ea + NegDev) =2200+2*(3.7+0.3)=             2208.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2208+2200)/2=                          2204.00 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
MAWPHC = 2 * f * z * ea / Dm =2*147.5*0.85*3.7/2204=         0.4210 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)
MAWPNC = 2 * f20 * z * (ea + c) / Dm
=2*180*0.85*(3.7+0)/2204=                                 0.5137 MPa
```

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

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/2204=                                  0.8897 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=0.8897[MPa]	34.2%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

```
Inside Radius of Shell
ris = Di / 2 (9.5-3) =2200/2=                             1100.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*1100+3.7)*3.7)=    90.30 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*2200,(3.7*90.3*(147.5-0.5*0.2)/0.2-1100*90.3)/(0.5*1100+0.5*3.7))
=   266.21 mm
Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                          (9.5-18)
=0.15*Sqr((2*1100+3.7)*3.7)=                              13.54 mm
Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(266.21,13.54)=              266.21 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 =2204/2=                                       1102.00 mm
Z = PI * R / L (8.5.2-7) =3.14*1102/3580=                  0.9670
Delta = 1.28 / Sqr( R * ea) (8.5.3-20) =1.28/Sqr(1102*3.7)=   0.0200
gamma = 0 for No Stiffeners
```

DETERMINATION OF eps FROM FIGURE 8.5-3 :

```
eps is a minimum when n= 6
eps (from fig. 8.5-3) = 0.000056
```

MEMBRANE YIELD py

```
py = Sige * ea / (R * (1 - gamma * G ))                           (8.5.3-15)
=138.2*3.7/(1102*(1-0*0))=                              0.4640 MPa
```

ELASTIC INSTABILITY pe

```
pm = E * ea * eps / R (8.5.2-5) =194028*3.7*5.5661E-05/1102=    0.0363 MPa
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
Value pr/py From Figure 8.5-5 Curve   1
Value1 =  ==                                               0.0389
pr = Value1 * py =0.0389*0.464=                            0.0180 MPa
Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.018/1.5=                        0.0120 MPa
```

External Pressure Pmax=0.012 >= Pext=0.002[MPa]	16.6%	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*0.012/0.002=   0.0300 %
Maximum unsupported length for given shell thickness Lmax =   21856 mm (en = 4 mm)
```

EN13445-4 Sect. 9.2 Ratio of Deformation

```
F = en / Dm * 100 (9.2-2) =4/2204*100=                         0.1815 %

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)
=2200*0.2/(2*147.5*0.85-0.2)=                                1.7561 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =1.76+0+0.3=                         2.0561 mm
```

Internal Pressure emina=2.06 <= en=4[mm]	51.4%	OK

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

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/2204=                                       0.8897 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=0.8897[MPa]	34.2%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

```
Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(266.21,13.54)=                  266.21 mm
```

8.5 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

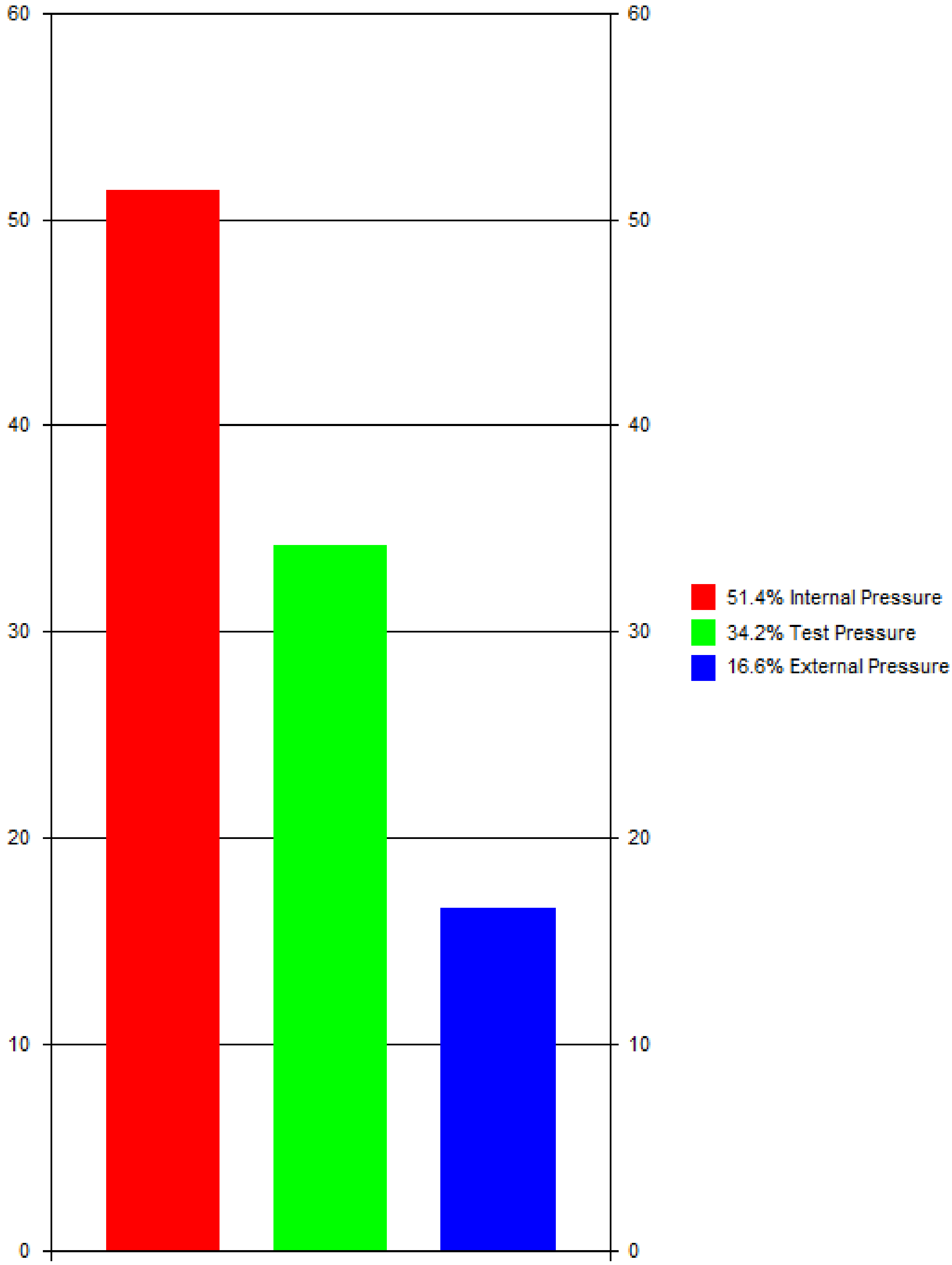
```
Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.018/1.5=                            0.0120 MPa
```

External Pressure Pmax=0.012 >= Pext=0.002[MPa]	16.6%	OK

```
Maximum unsupported length for given shell thickness Lmax =   21856 mm (en = 4 mm)
```

Volume:3.42 m3 Weight:197.7 kg (SG= 7.93)

UTILIZATION CHART - S1.2



Max.Utilization/Condition 51.4%

INPUT DATA

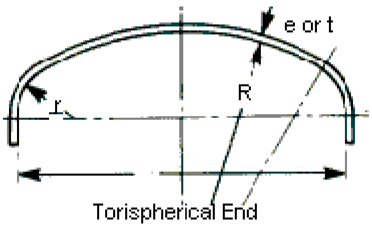
COMPONENT ATTACHMENT/LOCATION

```
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       2208.00 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl       10.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en        4.0000 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: YES
LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d         104.00 mm
```

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

7.7 Nozzles Which Encroach Into the Knuckle Region

```
V = LOG( 1000 * P / f) (7.7.7) =LOG(1000*0.2/147.5)=        0.1322
A = 0.54 + 0.41 * V - 0.044 * V ^ 3                              (7.7.8)
=0.54+0.41*0.1322-0.044*0.1322^3=                          0.5941
B = 7.77 - 4.53 * V + 0.744 * V ^ 2                              (7.7.9)
=7.77-4.53*0.1322+0.744*0.1322^2=                          7.1840
BetaK = MAX( A + B * dib / De, 1 + 0.5 * B * dib / De)           (7.7.10)
=MAX(0.5941+7.18*104/2208,1+0.5*7.18*104/2208)=            1.1692
```

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*1766.4/(2*147.5*0.85-0.5*0.2)=                  1.4095 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*1766.4+0.2*2200)*((0.2/(111*115.17)*(2200/340.03)^0.825)^(0.667)
=   3.0730 mm

7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(2.26/1766.4,0.04)=   0.0013
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0013)=                  2.8925
X = r / Di (7.5-11) =340.03/2203.48=                       0.1543
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                        (7.5-12)
=1.006-1/(6.2+(90*0.0013)^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*2.89^3+1.0383*2.89^2-1.2943*2.89+0.837)=  1.1356
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*0.0013-82.5*0.0013^2))=     0.5295
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)       (7.5-16)
=10*((0.2-0.1543)*1.14+(0.1543-0.1)*0.5295)=         0.8064
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * BetaK * P * (0.75 * R + 0.2 * Di) / f           (7.5-2)
=0.8064*1.17*0.2*(0.75*1766.4+0.2*2203.48)/147.5=    2.2570 mm

Required Minimum End Thickness Excl.Allow. emin :
emin = emin =3.07=                                     3.0730 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =3.07+0+0.3=                     3.3700 mm
```

Internal Pressure emina=3.37 <= en=4[mm]	84.2%	OK

```
Analysis Thickness
ea = en - c - th =4-0-0.3=                             3.7000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =2208-2*(4-0)=                 2200.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2208+2200)/2=                    2204.00 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(2200*3.07)=       16.44 mm
Since Lcyl <= Llim the minmum thickness of the straight flange is as the knuckle.
Minimum Thickness of Straight Flange Excl. Allow.
ecyl = MAX( ey, eb ) =MAX(2.26,3.07)=                  3.0730 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =3.07+0=                              3.0700 mm
```

7.7.2 Conditions of Applicability - Nozzles in Knuckle Region

» - The nozzle centre-line shall lie between normal to the wall of the end and parallel to the vessel centre-line.
» - The location of the nozzle shall be such that it does not cross the tangentline between knuckle and cylinder.
» - Nozzles parallel to the vessel centre line and with outside diameter in line with the outside diameter of the vessel are included in these requirements.
» - Welded on compensation is not permitted.
» - When the distance between the edge of the nozzle where it meets the knuckl
e and the knuckle/cylinder tan line is less than 2.5*SQR(e*r)== 80.8 mm the validit

»Geometry Check dib/De=0.0471 <= 0.6[mm] (7.7-1)« » OK«

»Geometry Check dib/SQR(e*De)=1.15 <= 6.7[mm] (7.7-2)« » OK«

```
»Minimum distance between edge of nozzle and the knuckle/cylinder tangent line:
Along Surface
MinSurfDist = 2.5 * Sqr( emin * r)
=2.5*Sqr(3.07*340.03)=                                        80.81 mm
In Radial Direction
MinRadDist = (1 - Cos( MinSurfDist / r)) * r
=(1-Cos(80.81/340.03))*340.03=                               9.5600 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=340.03 <= 0.2 * Di=440[mm] « » OK«
»Geometry Check r=340.03 >= 0.06 * Di=132[mm] « » OK«
»Geometry Check r=340.03 >= 2*e[mm] « » OK«
»Geometry Check e=3.07 <= 0.08*De=176.64[mm] « » OK«
»Geometry Check ea=3.7 >= 0.001*De=2.208[mm] « » OK«
»Geometry Check R=1766.4 <= De=2208[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*3.7/(1766.4+0.5*3.7)=                          0.6403 MPa
Py = f * ea / ( beta * BetaK1 * ( 0.75 * R + 0.2 * Di))            (7.5-7)
=180*3.7/(0.7859*1.1*(0.75*1766.4+0.2*2200))=              0.4360 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                  (7.5-8)
=111*180*(3.7/(0.75*1766.4+0.2*2200))^1.5*(340.03/2200)^0.825=   0.4110 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.411=                                                    0.4110 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*3.7/(1766.4+0.5*3.7)=                        0.5247 MPa
Py = f * ea / ( beta * BetaK1 * ( 0.75 * R + 0.2 * Di))            (7.5-7)
=147.5*3.7/(0.7859*1.1*(0.75*1766.4+0.2*2200))=            0.3572 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                  (7.5-8)
=111*115.17*(3.7/(0.75*1766.4+0.2*2200))^1.5*(340.03/2200)^0.825=   0.2630 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.263=                                                    0.2630 MPa
```

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

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                               (7.5-6)
=2*265*1*3.7/(1766.4+0.5*3.7)=                             1.1090 MPa
Py = f * ea / ( beta * BetaK1 * ( 0.75 * R + 0.2 * Di))            (7.5-7)
=265*3.7/(0.7859*1.1*(0.75*1766.4+0.2*2200))=              0.6418 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                  (7.5-8)
=111*257.14*(3.7/(0.75*1766.4+0.2*2200))^1.5*(340.03/2200)^0.825=   0.5872 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.5872=                                                   0.5872 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=0.5872[MPa]	51.9%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =1766.4=                                     1766.40 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea)                                     (9.5-2)
=Sqr((2*1766.4+3.7)*3.7)=                                  114.39 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)
=(3.7*114.39*(147.5-0.5*0.2)/0.2-1766.4*114.39)/(0.5*1766.4+0.5*3.7)
=   124.14 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                         (9.5-18)
=0.15*Sqr((2*1766.4+3.7)*3.7)=                                 17.16 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(124.14,17.16)=                    124.14 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 =1766.4+3.7/2=                               1768.25 mm
MEMBRANE YIELD py
py = 2 * Sige * ea / Rmean (8.7.1-1) =2*138.2*3.7/1768.25=       0.5784 MPa

ELASTIC INSTABILITY pm
pm = 1.21 * E * ea ^ 2 / Rmean ^ 2                                (8.7.1-2)
=1.21*194028*3.7^2/1768.25^2=                                  1.0279 MPa

Value pr/py From Figure 8.5-5 Curve   2
Value1 =  ==                                                      0.2938
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
pr = Value1 * py =0.2938*0.5784=                                  0.1699 MPa
Pmax = pr / S =0.1699/1.5=                                        0.1133 MPa
```

External Pressure Pmax=0.1133 >= 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 =3.07=                                                3.0730 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =3.07+0+0.3=                                3.3700 mm
```

Internal Pressure emina=3.37 <= en=4[mm]	84.2%	OK

```
Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =3.07+0=                                         3.0700 mm
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.411=                                                         0.4110 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.263=                                                         0.2630 MPa
```

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

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.5872= 0.5872 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=0.5872[MPa]	51.9%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(124.14,17.16)= 124.14 mm

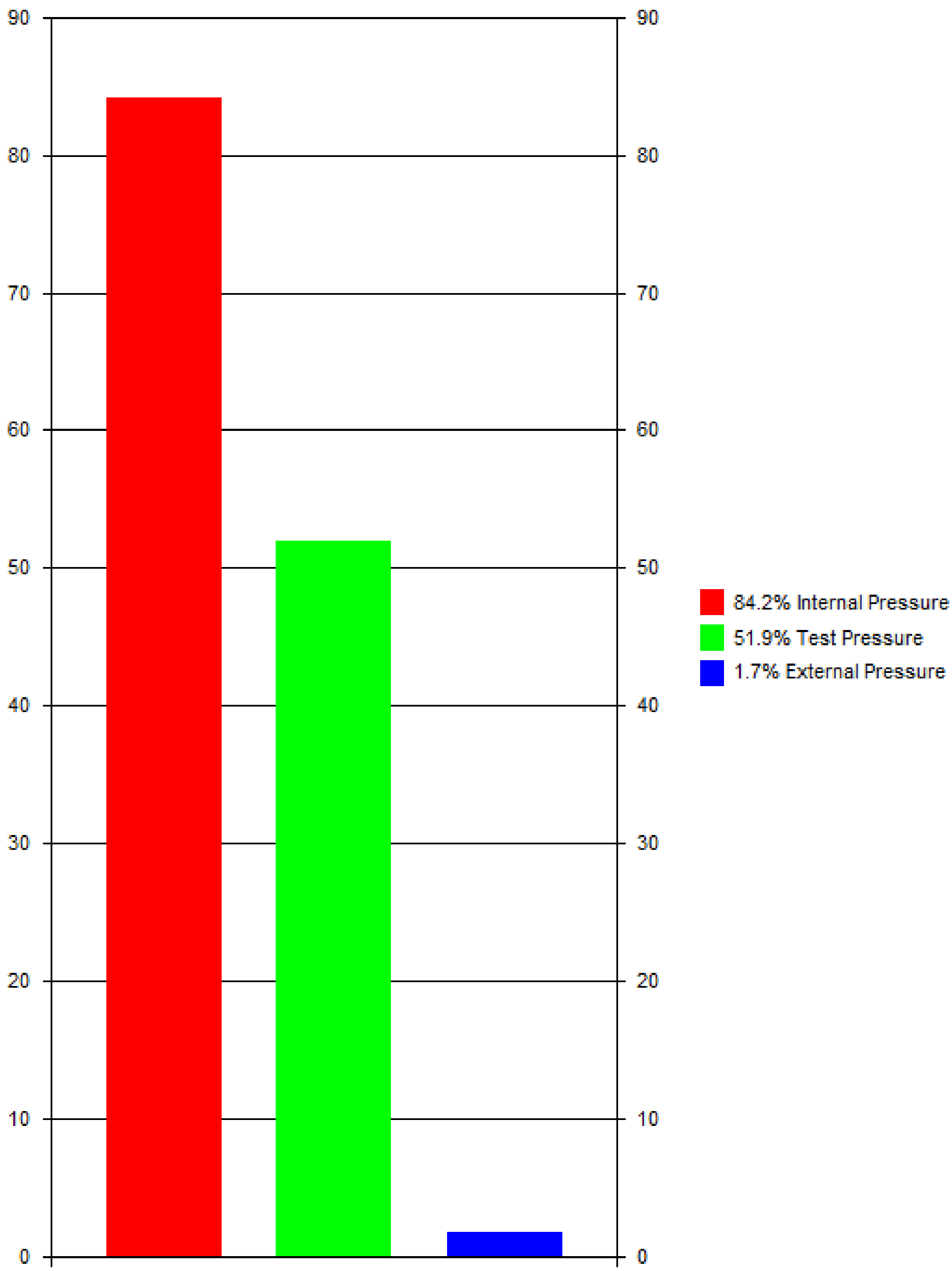
8.7 - SPHERICAL SHELL UNDER EXTERNAL PRESSURE

External Pressure Pmax=0.1133 >= Pext=0.002[MPa]	1.7%	OK

Volume:1.44 m3 Weight:170.3 kg (SG= 7.93)

EN13445:2014 Issue 5:2018+A5 - 7.5 DOMED ENDS
E3.1 20 June 2019 12:02 ConnID:S1.1

UTILIZATION CHART - E3.1



Max.Utilization/Condition 84.2%

INPUT DATA

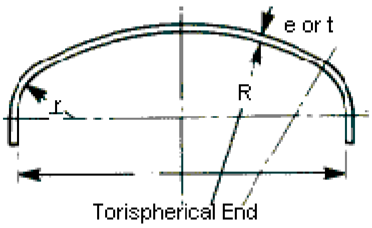
COMPONENT ATTACHMENT/LOCATION

Attachment: S1.2 Cylindrical Shell S1.1
Location: Along z-axis z1= 2400

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 2208.00 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl 40.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th 0.3000 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en 4.0000 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: YES
LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 104.00 mm

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

7.7 Nozzles Which Encroach Into the Knuckle Region

