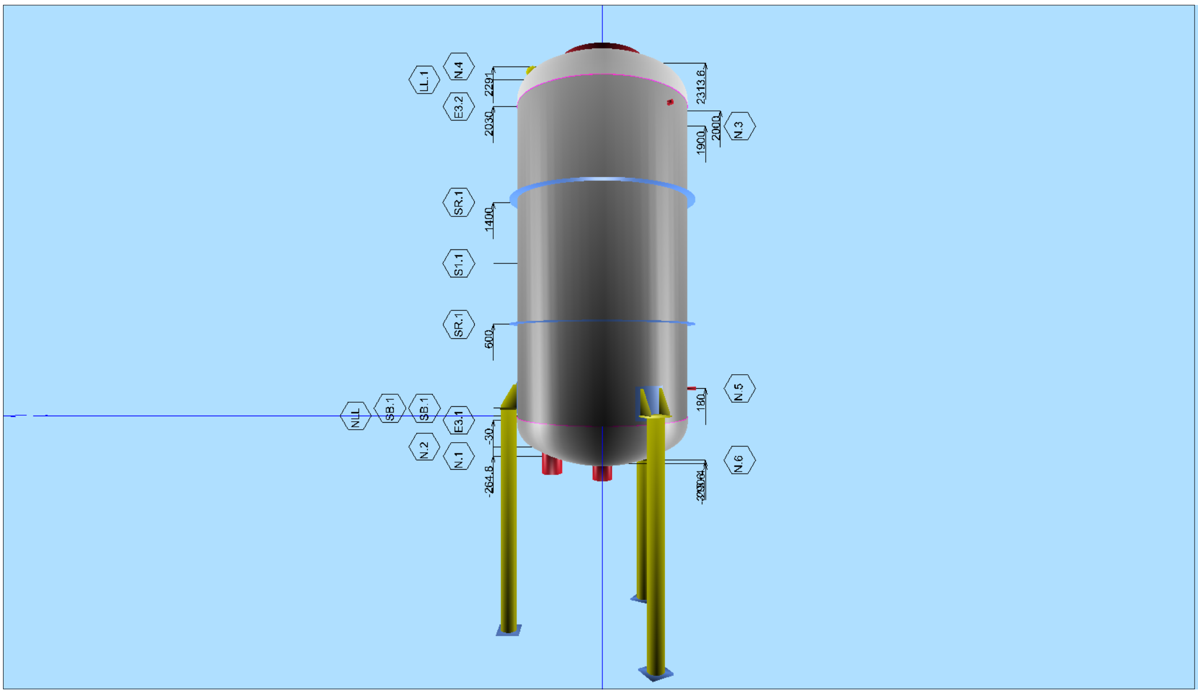
(0) Drawing

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



History of Revisions

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

5
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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	0.1
Hydrotest Pressure (MPa)	MPa	0.31
Maximum Design Temperature ('C)	'C	90
Minimum Design Temperature ('C)	'C	0
Operating Temperature ('C)	'C	
Corrosion Allowance (mm)	mm	0
Content of Vessel		
Specific Density of Oper.Liq		1.2
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	46.0 kg	45.1 kg	0.205 m3	205.0 kg	245.9 kg
E3.2	1	46.0 kg	38.2 kg	0.205 m3	205.0 kg	0.0 kg
LL.1	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.1	1	1.0 kg	1.0 kg	0.001 m3	1.0 kg	1.6 kg
N.2	1	1.0 kg	1.0 kg	0.002 m3	2.0 kg	1.9 kg
N.3	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.4	1	16.0 kg	16.0 kg	0.005 m3	5.0 kg	0.0 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	221.0 kg	221.0 kg	1.901 m3	1901.0 kg	0.0 kg
SB.1	1	34.0 kg	34.0 kg	0.000 m3	0.0 kg	0.0 kg
SR.1	2	24.0 kg	24.0 kg	0.000 m3	0.0 kg	0.0 kg
Total	**13**	**393.0 kg**	**384.2 kg**	**2.319 m3**	**2319.0 kg**	**249.4 kg**

Weight Summary/Condition	Weights
Empty Weight of Vessel incl. 5% Contingency	403 kg / 0.4 Tons
Total Test Weight of Vessel (Testing with Water)	2722 kg / 2.7 Tons
Total Operating Weight of Vessel	653 kg / 0.7 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	-3	0	-201	0	0	-118	0	0	-118
E3.2	0	0	2166	0	0	2118	0	0	2118
LL.1	430	0	2205	430	0	2205	430	0	2205
N.1	0	0	-361	0	0	-361	0	0	-361
N.2	330	0	-275	330	0	-275	330	0	-275
N.3	-403	403	1900	-403	403	1900	-403	403	1900
N.4	0	0	2327	0	0	2327	0	0	2327
N.5	-585	0	180	-585	0	180	-585	0	180
N.6	-194	52	-297	-194	52	-297	-194	52	-297
S1.1	0	0	996	0	0	1000	0	0	1000
SB.1	0	0	74	0	0	74	0	0	74
SR.1	0	0	1000	0	0	1000	0	0	1000

CENTER OF GRAVITY AT CONDITIONS BELOW	X	Y	Z
Empty Vessel	-1	1	939
Test Condition of Vessel (Testing with Water)	0	0	992
Operating Condition of Vessel	0	1	522

Max. Allowable Pressure MAWP

ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
E3.1	Torispherical End		0.000 MPa	1.024 MPa	0.741 MPa
E3.2	Torispherical End		0.000 MPa	1.024 MPa	0.741 MPa
N.1	Nozzle,Seamless Pipe	Outlet	0.004 MPa	0.893 MPa	0.738 MPa
N.2	Nozzle,Seamless Pipe	Inlet	0.003 MPa	0.726 MPa	0.600 MPa
N.3	Reinforcement Ring	Adaptor for level switch	0.000 MPa	1.318 MPa	1.094 MPa
N.4	Reinforcement Ring	Flange for Instrumental Top PI	0.000 MPa	1.668 MPa	1.367 MPa
N.5	Reinforcement Ring	Sample Valve	0.000 MPa	2.116 MPa	1.817 MPa
N.6	Reinforcement Ring	Adaptor for level transmitter	0.003 MPa	1.501 MPa	1.256 MPa
S1.1	Cylindrical Shell	Main Shell	0.000 MPa	1.026 MPa	0.840 MPa
	MAWP			**0.726 MPa**	**0.600 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	1.513	0.305	0.026	0.305	1.487
E3.2	Torispherical End-	0.200	1.513	0.305	0.003	0.305	1.510
GO.1	Nozzle Group: N.1 - N.6 Located in:E3.1 Torispherical End	0.204	1.731	NA	0.00286	NA	1.728
N.1	Nozzle,Seamless Pipe-Outlet	0.204	1.317	NA	0.027	NA	1.290
N.2	Nozzle,Seamless Pipe-Inlet	0.203	1.069	NA	0.026	NA	1.043
N.3	Reinforcement Ring-Adaptor for level switch	0.200	1.950	NA	0.001	NA	1.949
N.4	Reinforcement Ring-Flange for Instrumental Top PI	0.200	2.456	NA	0.000	NA	2.456
N.5	Reinforcement Ring-Sample Valve	0.200	3.146	NA	0.016	NA	3.130
N.6	Reinforcement Ring-Adaptor for level transmitter	0.203	2.228	NA	0.026	NA	2.201
S1.1	Cylindrical Shell-Main Shell	0.200	1.776	0.305	0.023	0.305	1.753

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) .......:     1.0430 MPa
```

PNEUMATIC TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..:     0.3100 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...:     1.0694 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	1.513	0.305	0.014	0.305	1.499
E3.2	Torispherical End-	0.200	1.513	0.305	0.019	0.305	1.494
GO.1	Nozzle Group: N.1 - N.6 Located in:E3.1 Torispherical End	0.204	1.731	NA	0.00286	NA	1.728

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
N.1	Nozzle,Seamless Pipe-Outlet	0.204	1.317	NA	0.014	NA	1.304
N.2	Nozzle,Seamless Pipe-Inlet	0.203	1.069	NA	0.007	NA	1.062
N.3	Reinforcement Ring-Adaptor for level switch	0.200	1.950	NA	0.021	NA	1.929
N.4	Reinforcement Ring-Flange for Instrumental Top Pl	0.200	2.456	NA	0.017	NA	2.440
N.5	Reinforcement Ring-Sample Valve	0.200	3.146	NA	0.020	NA	3.126
N.6	Reinforcement Ring-Adaptor for level transmitter	0.203	2.228	NA	0.014	NA	2.213
S1.1	Cylindrical Shell-Main Shell	0.200	1.776	0.305	0.019	0.305	1.757

```
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) .......:     1.0620 MPa
```

PNEUMATIC TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..:     0.3100 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...:     1.0694 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= 1110, wt= 4, h= 285.59, R= 888, r= 170.94, Not Applicable	ID 1, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
E3.2	1	Torispherical End-	De= 1110, wt= 4, h= 285.59, R= 888, r= 170.94, Not Applicable	ID 1, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
LL.1	1	Lifting Lugs-	LUG PL5x100x100,PAD PL4x50x130,FR=2kN,dh=40mm	ID 3, EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A
N.1	1	Nozzle,Seamless Pipe-Outlet	do=129,wt=2,L=106.3,ho=100	ID 2, EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT
N.2	1	Nozzle,Seamless Pipe-Inlet	do=129,wt=2,L=151.8,ho=100	ID 2, EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT
N.3	1	Reinforcement Ring-Adaptor for level switch	do=30,di=19,thk=34	ID 11, EN 10272:2016, 1.4435 X2CrNiMo18-14-3 bar, HT:AT

ID	No	Description	Component Dimensions	Material Standard
N.4	1	Reinforcement Ring-Flange for Instrumental Top PI	do=550,di=450,thk=25	ID 1, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
N.5	1	Reinforcement Ring-Sample Valve	do=28,di=8,thk=65	ID 12, EN 10222-5:2017, 1.4404 X2CrNiMo17-12-2 forging, HT:AT
N.6	1	Reinforcement Ring-Adaptor for level transmitter	do=65,di=38,thk=10	ID 13, EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT
S1.1	1	Cylindrical Shell-Main Shell	De= 1108, en= 4, L= 2000	ID 1, EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,
SB.1	1	Bracket Support-	3 off Legs;Pipe , H= 1620;3 off Brackets Type A, Vertical Vessels on Legs, R=2.	ID 3, EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A
SR.1	2	Stiff. Ring-	Rib Profile/Flat Bar , h= 50, t1= 8	ID 3, EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A

Notes, Warning & Error Messages

ID & Comp. Description	Notes/Warnings/Error Messages
S1.1 Cylindrical Shell Main Shell	
-	NOTE: Circularity tolerance limit(in % of radius) =0.006% (based on unsupported length L= 1000 mm
-	NOTE: Maximum unsupported length for given shell thickness Lmax = 1234 mm (en = 4 mm)
-	NOTE: Required minimum shell thickness due to external pressure emin(ext)= 3.71 mm (unsupported length L= 1000 mm)
-	NOTE: EN13445-4 Table 9.4.1 d) for requirement for heat treatment of austenitic steels.
N.2 Nozzle,Seamless Pipe Inlet	
-	NOTE : AREA REDUCED BY LOCATION IN DISHED END REF.FIG. 9.5-4
-	NOTE : If this nozzle is calculated using the method given in section 7.7(Nozzle in knuckle region), the utilization will be approximately 37.3%
SR.1 Stiff. Ring	
-	NOTE: METHOD APPLIES TO CYLINDERS THAT ARE CIRCULAR WITHIN 0.5% ON RADIUS
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
SB.1 Bracket Support	
-	NOTE: The local stresses due to loads from the legs are assumed to be taken by the cylindrical shell only.

TOTAL No. OF ERRORS/WARNINGS : 0

Nozzle List

ID	Service	SIZE	STANDARD/CLASS	ID	Standout	X	Y	Z	Rot.	Orient.
N.1	Outlet			125.4	100	0	0	-313.6	0	Radial
N.2	Inlet			125.4	100	330	0	-250.1	0	Non Rad.
N.3	Adaptor for level switch			19	34	-390.3	390.3	1900	135	Radial
N.4	Flange for Instrumental Top PI	DN45 0		450	25	0	0	2313.6	0	Radial
N.5	Sample Valve		Sample Valve	8	65	-552	0	180	180	Radial
N.6	Adaptor for level transmitter			38	10	-193.2	51.8	-290.8	165	Radial

Maximum Component Utilization - Umax

ID	Comp.Type	Umax(%)	Limited by
E3.1	Torispherical End	46.0%	Internal Pressure
E3.2	Torispherical End	46.0%	Internal Pressure
GO.1	Groups of Nozzles/Op	21.0%	Nozzle Reinforcement N.1 - N.6

ID	Comp.Type	Umax(%)	Limited by
LL.1	Lifting Lugs	96.5%	Combined Loads
N.1	Nozzle,Seamless Pipe	27.4%	Nozzle Reinforcement
N.2	Nozzle,Seamless Pipe	33.6%	Nozzle Reinforcement
N.3	Reinforcement Ring	18.2%	Nozzle Reinforcement
N.4	Reinforcement Ring	14.5%	Nozzle Reinforcement
N.5	Reinforcement Ring	10.9%	Nozzle Reinforcement
N.6	Reinforcement Ring	16.0%	Nozzle Reinforcement
S1.1	Cylindrical Shell	81.3%	External Pressure
SB.1	Bracket Support	82.5%	Bracket Baseplate Thickness
SR.1	Stiff. Ring	93.2%	Max.Stiff.Stress

```
Component with highest utilization    Umax = 96.5% LL.1

Average utilization of all components Umean= 45.2%
```

Material Data/Mechanical Properties

ID	Material Name	Temp	Rm	Rp	Rpt	f_d	f20	ftest	E-mod	Note
1	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, TG1, SS, Mat.Group:8.1, , Max.T= 8mm, SG=7.93	90	530	270	207.9	147.5	180	265	194028	
2	EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT TG1, SS, Mat.Group:8.1, , Max.T= 60mm, SG=7.93	90	490	225	202.6	135.1	150	214.3	194028	
3	EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A TG1, SS, Mat.Group:8.1, , Max.T= 8mm, SG=7.93	90	520	250	189.6	141.3	173.3	260	194028	
4	EN 10216-5:2013, 1.4307 X2CrNi18-9 seamless tube, HT:AT TG1, SS, Mat.Group:8.1, , Max.T= 60mm, SG=7.93	90	460	215	184	122.7	153.3	230	194028	
5	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, TG3, SS, Mat.Group:8.1, , Max.T= 8mm, SG=7.93	90	530	270	207.9	147.5	180	265	194028	
6	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , TG3, SS, Mat.Group:8.1, , Max.T= 75mm, SG=7.93	90	520	260	206.6	147.1	173.3	260	194028	
7	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 H=Hot Rolled Strip , TG3, SS, Mat.Group:8.1, , Max.T= 13.5mm, SG=7.93	90	530	260	206.6	147.5	176.7	265	194028	
8	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , TG3, SS, Mat.Group:8.1, , Max.T= 75mm, SG=7.93	90	520	260	206.6	147.1	173.3	260	194028	
9	EN 10217-7:2014, 1.4307 X2CrNi18-9 welded tube, HT:AT TG3, SS, Mat.Group:8.1, , Max.T= 60mm, SG=7.93	90	470	215	184.8	123.2	156.7	235	194028	
10	EN 10217-7:2014, 1.4307 X2CrNi18-9 welded tube, HT:AT TG3, SS, Mat.Group:1.1, , Max.T= 60mm, SG=7.93	90	470	215	184.8	123.2	156.7	235	194028	
11	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	
12	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	
13	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	

```
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 : A = annealed
HT : AT = solution annealed
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	2000	0.0	0.0	S1.1
LL.1	Lifting Lugs	430	0	2205	0.0	0.0	E3.2
N.1	Nozzle,Seamless Pipe	0	0	-314	0.0	0.0	E3.1
N.2	Nozzle,Seamless Pipe	330	0	-250	0.0	0.0	E3.1
N.3	Reinforcement Ring	-390	390	1900	90.0	135.0	S1.1
N.4	Reinforcement Ring	0	0	2314	0.0	0.0	E3.2
N.5	Reinforcement Ring	-552	0	180	90.0	180.0	S1.1
N.6	Reinforcement Ring	-193	52	-291	-13.0	165.0	E3.1
S1.1	Cylindrical Shell	0	0	0	0.0	0.0	
SB.1	Bracket Support	0	0	0	0.0	0.0	S1.1
SR.1	Stiff. Ring	0	0	600	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	0.46
E3.2 - End	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	4.0	4.0	270.0	0.46
N.1 Outlet - Nozzle	EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT	2.0	2.0	225.0	0.27
N.2 Inlet - Nozzle	EN 10217-7:2014, 1.4404 X2CrNiMo17-12-2 welded tube, HT:AT	2.0	2.0	225.0	0.34
N.3 Adaptor for level switch - Ring	EN 10272:2016, 1.4435 X2CrNiMo18-14-3 bar, HT:AT	5.5	5.5	235.0	0.18
N.4 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	0.14
N.5 Sample Valve - Ring	EN 10222-5:2017, 1.4404 X2CrNiMo17-12-2 forging, HT:AT	10.0	10.0	225.0	0.11
N.6 Adaptor for level transmitter - Ring	EN 10272:2016, 1.4404 X2CrNiMo17-12-2 bar, HT:AT	13.5	13.5	235.0	0.16
S1.1 Main Shell - Shell	EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,	4.0	4.0	270.0	0.81

ID-Description	Material Name	en(mm)	eB(mm)	Re(N/mm2)	f/fd
SR.1 - Stiffener	EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A	0.0	4.0	250.0	1.00

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 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.2 Inlet - 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.3 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.4 Flange for Instrumental Top Pl - Ring	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -196 C
N.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
SR.1 - Stiffener	0.0	0.0	0.0	NA	NA	From Table B.2-2 Aust.Stainless Steels - Lowest Minimum Metal Temp. TM= -273 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%

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

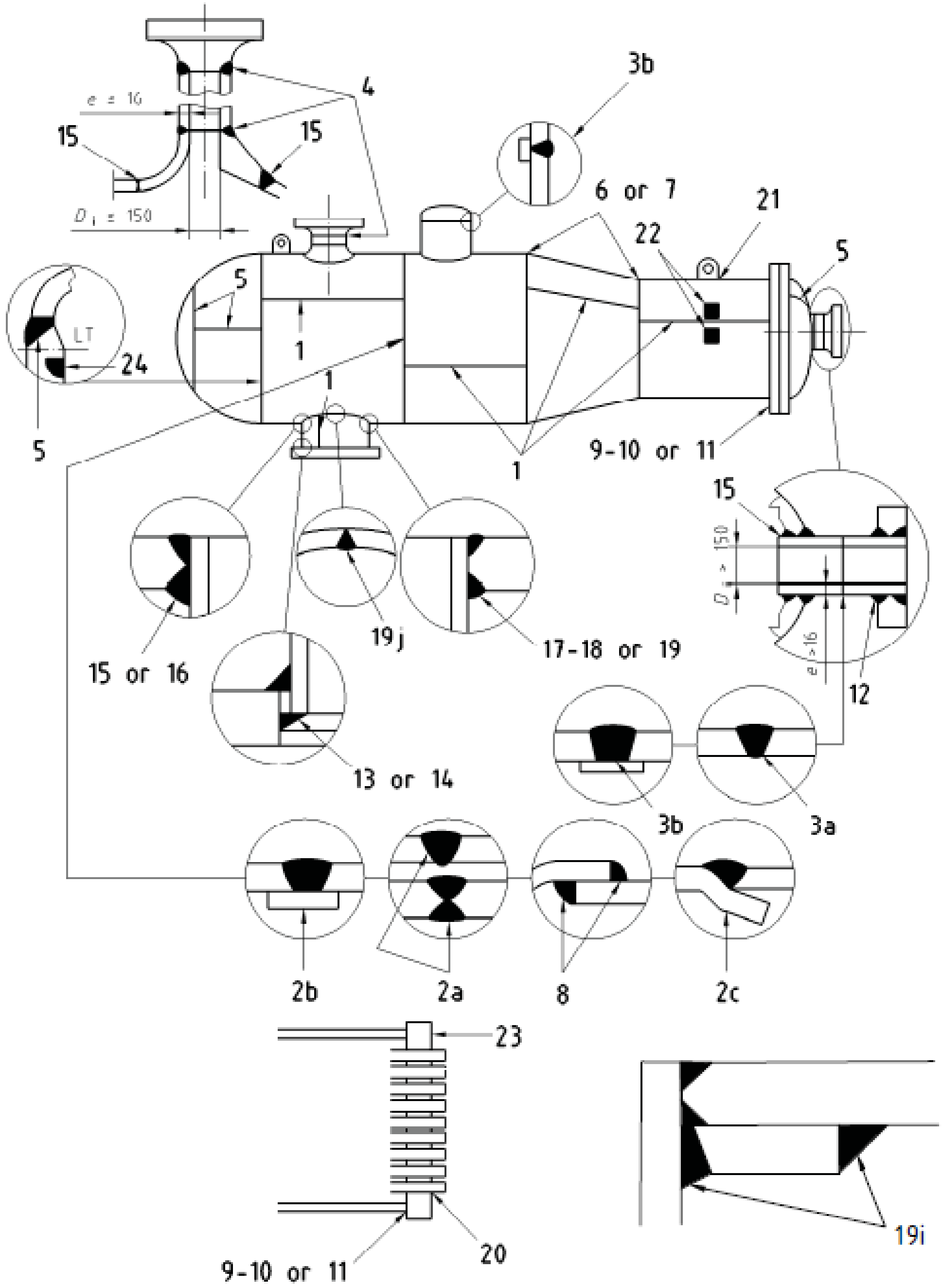
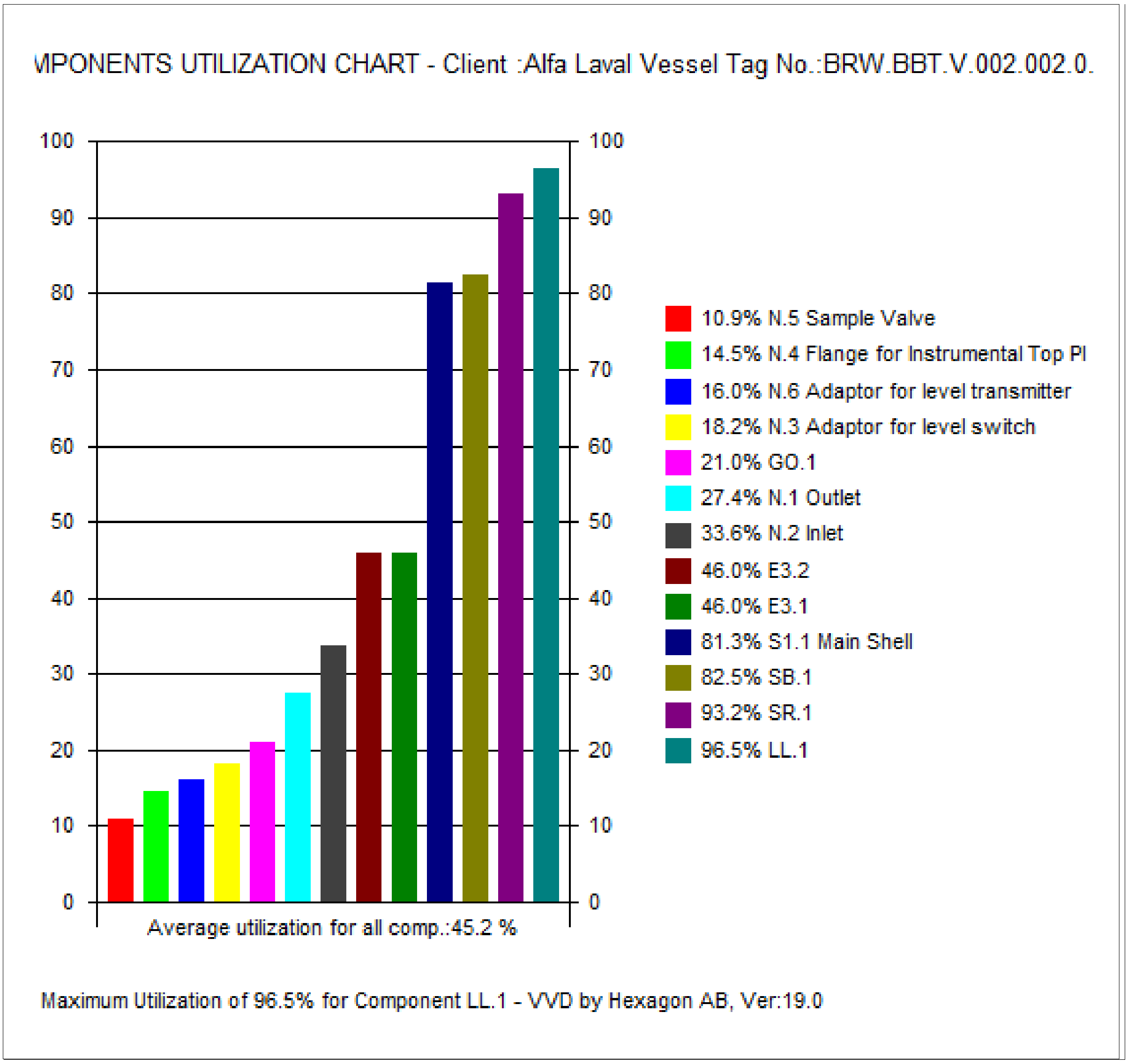