```
V = LOG( 1000 * P / f) (7.7.7) =LOG(1000*0.2/147.5)=        0.1322
A = 0.54 + 0.41 * V - 0.044 * V ^ 3                                 (7.7.8)
=0.54+0.41*0.1322-0.044*0.1322^3=                         0.5941
B = 7.77 - 4.53 * V + 0.744 * V ^ 2                                 (7.7.9)
=7.77-4.53*0.1322+0.744*0.1322^2=                         7.1840
BetaK = MAX( A + B * dib / De, 1 + 0.5 * B * dib / De)              (7.7.10)
=MAX(0.5941+7.18*104/2208,1+0.5*7.18*104/2208)=           1.1692
```

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*1766.4/(2*147.5*0.85-0.5*0.2)=                    1.4095 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*1766.4+0.2*2200)*((0.2/(111*115.17)*(2200/340.03)^0.825)^(0.667)
=   3.0730 mm

7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(2.26/1766.4,0.04)=     0.0013
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0013)=                     2.8925
X = r / Di (7.5-11) =340.03/2203.48=                         0.1543
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                            (7.5-12)
=1.006-1/(6.2+(90*0.0013)^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*2.89^3+1.0383*2.89^2-1.2943*2.89+0.837)=   1.1356
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*0.0013-82.5*0.0013^2))=       0.5295
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)           (7.5-16)
=10*((0.2-0.1543)*1.14+(0.1543-0.1)*0.5295)=           0.8064
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * BetaK * P * (0.75 * R + 0.2 * Di) / f               (7.5-2)
=0.8064*1.17*0.2*(0.75*1766.4+0.2*2203.48)/147.5=      2.2570 mm

Required Minimum End Thickness Excl.Allow. emin :
emin = emin =3.07=                                       3.0730 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =3.07+0+0.3=                       3.3700 mm
```

Internal Pressure emina=3.37 <= en=4[mm]	84.2%	OK

```
Analysis Thickness
ea = en - c - th =4-0-0.3=                               3.7000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =2208-2*(4-0)=                   2200.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2208+2200)/2=                      2204.00 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(2200*3.07)=          16.44 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*2200/(2*147.5*0.85-0.2)=                          1.7561 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =1.76+0=                                1.7600 mm
```

7.7.2 Conditions of Applicability - Nozzles in Knuckle Region

» - The nozzle centre-line shall lie between normal to the wall of the end and parallel to the vessel centre-line.
» - The location of the nozzle shall be such that it does not cross the tangentline between knuckle and cylinder.
» - Nozzles parallel to the vessel centre line and with outside diameter in line with the outside diameter of the vessel are included in these requirements.
» - Welded on compensation is not permitted.
» - When the distance between the edge of the nozzle where it meets the knuckl e and the knuckle/cylinder tan line is less than 2.5*SQR(e*r)== 80.8 mm the validit

»Geometry Check dib/De=0.0471 <= 0.6[mm] (7.7-1)« » OK«
»Geometry Check dib/SQR(e*De)=1.15 <= 6.7[mm] (7.7-2)« » OK«

```
»Minimum distance between edge of nozzle and the knuckle/cylinder tangent line:
Along Surface
MinSurfDist = 2.5 * Sqr( emin * r)
=2.5*Sqr(3.07*340.03)=                                     80.81 mm
In Radial Direction
MinRadDist = (1 - Cos( MinSurfDist / r)) * r
=(1-Cos(80.81/340.03))*340.03=                            9.5600 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=340.03 <= 0.2 * Di=440[mm] « » OK«
»Geometry Check r=340.03 >= 0.06 * Di=132[mm] « » OK«
»Geometry Check r=340.03 >= 2*e[mm] « » OK«
»Geometry Check e=3.07 <= 0.08*De=176.64[mm] « » OK«
»Geometry Check ea=3.7 >= 0.001*De=2.208[mm] « » OK«
»Geometry Check R=1766.4 <= De=2208[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*3.7/(1766.4+0.5*3.7)=                         0.6403 MPa
Py = f * ea / ( beta * BetaK1 * ( 0.75 * R + 0.2 * Di))             (7.5-7)
=180*3.7/(0.7859*1.1*(0.75*1766.4+0.2*2200))=             0.4360 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                   (7.5-8)
=111*180*(3.7/(0.75*1766.4+0.2*2200))^1.5*(340.03/2200)^0.825=   0.4110 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*180*0.85/(2200+3.7)=                               0.5138 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.411=                                                   0.4110 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*3.7/(1766.4+0.5*3.7)=                       0.5247 MPa
Py = f * ea / ( beta * BetaK1 * ( 0.75 * R + 0.2 * Di))             (7.5-7)
=147.5*3.7/(0.7859*1.1*(0.75*1766.4+0.2*2200))=           0.3572 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                   (7.5-8)
=111*115.17*(3.7/(0.75*1766.4+0.2*2200))^1.5*(340.03/2200)^0.825=   0.2630 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*147.5*0.85/(2200+3.7)=                             0.4210 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.263=                                                   0.2630 MPa
```

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

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                (7.5-6)
=2*265*1*3.7/(1766.4+0.5*3.7)=                            1.1090 MPa
Py = f * ea / ( beta * BetaK1 * ( 0.75 * R + 0.2 * Di))             (7.5-7)
=265*3.7/(0.7859*1.1*(0.75*1766.4+0.2*2200))=             0.6418 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                   (7.5-8)
=111*257.14*(3.7/(0.75*1766.4+0.2*2200))^1.5*(340.03/2200)^0.825=   0.5872 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*265*1/(2200+3.7)=                                  0.8899 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.5872=                                                  0.5872 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=0.5872[MPa]	51.9%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =1766.4=                                    1766.40 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea)                                     (9.5-2)
=Sqr((2*1766.4+3.7)*3.7)=                                  114.39 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)
=(3.7*114.39*(147.5-0.5*0.2)/0.2-1766.4*114.39)/(0.5*1766.4+0.5*3.7)
=   124.14 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                           (9.5-18)
=0.15*Sqr((2*1766.4+3.7)*3.7)=                              17.16 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(124.14,17.16)=                124.14 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 =1766.4+3.7/2=                           1768.25 mm
MEMBRANE YIELD py
py = 2 * Sige * ea / Rmean (8.7.1-1) =2*138.2*3.7/1768.25=   0.5784 MPa

ELASTIC INSTABILITY pm
pm = 1.21 * E * ea ^ 2 / Rmean ^ 2                                 (8.7.1-2)
=1.21*194028*3.7^2/1768.25^2=                              1.0279 MPa

Value pr/py From Figure 8.5-5 Curve   2
Value1 =  ==                                                 0.2938
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
pr = Value1 * py =0.2938*0.5784=                             0.1699 MPa
Pmax = pr / S =0.1699/1.5=                                   0.1133 MPa
```

External Pressure Pmax=0.1133 >= 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 =3.07=                                           3.0730 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =3.07+0+0.3=                           3.3700 mm
```

Internal Pressure emina=3.37 <= en=4[mm]	84.2%	OK

```
Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =1.76+0=                                    1.7600 mm
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.411= 0.4110 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.263= 0.2630 MPa

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

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.5872= 0.5872 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=0.5872[MPa]	51.9%	OK

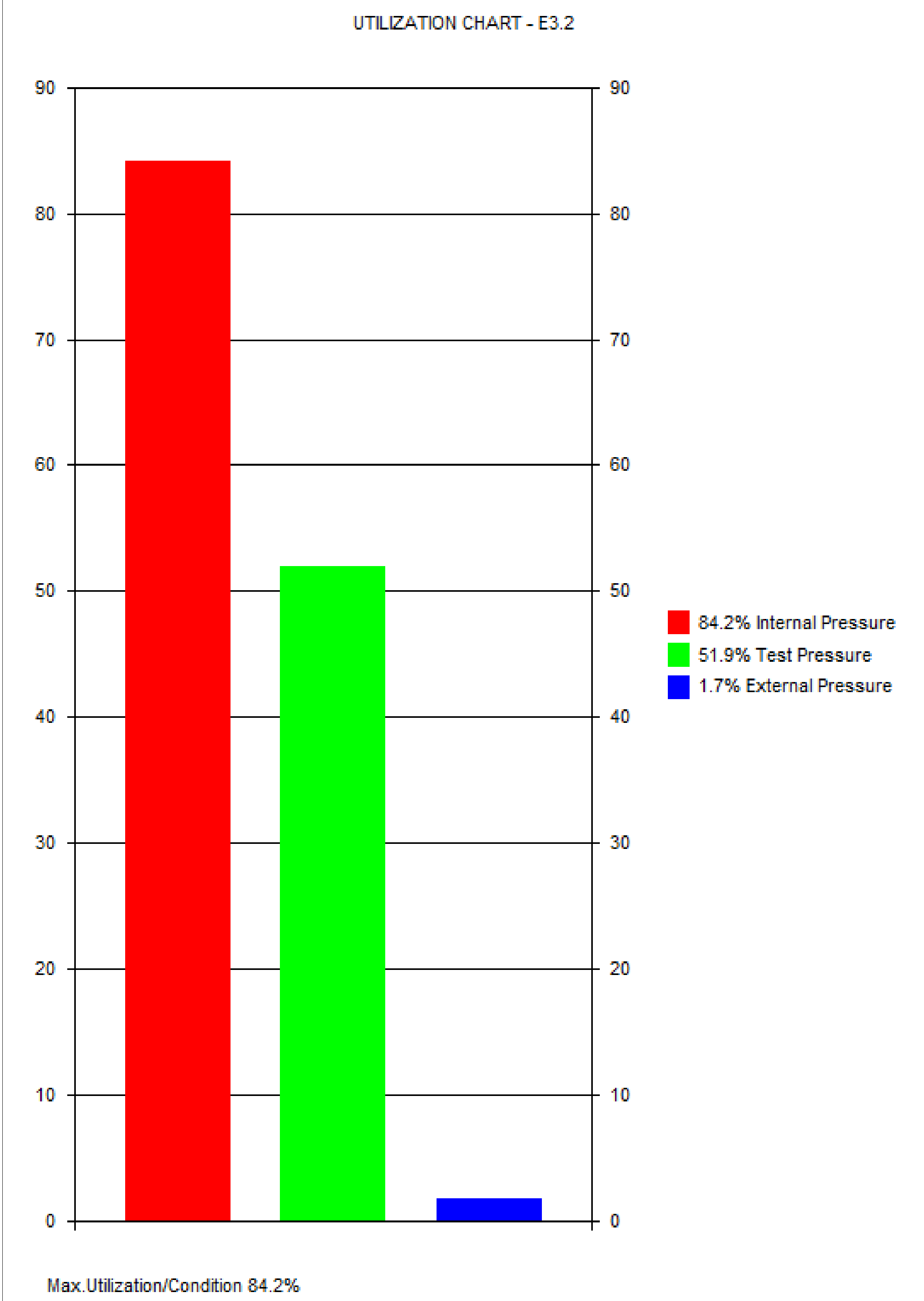
Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(124.14,17.16)= 124.14 mm

8.7 - SPHERICAL SHELL UNDER EXTERNAL PRESSURE

External Pressure Pmax=0.1133 >= Pext=0.002[MPa]	1.7%	OK

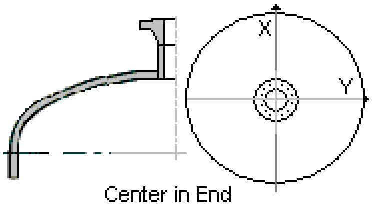
Volume:1.55 m3 Weight:176.8 kg (SG= 7.93)


UTILIZATION CHART - E3.2
90
80
70
60
50
40
30
20
10
0
84.2% Internal Pressure
51.9% Test Pressure
1.7% External Pressure
Max.Utilization/Condition 84.2%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

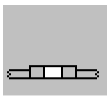
```
Attachment: E3.2    Torispherical End                                   S1.2
Connect this nozzle to the nozzle neck of another nozzle: NO
```



Center in End

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

GENERAL DESIGN DATA



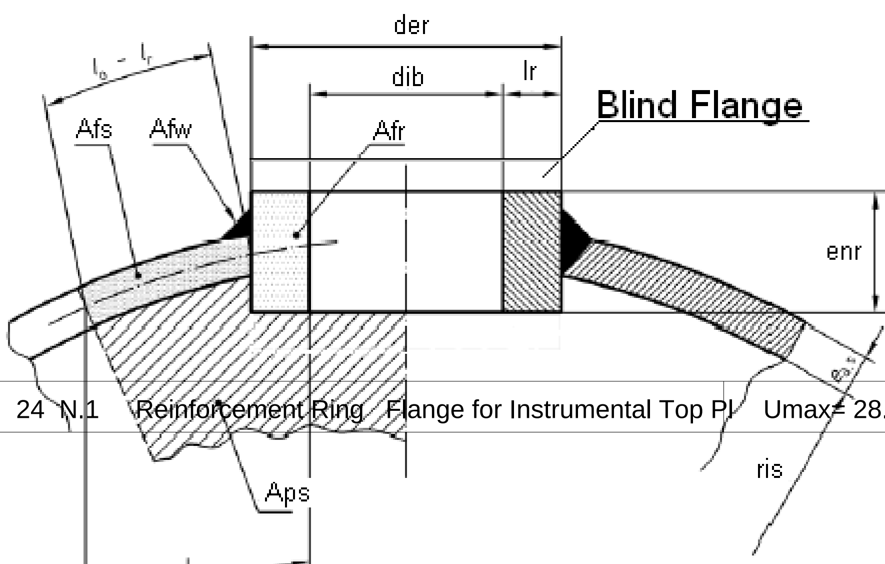
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          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       2208.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en         4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th         0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R        1766.40 mm
LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d         104.00 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 =4-0-0.3=                                      3.7000 mm
Ring Analysis Thickness ear
ear = enr - c =25-0=                                              25.00 mm
ris = R (9.5-4) =1766.4=                                        1766.40 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=829 >= De/10=220.8[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*3.7,3*50))=                                        25.00 mm
Limit of Reinforcement Along Shell and Ring Io
Io = Sqr(( 2 * ris + eam) * eam)                                        (9.5-46)
=Sqr((2*1766.4+9.49)*9.49)=                                     183.90 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io                                        (9.5-48)
=3.7+(25-3.7)*50/183.9=                                         9.4911 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*1766.4+3.7)*3.7)=                                       114.39 mm
Is = MIN( Iso , Io - Ir) (9.5-50) =MIN(114.39,183.9-50)=         114.39 mm
Area of Shell
Afs = eas * Is (9.5-54) =3.7*114.39=                             423.24 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*1766.4^2*(114.39+276.12)/(0.5*3.7+1766.4)+276.12*(3.7+0)=3,4556E05 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)
```
pAReq = P * (Aps + Apr + 0.5 * Apphi)                                   (9.5-7)
=0.2*(3.4556E05+5625+0.5*0)=                                     70.24 kN
```

Pressure Area Available pA(aval.)
```
pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P)                       (9.5-16)
=(423.24+0+0+1250)*(147.5-0.5*0.2)=                             246.64 kN
```

Nozzle Reinforcement pAAval=246.64 >= pAReq=70.24[kN]	28.4%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw+Afr)*fs/((Aps+Apr+0.5*Apphi)+0.5*(Afs+Afw+Afr+Afp)) (9.5-17)
=(423.24+0+1250)*147.5/((3.4556E05+5625+0.5*0)+0.5*(423.24+0+1250+0))
=   0.7011 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                1.2596 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*(3.4556E05+5625+0.5*0)=                               70.24 kN
```

Pressure Area Available pA(aval.)

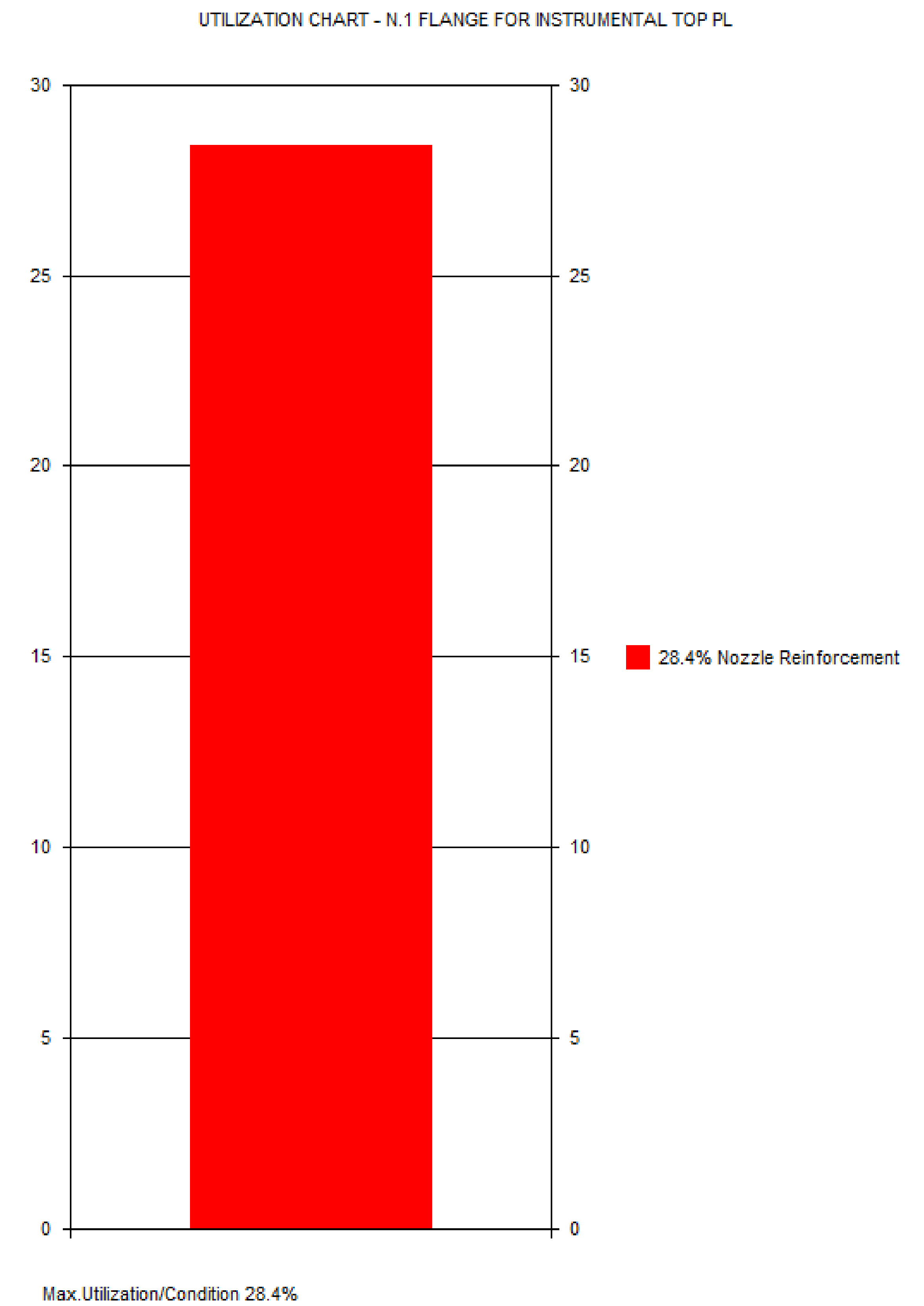
```
pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P)                  (9.5-16)
=(423.24+0+0+1250)*(147.5-0.5*0.2)=                       246.64 kN
```

Nozzle Reinforcement pAAval=246.64 >= pAReq=70.24[kN]	28.4%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw+Afr)*fs/((Aps+Apr+0.5*Apphi)+0.5*(Afs+Afw+Afr+Afp)) (9.5-17)
=(423.24+0+1250)*147.5/((3.4556E05+5625+0.5*0)+0.5*(423.24+0+1250+0))
=   0.7011 MPa
```

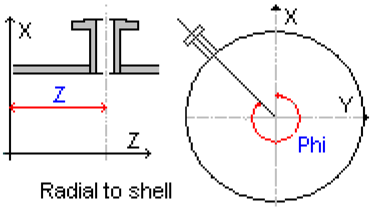
Volume:0.0046 m3 Weight:15.6 kg (SG= 7.93)


UTILIZATION CHART - N.1 FLANGE FOR INSTRUMENTAL TOP PL
30
25
20
15
10
5
0
28.4% Nozzle Reinforcement
Max.Utilization/Condition 28.4%

INPUT DATA

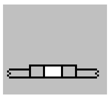
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.2    Cylindrical 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        2300.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi    65.00 Degr.
```

GENERAL DESIGN DATA



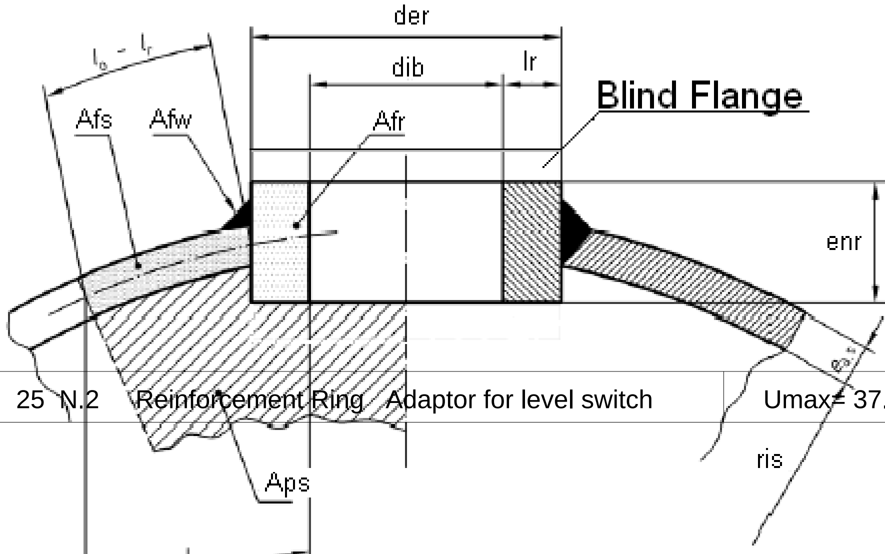
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          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       2208.00 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, 1.4435 X2CrNiMo18-14-3 bar, HT:AT THK<=160mm 90'C,A>=35%
Rm=500 Rp=235 Rpt=204.38 fr=143.33 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) =2208/2-3.7=	1100.30 mm
Allowable Stresses	
for/fob = Min(fs, fb) (9.5-8) =Min(147.5,143.33)=	143.33 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*1100.3+4.41)*4.41)=	99.33 mm	
Average Thickness Along Length Io		
eam = eas + (er - eas) * Ir / Io		(9.5-48)
=3.7+(16.5-3.7)*5.5/99.33=	4.4087 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*1100.3+3.7)*3.7)=	90.31 mm	
Is = MIN(Iso , Io - Ir) (9.5-50) =MIN(90.31,99.33-5.5)=	90.31 mm	
Area of Shell		
Afs = eas * Is (9.5-54) =3.7*90.31=	334.15 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)
=1100.3*(90.31+5.5+9.5)+9.5*(3.7+0)=	1,1591E05 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*1100.3^2*(90.31+15.)/(0.5*3.7+1100.3)+9.5*(3.7+0)=	57874.50 mm2	
Aps = MAX(ApsL ApsT) =MAX(1.1591E05,57874.5)=	1,1591E05 mm2	

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

pAReqL = P * (ApsL + Apr) (9.5-7) =0.2*(1.1591E05+156.75)=	23.21 kN	
pAReqT = P * (ApsT + Apr + 0.5 * Apphi)		(9.5-7)
=0.2*(57874.5+156.75+0.5*0)=	11.61 kN	
pAReq = MAX(pAReqL, pAReqT) =MAX(23212.92,11606.25)=	23.21 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)
=(334.15+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+90.75*(143.33-0.5*0.2)=    62.25 kN
```

Nozzle Reinforcement pAAval=62.25 >= pAReq=23.21[kN]	37.2%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(334.15+0)*147.5+90.75*143.33/((1.1591E05+156.75)+0.5*(334.15+0+90.75+0))
=   0.5357 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =   ==                                                  0.9567 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*(1.1591E05+156.75)=    23.21 kN
pAReqT = P * (ApsT + Apr + 0.5 * Apphi)                          (9.5-7)
=0.2*(57874.5+156.75+0.5*0)=                                11.61 kN
pAReq = MAX( pAReqL, pAReqT) =MAX(23212.92,11606.25)=          23.21 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)
=(334.15+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+90.75*(143.33-0.5*0.2)=    62.25 kN
```

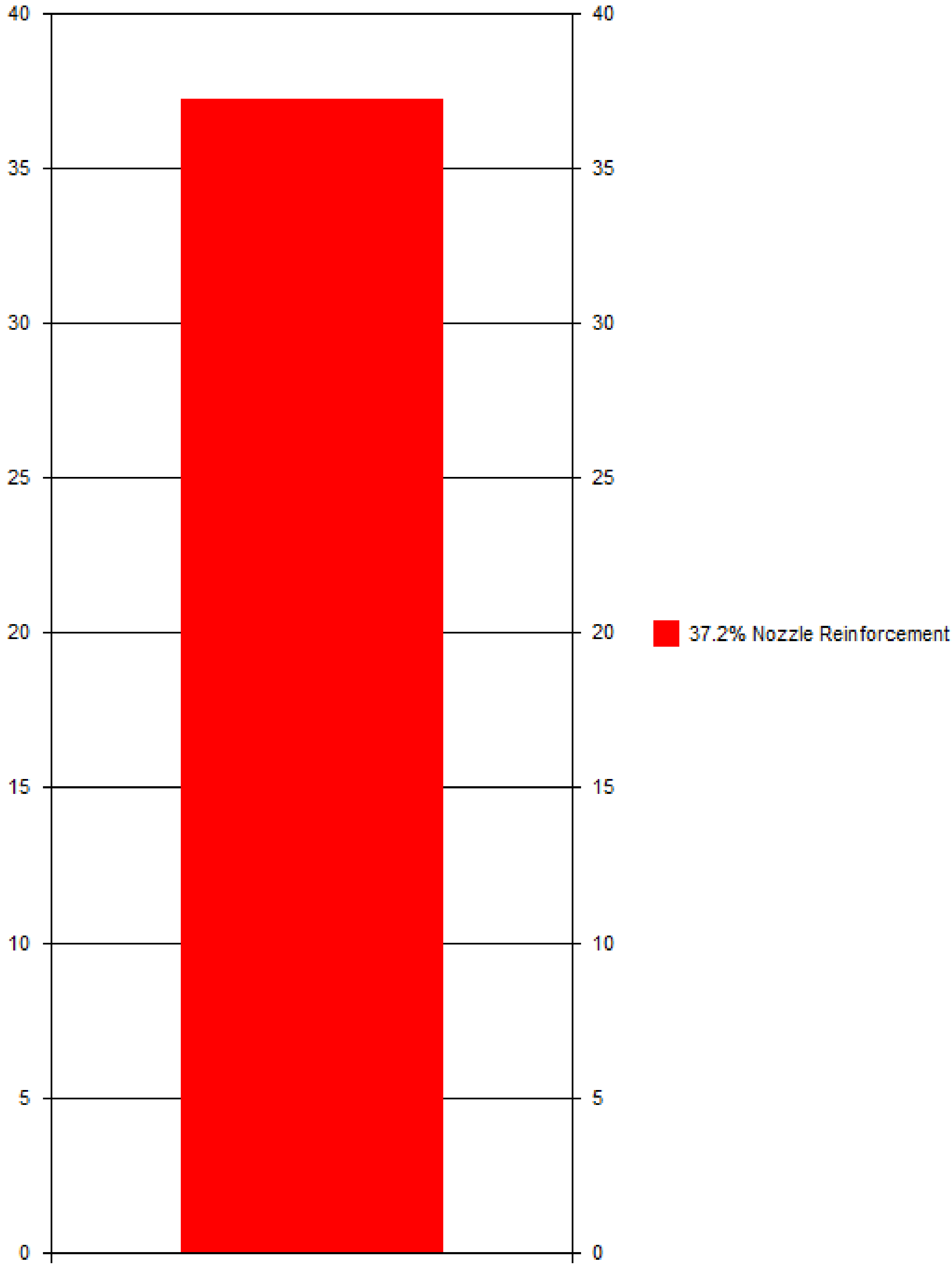
Nozzle Reinforcement pAAval=62.25 >= pAReq=23.21[kN]	37.2%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(334.15+0)*147.5+90.75*143.33/((1.1591E05+156.75)+0.5*(334.15+0+90.75+0))
=   0.5357 MPa
```

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

UTILIZATION CHART - N.2 ADAPTOR FOR LEVEL SWITCH



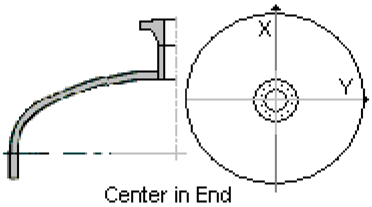
Max.Utilization/Condition 37.2%

20 June 2019 12:02 ConnID:E3.1

INPUT DATA

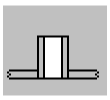
COMPONENT ATTACHMENT/LOCATION

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




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

GENERAL DESIGN DATA

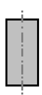


```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH        573.58 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       2208.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R        1766.40 mm
LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d         104.00 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

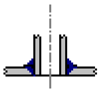


```
Delivery Form: Seamless Pipe
EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT THK<=60mm 90'C
Rm=490 Rp=225 Rpt=202.6 fb=135.07 f20=150 ftest=214.29 E=194028(N/mm2) ro=7.93
```

NOZZLE DIMENSIONAL DATA

EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.3 Outlet

20 June 2019 12:02 ConnID:E3.1

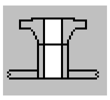


```
Attachment: Set In Flush Nozzle
Shape of Nozzle/Opening: Circular
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER.............................:deb       104.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       2.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:           10.00 %
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 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 =4-0-0.3=                                  3.7000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =2-0-0.2=                            1.8000 mm
ris = R (9.5-4) =1766.4=                                    1766.40 mm
dib = deb - 2 * eab =104-2*1.8=                              100.40 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=0.2056*104/(2*135.07*1+0.2056)=                           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/De=0.0455 <= 0.60=0.6[mm] (9.4.5.3)«» OK«

Min.Nozzle Thk. ebp=0.08 <= eab=1.8[mm]	4.4%	OK

»Location in End to Fig.9.5-4 L=1052 >= De/10=220.8[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*1766.4+3.7)*3.7)=                               114.39 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =3.7*114.39=                     423.24 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                           (9.5-76)
=MIN(Sqr((104-1.8)*1.8,)100)=                            13.56 mm
Set In Nozzle
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =1.8*(13.56+0+3.7)=  31.07 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*100.4*(13.56+3.7)=   866.61 mm2
Spherical Shell/End on any Section Aps
Aps = 0.5 * ris ^ 2 * (Is + a) / (0.5 * eas + ris)              (9.5-105)
=0.5*1766.4^2*(114.39+52.01)/(0.5*3.7+1766.4)=         1,4681E05 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                           (9.5-7)
=0.2056*(1.4681E05+866.61+0.5*0)=                        30.36 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)
=(423.24+0)*(147.5-0.5*0.2056)+0*(0-0.5*0.2056)+31.07*(135.07-0.5*0.2056)
=     66.58 kN
```

Nozzle Reinforcement pAAval=66.58 >= pAReq=30.36[kN]	45.6%	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)
=(423.24+0)*147.5+31.07*135.07/((1.4681E05+866.61+0.5*0)+0.5*(423.24+0+31.0
7+0))=                                                   =   0.4505 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                               0.8034 MPa
Weight of Nozzle: .5324kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.08 <= eab=1.8[mm]	4.4%	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*1766.4+3.7)*3.7)=                               114.39 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                           (9.5-76)
=MIN(Sqr((104-1.8)*1.8,)100)=                            13.56 mm
```

EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.3 Outlet
20 June 2019 12:02 ConnID:E3.1

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                          (9.5-7)
=0.2056*(1.4681E05+866.61+0.5*0)=                       30.36 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)
=(423.24+0)*(147.5-0.5*0.2056)+0*(0-0.5*0.2056)+31.07*(135.07-0.5*0.2056)
=     66.58 kN
```