Figure 6.6.2-3 — Type of welds

Utilization Chart

Utilization Chart



Surface Area

ID	No.	Description	Area Outside(m2)	Area Inside(m2)
E3.1	1	Torispherical End,	1.446	1.436
E3.2	1	Torispherical End,	1.446	1.436
LL.1	1	Lifting Lugs,	0.000	0.000
N.1	1	Nozzle,Seamless Pipe, Outlet	0.041	0.039
N.2	1	Nozzle,Seamless Pipe, Inlet	0.041	0.039
N.3	1	Reinforcement Ring, Adaptor for level switch	0.003	0.002
N.4	1	Reinforcement Ring, Flange for Instrumental Top PI	0.043	0.035
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	6.962	6.912
SB.1	1	Bracket Support,	1.773	0.000
SR.1	2	Stiff. Ring,	0.786	0.000
Total	**13**		**12.549**	**9.902**

Foundation Loading

No	Load Case	Fx(kN)	Fy(kN)	Fz(kN)	Mx(kNm)	My(kNm)	Mz(kNm)
1	SB.1-LC9 HYDROTEST	0.00	0.00	-38.21	0.00	0.01	0.00
2	SB.1-LC4 SHUT DOWN	0.00	0.00	-3.97	0.00	0.01	0.00
3	SB.1-LC5 INSTALLATION	0.00	0.00	-3.97	0.00	0.01	0.00
4	SB.1-LC1&2&3 OPER.WIND	0.00	0.00	-6.48	0.00	0.01	0.00
5	SB.1-OPER.SEISMIC	1.20	0.00	-6.48	0.00	2.75	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:

E3.2 Torispherical End
Comment:

N.1 Nozzle,Seamless Pipe Outlet

Comment:

N.2 Nozzle,Seamless Pipe Inlet
Comment:

SR.1 Stiff. Ring
Comment:

N.3 Reinforcement Ring Adaptor for level switch
Comment:

N.4 Reinforcement Ring Flange for Instrumental Top Pl
Comment:

N.5 Reinforcement Ring Sample Valve
Comment:

N.6 Reinforcement Ring Adaptor for level transmitter
Comment:

LL.1 Lifting Lugs
Comment:

SB.1 Bracket Support
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=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.2000
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       1100.00 mm
LENGTH OF CYLINDRICAL PART OF SHELL.................:Lcyl     2000.00 mm
SAFETY FACTOR (1.0 carbon and 1.25 austenitic steels):s        1.2500
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
Split shell into several shell courses and include welding information: NO
```

DATA FOR STIFFENER RINGS

```
SHELL STIFFENER RINGS: Shell provided with stiffening rings
UNSUPPORTED LENGTH OF SHELL (Fig. 8.5-2)............:L       1000.00 mm
THE WIDTH OF STIFFENER IN CONTACT WITH SHELL........:w        8.0000 mm
MODIFIED AREA OF STIFFENER..........................:Am       359.00 mm2
```

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)
=1100*0.2/(2*147.5*0.85-0.2)=                             0.8781 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =0.8781+0+0.3=                    1.1781 mm

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

»7.4.1 Cond.of Applicabilty emin/De=7.9248E-04 <= 0.16« » OK«

Internal Pressure emina=1.18 <= en=4[mm]	29.4%	OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

```
Outside Diameter of Shell
De = Di + 2 * (ea + NegDev) =1100+2*(3.7+0.3)=             1108.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(1108+1100)/2=                          1104.00 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
MAWPHC = 2 * f * z * ea / Dm =2*147.5*0.85*3.7/1104=         0.8404 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)
MAWPNC = 2 * f20 * z * (ea + c) / Dm
=2*180*0.85*(3.7+0)/1104=                                 1.0255 MPa
```

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

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/1104=                                         1.7763 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=1.78[MPa]	17.1%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

```
Inside Radius of Shell
ris = Di / 2 (9.5-3) =1100/2=                                    550.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*550+3.7)*3.7)=    63.90 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*1100,(3.7*63.9*(147.5-0.5*0.2)/0.2-550*63.9)/(0.5*550+0.5*3.7))
=   502.48 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                           (9.5-18)
=0.15*Sqr((2*550+3.7)*3.7)=                                    9.5856 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(502.48,9.59)=                     502.48 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 =1104/2=                                              552.00 mm
Z = PI * R / L (8.5.2-7) =3.14*552/1000=                         1.7342
Delta = 1.28 / Sqr( R * ea) (8.5.3-20) =1.28/Sqr(552*3.7)=       0.0283
Tmp1 = Delta * L =0.0283*1000=                                    28.32
G = G (8.5.3-22) =0=                                               0.00
N = (COSH( Tmp1) - COS( Tmp1)) / (SINH( Tmp1) + SIN( Tmp1))        (8.5.3-21)
=(COSH(28.32)-COS(28.32))/(SINH(28.32)+SIN(28.32))=            1.0000
B = 2 * ea * N / (Delta * (Am + w * ea))                           (8.5.3-18)
=2*3.7*1/(0.0283*(359+8*3.7))=                                 0.6723
gamma = Am * 0.85 / ((Am + w * ea) * (1 + B ))                     (8.5.3-16)
=359*0.85/((359+8*3.7)*(1+0.6723))=                            0.4696
```

DETERMINATION OF eps FROM FIGURE 8.5-3 :

```
eps is a minimum when n= 7
eps (from fig. 8.5-3) = 0.000284
```

MEMBRANE YIELD py

```
py = Sige * ea / (R * (1 - gamma * G ))                            (8.5.3-15)
=138.2*3.7/(552*(1-0.4696*0))=                                 0.9263 MPa
```

ELASTIC INSTABILITY pe

pm = E * ea * eps / R (8.5.2-5) =194028*3.7*2.8378E-04/552= 0.3691 MPa

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

Value pr/py From Figure 8.5-5 Curve 1
Value1 = == 0.1990
pr = Value1 * py =0.199*0.9263= 0.1843 MPa
Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.1843/1.5= 0.1229 MPa

External Pressure Pmax=0.1229 >= Pext=0.1[MPa]	81.3%	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*0.1229/0.1= 0.0061 %
Maximum unsupported length for given shell thickness Lmax = 1234 mm (en = 4 mm)

EN13445-4 Sect. 9.2 Ratio of Deformation

F = en / Dm * 100 (9.2-2) =4/1104*100= 0.3623 %

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)
=1100*0.2/(2*147.5*0.85-0.2)= 0.8781 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =0.8781+0+0.3= 1.1781 mm

Internal Pressure emina=1.18 <= en=4[mm]	29.4%	OK

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

Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*265*1*(3.7+0)/1104= 1.7763 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=1.78[MPa]	17.1%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(502.48,9.59)= 502.48 mm

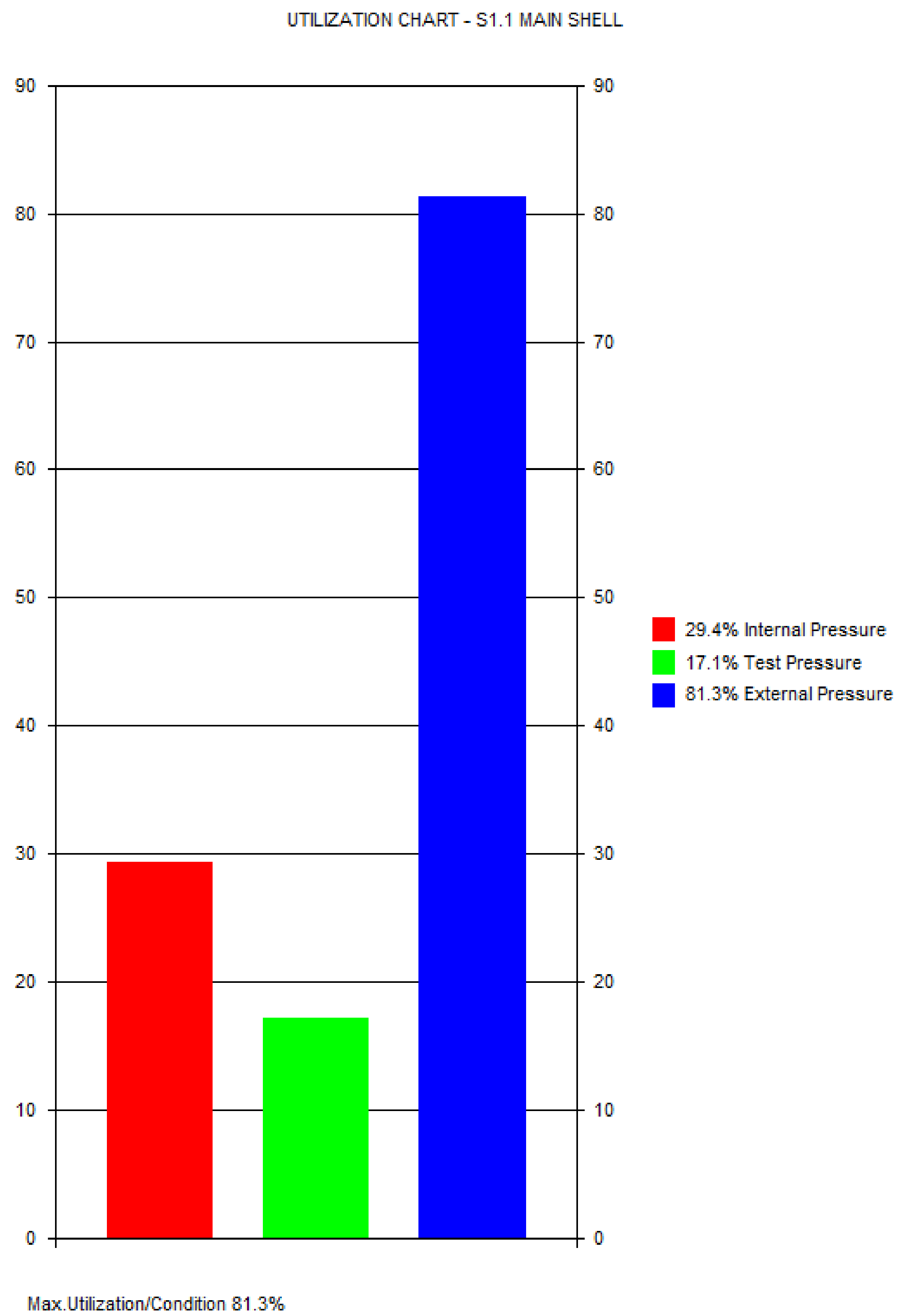
8.5 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

Max. Allowable External Pressure
Pmax = pr / S (8.5.2-8) =0.1843/1.5= 0.1229 MPa

External Pressure Pmax=0.1229 >= Pext=0.1[MPa]	81.3%	OK

Maximum unsupported length for given shell thickness Lmax = 1234 mm (en = 4 mm)

Volume:1.90 m3 Weight:220 kg (SG= 7.93)


UTILIZATION CHART - S1.1 MAIN SHELL
90
80
70
60
50
40
30
20
10
0
29.4% Internal Pressure
17.1% Test Pressure
81.3% External Pressure
Max.Utilization/Condition 81.3%

INPUT DATA

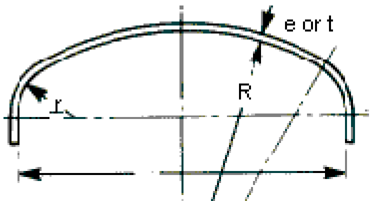
COMPONENT ATTACHMENT/LOCATION

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

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.2000
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       1110.00 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl       30.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en        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: NO
```

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

```
Required Thickness of End to Limit Membrane Stress in Central Part
es = P * R / (2 * f * z - 0.5 * P)                               (7.5-1)
=0.2*888/(2*147.5*0.85-0.5*0.2)=                         0.7086 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*888+0.2*1102)*((0.2/(111*115.17)*(1102/170.94)^0.825)^(0.667)
=   1.5404 mm

7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(0.9814/888,0.04)=      0.0011
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0011)=                   2.9566
```

```
X = r / Di (7.5-11) =170.94/1108.04=                      0.1543
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                             (7.5-12)
=1.006-1/(6.2+(90*0.0011)^4)=                            0.8447
Beta01 = N*(-0.1833*Z^3+1.0383*Z^2-1.2943*Z+0.837)              (7.5-15)
=0.8447*(-0.1833*2.96^3+1.0383*2.96^2-1.2943*2.96+0.837)=  1.1396
Beta02 = MAX( 0.5, 0.95 * (0.56 - 1.94 * Y - 82.5 * Y ^ 2))     (7.5-17)
=MAX(0.5,0.95*(0.56-1.94*0.0011-82.5*0.0011^2))=         0.5299
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)           (7.5-16)
=10*((0.2-0.1543)*1.14+(0.1543-0.1)*0.5299)=             0.8087
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * P * (0.75 * R + 0.2 * Di) / f                       (7.5-2)
=0.8087*0.2*(0.75*888+0.2*1108.04)/147.5=                0.9733 mm

Required Minimum End Thickness Excl.Allow. emin :
emin = emin =1.54=                                         1.5404 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =1.54+0+0.3=                         1.8400 mm
```

Internal Pressure emina=1.84 <= en=4[mm]	46.0%	OK

```
Analysis Thickness
ea = en - c - th =4-0-0.3=                                 3.7000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =1110-2*(4-0)=                     1102.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(1110+1102)/2=                        1106.00 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(1102*1.54)=          8.2403 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*1102/(2*147.5*0.85-0.2)=                            0.8797 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =0.8797+0=                                0.8800 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=170.94 <= 0.2 * Di=220.4[mm] « » OK«
»Geometry Check r=170.94 >= 0.06 * Di=66.12[mm] « » OK«
»Geometry Check r=170.94 >= 2*e[mm] « » OK«
»Geometry Check e=1.54 <= 0.08*De=88.8[mm] « » OK«
»Geometry Check ea=3.7 >= 0.001*De=1.11[mm] « » OK«
»Geometry Check R=888 <= De=1110[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/(888+0.5*3.7)=                           1.2723 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                  (7.5-7)
=180*3.7/(0.7309*(0.75*888+0.2*1102))=                   1.0280 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*888+0.2*1102))^1.5*(170.94/1102)^0.825=   1.1581 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*180*0.85/(1102+3.7)=                              1.0240 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.02=                                                   1.0240 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/(888+0.5*3.7)=                         1.0426 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                  (7.5-7)
=147.5*3.7/(0.7309*(0.75*888+0.2*1102))=                 0.8424 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*888+0.2*1102))^1.5*(170.94/1102)^0.825=   0.7410 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*147.5*0.85/(1102+3.7)=                               0.8391 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.741=                                                     0.7410 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/(888+0.5*3.7)=                                 2.2037 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                      (7.5-7)
=265*3.7/(0.7309*(0.75*888+0.2*1102))=                      1.5134 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*888+0.2*1102))^1.5*(170.94/1102)^0.825=   1.6544 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*265*1/(1102+3.7)=                                    1.7735 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.51=                                                      1.5134 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=1.51[MPa]	20.1%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =888=                                         888.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*888+3.7)*3.7)=    81.15 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*81.15*(147.5-0.5*0.2)/0.2-888*81.15)/(0.5*888+0.5*3.7)=   334.69 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                            (9.5-18)
=0.15*Sqr((2*888+3.7)*3.7)=                                  12.17 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(334.69,12.17)=                 334.69 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 =888+3.7/2=                                889.85 mm
MEMBRANE YIELD py
py = 2 * Sige * ea / Rmean (8.7.1-1) =2*138.2*3.7/889.85=     1.1493 MPa

ELASTIC INSTABILITY pm
pm = 1.21 * E * ea ^ 2 / Rmean ^ 2                                  (8.7.1-2)
=1.21*194028*3.7^2/889.85^2=                                4.0590 MPa

Value pr/py From Figure 8.5-5 Curve   2
Value1 =  ==                                                  0.4809
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
pr = Value1 * py =0.4809*1.15=                                0.5527 MPa
Pmax = pr / S =0.5527/1.5=                                    0.3684 MPa
```

External Pressure Pmax=0.3684 >= Pext=0.1[MPa]	27.1%	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 =1.54= 1.5404 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =1.54+0+0.3= 1.8400 mm

Internal Pressure emina=1.84 <= en=4[mm]	46.0%	OK

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =0.8797+0= 0.8800 mm

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.02= 1.0240 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.741= 0.7410 MPa

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

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.51= 1.5134 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=1.51[MPa]	20.1%	OK

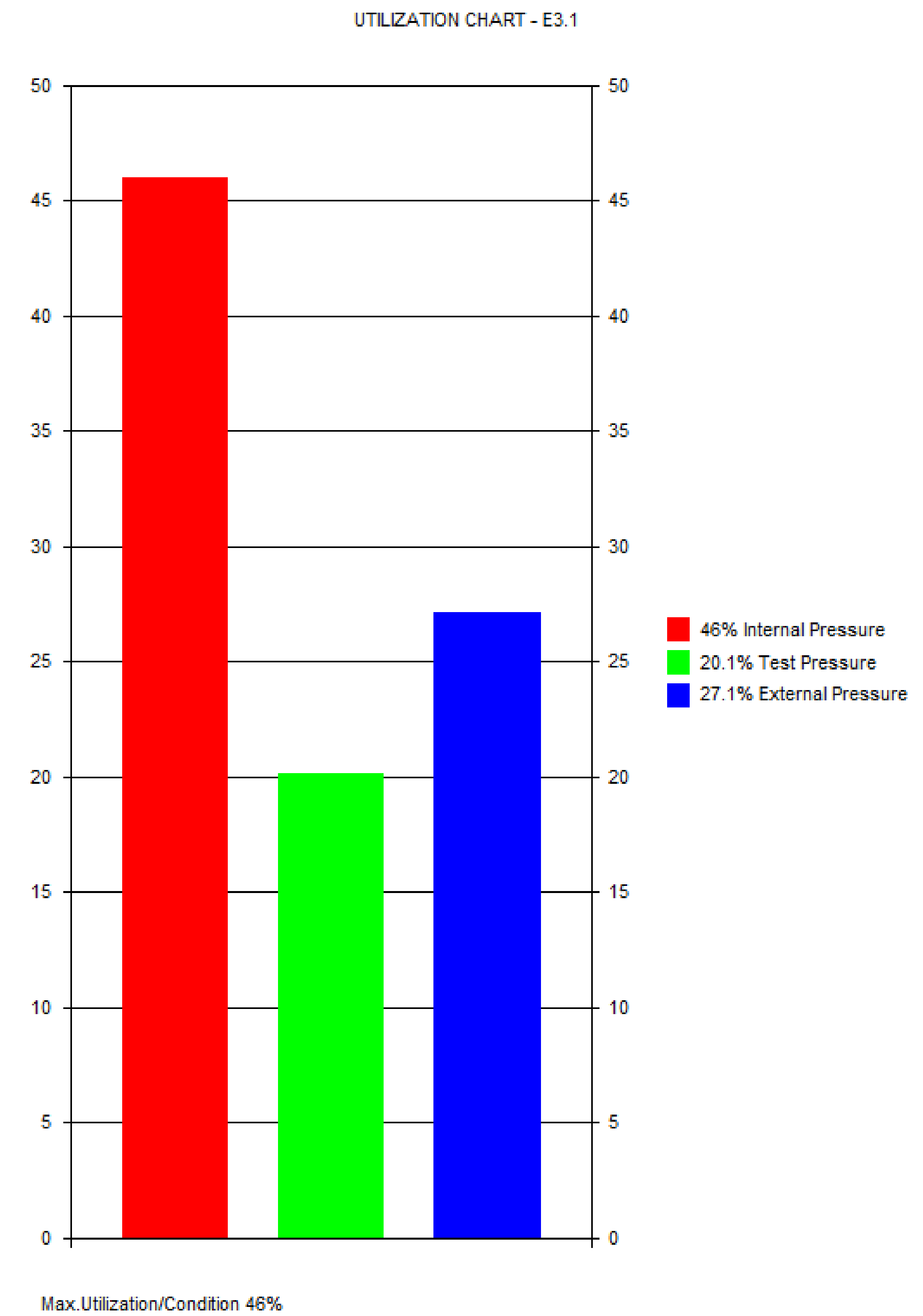
Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(334.69,12.17)= 334.69 mm