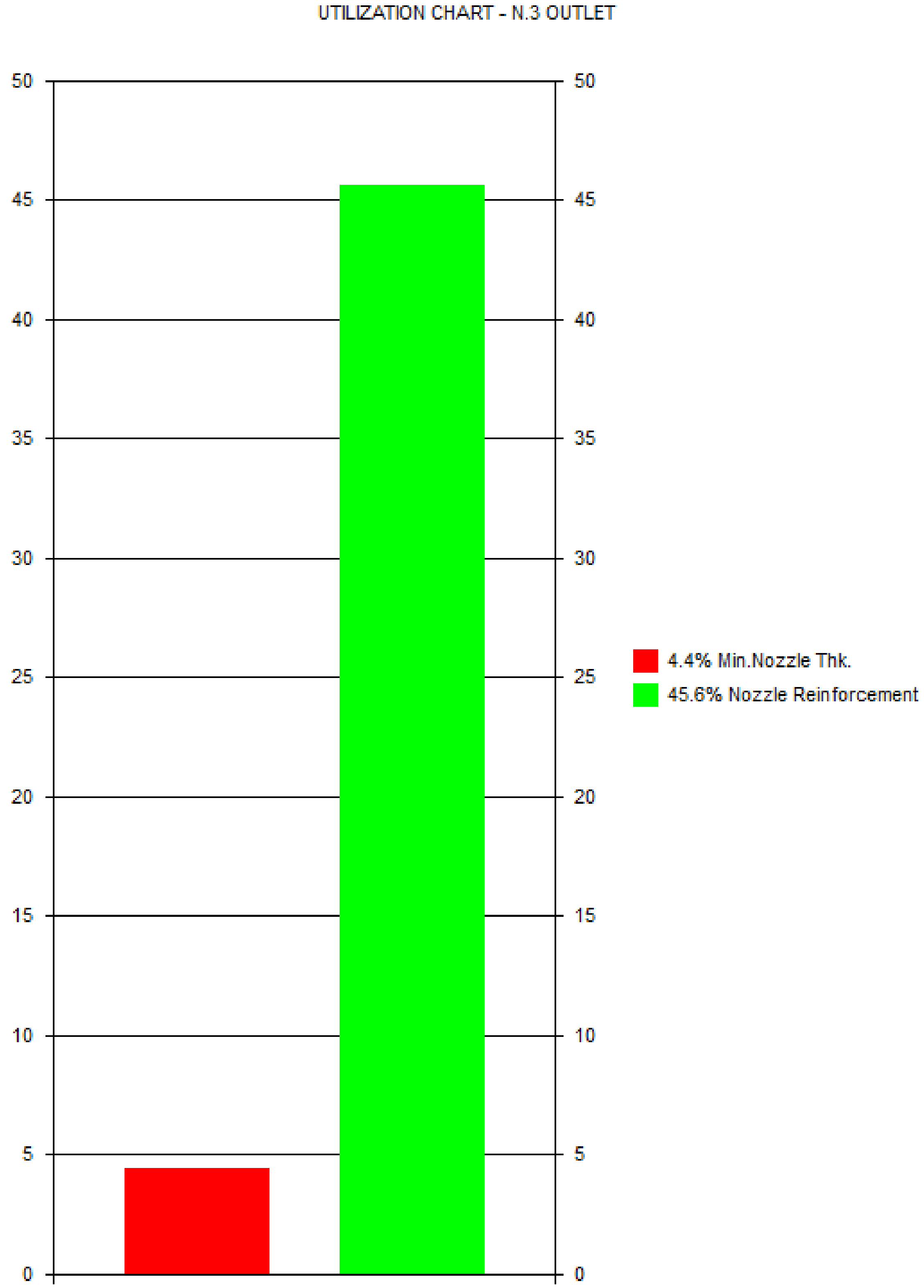
Nozzle Reinforcement pAAval=66.58 >= pAReq=30.36[kN]	45.6%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp)) (9.5-10)
=(423.24+0)*147.5+31.07*135.07/((1.4681E05+866.61+0.5*0)+0.5*(423.24+0+31.0
7+0))=                                                   =    0.4505 MPa
```

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

EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.3 Outlet
20 June 2019 12:02 ConnID:E3.1



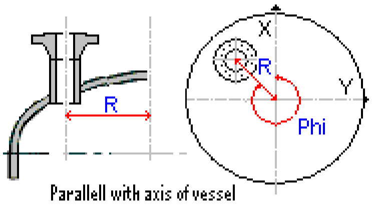
Max.Utilization/Condition 45.6%

20 June 2019 12:02 ConnID:E3.1

INPUT DATA

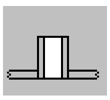
COMPONENT ATTACHMENT/LOCATION

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




```
Orientation & Location of Nozzle:
Axis of Nozzle is Parallel with Axis of End (Off Center)
Angle of Rotation of nozzle axis projected in the x-y plane:Phi   270.00 Degr.
Distance between Center of End and Center of Nozzle.:R         330.00 mm
```

GENERAL DESIGN DATA

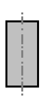


```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH        542.52 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       2208.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R        1766.40 mm
LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d         104.00 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

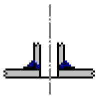


```
Delivery Form: Seamless Pipe
EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT THK<=60mm 90'C
Rm=490 Rp=225 Rpt=202.6 fb=135.07 f20=150 ftest=214.29 E=194028(N/mm2) ro=7.93
```

NOZZLE DIMENSIONAL DATA

EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.4 Outlet

20 June 2019 12:02 ConnID:E3.1

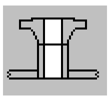


```
Attachment: Set On Nozzle
Shape of Nozzle/Opening: Circular
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER..............................:deb       104.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       2.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE................:           10.00 %
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 BETWN.BRANCH AXIS AND A LINE NORMAL TO MAIN BODY:Phi      10.77 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 =2-0-0.2=                             1.8000 mm
ris = R (9.5-4) =330=                                        1766.40 mm
dib = deb - 2 * eab =104-2*1.8=                               100.40 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=0.2053*104/(2*135.07*1+0.2053)=                            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/De=0.0455 <= 0.60=0.6[mm] (9.4.5.3)«» OK«

Min.Nozzle Thk. ebp=0.08 <= eab=1.8[mm]	4.4%	OK

»Location in End to Fig.9.5-4 L=722 >= De/10=220.8[mm] « » OK«

9.5.2.4.5 Nozzles oblique 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*1766.4+3.7)*3.7)=                               114.39 mm
Set On Nozzle
Afs = eas * (eb + Is) (9.5-81) =3.7*(1.8+114.39)=         429.90 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                            (9.5-76)
=MIN(Sqr((104-1.8)*1.8,)100)=                             13.56 mm
Set On Nozzle
Afb = eb * Ibo (9.5-80) =1.8*13.56=                         24.41 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-80) =0.5*100.4*(13.56+3.7)=   866.61 mm2

Additional Area due to Obliquity of Nozzle Ap(phi)
Apphi = 0.5 * dib ^ 2 * Tan( phi)                                (9.5-112)
=0.5*100.4^2*Tan(10.77)=                                958.47 mm2

Spherical Shell/End on any Section Aps
Aps = 0.5 * ris ^ 2 * (Is + a) / (0.5 * eas + ris)               (9.5-115)
=0.5*1766.4^2*(114.39+52.94)/(0.5*3.7+1766.4)=       1,4763E05 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                            (9.5-7)
=0.2053*(1.4763E05+866.61+0.5*958.47)=                    30.59 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)
=(429.9+0)*(147.5-0.5*0.2053)+0*(0-0.5*0.2053)+24.41*(135.07-0.5*0.2053)
=    66.66 kN
```

Nozzle Reinforcement pAAval=66.66 >= pAReq=30.59[kN]	45.8%	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)
=(429.9+0)*147.5+24.41*135.07/((1.4763E05+866.61+0.5*958.47)+0.5*(429.9+0+2
4.41+0))=                                                 =   0.4471 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                 0.7986 MPa

Weight of Nozzle: .6088kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.08 <= eab=1.8[mm]	4.4%	OK

9.5.2.4.5 Nozzles oblique to the shell, with or without reinforcement pads.

```
Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*1766.4+3.7)*3.7)=                               114.39 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                            (9.5-76)
=MIN(Sqr((104-1.8)*1.8,)100)=                             13.56 mm
```

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                                (9.5-7)
=0.2053*(1.4763E05+866.61+0.5*958.47)=                         30.59 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)
=(429.9+0)*(147.5-0.5*0.2053)+0*(0-0.5*0.2053)+24.41*(135.07-0.5*0.2053)
=    66.66 kN
```

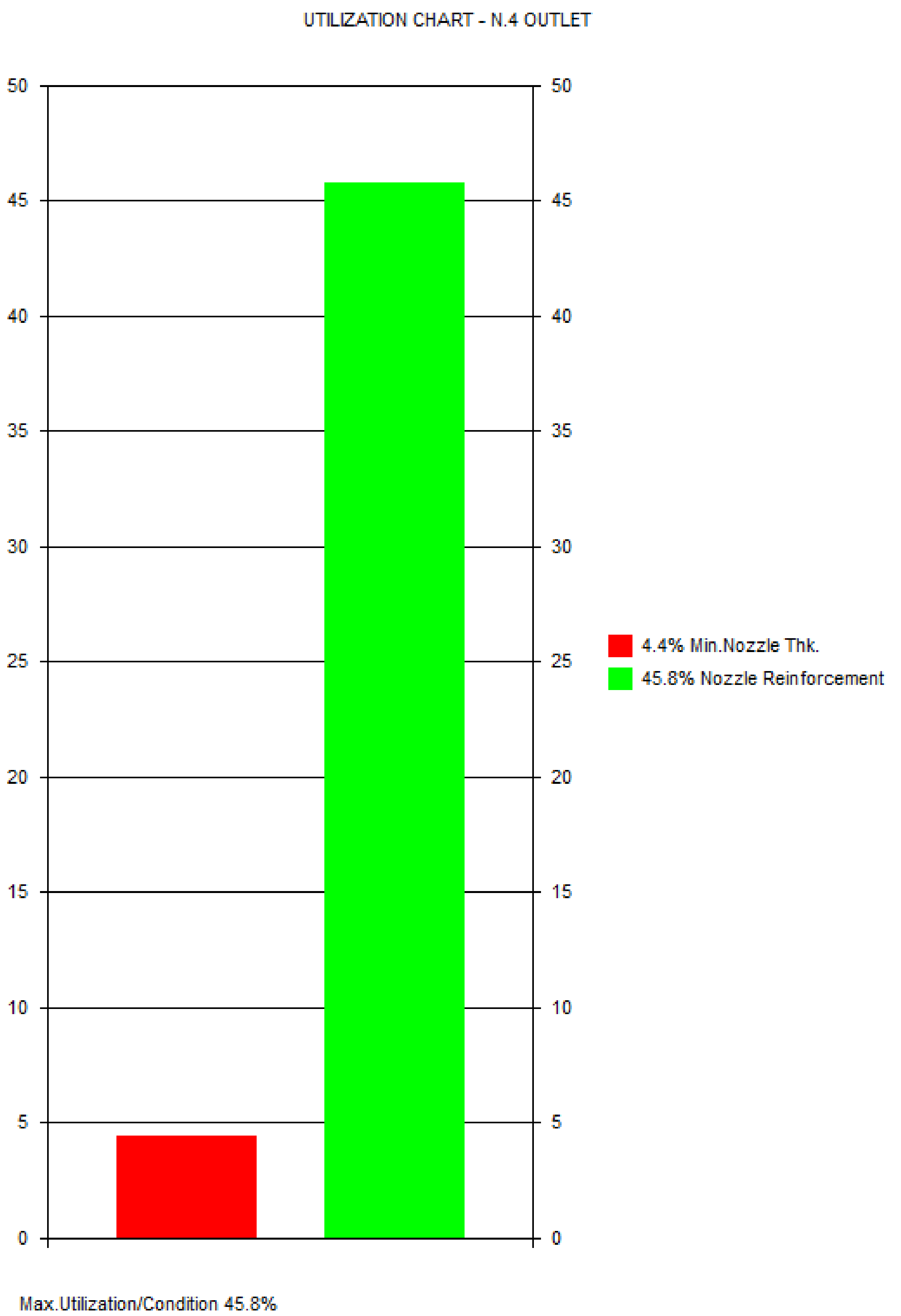
Nozzle Reinforcement pAAval=66.66 >= pAReq=30.59[kN]	45.8%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp)) (9.5-10)
=(429.9+0)*147.5+24.41*135.07/((1.4763E05+866.61+0.5*958.47)+0.5*(429.9+0+2
4.41+0))=                                                      =   0.4471 MPa
```

Volume:0.0009000 m3 Weight:0.6 kg (SG= 7.93)

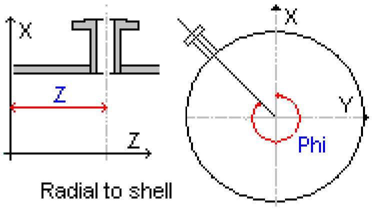
EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.4 Outlet
20 June 2019 12:02 ConnID:E3.1



INPUT DATA

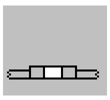
COMPONENT ATTACHMENT/LOCATION

```
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    20.00 Degr.
```

GENERAL DESIGN DATA



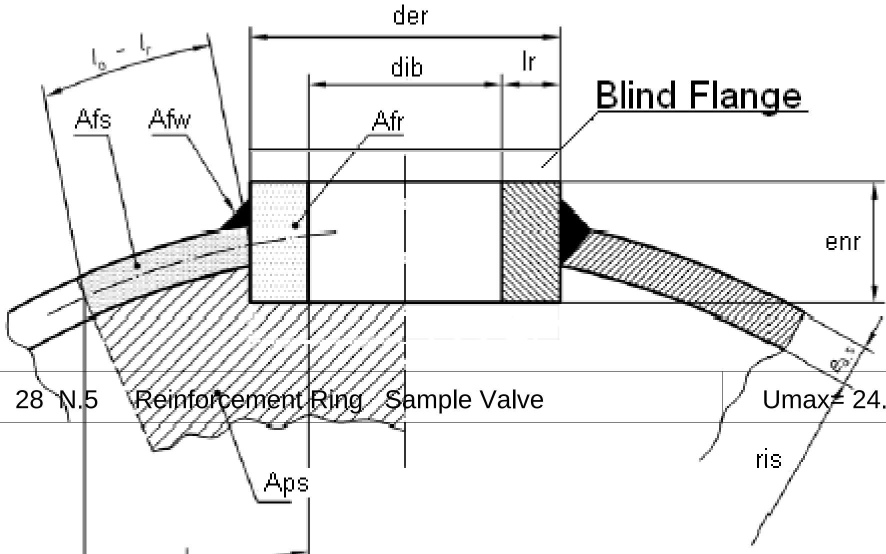
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH          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       2208.00 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         65.00 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 =65-0=                                         65.00 mm
Inside Radius of Curvature
ris = De / 2 - eas (9.5-3) =2208/2-3.7=                    1100.30 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(65,MAX(3*3.7,3*10))=                                  30.00 mm
Limit of Reinforcement Along Shell and Ring Io
Io = Sqr(( 2 * ris + eam) * eam)                                   (9.5-46)
=Sqr((2*1100.3+5.98)*5.98)=                               115.59 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io                                   (9.5-48)
=3.7+(30-3.7)*10/115.59=                                  5.9752 mm
Area of Ring Afr/Afb
Afr/Afb = er * Ir (9.5-55) =30*10=                          300.00 mm2

Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*1100.3+3.7)*3.7)=                                  90.31 mm
Is = MIN( Iso , Io - Ir) (9.5-50) =MIN(90.31,115.59-10)=     90.31 mm
Area of Shell
Afs = eas * Is (9.5-54) =3.7*90.31=                          334.15 mm2
```

Calculation of Pressure Loaded Areas

```
Apr/Apb = 0.5 * dib * er =0.5*8*30=                          120.00 mm2

Cyl.Shell in the Longitudinal Section Aps
ApsL = ris * (Is + Ir + a) + a * (eas + ep)                        (9.5-56)
=1100.3*(90.31+10+4)+4*(3.7+0)=                      1,1479E05 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*1100.3^2*(90.31+14.)/(0.5*3.7+1100.3)+4.*(3.7+0)=  57304.87 mm2

Aps = MAX( ApsL ApsT) =MAX(1.1479E05,57304.87)=          1,1479E05 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apr) (9.5-7) =0.2*(1.1479E05+120)=       22.98 kN

pAReqT = P * (ApsT + Apr + 0.5 * Apphi)                             (9.5-7)
=0.2*(57304.87+120+0.5*0)=                                 11.48 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(22981.44,11484.97)=         22.98 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)
=(334.15+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+300*(145.83-0.5*0.2)=    92.97 kN
```

Nozzle Reinforcement pAAval=92.97 >= pAReq=22.98[kN]	24.7%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(334.15+0)*147.5+300*145.83/((1.1479E05+120)+0.5*(334.15+0+300+0))
=   0.8074 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                 1.4064 MPa
Weight of Nozzle: .2915kg
```

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*(1.1479E05+120)=      22.98 kN
pAReqT = P * (ApsT + Apr + 0.5 * Apphi)                        (9.5-7)
=0.2*(57304.87+120+0.5*0)=                                11.48 kN
pAReq = MAX( pAReqL, pAReqT) =MAX(22981.44,11484.97)=        22.98 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)
=(334.15+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+300*(145.83-0.5*0.2)=    92.97 kN
```

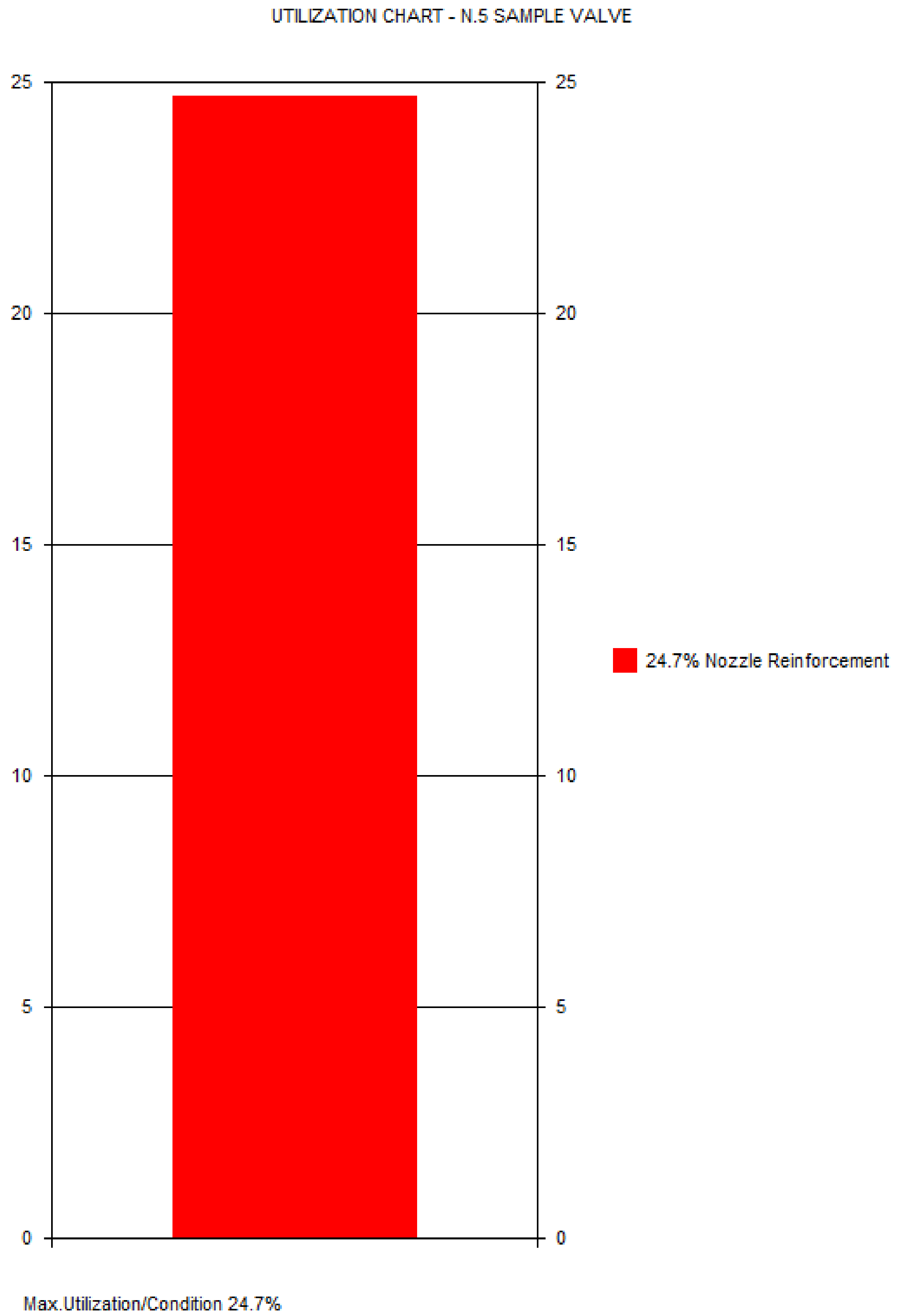
Nozzle Reinforcement pAAval=92.97 >= pAReq=22.98[kN]	24.7%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(334.15+0)*147.5+300*145.83/((1.1479E05+120)+0.5*(334.15+0+300+0))
=   0.8074 MPa
```

Volume:0.00 m3 Weight:0.3 kg (SG= 7.93)

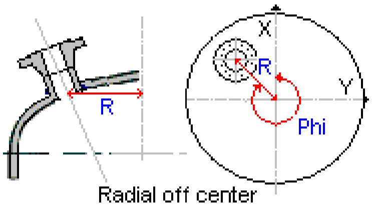
EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.5 Sample Valve 20 June 2019 12:02 ConnID:S1.1



INPUT DATA

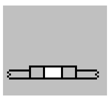
COMPONENT ATTACHMENT/LOCATION

```
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         200.00 mm
```

GENERAL DESIGN DATA



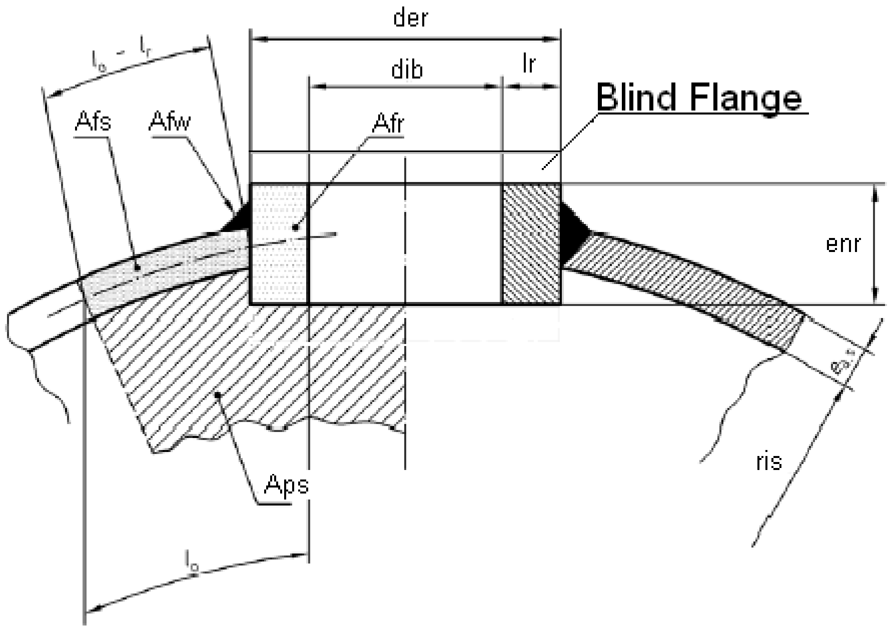
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.0020 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.0000
LIQUID HEAD.........................................:LH        562.23 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       2208.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R        1766.40 mm
LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d         104.00 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 =4-0-0.3=                                    3.7000 mm
Ring Analysis Thickness ear
ear = enr - c =8-0=                                            8.0000 mm
ris = R (9.5-4) =200=                                         1766.40 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=871.53 >= De/10=220.8[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*3.7,3*10.5))=                                   8.0000 mm
Limit of Reinforcement Along Shell and Ring Io
Io = Sqr(( 2 * ris + eam) * eam)                                     (9.5-46)
=Sqr((2*1766.4+4.07)*4.07)=                                  120.78 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io                                     (9.5-48)
=3.7+(8-3.7)*10.5/120.78=                                    4.0738 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*1766.4+3.7)*3.7)=                                    114.39 mm
```

```
Is = MIN( Iso , Io - Ir) (9.5-50) =MIN(114.39,120.78-10.5)=   110.28 mm
Area of Shell
Afs = eas * Is (9.5-54) =3.7*110.28=                          408.03 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*1766.4^2*(110.28+32.5)/(0.5*3.7+1766.4)+32.5*(3.7+0)=1,2609E05 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apr + 0.5 * Apphi)                               (9.5-7)
=0.2055*(1.2609E05+176+0.5*0)=                               25.95 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)
=(408.03+0)*(147.5-0.5*0.2055)+0*(0-0.5*0.2055)+84*(146.25-0.5*0.2055)
=     72.42 kN
```

Nozzle Reinforcement pAAval=72.42 >= pAReq=25.95[kN]	35.8%	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)
=(408.03+0)*147.5+84*146.25/((1.2609E05+176+0.5*0)+0.5*(408.03+0+84+0))
=   0.5728 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                   1.0207 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)
=0.2055*(1.2609E05+176+0.5*0)=                               25.95 kN
```

Pressure Area Available pA(aval.)

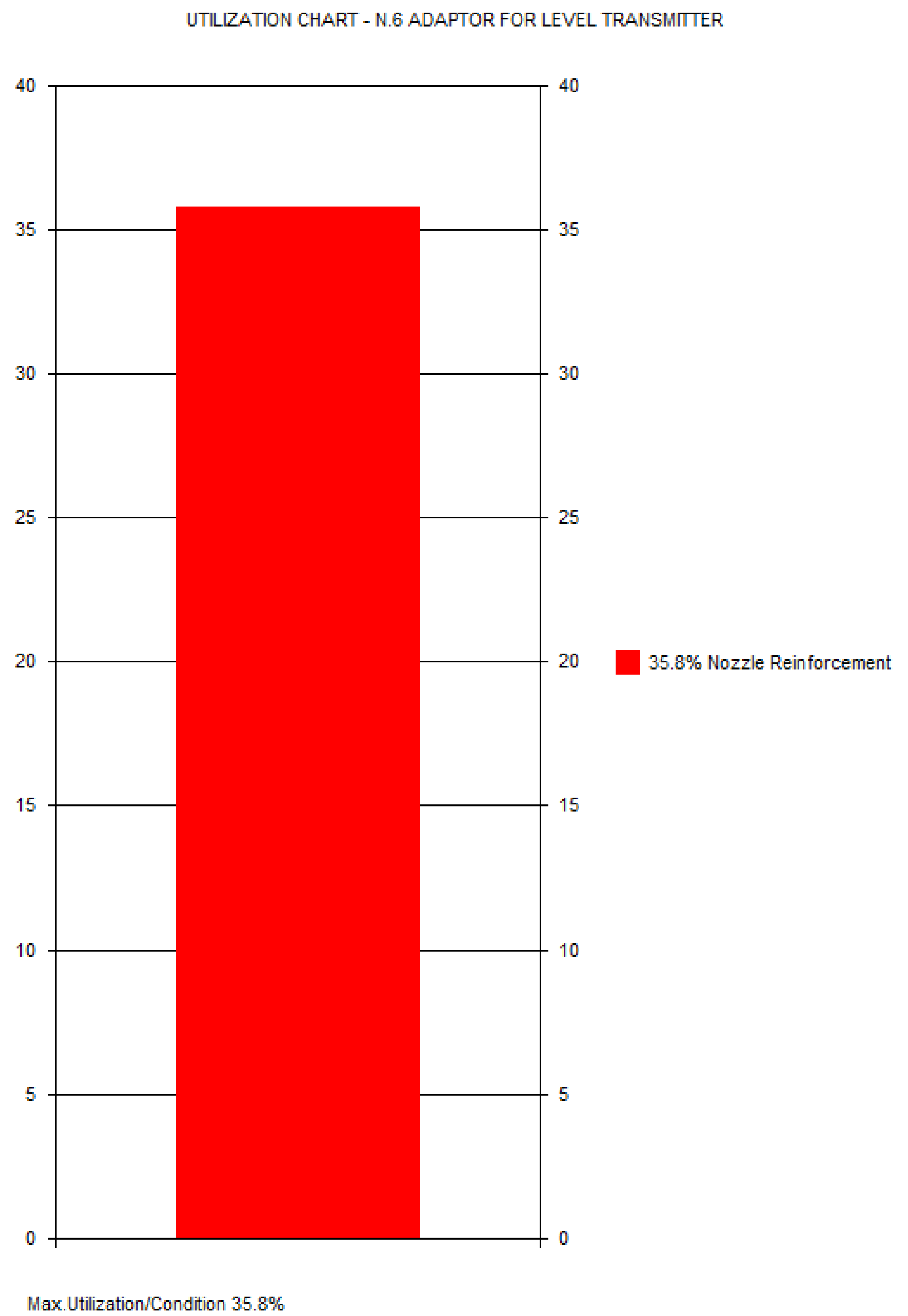
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afr*(fob-0.5*P)       (9.5-13)
=(408.03+0)*(147.5-0.5*0.2055)+0*(0-0.5*0.2055)+84*(146.25-0.5*0.2055)
=     72.42 kN
```

Nozzle Reinforcement pAAval=72.42 >= pAReq=25.95[kN]	35.8%	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)
=(408.03+0)*147.5+84*146.25/((1.2609E05+176+0.5*0)+0.5*(408.03+0+84+0))
=   0.5728 MPa
```

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


UTILIZATION CHART - N.6 ADAPTOR FOR LEVEL TRANSMITTER
40
35
30
25
20
15
10
5
0
35.8% Nozzle Reinforcement
Max.Utilization/Condition 35.8%

INPUT DATA

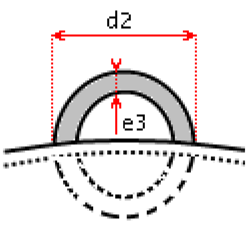
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    Main Shell
z-location of Bottom of Base Plate/Bottom Leg.......:z       -1400.00 mm
Angular Location....................................:phi       90.00 degr.
Load Analysis: Detailed Load Analysis Included(wind, seismic, blast etc.)
```

SHELL DATA

```
Shell Type: Cylindrical Shell
OUTSIDE DIAMETER OF SHELL...........................:De       2208.00 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
```

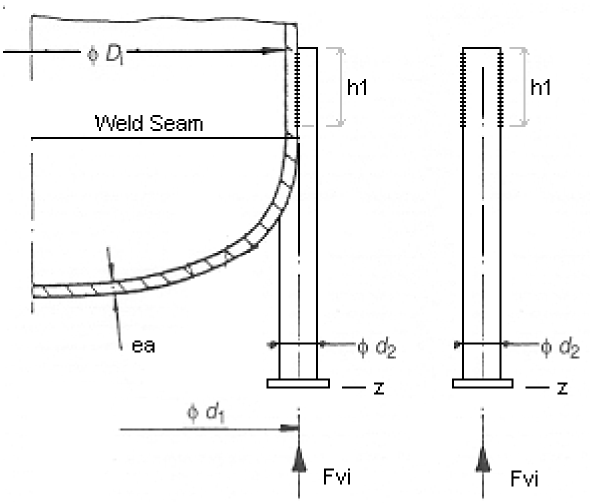
LEG DATA




```
Leg Geometry: Pipe
Legs are Cross Braced: NO
Comment (Optional):
OUTSIDE DIAMETER OF SUPPORTING LEG PIPE.............:d2        204.00 mm
WALL THICKNESS OF SUPPORTING LEG PIPE...............:e3        2.0000 mm
LEG CENTERLINE DIAMETER.............................:d1       2060.00 mm
NUMBER OF LEGS......................................:n         3.0000
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        1.5000 mm
LENGTH OF FILLET WELD ON LEG IN CYLINDRICAL SHELL...:h1        210.00 mm
WELD JOINT COEFFICIENT..............................:z         0.8000
```



DATA FOR REINFORCEMENT PAD

```
Reinforcement Pad: Included
WIDTH OF REINFORCEMENT PAD..........................:b2        220.00 mm
HEIGHT OF REINFORCEMENT PAD.........................:b3        230.00 mm
THICKNESS OF REINFORCEMENT PAD......................:e2        4.0000 mm
WELD BETWEEN SHELL AND PAD, THROAT DIMENSION........:apad      1.0000 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: NO
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.
	E3.1	2208	-1	10	4	-575.6	0	0.01	7.93
Main Shell	S1.1	2208	2208	1500	4	0	1500	3.31	7.93
	S1.2	2208	2208	900	4	1500	2400	1.99	7.93
	E3.2	2208	1	40	4	2400	3005.6	0.04	7.93
Flange for Instrumental Top Pl	N.1	550	550	25	50	3005.6	3028	0.01	7.93

Table COMPONENTS Continued

Description	Weight(kg)	Vol(m3)	Material Name	fd	fa	fcd	fca	E-Module
	170.3	1.437	EN10028-7:2016, 1.4404 X2CrNi	147.5	180	66.7	76.9	194028
Main Shell	329.4	5.702	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	66.7	76.9	194028
	197.7	3.421	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	66.7	76.9	194028
	176.8	1.551	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	66.7	76.9	194028
Flange for Instrumental 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
	1.25	0.3	199964	0
Main Shell	1.25	0.3	199964	0.01202
	1.25	0.3	199964	0.01202
	1.25	0.3	199964	0
Flange for Instrumental 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	0.2	0	0	0.18
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	1	1
Liquid Level (mm)	LL	FULL	EMPTY	EMPTY	0
Sp.Gravity (Liq.)	SG	1	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(3028--1400)=              4428.00 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:
V304 = Cv * I / (R * Tnat5) * W                                  (30-4)
=0.24*1/(2.2*0.1761)*2357.27=                             1460.51 kg
V305 = 2.5 * Ca * I * W / R (30-5) =2.5*0.24*1*2357.27/2.2=   642.89 kg
V342 = 0.56 * Ca * I * W (34-2) =0.56*0.24*1*2357.27=        316.82 kg
V = Max( Min( V3045 , V3055 ), V3425 )
=Max(Min(1460.51,642.89,)316.82)=                           642.89 kg
Shear force at bottom of vessel V
V = V * 9.81 / 1.4 =642.89*9.81/1.4=                        4.5048 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	0.4137 s	2.42 Hz
LOAD CASE NO: 2 - LC4 SHUT DOWN	0.1038 s	9.63 Hz
LOAD CASE NO: 3 - LC5 INSTALLATION	0.1038 s	9.63 Hz
LOAD CASE NO: 4 - LC1&2&3 OPER.WIND	0.1738 s	5.75 Hz
LOAD CASE NO: 5 - OPER.SEISMIC	0.1738 s	5.75 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	-127.65	0.01	0.03	0.00
LC4 SHUT DOWN	0.00	0.00	-8.04	0.01	0.04	0.00
LC5 INSTALLATION	0.00	0.00	-8.04	0.01	0.04	0.00
LC1&2&3 OPER.WIND	0.00	0.00	-22.53	0.01	0.04	0.00
OPER.SEISMIC	4.39	0.00	-22.53	0.01	3.68	0.00

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	-128.08	0.01	0.04	0.00
LC4 SHUT DOWN	0.00	0.00	-8.48	0.01	0.04	0.00
LC5 INSTALLATION	0.00	0.00	-8.48	0.01	0.04	0.00
LC1&2&3 OPER.WIND	0.00	0.00	-22.97	0.01	0.04	0.00
OPER.SEISMIC	4.39	0.00	-22.97	0.01	9.82	0.00

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)
=1.2765E05/3-4*36213.12/(3*2060)=                        -42.57 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=1.2765E05/3+4*36213.12/(3*2060)=                        -42.52 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	568.59	0.00	0.00	0.00	-42.55	38.3	0.0	38.3
2	120	568.59	0.00	0.00	0.00	-42.55	38.3	0.0	38.3
3	240	568.59	0.00	0.00	0.00	-42.55	38.3	0.0	38.3

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	60	568.59	0.00	0.00	0.00	-42.55	38.3	0.0	38.3
2	180	568.59	0.00	0.00	0.00	-42.55	38.3	0.0	38.3
3	300	568.59	0.00	0.00	0.00	-42.55	38.3	0.0	38.3

```
Horizontal force at each leg  Fhi = FH*I/SUM(I)
Moment at top of leg  Mi = F1*a1 + Fhi*L
Vertical force at each leg  Fvi = FV/n + FLi * Cos(Phi)
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)= 38.29 N/mm2
```

Axial Stresses in the Leg Siga=38.27 <= fl=235[N/mm2]	16.2%	OK
Combined Stresses in the Leg Sigc=38.29 <= 1.5*fl=352.5[N/mm2]	10.8%	OK

```
Maximum horizontal deflection at top of legs , Defl= 0 mm
```

Deflection in the Legs Defl=7.3605E-04 <= DeflMax=7.775[mm]	0.0%	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*1450/(71.51*110.56)=                                   0.2751
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*(0.2751-0.2)+0.2751^2)=                        0.5562
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5562+Sqr(0.5562^2-0.2751^2,))1)=                  0.9618
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-42.55,-42570)=                   42.57 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9618*1111.93*156.67/1=                                   167.55 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(5.6859E06/102*Cos(0)^2+5.6859E06/102*Sin(0)^2)=    8.7334 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	42.55	167.55	0.00	8.73	0.2541
2	120	42.55	167.55	0.00	8.73	0.2541
3	240	42.55	167.55	0.00	8.73	0.2541