8.7 - SPHERICAL SHELL UNDER EXTERNAL PRESSURE

External Pressure Pmax=0.3684 >= Pext=0.1[MPa]	27.1%	OK

Volume:0.2049 m3 Weight:45.7 kg (SG= 7.93)


UTILIZATION CHART - E3.1
50
45
40
35
30
25
20
15
10
5
0
46% Internal Pressure
20.1% Test Pressure
27.1% External Pressure
Max.Utilization/Condition 46%

INPUT DATA

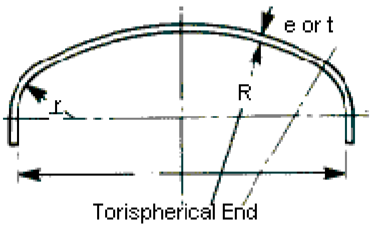
COMPONENT ATTACHMENT/LOCATION

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

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.2000
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       1110.00 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl       30.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en        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: NO
```

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

```
Required Thickness of End to Limit Membrane Stress in Central Part
es = P * R / (2 * f * z - 0.5 * P)                                 (7.5-1)
=0.2*888/(2*147.5*0.85-0.5*0.2)=                           0.7086 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*888+0.2*1102)*((0.2/(111*115.17)*(1102/170.94)^0.825)^(0.667)
=   1.5404 mm

7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(0.9814/888,0.04)=      0.0011
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0011)=                     2.9566
```

```
X = r / Di (7.5-11) =170.94/1108.04=                      0.1543
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                            (7.5-12)
=1.006-1/(6.2+(90*0.0011)^4)=                           0.8447
Beta01 = N*(-0.1833*Z^3+1.0383*Z^2-1.2943*Z+0.837)              (7.5-15)
=0.8447*(-0.1833*2.96^3+1.0383*2.96^2-1.2943*2.96+0.837)=  1.1396
Beta02 = MAX( 0.5, 0.95 * (0.56 - 1.94 * Y - 82.5 * Y ^ 2))     (7.5-17)
=MAX(0.5,0.95*(0.56-1.94*0.0011-82.5*0.0011^2))=        0.5299
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)           (7.5-16)
=10*((0.2-0.1543)*1.14+(0.1543-0.1)*0.5299)=            0.8087
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * P * (0.75 * R + 0.2 * Di) / f                       (7.5-2)
=0.8087*0.2*(0.75*888+0.2*1108.04)/147.5=               0.9733 mm

Required Minimum End Thickness Excl.Allow. emin :
emin = emin =1.54=                                        1.5404 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =1.54+0+0.3=                        1.8400 mm
```

Internal Pressure emina=1.84 <= en=4[mm]	46.0%	OK

```
Analysis Thickness
ea = en - c - th =4-0-0.3=                                3.7000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =1110-2*(4-0)=                    1102.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(1110+1102)/2=                       1106.00 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(1102*1.54)=         8.2403 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*1102/(2*147.5*0.85-0.2)=                           0.8797 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =0.8797+0=                               0.8800 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=170.94 <= 0.2 * Di=220.4[mm] « » OK«
»Geometry Check r=170.94 >= 0.06 * Di=66.12[mm] « » OK«
»Geometry Check r=170.94 >= 2*e[mm] « » OK«
»Geometry Check e=1.54 <= 0.08*De=88.8[mm] « » OK«
»Geometry Check ea=3.7 >= 0.001*De=1.11[mm] « » OK«
»Geometry Check R=888 <= De=1110[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/(888+0.5*3.7)=                          1.2723 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                  (7.5-7)
=180*3.7/(0.7309*(0.75*888+0.2*1102))=                  1.0280 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*888+0.2*1102))^1.5*(170.94/1102)^0.825=   1.1581 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*180*0.85/(1102+3.7)=                             1.0240 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.02=                                                  1.0240 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/(888+0.5*3.7)=                        1.0426 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                  (7.5-7)
=147.5*3.7/(0.7309*(0.75*888+0.2*1102))=                0.8424 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*888+0.2*1102))^1.5*(170.94/1102)^0.825=   0.7410 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*147.5*0.85/(1102+3.7)=                                 0.8391 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.741=                                                       0.7410 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/(888+0.5*3.7)=                                   2.2037 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                        (7.5-7)
=265*3.7/(0.7309*(0.75*888+0.2*1102))=                        1.5134 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*888+0.2*1102))^1.5*(170.94/1102)^0.825=   1.6544 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*265*1/(1102+3.7)=                                      1.7735 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.51=                                                        1.5134 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=1.51[MPa]	20.1%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =888=                                           888.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*888+3.7)*3.7)=    81.15 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*81.15*(147.5-0.5*0.2)/0.2-888*81.15)/(0.5*888+0.5*3.7)=   334.69 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                              (9.5-18)
=0.15*Sqr((2*888+3.7)*3.7)=                                    12.17 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(334.69,12.17)=                   334.69 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 =888+3.7/2=                                  889.85 mm
MEMBRANE YIELD py
py = 2 * Sige * ea / Rmean (8.7.1-1) =2*138.2*3.7/889.85=       1.1493 MPa

ELASTIC INSTABILITY pm
pm = 1.21 * E * ea ^ 2 / Rmean ^ 2                                    (8.7.1-2)
=1.21*194028*3.7^2/889.85^2=                                  4.0590 MPa

Value pr/py From Figure 8.5-5 Curve   2
Value1 =  ==                                                    0.4809
```

MAX. ALLOWABLE EXTERNAL PRESSURE Pmax

```
pr = Value1 * py =0.4809*1.15=                                  0.5527 MPa
Pmax = pr / S =0.5527/1.5=                                      0.3684 MPa
```

External Pressure Pmax=0.3684 >= Pext=0.1[MPa]	27.1%	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 =1.54= 1.5404 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =1.54+0+0.3= 1.8400 mm

Internal Pressure emina=1.84 <= en=4[mm]	46.0%	OK

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =0.8797+0= 0.8800 mm

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.02= 1.0240 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.741= 0.7410 MPa

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

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.51= 1.5134 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=1.51[MPa]	20.1%	OK

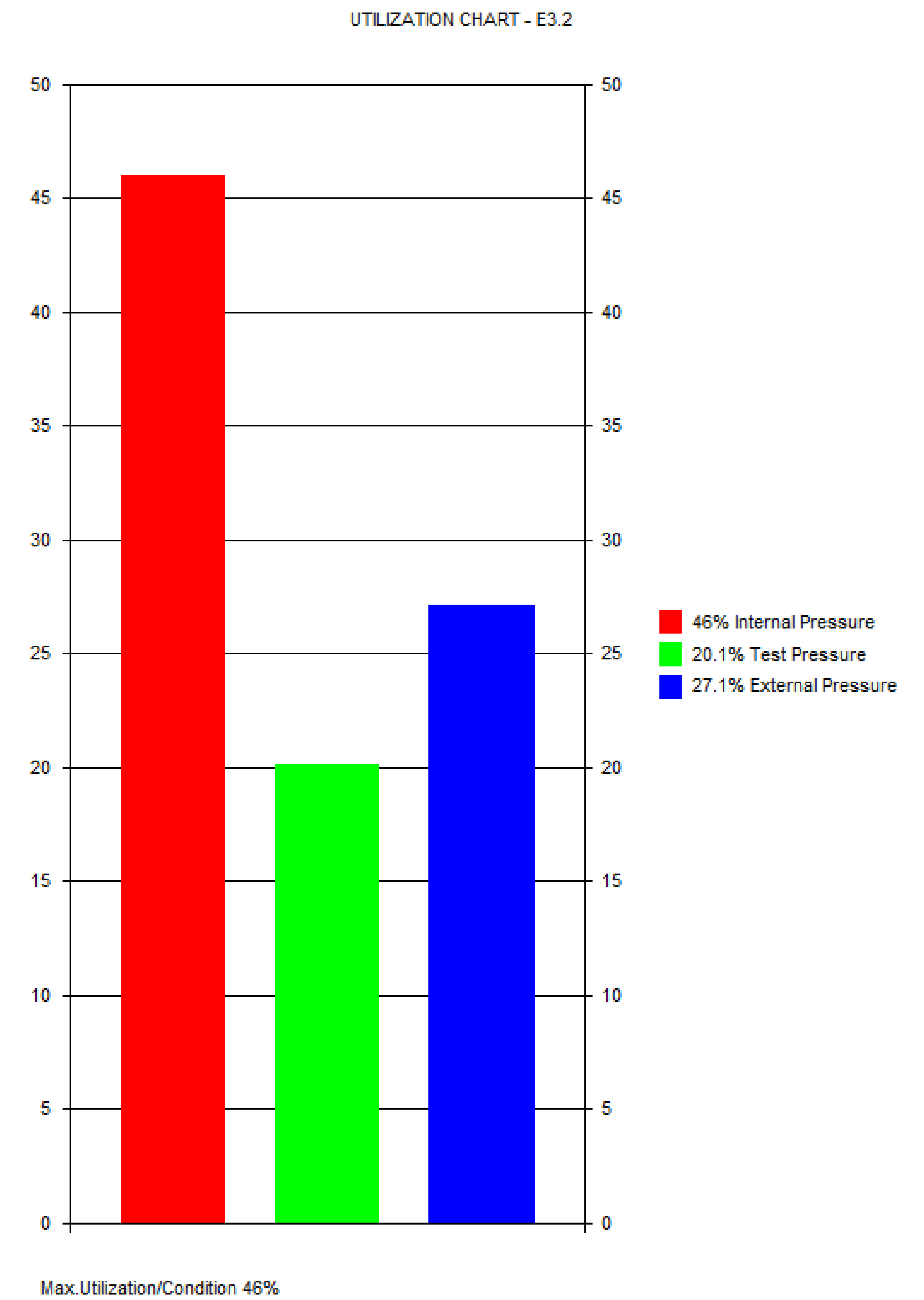
Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(334.69,12.17)= 334.69 mm

8.7 - SPHERICAL SHELL UNDER EXTERNAL PRESSURE

External Pressure Pmax=0.3684 >= Pext=0.1[MPa]	27.1%	OK

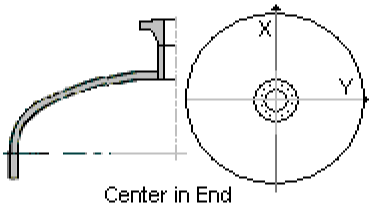
Volume:0.2049 m3 Weight:45.7 kg (SG= 7.93)


UTILIZATION CHART - E3.2
50
45
40
35
30
25
20
15
10
5
0
46% Internal Pressure
20.1% Test Pressure
27.1% External Pressure
Max.Utilization/Condition 46%

INPUT DATA

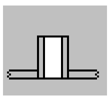
COMPONENT ATTACHMENT/LOCATION

```
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

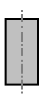


```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.2000
LIQUID HEAD.........................................:LH        313.59 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
Include Nozzle Load Calculation: NO
```

SHELL DATA (E3.1)

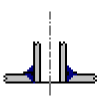
```
Shell Type: Torispherical End
OUTSIDE DIAMETER OF SHELL...........................:De       1110.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R         888.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fs=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

NOZZLE MATERIAL DATA



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

NOZZLE DIMENSIONAL DATA



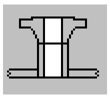
```
Attachment: Set In Flush Nozzle
Shape of Nozzle/Opening: Circular
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER.............................:deb       129.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       2.0000 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) =888= 888.00 mm
dib = deb - 2 * eab =129-2*1.8= 125.40 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=0.2037*129/(2*135.07*1+0.2037)= 0.1000 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=0.113 <= 0.60=0.6[mm] (9.4.5.3)«» OK«

Min.Nozzle Thk. ebp=0.1 <= eab=1.8[mm]	5.5%	OK

»Location in End to Fig.9.5-4 L=490.5 >= De/10=111[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*888+3.7)*3.7)= 81.15 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =3.7*81.15= 300.25 mm2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN(Sqr((deb - eb) * eb), ho) (9.5-76)
=MIN(Sqr((129-1.8)*1.8,)100)= 15.13 mm
Set In Nozzle
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =1.8*(15.13+0+3.7)= 33.90 mm2

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*125.4*(15.13+3.7)=  1180.73 mm2
Spherical Shell/End on any Section Aps
Aps = 0.5 * ris ^ 2 * (Is + a) / (0.5 * eas + ris)                (9.5-105)
=0.5*888^2*(81.15+64.56)/(0.5*3.7+888)=                  64558.06 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                               (9.5-7)
=0.2037*(64558.06+1180.73+0.5*0)=                         13.39 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)
=(300.25+0)*(147.5-0.5*0.2037)+0*(0-0.5*0.2037)+33.9*(135.07-0.5*0.2037)
=    48.83 kN
```

Nozzle Reinforcement pAAval=48.83 >= pAReq=13.39[kN]	27.4%	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)
=(300.25+0)*147.5+33.9*135.07/((64558.06+1180.73+0.5*0)+0.5*(300.25+0+33.9+
0))=                                                      =    0.7414 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                 1.3175 MPa
Weight of Nozzle: .6729kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.1 <= eab=1.8[mm]	5.5%	OK

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

```
Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*888+3.7)*3.7)=                                    81.15 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((129-1.8)*1.8,)100)=                             15.13 mm
```

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                               (9.5-7)
=0.2037*(64558.06+1180.73+0.5*0)=                         13.39 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)
=(300.25+0)*(147.5-0.5*0.2037)+0*(0-0.5*0.2037)+33.9*(135.07-0.5*0.2037)
=    48.83 kN
```

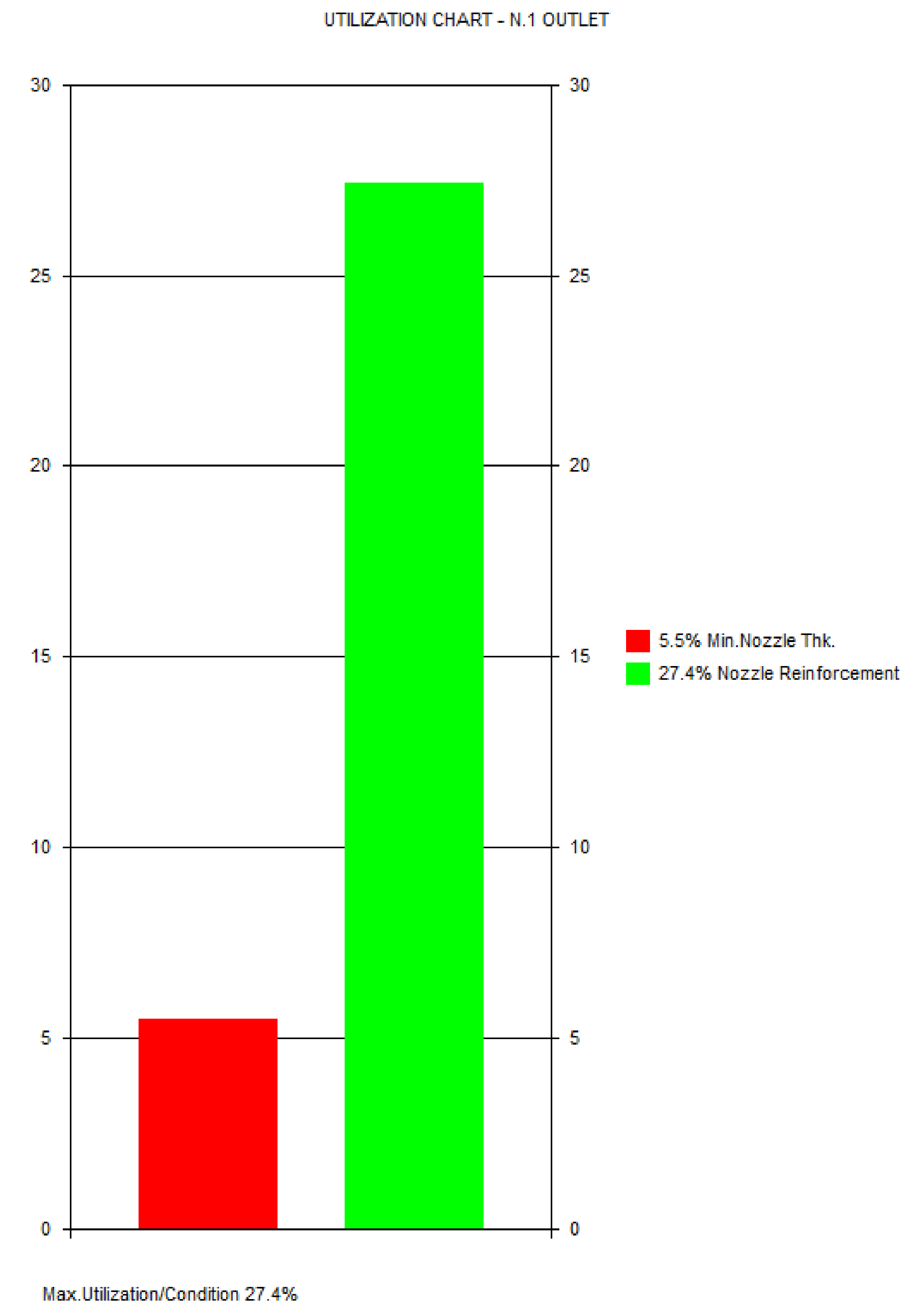
Nozzle Reinforcement pAAval=48.83 >= pAReq=13.39[kN]	27.4%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp)) (9.5-10)
=(300.25+0)*147.5+33.9*135.07/((64558.06+1180.73+0.5*0)+0.5*(300.25+0+33.9+
0))=                                                      =    0.7414 MPa
```

Volume:0.0013 m3 Weight:0.7 kg (SG= 7.93)

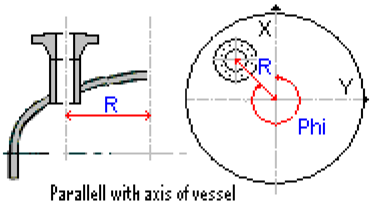
EN13445:2014 Issue 5:2018+A5 - 9.5 ISOLATED OPENINGS IN SHELLS
N.1 Outlet
20 June 2019 12:12 ConnID:E3.1



INPUT DATA

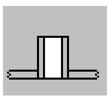
COMPONENT ATTACHMENT/LOCATION

```
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     0.00 Degr.
Distance between Center of End and Center of Nozzle.:R         330.00 mm
```

GENERAL DESIGN DATA

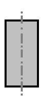


```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.2000
LIQUID HEAD.........................................:LH        250.15 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
Include Nozzle Load Calculation: NO
```

SHELL DATA (E3.1)

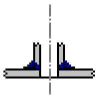
```
Shell Type: Torispherical End
OUTSIDE DIAMETER OF SHELL...........................:De       1110.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R         888.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip, THK<=8mm 90'C,A>=35%
Rm=530 Rp=270 Rpt=207.88 fs=147.5 f20=180 ftest=265 E=194028(N/mm2) ro=7.93
```

NOZZLE MATERIAL DATA



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

NOZZLE DIMENSIONAL DATA

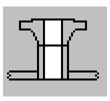


```
Attachment: Set On Nozzle
Shape of Nozzle/Opening: Circular
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER.............................:deb       129.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       2.0000 mm
Size 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      21.82 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=                                       888.00 mm
dib = deb - 2 * eab =129-2*1.8=                             125.40 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=0.2029*129/(2*135.07*1+0.2029)=                          0.1000 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=0.113 <= 0.60=0.6[mm] (9.4.5.3)«» OK«

Min.Nozzle Thk. ebp=0.1 <= eab=1.8[mm]	5.5%	OK

»Location in End to Fig.9.5-4 L=160.5 >= De/10=111[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 Reduced by Location in Dished End
Iso =  ==                                                     56.14 mm
Set On Nozzle
Afs = eas * (eb + Is) (9.5-81) =3.7*(1.8+56.14)=            214.36 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((129-1.8)*1.8,)100)=                               15.13 mm
Set On Nozzle
Afb = eb * Ibo (9.5-80) =1.8*15.13=                           27.24 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-80) =0.5*125.4*(15.13+3.7)=  1180.73 mm2

Additional Area due to Obliquity of Nozzle Ap(phi)
Apphi = 0.5 * dib ^ 2 * Tan( phi)                                  (9.5-112)
=0.5*125.4^2*Tan(21.82)=                                  3147.30 mm2

Spherical Shell/End on any Section Aps
Aps = 0.5 * ris ^ 2 * (Is + a) / (0.5 * eas + ris)                 (9.5-115)
=0.5*888^2*(56.14+69.58)/(0.5*3.7+888)=                  55702.24 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                              (9.5-7)
=0.2029*(55702.24+1180.73+0.5*3147.3)=                      11.86 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)
=(214.36+0)*(147.5-0.5*0.2029)+0*(0-0.5*0.2029)+27.24*(135.07-0.5*0.2029)
=    35.27 kN
```

Nozzle Reinforcement pAAval=35.27 >= pAReq=11.86[kN]	33.6%	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)
=(214.36+0)*147.5+27.24*135.07/((55702.24+1180.73+0.5*3147.3)+0.5*(214.36+0
+27.24+0))=                                                 =   0.6026 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                   1.0694 MPa

Weight of Nozzle: .9607kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.1 <= eab=1.8[mm]	5.5%	OK

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

```
Limit of Reinforcement Along Shell Reduced by Location in Dished End
Iso =  ==                                                     56.14 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((129-1.8)*1.8,)100)=                               15.13 mm
```

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                              (9.5-7)
=0.2029*(55702.24+1180.73+0.5*3147.3)=                          11.86 kN
```

Pressure Area Available pA(aval.)

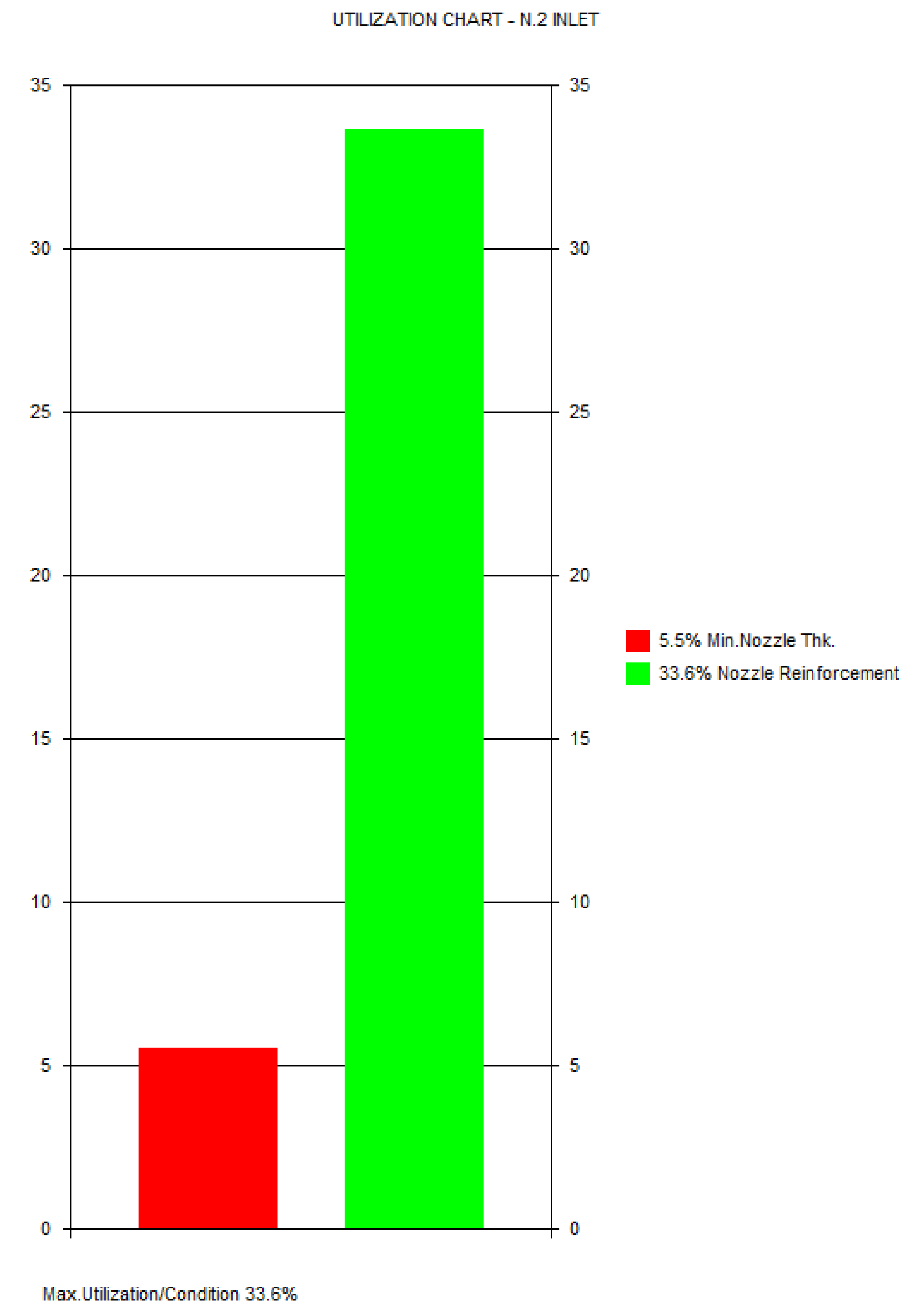
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)      (9.5-7)
=(214.36+0)*(147.5-0.5*0.2029)+0*(0-0.5*0.2029)+27.24*(135.07-0.5*0.2029)
=    35.27 kN
```

Nozzle Reinforcement pAAval=35.27 >= pAReq=11.86[kN]	33.6%	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)
=(214.36+0)*147.5+27.24*135.07/((55702.24+1180.73+0.5*3147.3)+0.5*(214.36+0
+27.24+0))=                                                     =    0.6026 MPa
```

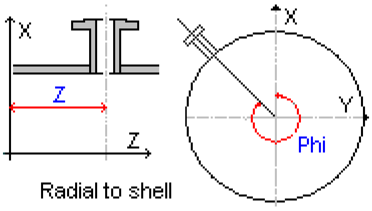
Volume:0.0016 m3 Weight:1 kg (SG= 7.93)


UTILIZATION CHART - N.2 INLET
35
30
25
20
15
10
5
0
5.5% Min.Nozzle Thk.
33.6% Nozzle Reinforcement
Max.Utilization/Condition 33.6%

INPUT DATA

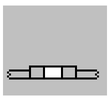
COMPONENT ATTACHMENT/LOCATION

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




```
Orientation & Location of Nozzle: Radial to Shell
z-location of nozzle along axis of attacment........:z        1900.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi   135.00 Degr.
```

GENERAL DESIGN DATA



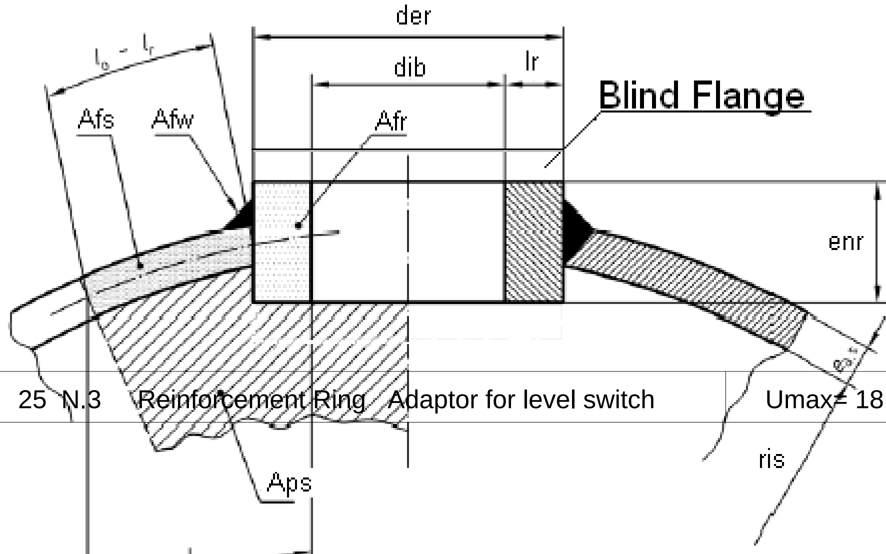
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.2000
LIQUID HEAD.........................................:LH          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       1108.00 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)..........................:Ir         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) =1108/2-3.7= 550.30 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*550.3+4.67)*4.67)= 72.31 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io (9.5-48)
=3.7+(16.5-3.7)*5.5/72.31= 4.6736 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*550.3+3.7)*3.7)= 63.92 mm
Is = MIN(Iso , Io - Ir) (9.5-50) =MIN(63.92,72.31-5.5)= 63.92 mm
Area of Shell
Afs = eas * Is (9.5-54) =3.7*63.92= 236.51 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)
=550.3*(63.92+5.5+9.5)+9.5*(3.7+0)= 43465.44 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*550.3^2*(63.92+15.)/(0.5*3.7+550.3)+9.5*(3.7+0)= 21678.05 mm2

Aps = MAX(ApsL ApsT) =MAX(43465.44,21678.05)= 43465.44 mm2

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

pAReqL = P * (ApsL + Apr) (9.5-7) =0.2*(43465.44+156.75)= 8.7244 kN

pAReqT = P * (ApsT + Apr + 0.5 * Apphi) (9.5-7)
=0.2*(21678.05+156.75+0.5*0)= 4.3670 kN

pAReq = MAX(pAReqL, pAReqT) =MAX(8724.44,4366.96)= 8.7244 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)
=(236.51+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+90.75*(143.33-0.5*0.2)=    47.86 kN
```

Nozzle Reinforcement pAAval=47.86 >= pAReq=8.72[kN]	18.2%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(236.51+0)*147.5+90.75*143.33/((43465.44+156.75)+0.5*(236.51+0+90.75+0))
=   1.0938 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                  1.9495 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*(43465.44+156.75)=     8.7244 kN
pAReqT = P * (ApsT + Apr + 0.5 * Apphi)                           (9.5-7)
=0.2*(21678.05+156.75+0.5*0)=                                4.3670 kN
pAReq = MAX( pAReqL, pAReqT) =MAX(8724.44,4366.96)=           8.7244 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)
=(236.51+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+90.75*(143.33-0.5*0.2)=    47.86 kN
```

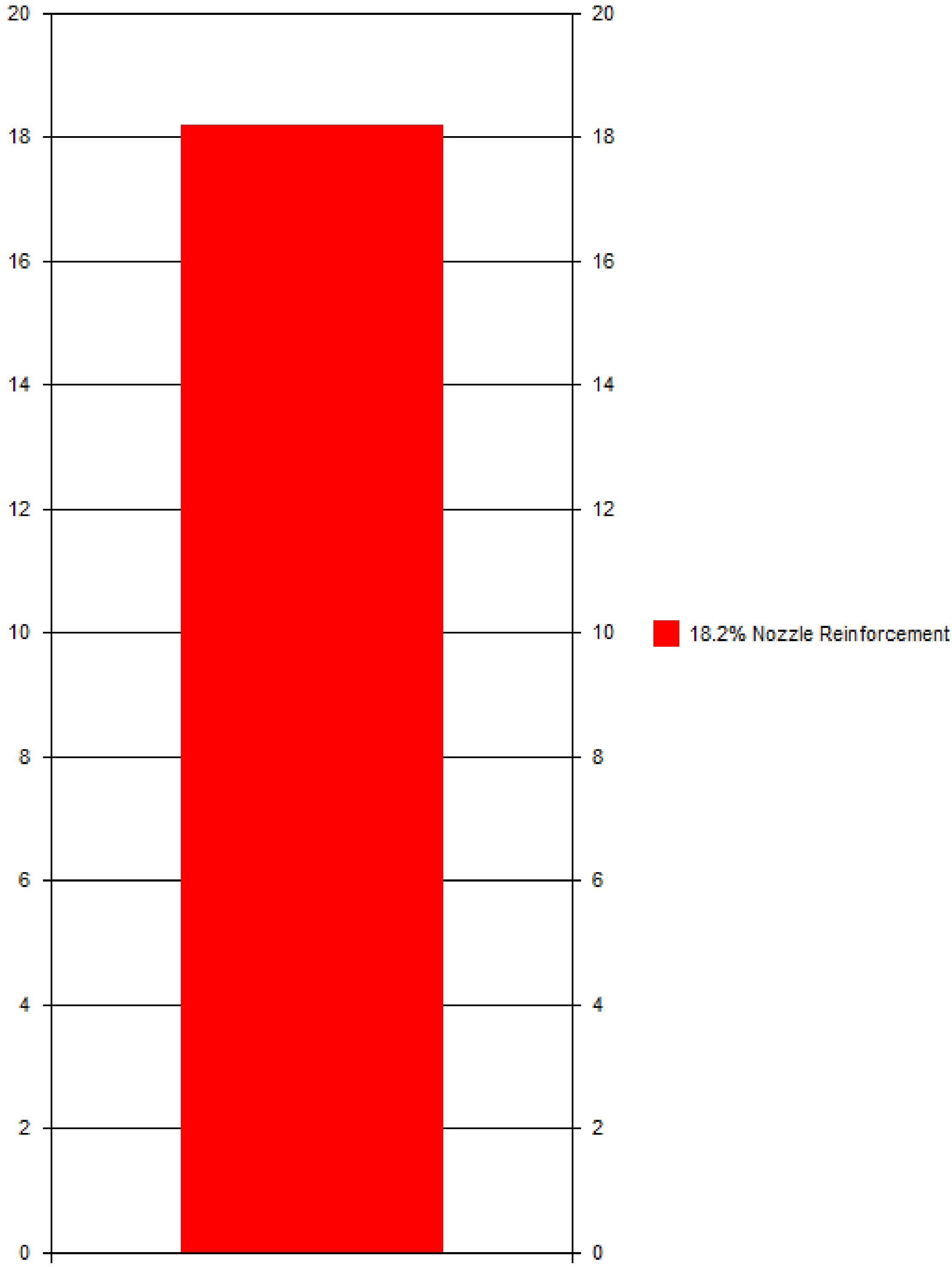
Nozzle Reinforcement pAAval=47.86 >= pAReq=8.72[kN]	18.2%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(236.51+0)*147.5+90.75*143.33/((43465.44+156.75)+0.5*(236.51+0+90.75+0))
=   1.0938 MPa
```

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

UTILIZATION CHART - N.3 ADAPTOR FOR LEVEL SWITCH

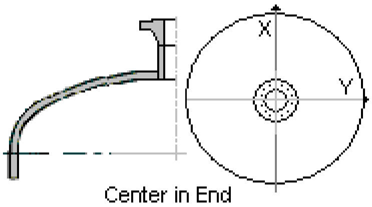


Max.Utilization/Condition 18.2%

INPUT DATA

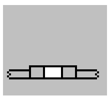
COMPONENT ATTACHMENT/LOCATION

```
Attachment: E3.2    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



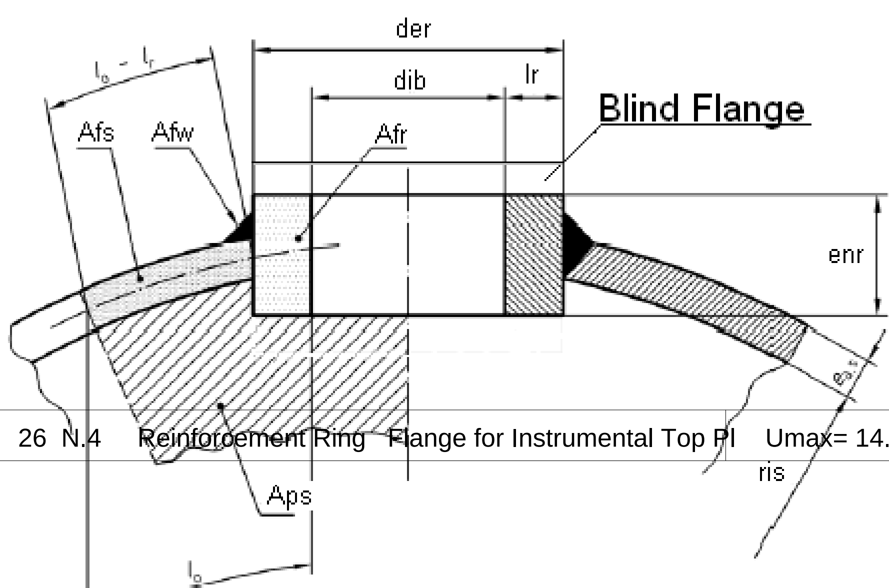
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.2000
LIQUID HEAD.........................................:LH          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       1110.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en         4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th         0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R         888.00 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) =888=                                               888.00 mm
Allowable Stresses
for/fob = Min( fs, fb) (9.5-8) =Min(147.5,147.5)=                   147.50 N/mm2
```

»Location in End to Fig.9.5-4 L=280 >= De/10=111[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*888+11.21)*11.21)=                                     141.79 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io                                           (9.5-48)
=3.7+(25-3.7)*50/141.79=                                        11.21 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*888+3.7)*3.7)=                                          81.15 mm
Is = MIN( Iso , Io - Ir) (9.5-50) =MIN(81.15,141.79-50)=          81.15 mm
Area of Shell
Afs = eas * Is (9.5-54) =3.7*81.15=                               300.25 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*888^2*(81.15+279.58)/(0.5*3.7+888)+279.58*(3.7+0)= 1,6086E05 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apr + 0.5 * Apphi)                                      (9.5-7)
=0.2*(1.6086E05+5625+0.5*0)=                                    33.30 kN
```

Pressure Area Available pA(aval.)

```
pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P)                          (9.5-16)
=(300.25+0+0+1250)*(147.5-0.5*0.2)=                            228.51 kN
```

Nozzle Reinforcement pAAval=228.51 >= pAReq=33.3[kN]	14.5%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw+Afr)*fs/((Aps+Apr+0.5*Apphi)+0.5*(Afs+Afw+Afr+Afp)) (9.5-17)
=(300.25+0+1250)*147.5/((1.6086E05+5625+0.5*0)+0.5*(300.25+0+1250+0))
=   1.3671 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                  2.4561 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*(1.6086E05+5625+0.5*0)=                                 33.30 kN
```

Pressure Area Available pA(aval.)

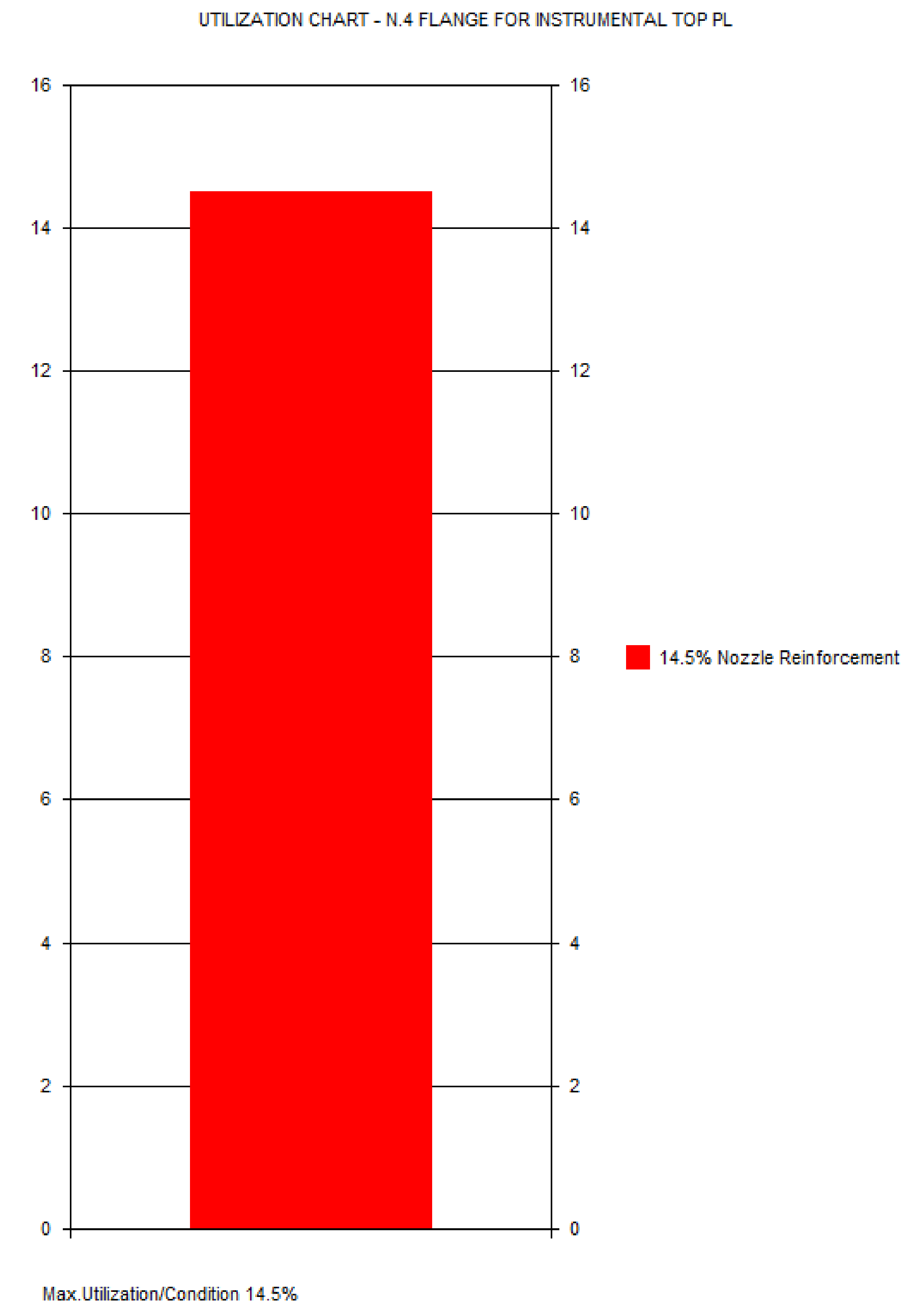
```
pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P)                  (9.5-16)
=(300.25+0+0+1250)*(147.5-0.5*0.2)=                         228.51 kN
```

Nozzle Reinforcement pAAval=228.51 >= pAReq=33.3[kN]	14.5%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw+Afr)*fs/((Aps+Apr+0.5*Apphi)+0.5*(Afs+Afw+Afr+Afp)) (9.5-17)
=(300.25+0+1250)*147.5/((1.6086E05+5625+0.5*0)+0.5*(300.25+0+1250+0))
=   1.3671 MPa
```

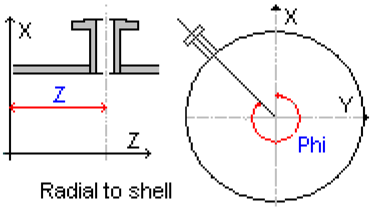
Volume:0.0046 m3 Weight:15.6 kg (SG= 7.93)


UTILIZATION CHART - N.4 FLANGE FOR INSTRUMENTAL TOP PL
16
14
12
10
8
6
4
2
0
14.5% Nozzle Reinforcement
Max.Utilization/Condition 14.5%

INPUT DATA

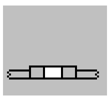
COMPONENT ATTACHMENT/LOCATION

```
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         180.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi   180.00 Degr.
```