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	60	42.55	167.55	0.00	8.73	0.2541
2	180	42.55	167.55	0.00	8.73	0.2541
3	300	42.55	167.55	0.00	8.73	0.2541

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(42548.85/1.6755E05+1.5*939.44/8.7334E06,-42570/1.6755E05)=    0.2541
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.2541 <= 1.0=1	25.4%	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 =210^2*1.5/3=                      22050.00 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =939.44/22050=                         0.0426 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-42570/(2*210*1.5)=            67.57 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(0.0426^2+3*67.57^2)=                               117.04 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=117.04 <= z*fld=188[N/mm2]	62.2%	OK

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

```
Shell Inside Diameter
Di = De - 2 * (en - c) =2208-2*(4-0)=                     2200.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2200=                                           2200.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0018« » OK«
»a) en/Deq=0.0018 <= 0.05« » OK«
»b) g/h1=0.9631 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=230 <= 1.5*h1=315[mm] « » OK«
»d) b2=220 >= 0.6*b3=138[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
=(1.2765E05+4*36213.12/(2200+2*(0+3.7+4)))/3=              42.57 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =1.94/3=                                    6,4789E-04 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =230/Sqr(2200*3.7)=   2.5493
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)            (16.10-12)
=1/Sqr(0.36+0.5*2.55+0.5*2.55^2)=                        0.4525
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.55,0.4)=   0.2039
Sigm = P * Deq / (2 * ea) (16.6-11) =0.2*2200/(2*3.7)=        59.46 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =59.46/(1.05*265)=           0.2137
Sigball = K1 * K2 * fs (16.6-6) =1.19*1.05*265=              330.59 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi                                  (16.10-14)
=0+4+0.6479*1555/42570.19=                               4.0237 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                  (16.10-15)
=(330.59*3.7^2*230/(0.4525*4.02))=                       571.73 kN
```

Loads in Cyl.Shell Fvi=42.57 <= Fimax=571.73[kN]	7.4%	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*1*(220+230)=                 900.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=1*230^2/6*(3*220+230)=                                  7,8468E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=1*220^2/6*(3*230+220)=                                  7,3407E06 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =1*(220+230)^3/6=        1,5188E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =42570.19/900=                          47.30 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(42570.19*0+0.6479*1555)*0.5*230/7.8468E06=               0.0148 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0.0148^2+3*47.3^2)=                                    81.93 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=81.93 <= z*fs=212[N/mm2]	38.6%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0.6479/900)=           7,1988E-04 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=42570.19*0*0.5*230/7.8468E06=                               0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0.6479*0*0.5*220/7.3407E06=                                 0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0.6479*1555*0.5*230/1.5188E07=                            0.0076 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0.6479*1555*0.5*220/1.5188E07=                            0.0073 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((47.3+0.0073)^2+(47.3+0.0076)^2)=                      66.90 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*66.9^2)=                                    115.88 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=115.88 <= z*fs=212[N/mm2]	54.6%	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)
=8041.06/3-4*38937.7/(3*2060)=                             -2.71 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=8041.06/3+4*38937.7/(3*2060)=                             -2.66 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	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.4
2	120	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.5
3	240	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.5

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	60	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.5
2	180	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.4
3	300	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.5

```
Horizontal force at each leg  Fhi = FH*I/SUM(I)
Moment at top of leg  Mi = F1*a1 + Fhi*L
Vertical force at each leg  Fvi = FV/n + FLi * Cos(Phi)
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)= 2.45 N/mm2
```

Axial Stresses in the Leg Siga=2.41 <= fl=156.67[N/mm2]	1.5%	OK
Combined Stresses in the Leg Sigc=2.45 <= 1.5*fl=235.[N/mm2]	1.0%	OK

```
Maximum horizontal deflection at top of legs , Defl= 0 mm
```

Deflection in the Legs Defl=0.0013 <= DeflMax=7.775[mm]	0.0%	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*1450/(71.51*110.56)=                                 0.2751
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*(0.2751-0.2)+0.2751^2)=                      0.5562
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5562+Sqr(0.5562^2-0.2751^2,))1)=                0.9618
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-2.68,-2710)=                   2.7056 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9618*1111.93*156.67/1=                                 167.55 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(5.6859E06/102*Cos(0)^2+5.6859E06/102*Sin(0)^2)=   8.7334 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	2.68	167.55	0.00	8.73	0.0163
2	120	2.68	167.55	0.00	8.73	0.0163
3	240	2.68	167.55	0.00	8.73	0.0163

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	60	2.68	167.55	0.00	8.73	0.0163
2	180	2.68	167.55	0.00	8.73	0.0163
3	300	2.68	167.55	0.00	8.73	0.0163

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(2681.19/1.6755E05+1.5*1722.33/8.7334E06,-2710/1.6755E05)=   0.0163
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0163 <= 1.0=1	1.6%	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 =210^2*1.5/3=                        22050.00 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =1722.33/22050=                          0.0781 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-2710/(2*210*1.5)=               4.2945 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(0.0781^2+3*4.29^2)=                                  7.4388 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=7.44 <= z*fld=125.34[N/mm2]	5.9%	OK

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

```
Shell Inside Diameter
Di = De - 2 * (en - c) =2208-2*(4-0)=                       2200.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2200=                                             2200.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0018« » OK«
»a) en/Deq=0.0018 <= 0.05« » OK«
»b) g/h1=0.9631 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=230 <= 1.5*h1=315[mm] « » OK«
»d) b2=220 >= 0.6*b3=138[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
=(8041.06+4*38937.7/(2200+2*(0+3.7+4)))/3=                2.7038 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =3.56/3=                                       0.0012 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =230/Sqr(2200*3.7)=   2.5493
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)             (16.10-12)
=1/Sqr(0.36+0.5*2.55+0.5*2.55^2)=                         0.4525
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.55,0.4)=   0.2039
Sigm = P * Deq / (2 * ea) (16.6-11) =0*2200/(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) =1.38*1.25*180=             310.73 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi (16.10-14) =0+4+1.19*1555/2703.79=   4.6831 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                   (16.10-15)
=(310.73*3.7^2*230/(0.4525*4.68))=                        461.70 kN
```

Loads in Cyl.Shell Fvi=2.7 <= Fimax=461.7[kN]	0.5%	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*1*(220+230)=                900.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=1*230^2/6*(3*220+230)=                                   7,8468E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=1*220^2/6*(3*230+220)=                                   7,3407E06 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =1*(220+230)^3/6=         1,5188E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =2703.79/900=                         3.0042 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(2703.79*0+1.19*1555)*0.5*230/7.8468E06=                 0.0271 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0.0271^2+3*3.^2)=                                    5.2035 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=5.2 <= z*fs=144.[N/mm2]	3.6%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(1.19/900)=                0.0013 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=2703.79*0*0.5*230/7.8468E06=                               0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=1.19*0*0.5*220/7.3407E06=                                  0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=1.19*1555*0.5*230/1.5188E07=                             0.0140 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=1.19*1555*0.5*220/1.5188E07=                             0.0134 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((3.+0.0134)^2+(3.+0.014)^2)=                         4.2679 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*4.27^2)=                                   7.3923 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=7.39 <= z*fs=144.[N/mm2]	5.1%	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)
=8041.06/3-4*37446.99/(3*2060)=                           -2.7 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=8041.06/3+4*37446.99/(3*2060)=                           -2.66 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	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.4
2	120	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.4
3	240	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.4

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	60	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.4
2	180	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.4
3	300	568.59	0.00	0.00	0.00	-2.68	2.4	0.0	2.4

```
Horizontal force at each leg  Fhi = FH*I/SUM(I)
Moment at top of leg  Mi = F1*a1 + Fhi*L
Vertical force at each leg  Fvi = FV/n + FLi * Cos(Phi)
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)= 2.44 N/mm2
```

Axial Stresses in the Leg Siga=2.41 <= fl=156.67[N/mm2]	1.5%	OK
Combined Stresses in the Leg Sigc=2.44 <= 1.5*fl=235.[N/mm2]	1.0%	OK

```
Maximum horizontal deflection at top of legs , Defl= 0 mm
```

Deflection in the Legs Defl=8.5871E-04 <= DeflMax=7.775[mm]	0.0%	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*1450/(71.51*110.56)=                                  0.2751
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*(0.2751-0.2)+0.2751^2)=                       0.5562
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5562+Sqr(0.5562^2-0.2751^2,))1)=                 0.9618
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-2.68,-2700)=                   2.7046 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9618*1111.93*156.67/1=                                  167.55 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(5.6859E06/102*Cos(0)^2+5.6859E06/102*Sin(0)^2)=   8.7334 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	2.68	167.55	0.00	8.73	0.0162
2	120	2.68	167.55	0.00	8.73	0.0162
3	240	2.68	167.55	0.00	8.73	0.0162

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	60	2.68	167.55	0.00	8.73	0.0162
2	180	2.68	167.55	0.00	8.73	0.0162
3	300	2.68	167.55	0.00	8.73	0.0162

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(2680.89/1.6755E05+1.5*1095.99/8.7334E06,-2700/1.6755E05)=   0.0162
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0162 <= 1.0=1	1.6%	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 =210^2*1.5/3=                      22050.00 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =1095.99/22050=                        0.0497 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-2700/(2*210*1.5)=             4.2930 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(0.0497^2+3*4.29^2)=                                7.4359 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=7.44 <= z*fld=125.34[N/mm2]	5.9%	OK

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

```
Shell Inside Diameter
Di = De - 2 * (en - c) =2208-2*(4-0)=                     2200.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2200=                                           2200.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0018« » OK«
»a) en/Deq=0.0018 <= 0.05« » OK«
»b) g/h1=0.9631 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=230 <= 1.5*h1=315[mm] « » OK«
»d) b2=220 >= 0.6*b3=138[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
=(8041.06+4*37446.99/(2200+2*(0+3.7+4)))/3=             2.7029 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =2.27/3=                                 7,5586E-04 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =230/Sqr(2200*3.7)=   2.5493
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)          (16.10-12)
=1/Sqr(0.36+0.5*2.55+0.5*2.55^2)=                       0.4525
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.55,0.4)=   0.2039
Sigm = P * Deq / (2 * ea) (16.6-11) =0*2200/(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) =1.38*1.25*180=             310.73 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi                                (16.10-14)
=0+4+0.7559*1555/2702.89=                               4.4349 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))               (16.10-15)
=(310.73*3.7^2*230/(0.4525*4.43))=                      487.55 kN
```

Loads in Cyl.Shell Fvi=2.7 <= Fimax=487.55[kN]	0.5%	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*1*(220+230)= 900.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=1*230^2/6*(3*220+230)= 7,8468E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=1*220^2/6*(3*230+220)= 7,3407E06 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =1*(220+230)^3/6= 1,5188E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =2702.89/900= 3.0032 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(2702.89*0+0.7559*1555)*0.5*230/7.8468E06= 0.0172 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr(Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0.0172^2+3*3.^2)= 5.2017 N/mm2

Total Stresses in Pad Weld Case A SigwTotPadx=5.2 <= z*fs=144.[N/mm2]	3.6%	OK

Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs(Fhi / Awpad) =Abs(0.7559/900)= 8,3984E-04 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=2702.89*0*0.5*230/7.8468E06= 0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0.7559*0*0.5*220/7.3407E06= 0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0.7559*1555*0.5*230/1.5188E07= 0.0089 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0.7559*1555*0.5*220/1.5188E07= 0.0085 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((3.+0.0085)^2+(3.+0.0089)^2)= 4.2595 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*4.26^2)= 7.3777 N/mm2

Total Stresses in Pad Weld Case B SigwTotPadB=7.38 <= z*fs=144.[N/mm2]	5.1%	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)
=22531.67/3-4*38117.58/(3*2060)= -7.54 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=22531.67/3+4*38117.58/(3*2060)= -7.49 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	568.59	0.00	0.00	0.00	-7.51	6.8	0.0	6.8
2	120	568.59	0.00	0.00	0.00	-7.51	6.8	0.0	6.8
3	240	568.59	0.00	0.00	0.00	-7.51	6.8	0.0	6.8

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	60	568.59	0.00	0.00	0.00	-7.51	6.8	0.0	6.8
2	180	568.59	0.00	0.00	0.00	-7.51	6.8	0.0	6.8
3	300	568.59	0.00	0.00	0.00	-7.51	6.8	0.0	6.8

```
Horizontal force at each leg  Fhi = FH*I/SUM(I)
Moment at top of leg  Mi = F1*a1 + Fhi*L
Vertical force at each leg  Fvi = FV/n + FLi * Cos(Phi)
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)= 6.8 N/mm2
```

Axial Stresses in the Leg Siga=6.76 <= fl=123.2[N/mm2]	5.4%	OK
Combined Stresses in the Leg Sigc=6.8 <= 1.5*fl=184.8[N/mm2]	3.6%	OK

```
Maximum horizontal deflection at top of legs , Defl= 0 mm
```

Deflection in the Legs Defl=0.0013 <= DeflMax=7.775[mm]	0.0%	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*1450/(71.51*110.56)=                                  0.2751
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*(0.2751-0.2)+0.2751^2)=                       0.5562
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5562+Sqr(0.5562^2-0.2751^2,))1)=                 0.9618
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-7.51,-7540)=                   7.5352 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9618*1111.93*156.67/1=                                  167.55 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(5.6859E06/102*Cos(0)^2+5.6859E06/102*Sin(0)^2)=   8.7334 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	7.51	167.55	0.00	8.73	0.0451
2	120	7.51	167.55	0.00	8.73	0.0451
3	240	7.51	167.55	0.00	8.73	0.0451

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	60	7.51	167.55	0.00	8.73	0.0451
2	180	7.51	167.55	0.00	8.73	0.0451
3	300	7.51	167.55	0.00	8.73	0.0451

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(7511.39/1.6755E05+1.5*1722.33/8.7334E06,-7540/1.6755E05)=    0.0451
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0451 <= 1.0=1	4.5%	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 =210^2*1.5/3=                       22050.00 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =1722.33/22050=                          0.0781 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-7540/(2*210*1.5)=               11.96 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(0.0781^2+3*11.96^2)=                                 20.72 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=20.72 <= z*fld=98.56[N/mm2]	21.0%	OK

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

```
Shell Inside Diameter
Di = De - 2 * (en - c) =2208-2*(4-0)=                     2200.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2200=                                           2200.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0018« » OK«
»a) en/Deq=0.0018 <= 0.05« » OK«
»b) g/h1=0.9631 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=230 <= 1.5*h1=315[mm] « » OK«
»d) b2=220 >= 0.6*b3=138[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
=(22531.67+4*38117.58/(2200+2*(0+3.7+4)))/3=            7.5335 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =3.56/3=                                     0.0012 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =230/Sqr(2200*3.7)=   2.5493
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)           (16.10-12)
=1/Sqr(0.36+0.5*2.55+0.5*2.55^2)=                       0.4525
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.55,0.4)=   0.2039
Sigm = P * Deq / (2 * ea) (16.6-11) =0.18*2200/(2*3.7)=       53.51 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =53.51/(1.25*147.5)=        0.2902
Sigball = K1 * K2 * fs (16.6-6) =1.1*1.25*147.5=            203.21 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi (16.10-14) =0+4+1.19*1555/7533.5=   4.2452 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                 (16.10-15)
=(203.21*3.7^2*230/(0.4525*4.25))=                      333.09 kN
```

Loads in Cyl.Shell Fvi=7.53 <= Fimax=333.09[kN]	2.2%	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*1*(220+230)=                  900.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=1*230^2/6*(3*220+230)=                                     7,8468E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=1*220^2/6*(3*230+220)=                                     7,3407E06 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =1*(220+230)^3/6=           1,5188E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =7533.5/900=                             8.3706 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(7533.5*0+1.19*1555)*0.5*230/7.8468E06=                     0.0271 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0.0271^2+3*8.37^2)=                                      14.50 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=14.5 <= z*fs=118.[N/mm2]	12.2%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(1.19/900)=                   0.0013 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=7533.5*0*0.5*230/7.8468E06=                                   0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=1.19*0*0.5*220/7.3407E06=                                     0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=1.19*1555*0.5*230/1.5188E07=                                0.0140 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=1.19*1555*0.5*220/1.5188E07=                                0.0134 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((8.37+0.0134)^2+(8.37+0.014)^2)=                         11.86 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*11.86^2)=                                      20.54 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=20.54 <= z*fs=118.[N/mm2]	17.4%	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)
=22531.67/3-4*3.6774E06/(3*2060)=                            -9.89 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=22531.67/3+4*3.6774E06/(3*2060)=                            -5.13 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	568.59	1.46	2.12	1.37	-6.14	5.5	38.0	43.6
2	120	568.59	1.46	2.12	1.37	-8.20	7.4	52.0	59.3
3	240	568.59	1.46	2.12	1.37	-8.20	7.4	52.0	59.3

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	I(cm4)	Fhi(kN)	Mi(kNm)	FL(kN)	Fvi(kN)	Siga N/mm2	Sigb N/mm2	Sigc N/mm2
1	60	568.59	1.46	2.12	1.03	-7.00	6.3	52.0	58.3
2	180	568.59	1.46	2.12	1.03	-8.54	7.7	38.0	45.7
3	300	568.59	1.46	2.12	1.03	-7.00	6.3	52.0	58.3

```
Horizontal force at each leg  Fhi = FH*I/SUM(I)
Moment at top of leg  Mi = F1*a1 + Fhi*L
Vertical force at each leg  Fvi = FV/n + FLi * Cos(Phi)
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)= 59.34 N/mm2
```

Axial Stresses in the Leg Siga=7.68 <= fl=235[N/mm2]	3.2%	OK
Combined Stresses in the Leg Sigc=59.34 <= 1.5*fl=352.5[N/mm2]	16.8%	OK

```
Maximum horizontal deflection at top of legs , Defl= 1.66 mm
```