GENERAL DESIGN DATA



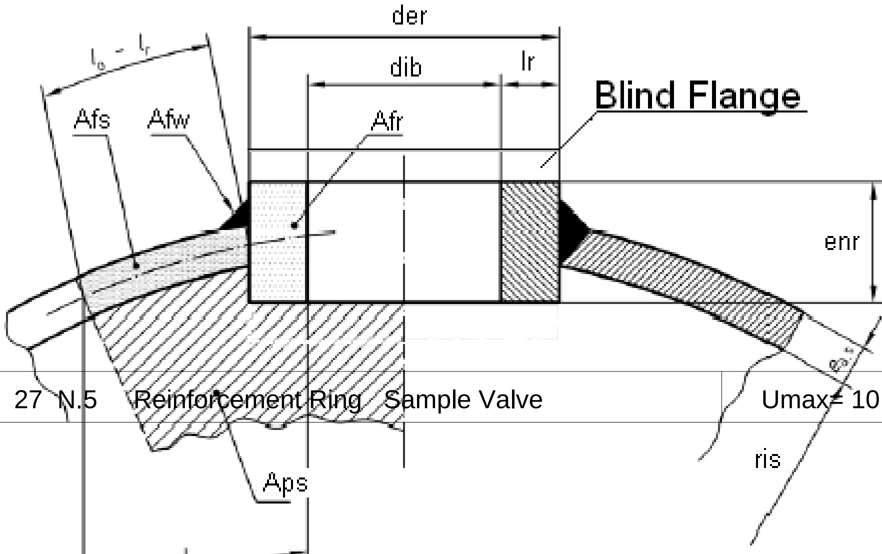
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.2000
LIQUID HEAD.........................................:LH          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       1108.00 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)..........................:lr          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): Sample Valve
```



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) =1108/2-3.7=                          550.30 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*550.3+6.73)*6.73)=                                      86.74 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io                                        (9.5-48)
=3.7+(30-3.7)*10/86.74=                                        6.7322 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*550.3+3.7)*3.7)=                                        63.92 mm
Is = MIN( Iso , Io - Ir) (9.5-50) =MIN(63.92,86.74-10)=           63.92 mm
Area of Shell
Afs = eas * Is (9.5-54) =3.7*63.92=                              236.51 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)
=550.3*(63.92+10+4)+4*(3.7+0)=                               42894.79 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*550.3^2*(63.92+14.)/(0.5*3.7+550.3)+4.*(3.7+0)=         21383.37 mm2

Aps = MAX( ApsL ApsT) =MAX(42894.79,21383.37)=                 42894.79 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apr) (9.5-7) =0.2*(42894.79+120)=           8.6030 kN

pAReqT = P * (ApsT + Apr + 0.5 * Apphi)                                 (9.5-7)
=0.2*(21383.37+120+0.5*0)=                                     4.3007 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(8602.96,4300.67)=              8.6030 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)
=(236.51+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+300*(145.83-0.5*0.2)=    78.58 kN
```

Nozzle Reinforcement pAAval=78.58 >= pAReq=8.6[kN]	10.9%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(236.51+0)*147.5+300*145.83/((42894.79+120)+0.5*(236.51+0+300+0))
=   1.8167 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =   ==                                                   3.1461 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*(42894.79+120)=         8.6030 kN

pAReqT = P * (ApsT + Apr + 0.5 * Apphi)                             (9.5-7)
=0.2*(21383.37+120+0.5*0)=                                    4.3007 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(8602.96,4300.67)=            8.6030 kN
```

Pressure Area Available pA(aval.)

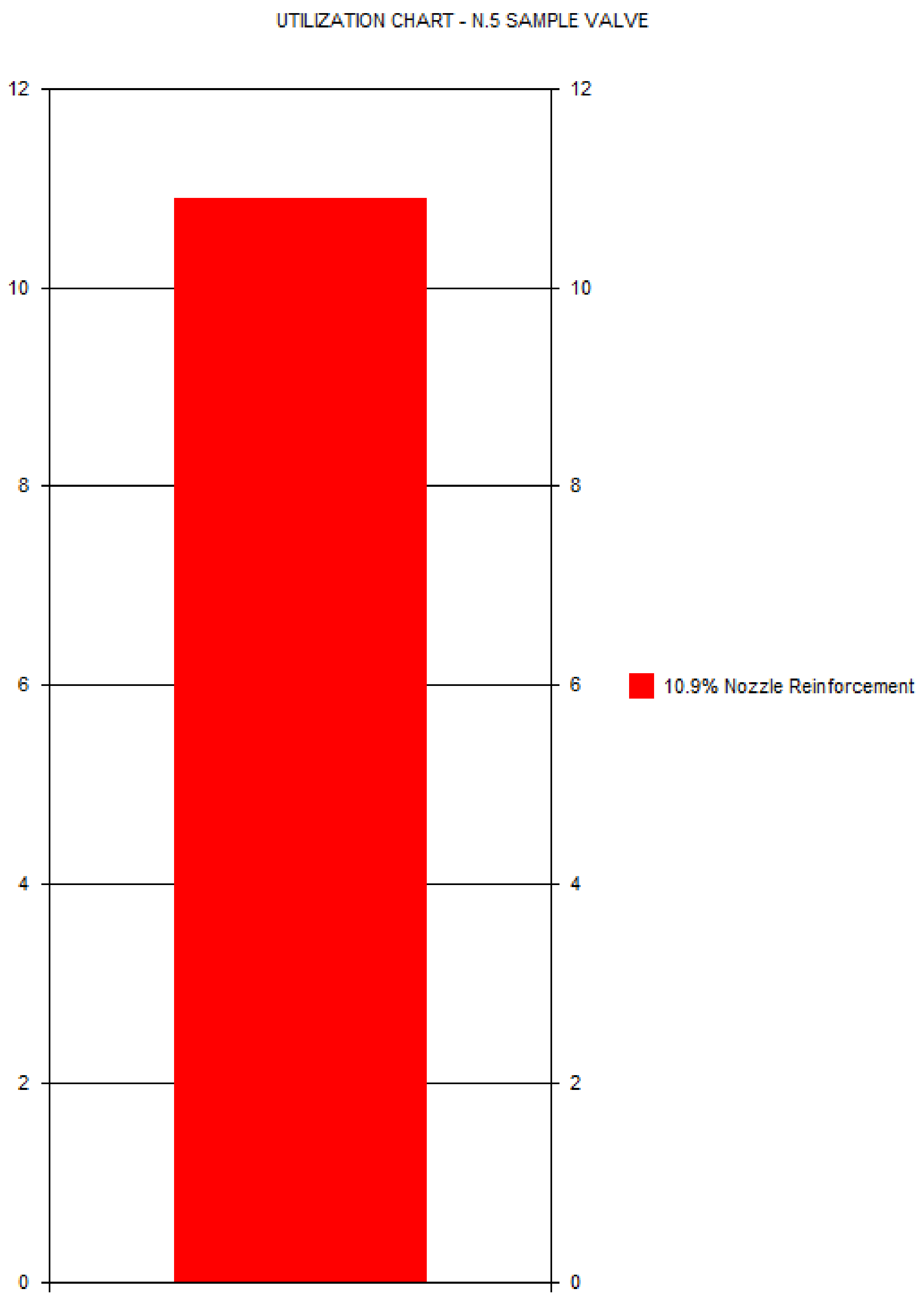
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afr*(fob-0.5*P)      (9.5-13)
=(236.51+0)*(147.5-0.5*0.2)+0*(0-0.5*0.2)+300*(145.83-0.5*0.2)=    78.58 kN
```

Nozzle Reinforcement pAAval=78.58 >= pAReq=8.6[kN]	10.9%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afr*fob/((ApsL+Apr)+0.5*(Afs+Afw+Afr+Afp))     (9.5-14)
=(236.51+0)*147.5+300*145.83/((42894.79+120)+0.5*(236.51+0+300+0))
=   1.8167 MPa
```

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

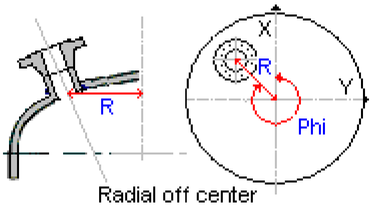


Max.Utilization/Condition 10.9%

INPUT DATA

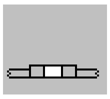
COMPONENT ATTACHMENT/LOCATION

```
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   165.00 Degr.
Distance between Center of End and Center of Nozzle.:R         200.00 mm
```

GENERAL DESIGN DATA



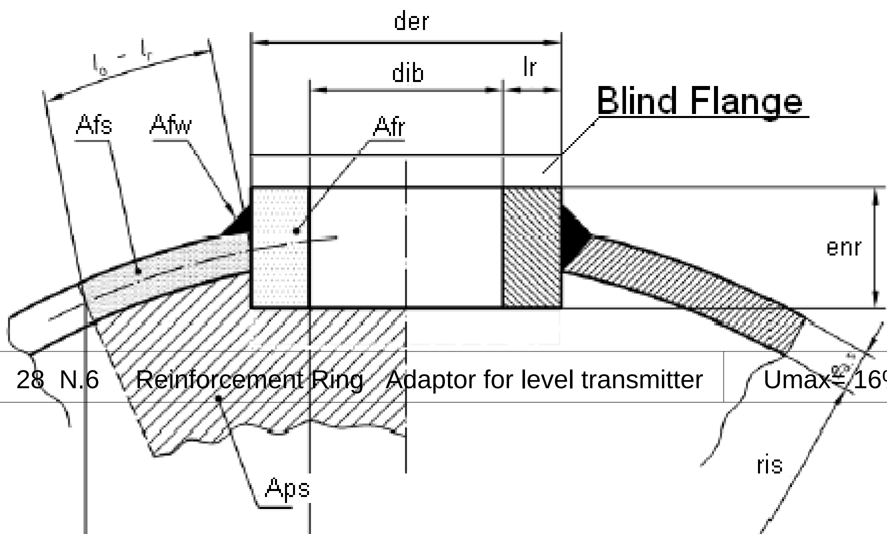
```
Type of Opening: Opening With Reinforcement Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID................:SG        1.2000
LIQUID HEAD.........................................:LH        290.83 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       1110.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)..................:R         888.00 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         13.50 mm
THICKNESS/HEIGTH OF RING............................:enr        10.00 mm
INSIDE DIAMETER OF RING (corroded)..................:dib        38.00 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 =10-0=                                               10.00 mm
ris = R (9.5-4) =200=                                             888.00 mm
Allowable Stresses
for/fob = Min( fs, fb) (9.5-8) =Min(147.5,146.25)=                146.25 N/mm2
```

»Location in End to Fig.9.5-4 L=323.05 >= De/10=111[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(10,MAX(3*3.7,3*13.5))=                                     10.00 mm
Limit of Reinforcement Along Shell and Ring Io
Io = Sqr(( 2 * ris + eam) * eam)                                        (9.5-46)
=Sqr((2*888+4.63)*4.63)=                                        91.34 mm
Average Thickness Along Length Io
eam = eas + (er - eas) * Ir / Io                                        (9.5-48)
=3.7+(10-3.7)*13.5/91.34=                                      4.6311 mm
Area of Ring Afr/Afb
Afr/Afb = er * Ir (9.5-55) =10*13.5=                              135.00 mm2

Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*888+3.7)*3.7)=                                          81.15 mm
Is = MIN( Iso , Io - Ir) (9.5-50) =MIN(81.15,91.34-13.5)=         77.84 mm
Area of Shell
Afs = eas * Is (9.5-54) =3.7*77.84=                               288.02 mm2
```

Calculation of Pressure Loaded Areas

```
Apr/Apb = 0.5 * dib * er =0.5*38*10=                              190.00 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*888^2*(77.84+32.51)/(0.5*3.7+888)+32.51*(3.7+0)=     49013.79 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apr + 0.5 * Apphi)                                   (9.5-7)
=0.2034*(49013.79+190+0.5*0)=                                   10.01 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)
=(288.02+0)*(147.5-0.5*0.2034)+0*(0-0.5*0.2034)+135*(146.25-0.5*0.2034)
=    62.18 kN
```

Nozzle Reinforcement pAAval=62.18 >= pAReq=10.01[kN]	16.0%	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)
=(288.02+0)*147.5+135*146.25/((49013.79+190+0.5*0)+0.5*(288.02+0+135+0))
=   1.2593 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                         2.2275 MPa
Weight of Nozzle: .1732kg
```

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)
=0.2034*(49013.79+190+0.5*0)=                                       10.01 kN
```

Pressure Area Available pA(aval.)

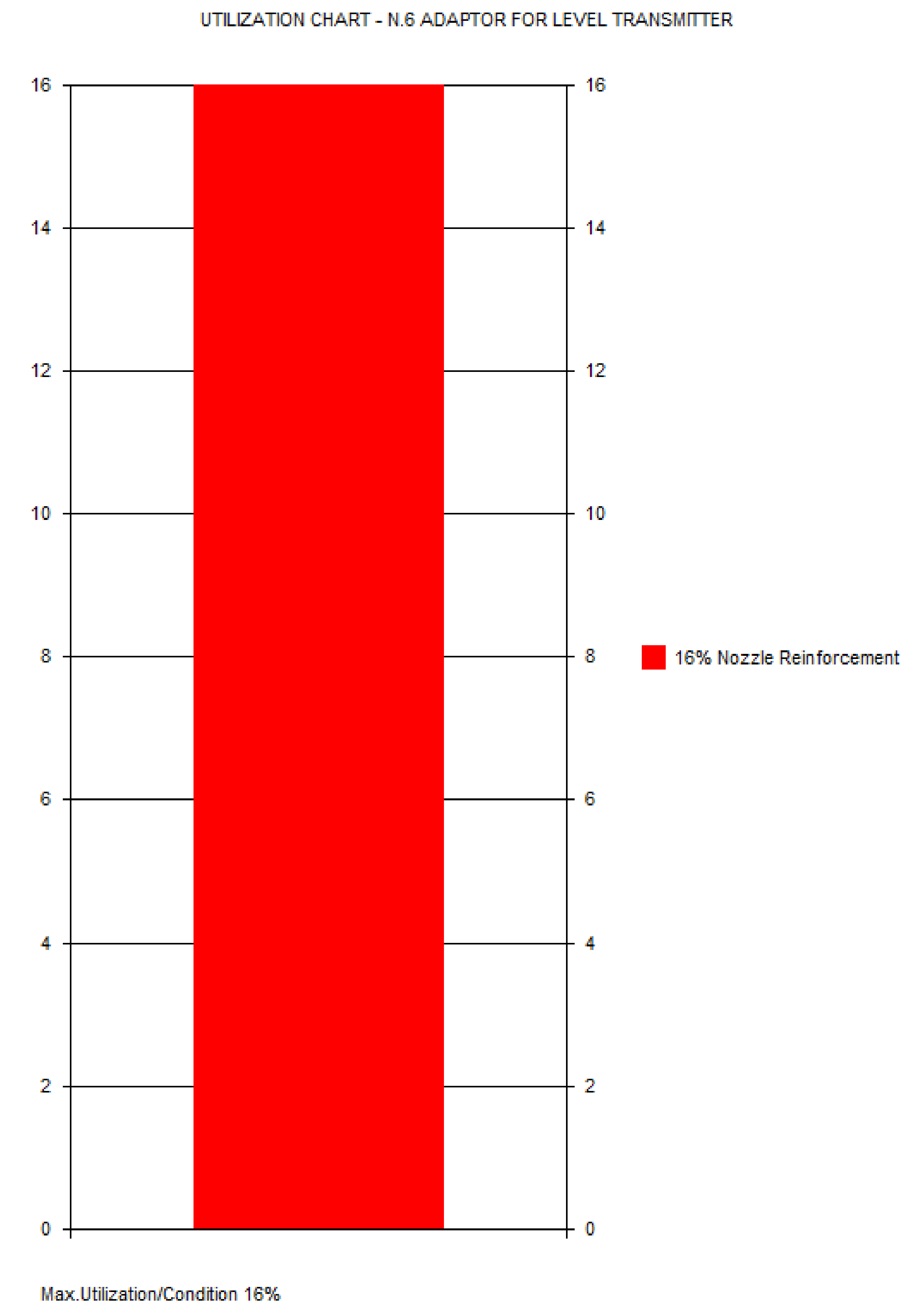
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afr*(fob-0.5*P)      (9.5-13)
=(288.02+0)*(147.5-0.5*0.2034)+0*(0-0.5*0.2034)+135*(146.25-0.5*0.2034)
=    62.18 kN
```

Nozzle Reinforcement pAAval=62.18 >= pAReq=10.01[kN]	16.0%	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)
=(288.02+0)*147.5+135*146.25/((49013.79+190+0.5*0)+0.5*(288.02+0+135+0))
=   1.2593 MPa
```

Volume:0.00 m3 Weight:0.2 kg (SG= 7.93)


UTILIZATION CHART - N.6 ADAPTOR FOR LEVEL TRANSMITTER
16
14
12
10
8
6
4
2
0
16% Nozzle Reinforcement
Max.Utilization/Condition 16%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    Main Shell
z-location of Centroid of Stiffener.................:z           600.00 mm
IDENTICAL COMPONENTS AT DIFFERENT LOCATIONS: YES
z-location of Centroid of Stiffener, component no.: 2:z         1400.00 mm
z-location of Centroid of Stiffener, component no.: 3:z            0.00 mm
z-location of Centroid of Stiffener, component no.: 4:z            0.00 mm
z-location of Centroid of Stiffener, component no.: 5:z            0.00 mm
z-location of Centroid of Stiffener, component no.: 6:z            0.00 mm
z-location of Centroid of Stiffener, component no.: 7:z            0.00 mm
z-location of Centroid of Stiffener, component no.: 8:z            0.00 mm
z-location of Centroid of Stiffener, component no.: 9:z            0.00 mm
z-location of Centroid of Stiffener, component no.: 10:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 11:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 12:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 13:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 14:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 15:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 16:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 17:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 18:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 19:z           0.00 mm
z-location of Centroid of Stiffener, component no.: 20:z           0.00 mm
```

GENERAL DESIGN DATA

```
PROCESS CARD:
General Design Data : Temp= 90°C, P=0.2000 MPa, c=0.0 mm, Pext=0.1000 MPa
```

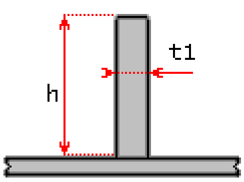
DATA FOR SHELL

```
NOMINAL WALL THICKNESS (uncorroded).................:en          4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th          0.3000 mm
OUTSIDE DIAMETER OF SHELL...........................:De         1108.00 mm
UNSUPPORTED LENGTH OF SHELL (Fig. 8.5-2)............:L          1000.00 mm
```

DATA FOR STIFFENING RING

```
STIFFENER LOCATION: External Stiffener
TYPE OF FORMING: Fabricated or Hot-Formed Stiffener
LIGHT/HEAVY TYPE: Light Stiffener
Specify the circularity tolerance limit to be applied for the design.: NO
DISTANCE BETWEEN HEAVY STIFFENERS (Table 8.5-1).....:LH         2000.00 mm
DISTANCE BETWEEN LIGHT STIFFENERS (Table 8.5-1).....:Ls         2000.00 mm
EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A THK<=8mm 90'C,A>=35%
Rm=520 Rp=250 Rpt=189.63 fst=141.25 f20=173.33 ftest=260 E=194028(N/mm2) ro=7.93
SAFETY FACTOR (1.0 carbon and 1.25 austenitic steels):s          1.2500
```

GEOMETRY & DIMENSIONS OF STIFFENER




```
Stiffener Geometry: Rib Profile/Flat Bar
TOTAL HEIGHT OF STIFFENER...........................:h            50.00 mm
THICKNESS OF THE WEB OF STIFFENER...................:t1          8.0000 mm
```

WELDING DATA

```
Include Welding Check of Stiffener Attachment Welds: NO
```

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

8.4.3 Nominal Elastic Limit Sige:

```
Sige = Rpt02 / s (8.4.3-1) =153.63/1.25=                    122.90 N/mm2
Analysis Thickness
ea = en - c - th =4-0-0.3=                                  3.7000 mm
```

Calculated Stiffener Properties

```
CROSS SECTIONAL AREA OF STIFFENER...................:As       400.00 mm2
WIDTH OF STIFFENER IN CONTACT WITH SHELL............:wi       8.0000 mm
RADIUS TO THE PART OF THE STIFF.FURTHEST FROM SHELL.:Rf       604.00 mm
RADIUS OF CENTROID OF RING STIFFENER CROSS SECTION..:Rs       579.00 mm
SECOND MOMENT OF AREA ABOUT AXIS THROUGH CENTROID...:Is       8.3333 cm4
```

SECT. 8.5.3.6 - DESIGN OF LIGHT STIFFENERS

```
Fabricated or Hot-Formed Stiffener (low residual stress) Sf=1.2
8.4.4 Minimum Safety Factor for Design Condition S=  1.5
Shell Radius
R = (De - ea) / 2 =(1108-3.7)/2=                            552.15 mm
Delta = 1.28 / Sqr( R * ea) (8.5.3-20) =1.28/Sqr(552.15*3.7)=   0.0283 mm(-1)
DL = Delta * L =0.0283*1000=                                 28.32
N = (COSH( DL) - COS( DL)) / (SINH( DL) + SIN( DL))               (8.5.3-21)
=(COSH(28.32)-COS(28.32))/(SINH(28.32)+SIN(28.32))=        1.0000
Modified Area of Stiffener
Am = (R ^ 2 / Rs ^ 2) * As (8.5.3-17) =(552.15^2/579^2)*400=   363.76 mm2
```

Calculation Details for Max.Stresses when n= 5

```
8.5.3.6.3 Determination of Le(effective length acting with stiffener)
Le = y1 * Sqr( R * ea) / Sqr( y3 * x + Sqr( 1 + y2 * x ^ 2))      (8.5.3-34)
=1.56*Sqr(552.15*3.7)/Sqr(0.6839*0.1675+Sqr(1+1.2*0.1675^2))=    66.30 mm

Cross Sectional Area of Stiffener and Effective Length of Shell
Ae = As + ea * Le (8.5.3-30/54) =400+3.7*66.3=               645.31 mm2

Parameter in Calculation of Overall Collapse
Xe = (ea^2*Le*0.5+As*(ea/2+lambda*(R-Rs)))/Ae                     (8.5.3-27)
=(3.7^2*66.3*0.5+400*(3.7/2+-1*(552.15-579)))/645.31=       18.49 mm