Deflection in the Legs Defl=1.66 <= DeflMax=7.775[mm]	21.3%	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*1450/(71.51*110.56)=                                  0.2751
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*(0.2751-0.2)+0.2751^2)=                       0.5562
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.5562+Sqr(0.5562^2-0.2751^2,))1)=                 0.9618
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-8.54,-9890)=                   9.8908 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9618*1111.93*156.67/1=                                  167.55 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(5.6859E06/102*Cos(0)^2+5.6859E06/102*Sin(0)^2)=   8.7334 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	6.14	167.55	2.12	8.73	0.4009
2	120	8.20	167.55	2.12	8.73	0.4132
3	240	8.20	167.55	2.12	8.73	0.4132

CASE 2 (first leg at angle Phi = 60 degrees)

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	60	7.00	167.55	2.12	8.73	0.4060
2	180	8.54	167.55	2.12	8.73	0.4152
3	300	7.00	167.55	2.12	8.73	0.4060

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(8539.99/1.6755E05+1.5*2.1206E06/8.7334E06,-9890/1.6755E05)=   0.4152
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.4152 <= 1.0=1	41.5%	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 =210^2*1.5/3=                      22050.00 mm3
Bending Stress in Weld between Leg and Pad, Sigbw
Sigbw = MiMax / Zw =2.1206E06/22050=                       96.17 N/mm2
Shear Stress in Weld between Leg and Pad, Tauw
Tauw = F1 / (2 * h1 * aw) =-9890/(2*210*1.5)=              15.70 N/mm2
Combined Stress in Weld between Leg and Pad, SigTotw
SigTotw = Sqr( Sigbw ^ 2 + 3 * Tauw ^ 2)
=Sqr(96.17^2+3*15.7^2)=                                  99.94 N/mm2
```

Combined Stress in Welds betw.Leg and Pad Tauw=99.94 <= z*fld=188[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) =2208-2*(4-0)=                    2200.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =2200=                                          2200.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0018« » OK«
»a) en/Deq=0.0018 <= 0.05« » OK«
»b) g/h1=0.9631 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=230 <= 1.5*h1=315[mm] « » OK«
»d) b2=220 >= 0.6*b3=138[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
=(22531.67+4*3.6774E06/(2200+2*(0+3.7+4)))/3=           9.7238 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =4387.52/3=                                  1.4625 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =230/Sqr(2200*3.7)=   2.5493
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)            (16.10-12)
=1/Sqr(0.36+0.5*2.55+0.5*2.55^2)=                       0.4525
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*2.55,0.4)=   0.2039
Sigm = P * Deq / (2 * ea) (16.6-11) =0.18*2200/(2*3.7)=      53.51 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =53.51/(1.05*265)=         0.1923
Sigball = K1 * K2 * fs (16.6-6) =1.21*1.05*265=            336.86 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi                                  (16.10-14)
=0+4+1462.51*1555/9723.79=                              237.88 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                  (16.10-15)
=(336.86*3.7^2*230/(0.4525*237.88))=                    9.8539 kN
```

Loads in Cyl.Shell Fvi=9.72 <= Fimax=9.85[kN]	98.6%	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*1*(220+230)=                  900.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=1*230^2/6*(3*220+230)=                                     7,8468E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=1*220^2/6*(3*230+220)=                                     7,3407E06 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =1*(220+230)^3/6=           1,5188E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =9723.79/900=                             10.80 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(9723.79*0+1462.51*1555)*0.5*230/7.8468E06=                  33.33 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(33.33^2+3*10.8^2)=                                       38.22 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=38.22 <= z*fs=212[N/mm2]	18.0%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(1462.51/900)=                1.6250 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=9723.79*0*0.5*230/7.8468E06=                                  0.00 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=1462.51*0*0.5*220/7.3407E06=                                  0.00 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=1462.51*1555*0.5*230/1.5188E07=                              17.22 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=1462.51*1555*0.5*220/1.5188E07=                              16.47 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((10.8+16.47)^2+(10.8+17.22)^2)=                          39.11 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0^2+0^2+3*39.11^2)=                                      67.73 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=67.73 <= z*fs=212[N/mm2]	31.9%	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	-127.65	0.01	0.03	0.00
LC4 SHUT DOWN	0.00	0.00	-8.04	0.01	0.04	0.00
LC5 INSTALLATION	0.00	0.00	-8.04	0.01	0.04	0.00
LC1&2&3 OPER.WIND	0.00	0.00	-22.53	0.01	0.04	0.00
OPER.SEISMIC	4.39	0.00	-22.53	0.01	3.68	0.00

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	-128.08	0.01	0.04	0.00
LC4 SHUT DOWN	0.00	0.00	-8.48	0.01	0.04	0.00
LC5 INSTALLATION	0.00	0.00	-8.48	0.01	0.04	0.00
LC1&2&3 OPER.WIND	0.00	0.00	-22.97	0.01	0.04	0.00
OPER.SEISMIC	4.39	0.00	-22.97	0.01	9.82	0.00

LOAD CASE NO: 1 - LC9 HYDROTEST

Axial Stresses in the Leg Siga=38.27 <= fl=235[N/mm2]	16.2%	OK
Combined Stresses in the Leg Sigc=38.29 <= 1.5*fl=352.5[N/mm2]	10.8%	OK
Deflection in the Legs Defl=7.3605E-04 <= DeflMax=7.775[mm]	0.0%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.2541 <= 1.0=1	25.4%	OK

Combined Stress in Welds betw.Leg and Pad Tauw=117.04 <= z*fld=188[N/mm2]	62.2%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(1.2765E05+4*36213.12/(2200+2*(0+3.7+4)))/3=              42.57 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                     (16.10-15)
=(330.59*3.7^2*230/(0.4525*4.02))=                        571.73 kN
```

Loads in Cyl.Shell Fvi=42.57 <= Fimax=571.73[kN]	7.4%	OK

Total Stresses in Pad Weld Case A SigwTotPadx=81.93 <= z*fs=212[N/mm2]	38.6%	OK

Total Stresses in Pad Weld Case B SigwTotPadB=115.88 <= z*fs=212[N/mm2]	54.6%	OK

LOAD CASE NO: 2 - LC4 SHUT DOWN

Axial Stresses in the Leg Siga=2.41 <= fl=156.67[N/mm2]	1.5%	OK
Combined Stresses in the Leg Sigc=2.45 <= 1.5*fl=235.[N/mm2]	1.0%	OK
Deflection in the Legs Defl=0.0013 <= DeflMax=7.775[mm]	0.0%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0163 <= 1.0=1	1.6%	OK

Combined Stress in Welds betw.Leg and Pad Tauw=7.44 <= z*fld=125.34[N/mm2]	5.9%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(8041.06+4*38937.7/(2200+2*(0+3.7+4)))/3=              2.7038 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                     (16.10-15)
=(310.73*3.7^2*230/(0.4525*4.68))=                        461.70 kN
```

Loads in Cyl.Shell Fvi=2.7 <= Fimax=461.7[kN]	0.5%	OK

Total Stresses in Pad Weld Case A SigwTotPadx=5.2 <= z*fs=144.[N/mm2]	3.6%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=7.39 <= z*fs=144.[N/mm2]	5.1%	OK

LOAD CASE NO: 3 - LC5 INSTALLATION

Axial Stresses in the Leg Siga=2.41 <= fl=156.67[N/mm2]	1.5%	OK
Combined Stresses in the Leg Sigc=2.44 <= 1.5*fl=235.[N/mm2]	1.0%	OK
Deflection in the Legs Defl=8.5871E-04 <= DeflMax=7.775[mm]	0.0%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0162 <= 1.0=1	1.6%	OK
Combined Stress in Welds betw.Leg and Pad Tauw=7.44 <= z*fld=125.34[N/mm2]	5.9%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(8041.06+4*37446.99/(2200+2*(0+3.7+4)))/3=                2.7029 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                      (16.10-15)
=(310.73*3.7^2*230/(0.4525*4.43))=                          487.55 kN
```

Loads in Cyl.Shell Fvi=2.7 <= Fimax=487.55[kN]	0.5%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=5.2 <= z*fs=144.[N/mm2]	3.6%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=7.38 <= z*fs=144.[N/mm2]	5.1%	OK

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

Axial Stresses in the Leg Siga=6.76 <= fl=123.2[N/mm2]	5.4%	OK
Combined Stresses in the Leg Sigc=6.8 <= 1.5*fl=184.8[N/mm2]	3.6%	OK
Deflection in the Legs Defl=0.0013 <= DeflMax=7.775[mm]	0.0%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0451 <= 1.0=1	4.5%	OK
Combined Stress in Welds betw.Leg and Pad Tauw=20.72 <= z*fld=98.56[N/mm2]	21.0%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(22531.67+4*38117.58/(2200+2*(0+3.7+4)))/3=               7.5335 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                      (16.10-15)
=(203.21*3.7^2*230/(0.4525*4.25))=                          333.09 kN
```

Loads in Cyl.Shell Fvi=7.53 <= Fimax=333.09[kN]	2.2%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=14.5 <= z*fs=118.[N/mm2]	12.2%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=20.54 <= z*fs=118.[N/mm2]	17.4%	OK

LOAD CASE NO: 5 - OPER.SEISMIC

Axial Stresses in the Leg Siga=7.68 <= fl=235[N/mm2]	3.2%	OK
Combined Stresses in the Leg Sigc=59.34 <= 1.5*fl=352.5[N/mm2]	16.8%	OK
Deflection in the Legs Defl=1.66 <= DeflMax=7.775[mm]	21.3%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.4152 <= 1.0=1	41.5%	OK

Combined Stress in Welds betw.Leg and Pad Tauw=99.94 <= z*fld=188[N/mm2]	53.1%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(22531.67+4*3.6774E06/(2200+2*(0+3.7+4)))/3=             9.7238 kN
```

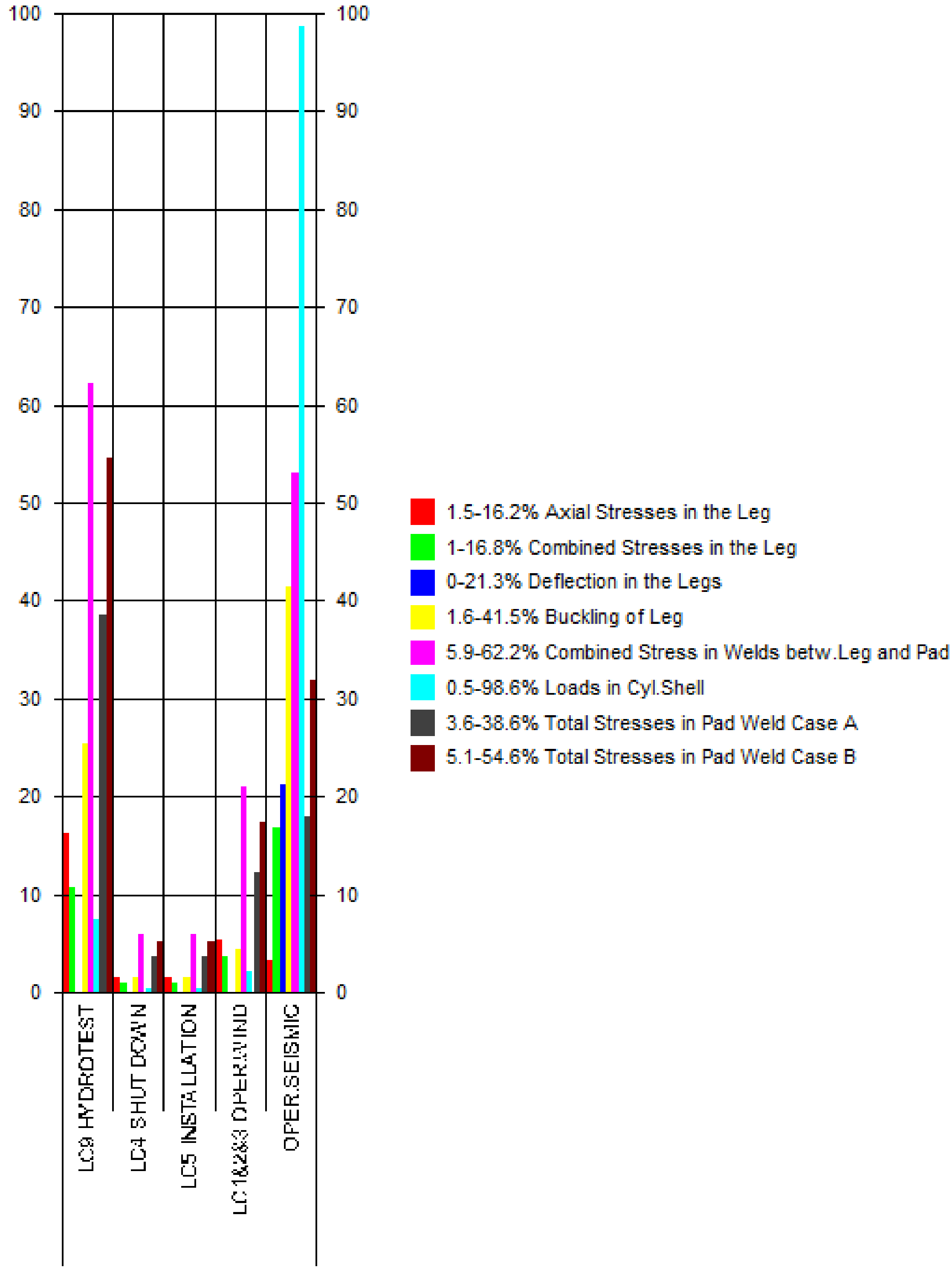
16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                      (16.10-15)
=(336.86*3.7^2*230/(0.4525*237.88))=                      9.8539 kN
```

Loads in Cyl.Shell Fvi=9.72 <= Fimax=9.85[kN]	98.6%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=38.22 <= z*fs=212[N/mm2]	18.0%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=67.73 <= z*fs=212[N/mm2]	31.9%	OK

Volume:0.00 m3 Weight:48.7 kg (SG= 7.93)

UTILIZATION CHART - SL.1



Max.Utilization/Condition 98.6% CASE:OPER.SEISMIC

EN13445 - 9.6 MULTIPLE OPENINGS
GO.1 20 June 2019 12:02

SUMMARY OF CALCULATION RESULTS :
No. of Nozzles Considered : 3
No. of Permutations ......: 3
No. of Nozzle Pairs Classified as Groups ....: 2
No. of Nozzle Groups Requiring Additional Reinforcement : 0

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-
1	N.3	N.4	228	229	332	Yes	60669	132779	45%	OK
2	N.3	N.6	116	229	200	Yes	36572	84844	43%	OK
3	N.4	N.6	436	229	520	No	---N/A---	---N/A---	N/A	N/A

Max.test pressure Ptmax= .802 for Nozzle Group: N.3 - N.4 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 : 3/ 3

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.............................:Temp 90.00 °C
DESIGN PRESSURE.....................................:P 0.2056 MPa
INTERNAL CORROSION ALLOWANCE........................:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.1 Torispherical End
OUTSIDE DIAMETER OF SHELL...........................:De 2208.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en 4.0000 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.3 Outlet

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.............................:deb 104.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb 2.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............: 0.2000 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded).:epb 0.0800 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.4 Outlet

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.............................:deb 104.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb 2.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............: 0.2000 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded).:epb 0.0800 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
```

CALCULATION DATA

Nozzle Group: N.3 - N.4 Located in:E3.1 Torispherical End

Preliminary Calculations

```
Center Distance Between Nozzles Lb = ==                      331.95 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 =331.95-52.01-52.01=                        227.94 mm
ApLs = 0.5 * ris ^ 2 * Lb / (ris + 0.5 * eas)                      (9.6-5)
=0.5*1766.4^2*331.95/(1766.4+0.5*3.7)=                  2,9287E05 mm2
AfLs = (Lb - a1 - a2 + tn2 - c - dev2) * eas                       (9.6-7)
=(331.95-52.01-52.01+2-0-0.2)*3.7=                         850.02 mm2
```

Pressure Area Required pA(req.)

```
pAReq = P*(ApLs+Apb1+0.5*Apphi1+Apb2+0.5*Apphi2)                   (9.6-4)
=0.2056*(2.9287E05+866.61+0.5*0+866.61+0.5*958.47)=         60.67 kN
```

Pressure Area Available pA(aval.)

```
pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)
=0*(0-0.5*0.2056)+31.07*(135.07-0.5*0.2056)=               4.1939 kN
pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)
=0*(0-0.5*0.2056)+24.41*(135.07-0.5*0.2056)=               3.2951 kN
pAAval = (AfLs+Afw1+Afw2)*(fs-0.5*P)+pANozz1+pANozz2               (9.6-4)
=(850.02+0+0)*(147.5-0.5*0.2056)+4193.93+3295.05=          132.78 kN
```

Nozzle Reinforcement N.3 - N.4 pAAval=132.78 >= pAReq=60.67[kN]	45.6%	OK

GENERAL DESIGN DATA

```
CALCULATION TEMPERATURE.............................:Temp       90.00 °C
DESIGN PRESSURE.....................................:P         0.2056 MPa
INTERNAL CORROSION ALLOWANCE........................:c           0.00 mm
```

SHELL DATA

```
Nozzles on Component :E3.1   Torispherical End
OUTSIDE DIAMETER OF SHELL...........................:De       2208.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 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.3 Outlet

```
NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.............................:deb       104.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       2.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:          0.2000 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded).:epb       0.0800 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.6 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.3 - N.6 Located in:E3.1 Torispherical End

Preliminary Calculations

```
Center Distance Between Nozzles Lb = ==                     200.43 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 =200.43-52.01-32.5=                        115.92 mm
ApLs = 0.5 * ris ^ 2 * Lb / (ris + 0.5 * eas)                     (9.6-5)
=0.5*1766.4^2*200.43/(1766.4+0.5*3.7)=              1,7683E05 mm2

AfLs = (Lb - a1 - a2 + tn2 - c - dev2) * eas                      (9.6-7)
=(200.43-52.01-32.5+10.5-0-1.05)*3.7=                  463.87 mm2
```

Pressure Area Required pA(req.)