Second Moment of Area of the Composite Cross-Section of Stiffener and Shell
Ie = ea^3*Le/3+Is+As*(ea/2+lambda*(R-Rs))^2-Ae*Xe^2              (8.5.3-26)
=3.7^3*66.3/3+8.33+400*(3.7/2+-1*(552.15-579))^2-645.31*18.49^2=1,9323E05 mm4

beta = 1/(n^2-1+0.5*(PI*R/LH)^2)*(n^2*(LH/PI/R)^2+1)^2           (8.5.3-25)
=1/(5^2-1+0.5*(3.14*552.15/2000)^2)*(5^2*(2000/3.14/552.15)^2+1)^2=3,5004E-05
Theoretical Elastic Instability Pressure of a Stiffener
pg = E * ea * beta / R + (n ^ 2 - 1) * E * Ie / R ^ 3 / Ls       (8.5.3-24)
=194028*3.7*3.5004E-05/552.15+(5^2-1)*194028*1.9323E05/552.15^3/2000
=   2.7183 MPa

dmean = Max( Xe, lambda * (R - Rf) - Xe + 0.5 * ea)              (8.5.3-40)
=Max(18.49,-1*(552.15-604)-18.49+0.5*3.7)=                  35.21 mm
Pressure Causing Circumferential Yield in a Stiffener
Pys = Siges*ea*Rf/(R^2*0.85)*(1+Am/(wi*ea+2*N*ea/Delta))         (8.5.3-38)
=122.9*3.7*604/(552.15^2*0.85)*(1+363.76/(8*3.7+2*1.*3.7/0.0283))=   2.3852 MPa

PSSf = Pext * Sf * S =0.1*1.2*1.5=                           0.1800 MPa
```

8.5.3.6.4 Maximum Stresses in the Stiffener

```
Sigs = PSSf*Siges/Pys+E*dmean*CirTol*(n^2-1)*PSSf/(R*(pg-PSSf))     (8.5.3-37)
=0.18*122.9/2.39+194028*35.21*0.005*(5^2-1)*0.18/(552.15*(2.72-0.18))
=   114.56 N/mm2
```

Calculation summary for each n from n=2 to n=6

	n= 2	n= 3	n= 4	n= 5	n= 6
Le (34) mm =	69.8643	69.0337	67.8484	66.2992	64.3911
Ae (30) mm2 =	658.5	655.42	651.04	645.31	638.25
Xe (27) mm =	18.16	18.236	18.347	18.493	18.677
Ie (26) cm4 =	19.683	19.6	19.481	19.323	19.125
dmean(49) mm =	35.54	35.464	35.353	35.207	35.023
pg/H(24) MPa =	9.99	1.827	1.855	2.718	3.873
Pys (47) MPa =	2.385	2.385	2.385	2.385	2.385
Pmax MPa =	5.5499	1.0151	1.0303	1.5101	2.1517
Sigs(46)N/mm2=	12.7121	63.7455	109.4252	114.5562	114.2473

Check of Maximum Stiffener Stress

	n= 2	n= 3	n= 4	n= 5	n= 6
0<=Sigs<=Siges	U= 11%	U= 52%	U= 89%	U= 94%	U= 93%

Max.Stiff.Stress Sigs=114.56 <= Siges=122.9[N/mm2] (8.5.3-37)	93.2%	OK

Check of Elastic Instability

	n= 2	n= 3	n= 4	n= 5	n= 6
Pext<=pg/Sf*k	U= 2%	U= 10%	U= 10%	U= 7%	U= 5%

Elastic Instability PSSf=0.18 <= pg=2.72[N/mm2] (8.5.3-31)	6.6%	OK

8.5.3.8 Stiffener Tripping

```
8.5.3.8.2 For a flat bar stiffener
Values of SigX (Sigi/E)(d/ew)^2 (from Table 8.5-5) =1.14
Sige = SigX * E / (h / t1) ^ 2 =1.14*194028/(50/8)^2=        5662.51 N/mm2
```

Tripping Check Sige/4=1415.63 > Pext*Siges/Pys=5.15[N/mm2] (8.5.3-54)	0.3%	OK

CALCULATION SUMMARY

SECT. 8.5.3.6 - DESIGN OF LIGHT STIFFENERS

```
Sigs = PSSf*Siges/Pys+E*dmean*CirTol*(n^2-1)*PSSf/(R*(pg-PSSf))     (8.5.3-37)
=0.18*122.9/2.39+194028*35.21*0.005*(5^2-1)*0.18/(552.15*(2.72-0.18))
=   114.56 N/mm2
```

Check of Maximum Stiffener Stress

	n= 2	n= 3	n= 4	n= 5	n= 6
0<=Sigs<=Siges	U= 11%	U= 52%	U= 89%	U= 94%	U= 93%

Max.Stiff.Stress Sigs=114.56 <= Siges=122.9[N/mm2] (8.5.3-37)	93.2%	OK

Check of Elastic Instability

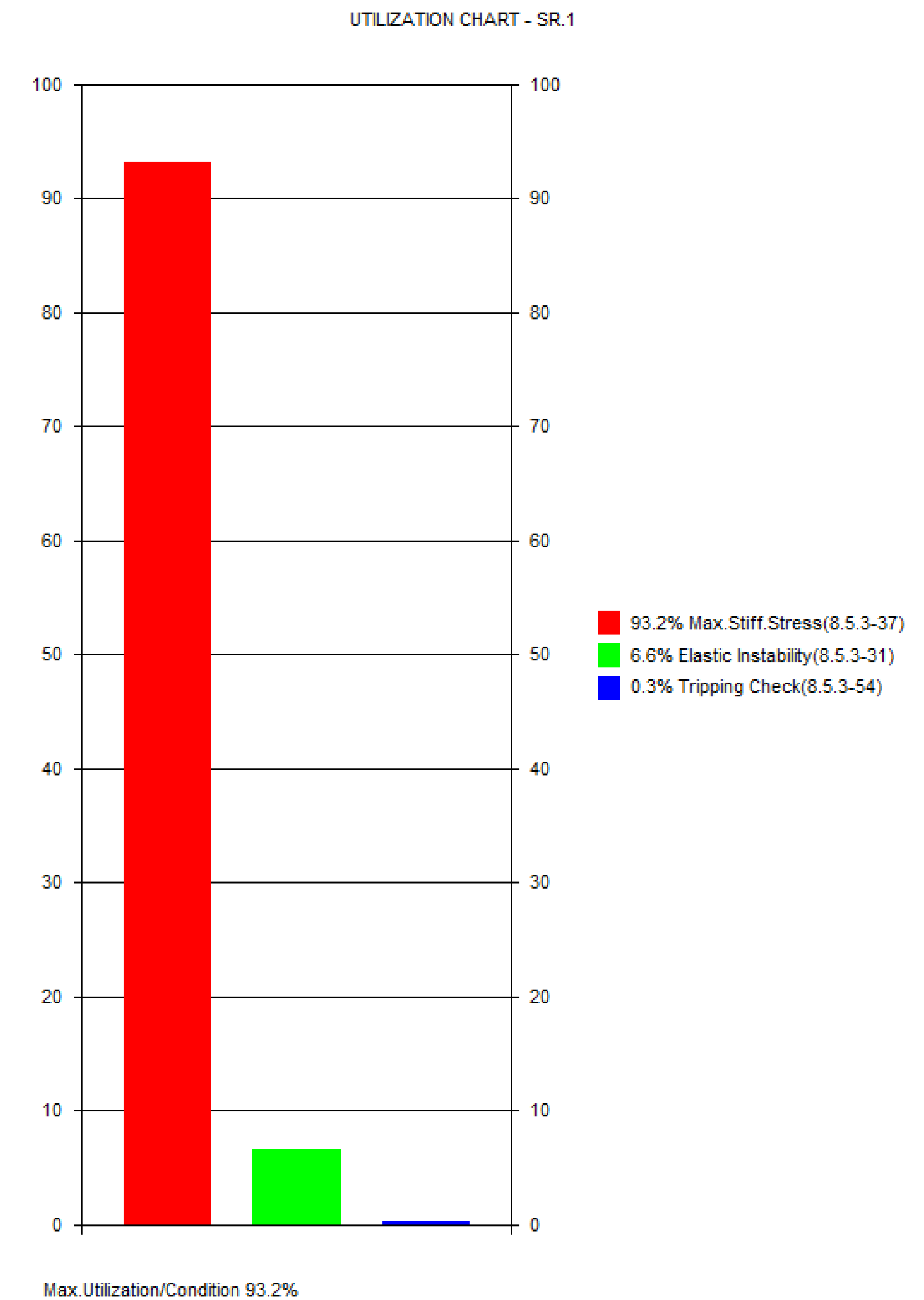
	n= 2	n= 3	n= 4	n= 5	n= 6
Pext<=pg/Sf*k	U= 2%	U= 10%	U= 10%	U= 7%	U= 5%

Elastic Instability PSSf=0.18 <= pg=2.72[N/mm2] (8.5.3-31)	6.6%	OK

8.5.3.8 Stiffener Tripping

Tripping Check Sige/4=1415.63 > Pext*Siges/Pys=5.15[N/mm2] (8.5.3-54)	0.3%	OK

Volume:0 m3 Total Weight:23.1 kg Average Weight of 2 components:11.5 kg (SG= 7.93)


UTILIZATION CHART - SR.1
100
90
80
70
60
50
40
30
20
10
0
93.2% Max.Stiff.Stress(8.5.3-37)
6.6% Elastic Instability(8.5.3-31)
0.3% Tripping Check(8.5.3-54)
Max.Utilization/Condition 93.2%

INPUT DATA

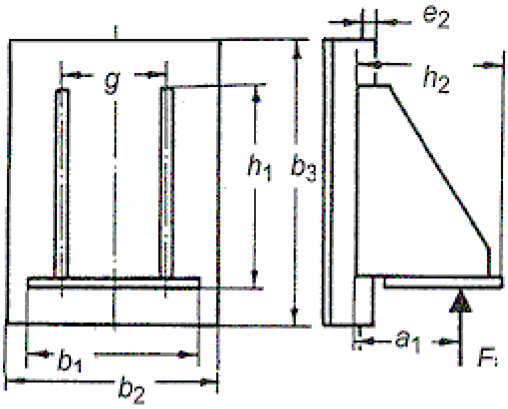
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    Main Shell
z-location of Bottom of Bracket Support at Loc.of Load Interaction:z    50.00 mm
Angular Location of First Bracket Support...........:phi         0.00 degr.
Attach Legs to Bracket Support: YES
Load Analysis: Detailed Load Analysis Included(wind, seismic, blast etc.)
```

SHELL DATA

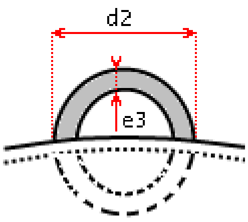
```
Shell Type: Cylindrical Shell
OUTSIDE DIAMETER OF SHELL...........................:De       1108.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled 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
```

BRACKET GEOMETRY




```
Type of Bracket Support: Type A
Number of Gussets/Rib Plates: 2 off Web/Rib plates per bracket
EN 10028-7:2016, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A THK<=8mm 90'C,A>=35%
Rm=520 Rp=250 Rpt=189.63 fb=141.25 f20=173.33 ftest=260 E=194028(N/mm2) ro=7.93
FLANGE WIDTH OF BRACKET.............................:b1        158.00 mm
DISTANCE BETWEEN WEBS OF BRACKET....................:g         140.00 mm
HEIGHT OF THE LEG SUPPORT...........................:h        1470.00 mm
LENGTH OF FILLET WELD ON LEG IN CYLINDRICAL SHELL...:h1        150.00 mm
DEPTH OF BRACKET....................................:h2        100.00 mm
NUMBER OF BRACKETS..................................:n         3.0000
DIST.FROM CENTRE OF LOAD TO SHELL OR REINF.PLATE....:a1         54.00 mm
THICKNESS OF RIB/WEB PLATES.........................:er        8.0000 mm
THICKNESS OF CONSOLE/BASE PLATE.....................:ec         10.00 mm
BASE PLATE LOAD BEARING WIDTH.......................:a2        104.00 mm
```

LEG DATA




```
Leg Geometry: Pipe
Legs are Cross Braced: NO
Comment (Optional):
OUTSIDE DIAMETER OF SUPPORTING LEG PIPE.............:d2        104.00 mm
WALL THICKNESS OF SUPPORTING LEG PIPE...............:e3        2.0000 mm
LEG CENTERLINE DIAMETER.............................:d1       1224.00 mm
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
```

DATA FOR REINFORCEMENT PAD

```
Reinforcement Pad: Included
WIDTH OF REINFORCEMENT PAD..........................:b2        200.00 mm
HEIGHT OF REINFORCEMENT PAD.........................:b3        200.00 mm
THICKNESS OF REINFORCEMENT PAD......................:e2        4.0000 mm
```

WELDING DATA

```
WELD JOINT COEFFICIENT..............................:z         0.8500
WELD BETWEEN BASE PLATE AND SHELL/PAD, THROAT DIMENSION:ab     2.0000 mm
WELD BETWEEN RIB PLATE AND SHELL/PAD, THROAT DIMENSION:ag      2.0000 mm
WELD BETWEEN SHELL AND PAD, THROAT DIMENSION........:apad      2.0000 mm
```

ANCHOR BOLT DATA

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

GENERAL LOAD DATA

```
Wind Load: YES
Type of Wind Load: User Defined - Wind Velocity
Wind Load Distribution: Evenly Wind Load Distribution
MAXIMUM/PEAK WIND VELOCITY..........................:Lw        1.0000 m/s
WIND FORCE/VESSEL SHAPE/DRAG COEFFICIENT............:Cf        0.7000
Check the possibility of wind induced vibration to RKF Part 3 BR-K1 Sect.5.2: 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:

Iienaiea	ID	Do1(mm)	Do2(mm)	L(mm)	Thk(mm)	z1(mm)	z2(mm)	A(m2)	Sp.Dens.	Weight(kg)
	E3.1	1110	-1	30	4	-315.6	0	0.02	7.93	45.7
Main Shell	S1.1	1108	1108	2000	4	0	2000	2.22	7.93	220
	E3.2	1110	1	30	4	2000	2315.6	0.02	7.93	45.7
Flange for Instrumental Top Pl	N.4	550	550	25	50	2315.6	2338	0.01	7.93	15.6

Table COMPONENTS Continued

Iienaiea	Vol(m3)	Material Name	fd	fa	fcd	fca	Iiaoeu oi?oainoe E
	0.205	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	85.9	106	194028
Main Shell	1.901	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	85.9	106.1	194028
	0.205	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	85.9	106	194028
Flange for Instrumental Top Pl	0.005	EN 10028-7:2016, 1.4404 X2CrNi	147.5	180	108	139.7	194028

Table COMPONENTS Continued

Iienaiea	S	Thinning(mm)	E20-Module	Pemax
	1.25	0.3	199964	0
Main Shell	1.25	0.3	199964	0.12289
	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	0.1	0	0	0.1
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	1.5	0	0	1.2
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)	0.1
Temperature D/A	D
Corrosion (mm)	0
Stress M-Factor :	1.425
Liquid Level (mm)	0
Sp.Gravity (Liq.)	1.2
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(2338--1420)=                3758.00 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*0.2676)*650.53=                                265.19 kg
V305 = 2.5 * Ca * I * W / R (30-5) =2.5*0.24*1*650.53/2.2=   177.42 kg
V342 = 0.56 * Ca * I * W (34-2) =0.56*0.24*1*650.53=          87.43 kg
V = Max( Min( V3045 , V3055 ), V3425 )
=Max(Min(265.19,177.42,)87.43)=                             177.42 kg
Shear force at bottom of vessel V
V = V * 9.81 / 1.4 =177.42*9.81/1.4=                          1.2432 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	0.6523 s	1.53 Hz
LOAD CASE NO: 2 - LC4 SHUT DOWN	0.2029 s	4.93 Hz
LOAD CASE NO: 3 - LC5 INSTALLATION	0.2029 s	4.93 Hz
LOAD CASE NO: 4 - LC1&2&3 OPER.WIND	0.2632 s	3.80 Hz
LOAD CASE NO: 5 - OPER.SEISMIC	0.2632 s	3.80 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	-37.91	0.00	0.00	0.00
LC4 SHUT DOWN	0.00	0.00	-3.67	0.00	0.01	0.00
LC5 INSTALLATION	0.00	0.00	-3.67	0.00	0.00	0.00
LC1&2&3 OPER.WIND	0.00	0.00	-6.18	0.00	0.00	0.00
OPER.SEISMIC	1.20	0.00	-6.18	0.00	0.98	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	-38.21	0.00	0.01	0.00
LC4 SHUT DOWN	0.00	0.00	-3.97	0.00	0.01	0.00
LC5 INSTALLATION	0.00	0.00	-3.97	0.00	0.01	0.00
LC1&2&3 OPER.WIND	0.00	0.00	-6.48	0.00	0.01	0.00
OPER.SEISMIC	1.20	0.00	-6.48	0.00	2.75	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)
=37914.88/3-4*6226.91/(3*1224)=                               -12.65 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=37914.88/3+4*6226.91/(3*1224)=                               -12.63 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	73.49	0.00	0.68	0.74	-11.89	21.2	48.3	69.5
2	120	73.49	0.00	0.68	0.74	-13.01	23.1	66.0	89.1
3	240	73.49	0.00	0.68	0.74	-13.01	23.1	66.0	89.1

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	73.49	0.00	0.68	0.56	-12.36	22.0	66.0	88.0
2	180	73.49	0.00	0.68	0.56	-13.20	23.5	48.3	71.8
3	300	73.49	0.00	0.68	0.56	-12.36	22.0	66.0	88.0

```
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)= 89.15 N/mm2
```

Axial Stresses in the Leg Siga=23.48 <= fl=235[N/mm2]	9.9%	OK
Combined Stresses in the Leg Sigc=89.15 <= 1.5*fl=352.5[N/mm2]	25.2%	OK

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

Deflection in the Legs Defl=0.0018 <= DeflMax=7.35[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*1470/(36.16*110.56)=                                   0.5516
From table 6.2: Selection of buckling curve : a
Imperfection factor alfa from Table  6.1: alfa= .21
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.21*(0.5516-0.2)+0.5516^2)=                        0.6891
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.6891+Sqr(0.6891^2-0.5516^2,))1)=                  0.9074
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-13.2,-12650)=                    13.20 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9074*562.15*156.67/1=                                     79.92 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(7.3488E05/52*Cos(0)^2+7.3488E05/52*Sin(0)^2)=     2.2141 kNm
```

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

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	0	11.89	79.92	0.00	2.21	0.1491
2	120	13.01	79.92	0.00	2.21	0.1630
3	240	13.01	79.92	0.00	2.21	0.1630

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

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	60	12.36	79.92	0.00	2.21	0.1549
2	180	13.20	79.92	0.00	2.21	0.1654
3	300	12.36	79.92	0.00	2.21	0.1549

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(13196.46/79919.66+1.5*361.72/2.2141E06,-12650/79919.66)=    0.1654
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.1654 <= 1.0=1	16.5%	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.
```

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

```
Shell Inside Diameter
Di = De - 2 * (en - c) =1108-2*(4-0)=                        1100.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =1100=                                              1100.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0036« » OK«
»a) en/Deq=0.0036 <= 0.05« » OK«
»b) g/h1=0.9333 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1=0.9333« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=200 <= 1.5*h1=225[mm] « » OK«
»d) b2=200 >= 0.6*b3=120[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
=(37914.88+4*6226.91/(1100+2*(54+3.7+4)))/3=                 12.65 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =0.7382/3=                                    2,4607E-04 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =200/Sqr(1100*3.7)=     3.1350
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)                 (16.10-12)
=1/Sqr(0.36+0.5*3.13+0.5*3.13^2)=                            0.3823
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*3.13,0.4)=    0.2508
Sigm = P * Deq / (2 * ea) (16.6-11) =0.2*1100/(2*3.7)=          29.73 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =29.73/(1.05*265)=             0.1068
Sigball = K1 * K2 * fs (16.6-6) =1.24*1.05*265=                344.63 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi                                        (16.10-14)
=54+4+0.2461*1470/12645.08=                                  58.03 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                       (16.10-15)
=(344.63*3.7^2*200/(0.3823*58.03))=                          42.53 kN
```

Loads in Cyl.Shell Fvi=12.65 <= Fimax=42.53[kN]	29.7%	OK

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

Bracket Baseplate Minimum Thickness

Base Plate Bearing Pressure Pb
Pb = Fvi / (b1 * a2) =12645.08/(158*104)= 0.7695 N/mm2

Baseplate with Double Gusset, D.Moss 3rd.ed. p. 190

Required Thickness due to Bending Moment(simply supported/fixed beam)
tbBending = Sqr(Fvi * g / ((h2 - dh) * fb))
=Sqr(12645.08*140/((100-0)*260))= 8.2516 mm

(ROARK Table 26)
tbBearing = Sqr(beta * Pb * h2 ^ 2 / fb)
=Sqr(0.87*0.7695*100^2/260)= 5.0744 mm

tbmin = MAX(tbBending , tbBearing) =MAX(8.25,5.07)= 8.2516 mm

Bracket Baseplate Thickness tbmin=8.25 <= ec=10[mm]	82.5%	OK

Stresses in Gusset/Rib Plate (D.MOSS 3rd.Ed. Page 189)

Axial Load on Gusset/Rib
Fga = Fvi * Sin(teta) + Fhi * Cos(teta))
=12645.08*Sin(56.3)+0.2461*Cos(56.3))= 10.52 kN
Bending Moment on Gusset/Rib
Mgb = Fvi*Cos(teta)*(a1-h2/2)*Sin(teta)+Fhi*h
=12645.08*Cos(56.3)*(54-100/2)*Sin(56.3)+0.2461*1470= 23.71 kNmm
Required Thickness of Gusset/Rib Plate
trmin = 2/(ng*fbc)*(Fga/(h2*Sin(teta))+6*Mgb/(h2*Sin(teta))^2)
=2/(2*130)*(10521.48/(100*Sin(56.3))+6*23.71/(100*Sin(56.3))^2)= 1.1308 mm

Gusset/Rib Plate trmin=1.13 <= er=8[mm]	14.1%	OK

Fillet Weld Sizing

Continous welding is assumed for all fillet welds.

Fillet Welds on Gussets and Baseplate

Throat Area of Weld
Aw = 4 * ag * h1 =4*2*150= 1200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixx = 2 * ag * h1 ^ 3 / 6 =2*2*150^3/6= 2,25E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyy = 2 * ag * h1 ^ 2 * b1 / 2 =2*2*150^2*158/2= 7,11E06 mm4
Polar Moment of Inertia
Jxy = 2 * ag * h1 * (3 * b1 ^ 2 + h1 ^ 2) / 6
=2*2*150*(3*158^2+150^2)/6= 9,7392E06 mm4
Primary Shear Stress in Weld
Tauw = Fvi / Aw =12645.08/1200= 10.54 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwx = (Fvi * a1 + Fhi * h) * ry / Ixx
=(12645.08*54+0.2461*1470)*75/2.25E06= 22.77 N/mm2
Total Stresses in Weld Case A
SigwTotx = Sqr(Sigwx ^ 2 + 3 * Tauw ^ 2)
=Sqr(22.77^2+3*10.54^2)= 29.18 N/mm2

Total Stresses in Weld Case A SigwTotx=29.18 <= z*fb=221[N/mm2]	13.2%	OK

Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauyw = Abs(Fhi / Aw) =Abs(0.2461/1200)= 2,0505E-04 N/mm2
Normal Stress in Weld X-X

```
SigwxB = Fvi * a1 * ry / Ixx =12645.08*54*75/2.25E06=          22.76 N/mm2
Normal Stress in Weld Y-Y
SigwyB = Fhi * a1 * rx / Iyy =0.2461*54*79/7.11E06=        1,4764E-04 N/mm2
Shear due to Torsional Moment y-y
TauyTw = Fhi * h * ry / Jxy =0.2461*1470*75/9.7392E06=       0.0028 N/mm2
Shear due to Torsional Moment x-x
TauxTw = Fhi * h * rx / Jxy =0.2461*1470*79/9.7392E06=       0.0029 N/mm2
Total Shear Stresses
TauTot = Sqr(( Tauw + TauxTw) ^ 2 + (Tauw + TauyTw) ^ 2)
=Sqr((10.54+0.0029)^2+(10.54+0.0028)^2)=                   14.91 N/mm2
Total Stresses in Weld Case B
SigwTotB = Sqr( SigwxB ^ 2 + SigwyB ^ 2 + 3 * TauTot ^ 2)
=Sqr(22.76^2+1.4764E-04^2+3*14.91^2)=                      34.42 N/mm2
```

Total Stresses in Weld Case B SigwTotB=34.42 <= z*fb=221[N/mm2]	15.5%	OK

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(200+200)=               1600.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=2*200^2/6*(3*200+200)=                                1,0667E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*200^2/6*(3*200+200)=                                1,0667E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(200+200)^3/6=      2,1333E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =12645.08/1600=                       7.9032 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(12645.08*54+0.2461*1470)*0.5*200/1.0667E07=             6.4050 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(6.4^2+3*7.9^2)=                                       15.11 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=15.11 <= z*fs=225.25[N/mm2]	6.7%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0.2461/1600)=            1,5379E-04 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=12645.08*54*0.5*200/1.0667E07=                           6.4016 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0.2461*54*0.5*200/1.0667E07=                          1,2457E-04 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0.2461*1470*0.5*200/2.1333E07=                           0.0017 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0.2461*1470*0.5*200/2.1333E07=                           0.0017 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((7.9+0.0017)^2+(7.9+0.0017)^2)=                       11.18 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(6.4^2+1.2457E-04^2+3*11.18^2)=                        20.39 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=20.39 <= z*fs=225.25[N/mm2]	9.0%	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)
=3667.39/3-4*7007.85/(3*1224)=                          -1.23 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=3667.39/3+4*7007.85/(3*1224)=                          -1.21 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	73.49	0.00	0.07	0.07	-1.15	2.0	4.7	6.8
2	120	73.49	0.00	0.07	0.07	-1.26	2.2	6.4	8.7
3	240	73.49	0.00	0.07	0.07	-1.26	2.2	6.4	8.7

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	73.49	0.00	0.07	0.05	-1.20	2.1	6.4	8.5
2	180	73.49	0.00	0.07	0.05	-1.28	2.3	4.7	7.0
3	300	73.49	0.00	0.07	0.05	-1.20	2.1	6.4	8.5

```
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)= 8.66 N/mm2
```

Axial Stresses in the Leg Siga=2.27 <= fl=156.67[N/mm2]	1.4%	OK
Combined Stresses in the Leg Sigc=8.66 <= 1.5*fl=235.[N/mm2]	3.6%	OK

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

Deflection in the Legs Defl=0.0033 <= DeflMax=7.35[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.
Lambda = K1 * L / (r * Lambda1)
=1.5*1470/(36.16*110.56)=                                 0.5516
From table 6.2: Selection of buckling curve : a
Imperfection factor alfa from Table  6.1: alfa= .21
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.21*(0.5516-0.2)+0.5516^2)=                      0.6891
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.6891+Sqr(0.6891^2-0.5516^2,))1)=                0.9074
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-1.28,-1230)=                   1.2773 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9074*562.15*156.67/1=                                   79.92 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(7.3488E05/52*Cos(0)^2+7.3488E05/52*Sin(0)^2)=     2.2141 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	1.15	79.92	0.00	2.21	0.0148
2	120	1.26	79.92	0.00	2.21	0.0162
3	240	1.26	79.92	0.00	2.21	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	1.20	79.92	0.00	2.21	0.0154
2	180	1.28	79.92	0.00	2.21	0.0164
3	300	1.20	79.92	0.00	2.21	0.0154

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(1277.27/79919.66+1.5*663.14/2.2141E06,-1230/79919.66)=   0.0164
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0164 <= 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.
```

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

```
Shell Inside Diameter
Di = De - 2 * (en - c) =1108-2*(4-0)=                        1100.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =1100=                                              1100.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0036« » OK«
»a) en/Deq=0.0036 <= 0.05« » OK«
»b) g/h1=0.9333 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1=0.9333« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=200 <= 1.5*h1=225[mm] « » OK«
»d) b2=200 >= 0.6*b3=120[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
=(3667.39+4*7007.85/(1100+2*(54+3.7+4)))/3=                1.2301 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =1.35/3=                                    4,5112E-04 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =200/Sqr(1100*3.7)=   3.1350
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)              (16.10-12)
=1/Sqr(0.36+0.5*3.13+0.5*3.13^2)=                          0.3823
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*3.13,0.4)=   0.2508
Sigm = P * Deq / (2 * ea) (16.6-11) =0*1100/(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) =1.33*1.25*180=            299.81 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi                                    (16.10-14)
=54+4+0.4511*1470/1230.1=                                   58.54 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                    (16.10-15)
=(299.81*3.7^2*200/(0.3823*58.54))=                         36.68 kN
```

Loads in Cyl.Shell Fvi=1.23 <= Fimax=36.68[kN]	3.3%	OK

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

Bracket Baseplate Minimum Thickness

Base Plate Bearing Pressure Pb
Pb = Fvi / (b1 * a2) =1230.1/(158*104)= 0.0749 N/mm2

Baseplate with Double Gusset, D.Moss 3rd.ed. p. 190

Required Thickness due to Bending Moment(simply supported/fixed beam)
tbBending = Sqr(Fvi * g / ((h2 - dh) * fb))
=Sqr(1230.1*140/((100-0)*173.33))= 3.1521 mm

(ROARK Table 26)
tbBearing = Sqr(beta * Pb * h2 ^ 2 / fb)
=Sqr(0.87*0.0749*100^2/173.33)= 1.9384 mm

tbmin = MAX(tbBending , tbBearing) =MAX(3.15,1.94)= 3.1521 mm

Bracket Baseplate Thickness tbmin=3.15 <= ec=10[mm]	31.5%	OK

Stresses in Gusset/Rib Plate (D.MOSS 3rd.Ed. Page 189)

Axial Load on Gusset/Rib
Fga = Fvi * Sin(teta) + Fhi * Cos(teta))
=1230.1*Sin(56.3)+0.4511*Cos(56.3))= 1.0238 kN
Bending Moment on Gusset/Rib
Mgb = Fvi*Cos(teta)*(a1-h2/2)*Sin(teta)+Fhi*h
=1230.1*Cos(56.3)*(54-100/2)*Sin(56.3)+0.4511*1470= 2.9341 kNmm
Required Thickness of Gusset/Rib Plate
trmin = 2/(ng*fbc)*(Fga/(h2*Sin(teta))+6*Mgb/(h2*Sin(teta))^2)
=2/(2*86.67)*(1023.76/(100*Sin(56.3))+6*2.93/(100*Sin(56.3))^2)= 0.1713 mm

Gusset/Rib Plate trmin=0.1713 <= er=8[mm]	2.1%	OK

Fillet Weld Sizing

Continous welding is assumed for all fillet welds.

Fillet Welds on Gussets and Baseplate

Throat Area of Weld
Aw = 4 * ag * h1 =4*2*150= 1200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixx = 2 * ag * h1 ^ 3 / 6 =2*2*150^3/6= 2,25E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyy = 2 * ag * h1 ^ 2 * b1 / 2 =2*2*150^2*158/2= 7,11E06 mm4
Polar Moment of Inertia
Jxy = 2 * ag * h1 * (3 * b1 ^ 2 + h1 ^ 2) / 6
=2*2*150*(3*158^2+150^2)/6= 9,7392E06 mm4
Primary Shear Stress in Weld
Tauw = Fvi / Aw =1230.1/1200= 1.0251 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwx = (Fvi * a1 + Fhi * h) * ry / Ixx
=(1230.1*54+0.4511*1470)*75/2.25E06= 2.2363 N/mm2
Total Stresses in Weld Case A
SigwTotx = Sqr(Sigwx ^ 2 + 3 * Tauw ^ 2)
=Sqr(2.24^2+3*1.03^2)= 2.8554 N/mm2

Total Stresses in Weld Case A SigwTotx=2.86 <= z*fb=147.33[N/mm2]	1.9%	OK

Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauyw = Abs(Fhi / Aw) =Abs(0.4511/1200)= 3,7593E-04 N/mm2
Normal Stress in Weld X-X

```
SigwxB = Fvi * a1 * ry / Ixx =1230.1*54*75/2.25E06=          2.2142 N/mm2
Normal Stress in Weld Y-Y
SigwyB = Fhi * a1 * rx / Iyy =0.4511*54*79/7.11E06=       2,7067E-04 N/mm2
Shear due to Torsional Moment y-y
TauyTw = Fhi * h * ry / Jxy =0.4511*1470*75/9.7392E06=       0.0051 N/mm2
Shear due to Torsional Moment x-x
TauxTw = Fhi * h * rx / Jxy =0.4511*1470*79/9.7392E06=       0.0054 N/mm2
Total Shear Stresses
TauTot = Sqr(( Tauw + TauxTw) ^ 2 + (Tauw + TauyTw) ^ 2)
=Sqr((1.03+0.0054)^2+(1.03+0.0051)^2)=                     1.4571 N/mm2
Total Stresses in Weld Case B
SigwTotB = Sqr( SigwxB ^ 2 + SigwyB ^ 2 + 3 * TauTot ^ 2)
=Sqr(2.21^2+2.7067E-04^2+3*1.46^2)=                        3.3574 N/mm2
```

Total Stresses in Weld Case B SigwTotB=3.36 <= z*fb=147.33[N/mm2]	2.2%	OK

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(200+200)=                1600.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=2*200^2/6*(3*200+200)=                                  1,0667E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*200^2/6*(3*200+200)=                                  1,0667E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(200+200)^3/6=        2,1333E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =1230.1/1600=                          0.7688 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(1230.1*54+0.4511*1470)*0.5*200/1.0667E07=                 0.6290 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0.629^2+3*0.7688^2)=                                   1.4727 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=1.47 <= z*fs=153.[N/mm2]	0.9%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0.4511/1600)=           2,8195E-04 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=1230.1*54*0.5*200/1.0667E07=                               0.6227 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0.4511*54*0.5*200/1.0667E07=                            2,2838E-04 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0.4511*1470*0.5*200/2.1333E07=                             0.0031 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0.4511*1470*0.5*200/2.1333E07=                             0.0031 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((0.7688+0.0031)^2+(0.7688+0.0031)^2)=                  1.0917 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0.6227^2+2.2838E-04^2+3*1.09^2)=                       1.9907 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=1.99 <= z*fs=153.[N/mm2]	1.3%	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)
=3667.39/3-4*6653.83/(3*1224)=                            -1.23 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=3667.39/3+4*6653.83/(3*1224)=                            -1.22 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	73.49	0.00	0.07	0.07	-1.15	2.0	4.7	6.8
2	120	73.49	0.00	0.07	0.07	-1.26	2.2	6.4	8.7
3	240	73.49	0.00	0.07	0.07	-1.26	2.2	6.4	8.7

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	73.49	0.00	0.07	0.05	-1.20	2.1	6.4	8.5
2	180	73.49	0.00	0.07	0.05	-1.28	2.3	4.7	7.0
3	300	73.49	0.00	0.07	0.05	-1.20	2.1	6.4	8.5

```
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)= 8.66 N/mm2
```

Axial Stresses in the Leg Siga=2.27 <= fl=156.67[N/mm2]	1.4%	OK
Combined Stresses in the Leg Sigc=8.66 <= 1.5*fl=235.[N/mm2]	3.6%	OK

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

Deflection in the Legs Defl=0.0021 <= DeflMax=7.35[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*1470/(36.16*110.56)=                                 0.5516
From table 6.2: Selection of buckling curve : a
Imperfection factor alfa from Table  6.1: alfa= .21
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.21*(0.5516-0.2)+0.5516^2)=                      0.6891
Kappa = MIN( 1 / (phi + Sqr( phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.6891+Sqr(0.6891^2-0.5516^2,))1)=                0.9074
Maximum Compressive Force in Leg
NFd = MAX( FviMin, F1) =MAX(-1.28,-1230)=                   1.2771 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9074*562.15*156.67/1=                                   79.92 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos( 0) ^ 2 + Iyy / a * Sin( 0) ^ 2)
=156.67*(7.3488E05/52*Cos(0)^2+7.3488E05/52*Sin(0)^2)=    2.2141 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	1.15	79.92	0.00	2.21	0.0147
2	120	1.26	79.92	0.00	2.21	0.0160
3	240	1.26	79.92	0.00	2.21	0.0160

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

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	60	1.20	79.92	0.00	2.21	0.0152
2	180	1.28	79.92	0.00	2.21	0.0163
3	300	1.20	79.92	0.00	2.21	0.0152

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(1277.06/79919.66+1.5*422./2.2141E06,-1230/79919.66)=   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.
```

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

```
Shell Inside Diameter
Di = De - 2 * (en - c) =1108-2*(4-0)=                       1100.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =1100=                                             1100.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0036« » OK«
»a) en/Deq=0.0036 <= 0.05« » OK«
»b) g/h1=0.9333 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1=0.9333« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=200 <= 1.5*h1=225[mm] « » OK«
»d) b2=200 >= 0.6*b3=120[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
=(3667.39+4*6653.83/(1100+2*(54+3.7+4)))/3=              1.2297 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =0.8612/3=                                  2,8708E-04 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =200/Sqr(1100*3.7)=   3.1350
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)         (16.10-12)
=1/Sqr(0.36+0.5*3.13+0.5*3.13^2)=                         0.3823
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*3.13,0.4)=   0.2508
Sigm = P * Deq / (2 * ea) (16.6-11) =0*1100/(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) =1.33*1.25*180=           299.81 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi                               (16.10-14)
=54+4+0.2871*1470/1229.72=                                 58.34 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))               (16.10-15)
=(299.81*3.7^2*200/(0.3823*58.34))=                        36.80 kN
```

Loads in Cyl.Shell Fvi=1.23 <= Fimax=36.8[kN]	3.3%	OK

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

Bracket Baseplate Minimum Thickness

```
Base Plate Bearing Pressure Pb
Pb = Fvi / (b1 * a2) =1229.72/(158*104)=                    0.0748 N/mm2
```

Baseplate with Double Gusset, D.Moss 3rd.ed. p. 190

```
Required Thickness due to Bending Moment(simply supported/fixed beam)
tbBending = Sqr( Fvi * g / ((h2 - dh) * fb))
=Sqr(1229.72*140/((100-0)*173.33))=                       3.1516 mm
(ROARK Table 26)
tbBearing = Sqr( beta * Pb * h2 ^ 2 / fb)
=Sqr(0.87*0.0748*100^2/173.33)=                           1.9381 mm
tbmin = MAX( tbBending , tbBearing) =MAX(3.15,1.94)=        3.1516 mm
```

Bracket Baseplate Thickness tbmin=3.15 <= ec=10[mm]	31.5%	OK

Stresses in Gusset/Rib Plate (D.MOSS 3rd.Ed. Page 189)

```
Axial Load on Gusset/Rib
Fga = Fvi * Sin( teta) + Fhi * Cos( teta))
=1229.72*Sin(56.3)+0.2871*Cos(56.3))=                     1.0233 kN
Bending Moment on Gusset/Rib
Mgb = Fvi*Cos(teta)*(a1-h2/2)*Sin(teta)+Fhi*h
=1229.72*Cos(56.3)*(54-100/2)*Sin(56.3)+0.2871*1470=      2.6922 kNmm
Required Thickness of Gusset/Rib Plate
trmin = 2/(ng*fbc)*(Fga/(h2*Sin(teta))+6*Mgb/(h2*Sin(teta))^2)
=2/(2*86.67)*(1023.34/(100*Sin(56.3))+6*2.69/(100*Sin(56.3))^2)=   0.1688 mm
```

Gusset/Rib Plate trmin=0.1688 <= er=8[mm]	2.1%	OK

Fillet Weld Sizing

Continous welding is assumed for all fillet welds.

Fillet Welds on Gussets and Baseplate

```
Throat Area of Weld
Aw = 4 * ag * h1 =4*2*150=                                 1200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixx = 2 * ag * h1 ^ 3 / 6 =2*2*150^3/6=                   2,25E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyy = 2 * ag * h1 ^ 2 * b1 / 2 =2*2*150^2*158/2=          7,11E06 mm4
Polar Moment of Inertia
Jxy = 2 * ag * h1 * (3 * b1 ^ 2 + h1 ^ 2) / 6
=2*2*150*(3*158^2+150^2)/6=                              9,7392E06 mm4
Primary Shear Stress in Weld
Tauw = Fvi / Aw =1229.72/1200=                              1.0248 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwx = (Fvi * a1 + Fhi * h) * ry / Ixx
=(1229.72*54+0.2871*1470)*75/2.25E06=                     2.2276 N/mm2
Total Stresses in Weld Case A
SigwTotx = Sqr( Sigwx ^ 2 + 3 * Tauw ^ 2)
=Sqr(2.23^2+3*1.02^2)=                                    2.8482 N/mm2
```

Total Stresses in Weld Case A SigwTotx=2.85 <= z*fb=147.33[N/mm2]	1.9%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauyw = Abs( Fhi / Aw) =Abs(0.2871/1200)=                 2,3923E-04 N/mm2
Normal Stress in Weld X-X
```

```
SigwxB = Fvi * a1 * ry / Ixx =1229.72*54*75/2.25E06=          2.2135 N/mm2
Normal Stress in Weld Y-Y
SigwyB = Fhi * a1 * rx / Iyy =0.2871*54*79/7.11E06=       1,7225E-04 N/mm2
Shear due to Torsional Moment y-y
TauyTw = Fhi * h * ry / Jxy =0.2871*1470*75/9.7392E06=        0.0032 N/mm2
Shear due to Torsional Moment x-x
TauxTw = Fhi * h * rx / Jxy =0.2871*1470*79/9.7392E06=        0.0034 N/mm2
Total Shear Stresses
TauTot = Sqr(( Tauw + TauxTw) ^ 2 + (Tauw + TauyTw) ^ 2)
=Sqr((1.02+0.0034)^2+(1.02+0.0032)^2)=                      1.4540 N/mm2
Total Stresses in Weld Case B
SigwTotB = Sqr( SigwxB ^ 2 + SigwyB ^ 2 + 3 * TauTot ^ 2)
=Sqr(2.21^2+1.7225E-04^2+3*1.45^2)=                         3.3528 N/mm2
```

Total Stresses in Weld Case B SigwTotB=3.35 <= z*fb=147.33[N/mm2]	2.2%	OK

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(200+200)=                  1600.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=2*200^2/6*(3*200+200)=                                   1,0667E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*200^2/6*(3*200+200)=                                   1,0667E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(200+200)^3/6=         2,1333E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =1229.72/1600=                          0.7686 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(1229.72*54+0.2871*1470)*0.5*200/1.0667E07=                0.6265 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(0.6265^2+3*0.7686^2)=                                  1.4713 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=1.47 <= z*fs=153.[N/mm2]	0.9%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0.2871/1600)=             1,7942E-04 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=1229.72*54*0.5*200/1.0667E07=                              0.6225 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0.2871*54*0.5*200/1.0667E07=                             1,4533E-04 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0.2871*1470*0.5*200/2.1333E07=                             0.0020 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0.2871*1470*0.5*200/2.1333E07=                             0.0020 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((0.7686+0.002)^2+(0.7686+0.002)^2)=                    1.0897 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(0.6225^2+1.4533E-04^2+3*1.09^2)=                       1.9875 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=1.99 <= z*fs=153.[N/mm2]	1.2%	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)
=6175.15/3-4*5593.02/(3*1224)= -2.06 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=6175.15/3+4*5593.02/(3*1224)= -2.05 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	73.49	0.00	0.11	0.12	-1.94	3.4	7.9	11.4
2	120	73.49	0.00	0.11	0.12	-2.12	3.8	10.8	14.5
3	240	73.49	0.00	0.11	0.12	-2.12	3.8	10.8	14.5

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	73.49	0.00	0.11	0.09	-2.01	3.6	10.8	14.4
2	180	73.49	0.00	0.11	0.09	-2.15	3.8	7.9	11.7
3	300	73.49	0.00	0.11	0.09	-2.01	3.6	10.8	14.4

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)= 14.55 N/mm2

Axial Stresses in the Leg Siga=3.82 <= fl=123.2[N/mm2]	3.1%	OK
Combined Stresses in the Leg Sigc=14.55 <= 1.5*fl=184.8[N/mm2]	7.8%	OK

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

Deflection in the Legs Defl=0.0033 <= DeflMax=7.35[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*1470/(36.16*110.56)= 0.5516
From table 6.2: Selection of buckling curve : a
Imperfection factor alfa from Table 6.1: alfa= .21
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.21*(0.5516-0.2)+0.5516^2)= 0.6891
Kappa = MIN(1 / (phi + Sqr(phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.6891+Sqr(0.6891^2-0.5516^2,))1)= 0.9074
Maximum Compressive Force in Leg
NFd = MAX(FviMin, F1) =MAX(-2.15,-2060)= 2.1500 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9074*562.15*156.67/1= 79.92 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos(0) ^ 2 + Iyy / a * Sin(0) ^ 2)
=156.67*(7.3488E05/52*Cos(0)^2+7.3488E05/52*Sin(0)^2)= 2.2141 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	1.94	79.92	0.00	2.21	0.0247
2	120	2.12	79.92	0.00	2.21	0.0270
3	240	2.12	79.92	0.00	2.21	0.0270

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

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	60	2.01	79.92	0.00	2.21	0.0256
2	180	2.15	79.92	0.00	2.21	0.0274
3	300	2.01	79.92	0.00	2.21	0.0256

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(2150.01/79919.66+1.5*663.14/2.2141E06,-2060/79919.66)=    0.0274
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0274 <= 1.0=1	2.7%	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.