```
pAReq = P*(ApLs+Apb1+0.5*Apphi1+Apb2+0.5*Apphi2)                  (9.6-4)
=0.2056*(1.7683E05+866.61+0.5*0+176+0.5*0)=             36.57 kN
```

Pressure Area Available pA(aval.)

```
pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)
=0*(0-0.5*0.2056)+31.07*(135.07-0.5*0.2056)=           4.1939 kN
pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)
=0*(0-0.5*0.2056)+84*(146.25-0.5*0.2056)=               12.28 kN
pAAval = (AfLs+Afw1+Afw2)*(fs-0.5*P)+pANozz1+pANozz2              (9.6-4)
=(463.87+0+0)*(147.5-0.5*0.2056)+4193.93+12276.36=      84.84 kN
```

Nozzle Reinforcement N.3 - N.6 pAAval=84.84 >= pAReq=36.57[kN]	43.1%	OK

```
Max.test pressure Ptmax= .802 for Nozzle Group: N.3 - N.4 Located in:E3.1
Torispherical End
==                                                      0.8020 MPa
```

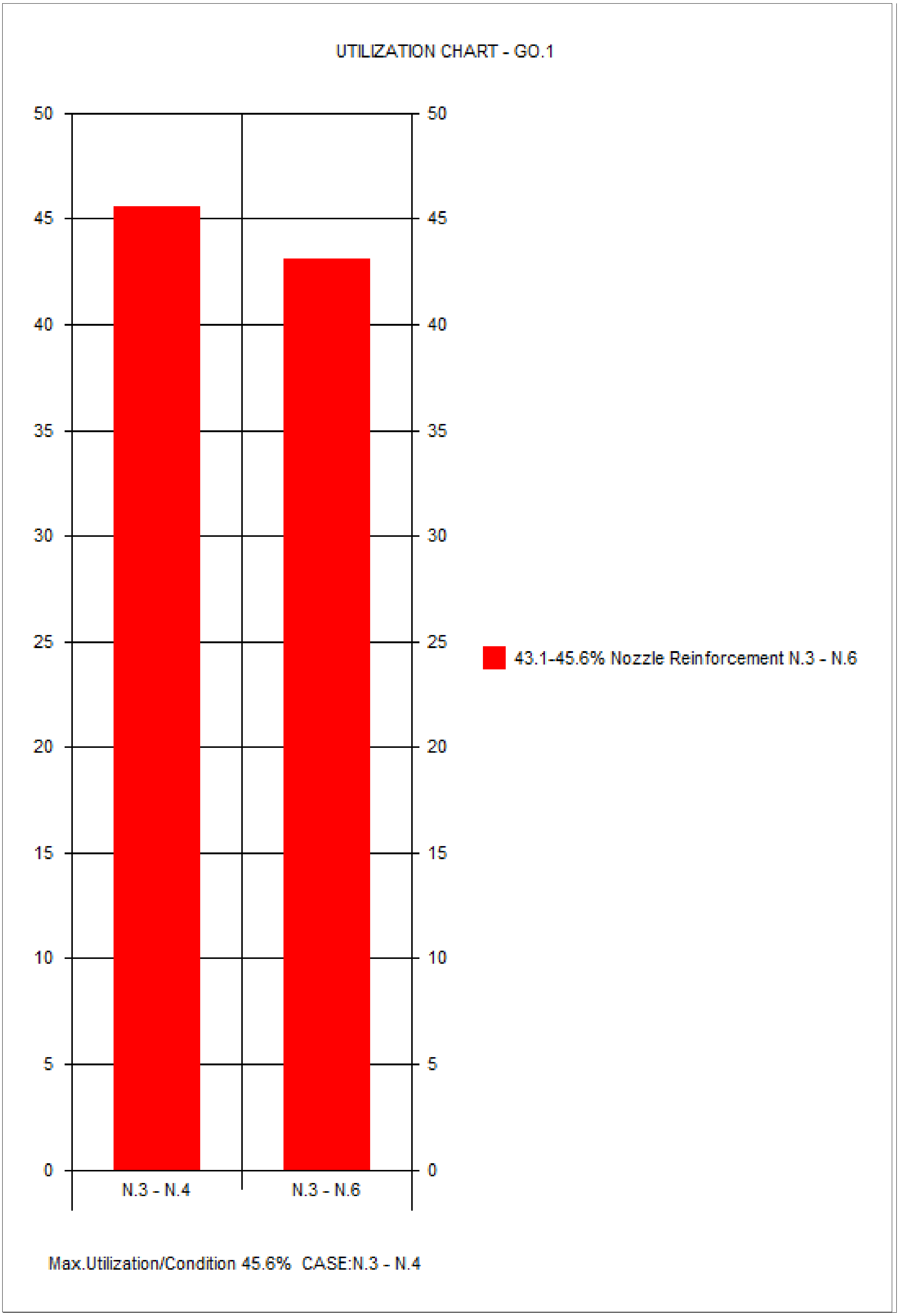
CALCULATION SUMMARY

Nozzle Group: N.3 - N.4 Located in:E3.1 Torispherical End

Nozzle Reinforcement N.3 - N.4 pAAval=132.78 >= pAReq=60.67[kN]	45.6%	OK

Nozzle Group: N.3 - N.6 Located in:E3.1 Torispherical End

Nozzle Reinforcement N.3 - N.6 pAAval=84.84 >= pAReq=36.57[kN]	43.1%	OK


UTILIZATION CHART - GO.1
50
45
40
35
30
25
20
15
10
5
0
N.3 - N.4
N.3 - N.6
43.1-45.6% Nozzle Reinforcement N.3 - N.6
Max.Utilization/Condition 45.6% CASE:N.3 - N.4

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

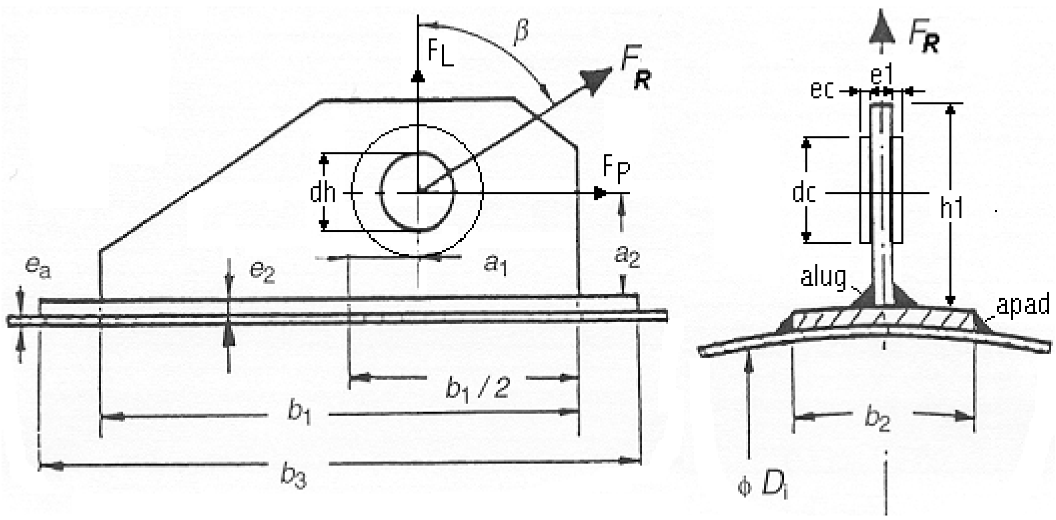
```
Attachment: E3.2    Torispherical End                                  S1.2
Off center radius of lug............................:R         850.00 mm
Angular rotation of lug.............................:angle       0.00 degr.
Extent of Analysis: Check Lug and Loads in Shell
Type of Lifting Lug:
Symmetric 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        1766.40 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 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, 1.4301 X5CrNi18-10 C=Cold Rolled Strip, HT: THK<=8mm 90'C,A>=35%
Rm=540 Rp=260 Rpt=199.63 f=153.75 f20=180 ftest=270 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        120.00 mm
LENGTH OF REINFORCEMENT PAD.........................:b3        180.00 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	6.5
Angle of Sling Leg From Vertical	Beta	degr.	45
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 =4-0-0.3= 3.7000 mm
16.6.3 Equivalent Shell Diameter
Deq = R (16.6-3) =850= 1766.40 mm
Lambda = b / SQR(Deq * ea) (16.6-13/17) =180/SQR(1766.4*3.7)= 2.2265

16.7.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0023« » OK«
»a) en/Deq=0.0023 <= 0.05« » OK«
»16.7.3 b) e2=5 >= en=4[mm] « » OK«
»16.7.3 b) b3=180 <= 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*6500*Cos(45)= 9.1924 kN

Parallel Force Component
FP = SL * FR * Sin(beta) =2*6500*Sin(45)= 9.1924 kN

Side/Skew Load - 0% Lateral Load
Fside = PS / 100 * SL * FR =0/100*2*6500= 0.00 kN

External Moment Along Load Direction
ML = SL * FR * ((a2 + e2) * Sin(beta) - a1 * Cos(beta))
=2*6500*((60+5)*Sin(45)-0*Cos(45))= 0.5975 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) =9192.39/(10*130)= 7.0711 N/mm2
Bending Stress due to FP
SigBendL = 6 * FP * a2 / (e1 * b1 ^ 2)
=6*9192.39*60/(10*130^2)= 19.58 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) =9192.39/(130*10)= 7.0711 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((7.07+19.58+0)^2+3*(7.07^2+0^2))=                       29.33 N/mm2
```

Effective Stress in the Lug Foot Sige=29.33 <= fl=180[N/mm2]	16.2%	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=29.33 <= z*MIN(fl,fs)=153[N/mm2]	19.1%	OK

Double Fillet Welds on Reinforcement Pad(Bednar Chapter 10.3)

```
Weld Length
Lwpad = 2 * (b2 + b3) =2*(120+180)=                          600.00 mm
Section Modulus(around axis transverse to lug)
Zxpad = b2 * b3 + b3 ^ 2 / 3 =120*180+180^2/3=             32400.00 mm2
Section Modulus(around axis along lug)
Zypad = b3 * b2 + b2 ^ 2 / 3 =180*120+120^2/3=             26400.00 mm2
Unit force due to FL
f1p = FL / Lwpad =9192.39/600=                                 15.32 N/mm
Unit force due to FP and Fside
f2p = SQR( FP ^ 2 + Fside ^ 2) / Lwpad
=SQR(9192.39^2+0^2)/600=                                     15.32 N/mm
Bending
f3p = MAX((FP*a2-FL*a1)/Zxpad,Fside*a2/Zypad)
=MAX((9192.39*60-9192.39*0)/32400,0*60/26400)=               17.02 N/mm
Resultant Load
ftot = SQR(( f1p + f3p) ^ 2 + f2p ^ 2)
=SQR((15.32+17.02)^2+15.32^2)=                               35.79 N/mm
Required Weld Size, Throat Dimension
apadmin = fptot / (z * fs) =35.79/(0.85*180)=                 0.2339 mm
```

Required Pad Weld Size apadmin=0.2339 <= apad=2[mm]	11.6%	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*6500/(10*2*(100-60-40/2))=                              97.50 N/mm2
```

Tear Out Stress TauTearOut=97.5 <= Re(lug)=260[N/mm2]	37.5%	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*6500/(10*40))=                                  135.11 N/mm2
```

Bearing Stress(pin in hole) SigBearing=135.11 <= Re(lug)=260[N/mm2]	51.9%	OK

16.6.7 - Global Circumferential Membrane Stress

```
Sigmy = P * Deq / (2 * ea) (16.6-11/12) =0*1766.4/(2*3.7)=     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*2.23^2))=                         0.7316
K14 = 1 / (0.6 * Sqr( 1 + 0.03 * Lambda ^ 2))                (16.6-16)
=1/(0.6*Sqr(1+0.03*2.23^2))=                         1.5550
K15 = MIN( 1 + 2.6 * (Deq / ea) ^ (0.3) * (b2 / Deq), 2)      (16.7-2)
=MIN(1+2.6*(1766.4/3.7)^(0.3)*(120/1766.4,)2)=       2.0000
Ny1 = MIN( 0.08 * Lambda , 0.2) (16.6-14) =MIN(0.08*2.23,0.2)=   0.1781
Ny2 = Sigmy / (K2 * fs) (16.6-8) =0/(1.25*180)=             0.00
```

```
K1 from figure 16.6-1 =    1.406
Bending Limit Stress Sigball
Sigball = K1 * K2 * fs (16.6-6) =1.41*1.25*180=          316.33 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)
=2*316.33*3.7^2/(0.7316*Abs(Cos(0.7854))+1.56*Abs((60+5)*Sin(0.7854)-0*Cos(
0.7854))/180)=                                              =   9.4721 kN
```

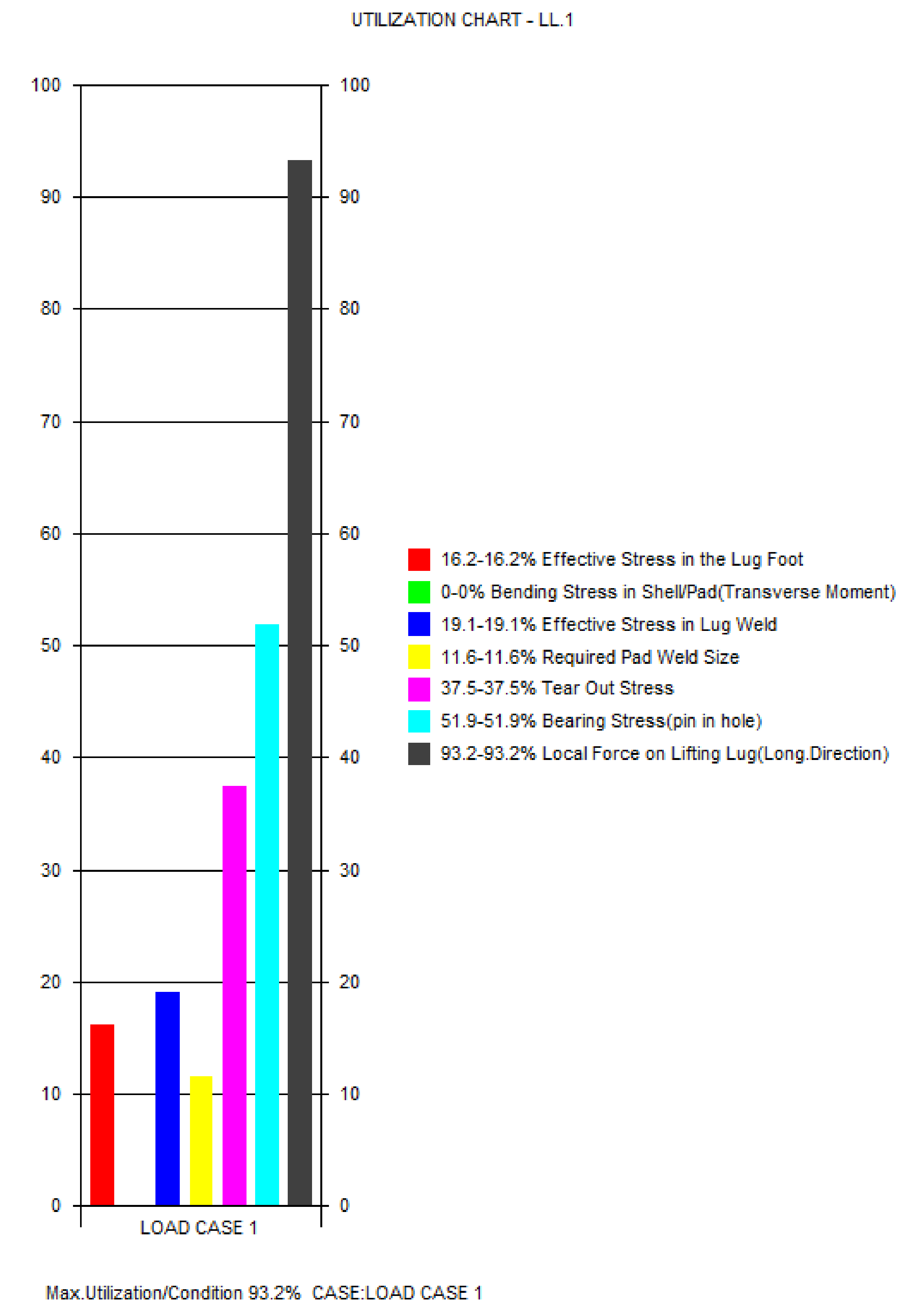
Local Force on Lifting Lug(Long.Direction) SL*FR=13 <= FRmax*(Sigballt/Sigball)=13.95[kN]	93.2%	OK

CALCULATION SUMMARY

LOAD CASE NO: 1 - LOAD CASE 1

Effective Stress in the Lug Foot Sige=29.33 <= fl=180[N/mm2]	16.2%	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=29.33 <= z*MIN(fl,fs)=153[N/mm2]	19.1%	OK
Required Pad Weld Size apadmin=0.2339 <= apad=2[mm]	11.6%	OK
Tear Out Stress TauTearOut=97.5 <= Re(lug)=260[N/mm2]	37.5%	OK
Bearing Stress(pin in hole) SigBearing=135.11 <= Re(lug)=260[N/mm2]	51.9%	OK
Local Force on Lifting Lug(Long.Direction) SL*FR=13 <= FRmax*(Sigballt/Sigball)=13.95[kN]	93.2%	OK

Volume:0.00 m3 Weight:1.6 kg (SG= 7.93)


UTILIZATION CHART - LL.1
100
90
80
70
60
50
40
30
20
10
0
LOAD CASE 1
16.2-16.2% Effective Stress in the Lug Foot
0-0% Bending Stress in Shell/Pad(Transverse Moment)
19.1-19.1% Effective Stress in Lug Weld
11.6-11.6% Required Pad Weld Size
37.5-37.5% Tear Out Stress
51.9-51.9% Bearing Stress(pin in hole)
93.2-93.2% Local Force on Lifting Lug(Long.Direction)
Max.Utilization/Condition 93.2% CASE:LOAD CASE 1