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

```
Shell Inside Diameter
Di = De - 2 * (en - c) =1108-2*(4-0)=                    1100.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =1100=                                          1100.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0036« » OK«
»a) en/Deq=0.0036 <= 0.05« » OK«
»b) g/h1=0.9333 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1=0.9333« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=200 <= 1.5*h1=225[mm] « » OK«
»d) b2=200 >= 0.6*b3=120[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
=(6175.15+4*5593.02/(1100+2*(54+3.7+4)))/3=            2.0645 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =1.35/3=                                4,5112E-04 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =200/Sqr(1100*3.7)=   3.1350
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)             (16.10-12)
=1/Sqr(0.36+0.5*3.13+0.5*3.13^2)=                      0.3823
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*3.13,0.4)=   0.2508
Sigm = P * Deq / (2 * ea) (16.6-11) =0.18*1100/(2*3.7)=       26.76 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =26.76/(1.25*147.5)=         0.1451
Sigball = K1 * K2 * fs (16.6-6) =1.2*1.25*147.5=             221.46 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi                                   (16.10-14)
=54+4+0.4511*1470/2064.48=                              58.32 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                   (16.10-15)
=(221.46*3.7^2*200/(0.3823*58.32))=                     27.19 kN
```

Loads in Cyl.Shell Fvi=2.06 <= Fimax=27.19[kN]	7.5%	OK

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

Bracket Baseplate Minimum Thickness

Base Plate Bearing Pressure Pb
Pb = Fvi / (b1 * a2) =2064.48/(158*104)= 0.1256 N/mm2

Baseplate with Double Gusset, D.Moss 3rd.ed. p. 190

Required Thickness due to Bending Moment(simply supported/fixed beam)
tbBending = Sqr(Fvi * g / ((h2 - dh) * fb))
=Sqr(2064.48*140/((100-0)*141.25))= 4.5235 mm

(ROARK Table 26)
tbBearing = Sqr(beta * Pb * h2 ^ 2 / fb)
=Sqr(0.87*0.1256*100^2/141.25)= 2.7818 mm

tbmin = MAX(tbBending , tbBearing) =MAX(4.52,2.78)= 4.5235 mm

Bracket Baseplate Thickness tbmin=4.52 <= ec=10[mm]	45.2%	OK

Stresses in Gusset/Rib Plate (D.MOSS 3rd.Ed. Page 189)

Axial Load on Gusset/Rib
Fga = Fvi * Sin(teta) + Fhi * Cos(teta))
=2064.48*Sin(56.3)+0.4511*Cos(56.3))= 1.7180 kN
Bending Moment on Gusset/Rib
Mgb = Fvi*Cos(teta)*(a1-h2/2)*Sin(teta)+Fhi*h
=2064.48*Cos(56.3)*(54-100/2)*Sin(56.3)+0.4511*1470= 4.4745 kNmm
Required Thickness of Gusset/Rib Plate
trmin = 2/(ng*fbc)*(Fga/(h2*Sin(teta))+6*Mgb/(h2*Sin(teta))^2)
=2/(2*70.625)*(1718./(100*Sin(56.3))+6*4.47/(100*Sin(56.3))^2)= 0.3473 mm

Gusset/Rib Plate trmin=0.3473 <= er=8[mm]	4.3%	OK

Fillet Weld Sizing

Continous welding is assumed for all fillet welds.

Fillet Welds on Gussets and Baseplate

Throat Area of Weld
Aw = 4 * ag * h1 =4*2*150= 1200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixx = 2 * ag * h1 ^ 3 / 6 =2*2*150^3/6= 2,25E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyy = 2 * ag * h1 ^ 2 * b1 / 2 =2*2*150^2*158/2= 7,11E06 mm4
Polar Moment of Inertia
Jxy = 2 * ag * h1 * (3 * b1 ^ 2 + h1 ^ 2) / 6
=2*2*150*(3*158^2+150^2)/6= 9,7392E06 mm4
Primary Shear Stress in Weld
Tauw = Fvi / Aw =2064.48/1200= 1.7204 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwx = (Fvi * a1 + Fhi * h) * ry / Ixx
=(2064.48*54+0.4511*1470)*75/2.25E06= 3.7382 N/mm2
Total Stresses in Weld Case A
SigwTotx = Sqr(Sigwx ^ 2 + 3 * Tauw ^ 2)
=Sqr(3.74^2+3*1.72^2)= 4.7805 N/mm2

Total Stresses in Weld Case A SigwTotx=4.78 <= z*fb=120.06[N/mm2]	3.9%	OK

Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauyw = Abs(Fhi / Aw) =Abs(0.4511/1200)= 3,7593E-04 N/mm2
Normal Stress in Weld X-X

```
SigwxB = Fvi * a1 * ry / Ixx =2064.48*54*75/2.25E06=          3.7161 N/mm2
Normal Stress in Weld Y-Y
SigwyB = Fhi * a1 * rx / Iyy =0.4511*54*79/7.11E06=        2,7067E-04 N/mm2
Shear due to Torsional Moment y-y
TauyTw = Fhi * h * ry / Jxy =0.4511*1470*75/9.7392E06=        0.0051 N/mm2
Shear due to Torsional Moment x-x
TauxTw = Fhi * h * rx / Jxy =0.4511*1470*79/9.7392E06=        0.0054 N/mm2
Total Shear Stresses
TauTot = Sqr(( Tauw + TauxTw) ^ 2 + (Tauw + TauyTw) ^ 2)
=Sqr((1.72+0.0054)^2+(1.72+0.0051)^2)=                      2.4404 N/mm2
Total Stresses in Weld Case B
SigwTotB = Sqr( SigwxB ^ 2 + SigwyB ^ 2 + 3 * TauTot ^ 2)
=Sqr(3.72^2+2.7067E-04^2+3*2.44^2)=                         5.6282 N/mm2
```

Total Stresses in Weld Case B SigwTotB=5.63 <= z*fb=120.06[N/mm2]	4.6%	OK

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(200+200)=                  1600.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=2*200^2/6*(3*200+200)=                                   1,0667E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*200^2/6*(3*200+200)=                                   1,0667E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(200+200)^3/6=         2,1333E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =2064.48/1600=                          1.2903 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(2064.48*54+0.4511*1470)*0.5*200/1.0667E07=                1.0514 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(1.05^2+3*1.29^2)=                                      2.4698 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=2.47 <= z*fs=125.38[N/mm2]	1.9%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(0.4511/1600)=            2,8195E-04 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=2064.48*54*0.5*200/1.0667E07=                              1.0451 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=0.4511*54*0.5*200/1.0667E07=                             2,2838E-04 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=0.4511*1470*0.5*200/2.1333E07=                             0.0031 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=0.4511*1470*0.5*200/2.1333E07=                             0.0031 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((1.29+0.0031)^2+(1.29+0.0031)^2)=                      1.8292 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(1.05^2+2.2838E-04^2+3*1.83^2)=                         3.3361 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=3.34 <= z*fs=125.38[N/mm2]	2.6%	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)
=6175.15/3-4*9.7952E05/(3*1224)= -3.13 kN
Maximum Eccentric Load F2 (tension side)
F2 = FV / n + 4 * MA / (n * d1)
=6175.15/3+4*9.7952E05/(3*1224)= -0.9914 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	73.49	0.40	0.76	0.82	-1.23	2.2	53.6	55.8
2	120	73.49	0.40	0.76	0.82	-2.47	4.4	48.7	53.1
3	240	73.49	0.40	0.76	0.82	-2.47	4.4	48.7	53.1

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	73.49	0.40	0.76	0.62	-1.75	3.1	65.0	68.2
2	180	73.49	0.40	0.76	0.62	-2.68	4.8	29.7	34.5
3	300	73.49	0.40	0.76	0.62	-1.75	3.1	65.0	68.2

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)= 68.16 N/mm2

Axial Stresses in the Leg Siga=4.76 <= fl=235[N/mm2]	2.0%	OK
Combined Stresses in the Leg Sigc=68.16 <= 1.5*fl=352.5[N/mm2]	19.3%	OK

Maximum horizontal deflection at top of legs , Defl= 2.97 mm

Deflection in the Legs Defl=2.97 <= DeflMax=7.35[mm]	40.4%	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*1470/(36.16*110.56)= 0.5516
From table 6.2: Selection of buckling curve : a
Imperfection factor alfa from Table 6.1: alfa= .21
phi = 0.5 * (1 + alfa * (Lambdam - 0.2) + Lambdam ^ 2)
=0.5*(1+0.21*(0.5516-0.2)+0.5516^2)= 0.6891
Kappa = MIN(1 / (phi + Sqr(phi ^ 2 - Lambdam ^ 2)), 1)
=MIN(1/(0.6891+Sqr(0.6891^2-0.5516^2,))1)= 0.9074
Maximum Compressive Force in Leg
NFd = MAX(FviMin, F1) =MAX(-2.68,-3130)= 3.1254 kN

Maximum Allowable Compressive Force
Nbrd = Kappa * A * fY / GammaM1
=0.9074*562.15*156.67/1= 79.92 kN

Maximum Allowable Moment(depends on angle phi)
Mbrd = fY * (Ixx / b * Cos(0) ^ 2 + Iyy / a * Sin(0) ^ 2)
=156.67*(7.3488E05/52*Cos(0)^2+7.3488E05/52*Sin(0)^2)= 2.2141 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	1.23	79.92	0.59	2.21	0.4142
2	120	2.47	79.92	0.59	2.21	0.4297
3	240	2.47	79.92	0.59	2.21	0.4297

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

Leg No	Phi	NFd(kN)	Nbrd(kN)	MFMax(kNm)	Mbrd(kNm)	Buckling Ratio
1	60	1.75	79.92	0.59	2.21	0.4206
2	180	2.68	79.92	0.59	2.21	0.4322
3	300	1.75	79.92	0.59	2.21	0.4206

```
Maximum Buckling Ratio
RatioBucklingMax = MAX(NFd/Nbrd+K1*MFm/Mbrd,F1/Nbrd)
=MAX(2677.13/79919.66+1.5*5.8858E05/2.2141E06,-3130/79919.66)=   0.4322
```

Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.4322 <= 1.0=1	43.2%	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.
```

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

```
Shell Inside Diameter
Di = De - 2 * (en - c) =1108-2*(4-0)=                      1100.00 mm
16.6.3 Equivalent Shell Diameter
Deq = Di =1100=                                            1100.00 mm
```

16.10.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0036« » OK«
»a) en/Deq=0.0036 <= 0.05« » OK«
»b) g/h1=0.9333 <= 1.0=1« » OK«
»b) 0.2=0.2 <= g/h1=0.9333« » OK«
»d) e2=4 >= en=4[mm] « » OK«
»d) b3=200 <= 1.5*h1=225[mm] « » OK«
»d) b2=200 >= 0.6*b3=120[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
=(6175.15+4*9.7952E05/(1100+2*(54+3.7+4)))/3=          3.1259 kN

Horizontal Force Fhi on Each Bracket/Leg, Fhi:
Fhi = FH / n =1201.17/3=                                 0.4004 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Lamda = b3 / Sqr( Deq * ea) (16.10-11) =200/Sqr(1100*3.7)=   3.1350
K17 = 1 / Sqr( 0.36 + 0.5 * Lamda + 0.5 * Lamda ^ 2)         (16.10-12)
=1/Sqr(0.36+0.5*3.13+0.5*3.13^2)=                      0.3823
Ny1 = MIN( 0.08 * Lamda , 0.4) (16.10-13) =MIN(0.08*3.13,0.4)=   0.2508
Sigm = P * Deq / (2 * ea) (16.6-11) =0.18*1100/(2*3.7)=      26.76 N/mm2
Ny2 = Sigm / (K2 * fs) (16.6-8) =26.76/(1.05*265)=         0.0962
Sigball = K1 * K2 * fs (16.6-6) =1.25*1.05*265=            347.44 N/mm2
a1eq = a1 + e2 + Fhi * h / Fvi                               (16.10-14)
=54+4+400.39*1470/3125.92=                             246.29 mm
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))               (16.10-15)
=(347.44*3.7^2*200/(0.3823*246.29))=                    10.10 kN
```

Loads in Cyl.Shell Fvi=3.13 <= Fimax=10.1[kN]	30.9%	OK

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

Bracket Baseplate Minimum Thickness

```
Base Plate Bearing Pressure Pb
Pb = Fvi / (b1 * a2) =3125.92/(158*104)=                0.1902 N/mm2
```

Baseplate with Double Gusset, D.Moss 3rd.ed. p. 190

```
Required Thickness due to Bending Moment(simply supported/fixed beam)
tbBending = Sqr( Fvi * g / ((h2 - dh) * fb))
=Sqr(3125.92*140/((100-0)*260))=                       4.1027 mm
(ROARK Table 26)
tbBearing = Sqr( beta * Pb * h2 ^ 2 / fb)
=Sqr(0.87*0.1902*100^2/260)=                           2.5230 mm
tbmin = MAX( tbBending , tbBearing) =MAX(4.1,2.52)=      4.1027 mm
```

Bracket Baseplate Thickness tbmin=4.1 <= ec=10[mm]	41.0%	OK

Stresses in Gusset/Rib Plate (D.MOSS 3rd.Ed. Page 189)

```
Axial Load on Gusset/Rib
Fga = Fvi * Sin( teta) + Fhi * Cos( teta))
=3125.92*Sin(56.3)+400.39*Cos(56.3))=                  2.8230 kN
Bending Moment on Gusset/Rib
Mgb = Fvi*Cos(teta)*(a1-h2/2)*Sin(teta)+Fhi*h
=3125.92*Cos(56.3)*(54-100/2)*Sin(56.3)+400.39*1470=   594.35 kNmm
Required Thickness of Gusset/Rib Plate
trmin = 2/(ng*fbc)*(Fga/(h2*Sin(teta))+6*Mgb/(h2*Sin(teta))^2)
=2/(2*130)*(2823.02/(100*Sin(56.3))+6*594.35/(100*Sin(56.3))^2)=   4.2233 mm
```

Gusset/Rib Plate trmin=4.22 <= er=8[mm]	52.7%	OK

Fillet Weld Sizing

Continous welding is assumed for all fillet welds.

Fillet Welds on Gussets and Baseplate

```
Throat Area of Weld
Aw = 4 * ag * h1 =4*2*150=                              1200.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixx = 2 * ag * h1 ^ 3 / 6 =2*2*150^3/6=                2,25E06 mm4
Moment of Inertia(about vertical axis y-y)
Iyy = 2 * ag * h1 ^ 2 * b1 / 2 =2*2*150^2*158/2=       7,11E06 mm4
Polar Moment of Inertia
Jxy = 2 * ag * h1 * (3 * b1 ^ 2 + h1 ^ 2) / 6
=2*2*150*(3*158^2+150^2)/6=                          9,7392E06 mm4
Primary Shear Stress in Weld
Tauw = Fvi / Aw =3125.92/1200=                          2.6049 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwx = (Fvi * a1 + Fhi * h) * ry / Ixx
=(3125.92*54+400.39*1470)*75/2.25E06=                  25.25 N/mm2
Total Stresses in Weld Case A
SigwTotx = Sqr( Sigwx ^ 2 + 3 * Tauw ^ 2)
=Sqr(25.25^2+3*2.6^2)=                                 25.65 N/mm2
```

Total Stresses in Weld Case A SigwTotx=25.65 <= z*fb=221[N/mm2]	11.6%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauyw = Abs( Fhi / Aw) =Abs(400.39/1200)=               0.3337 N/mm2
Normal Stress in Weld X-X
```

```
SigwxB = Fvi * a1 * ry / Ixx =3125.92*54*75/2.25E06=          5.6267 N/mm2
Normal Stress in Weld Y-Y
SigwyB = Fhi * a1 * rx / Iyy =400.39*54*79/7.11E06=           0.2402 N/mm2
Shear due to Torsional Moment y-y
TauyTw = Fhi * h * ry / Jxy =400.39*1470*75/9.7392E06=        4.5325 N/mm2
Shear due to Torsional Moment x-x
TauxTw = Fhi * h * rx / Jxy =400.39*1470*79/9.7392E06=        4.7743 N/mm2
Total Shear Stresses
TauTot = Sqr(( Tauw + TauxTw) ^ 2 + (Tauw + TauyTw) ^ 2)
=Sqr((2.6+4.77)^2+(2.6+4.53)^2)=                             10.27 N/mm2
Total Stresses in Weld Case B
SigwTotB = Sqr( SigwxB ^ 2 + SigwyB ^ 2 + 3 * TauTot ^ 2)
=Sqr(5.63^2+0.2402^2+3*10.27^2)=                             18.65 N/mm2
```

Total Stresses in Weld Case B SigwTotB=18.65 <= z*fb=221[N/mm2]	8.4%	OK

Fillet Welds on Reinforcement Pad

```
Weld Area of Pad
Awpad = 2 * apad * (b2 + b3) =2*2*(200+200)=                 1600.00 mm2
Moment of Inertia(about horizontal axis x-x)
Ixxpad = apad * b3 ^ 2 / 6 * (3 * b2 + b3)
=2*200^2/6*(3*200+200)=                                  1,0667E07 mm4
Moment of Inertia(about vertical axis y-y)
Iyypad = apad * b2 ^ 2 / 6 * (3 * b3 + b2)
=2*200^2/6*(3*200+200)=                                  1,0667E07 mm4
Polar Moment of Inertia
Jxypad = apad * (b2 + b3) ^ 3 / 6 =2*(200+200)^3/6=        2,1333E07 mm4
Primary Shear Stress in Weld
Tauwpad = Fvi / Awpad =3125.92/1600=                          1.9537 N/mm2
Case A, Horizontal Load in Radial Direction
Normal Stress in Weld
Sigwpadx = (Fvi * a1 + Fhi * h) * 0.5 * b3 / Ixxpad
=(3125.92*54+400.39*1470)*0.5*200/1.0667E07=                7.1004 N/mm2
Total Stresses in Pad Weld Case A
SigwTotPadx = Sqr( Sigwpadx ^ 2 + 3 * Tauwpad ^ 2)
=Sqr(7.1^2+3*1.95^2)=                                       7.8655 N/mm2
```

Total Stresses in Pad Weld Case A SigwTotPadx=7.87 <= z*fs=225.25[N/mm2]	3.4%	OK

```
Case B, Horizontal Load in Transverse Direction
Shear Stress in Horizontal Direction
Tauywpad = Abs( Fhi / Awpad) =Abs(400.39/1600)=               0.2502 N/mm2
Normal Stress in Weld X-X
SigwpadxB = Fvi * a1 * 0.5 * b3 / Ixxpad
=3125.92*54*0.5*200/1.0667E07=                              1.5825 N/mm2
Normal Stress in Weld Y-Y
SigwpadyB = Fhi * a1 * 0.5 * b2 / Iyypad
=400.39*54*0.5*200/1.0667E07=                               0.2027 N/mm2
Shear due to Torsional Moment y-y
TauyTwpad = Fhi * h * 0.5 * b3 / Jxypad
=400.39*1470*0.5*200/2.1333E07=                             2.7589 N/mm2
Shear due to Torsional Moment x-x
TauxTwpad = Fhi * h * 0.5 * b2 / Jxypad
=400.39*1470*0.5*200/2.1333E07=                             2.7589 N/mm2
Total Shear Stresses
TauTot = Sqr((Tauwpad+TauxTwpad)^2+(Tauwpad+TauyTwpad)^2)
=Sqr((1.95+2.76)^2+(1.95+2.76)^2)=                          6.6647 N/mm2
Total Stresses in Pad Weld Case B
SigwTotPadB = Sqr(SigwpadxB^2+SigwpadyB^2+3*TauTot^2)
=Sqr(1.58^2+0.2027^2+3*6.66^2)=                              11.65 N/mm2
```

Total Stresses in Pad Weld Case B SigwTotPadB=11.65 <= z*fs=225.25[N/mm2]	5.1%	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	-37.91	0.00	0.00	0.00
LC4 SHUT DOWN	0.00	0.00	-3.67	0.00	0.01	0.00
LC5 INSTALLATION	0.00	0.00	-3.67	0.00	0.00	0.00
LC1&2&3 OPER.WIND	0.00	0.00	-6.18	0.00	0.00	0.00
OPER.SEISMIC	1.20	0.00	-6.18	0.00	0.98	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	-38.21	0.00	0.01	0.00
LC4 SHUT DOWN	0.00	0.00	-3.97	0.00	0.01	0.00
LC5 INSTALLATION	0.00	0.00	-3.97	0.00	0.01	0.00
LC1&2&3 OPER.WIND	0.00	0.00	-6.48	0.00	0.01	0.00
OPER.SEISMIC	1.20	0.00	-6.48	0.00	2.75	0.00

LOAD CASE NO: 1 - LC9 HYDROTEST

Axial Stresses in the Leg Siga=23.48 <= fl=235[N/mm2]	9.9%	OK
Combined Stresses in the Leg Sigc=89.15 <= 1.5*fl=352.5[N/mm2]	25.2%	OK
Deflection in the Legs Defl=0.0018 <= DeflMax=7.35[mm]	0.0%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.1654 <= 1.0=1	16.5%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(37914.88+4*6226.91/(1100+2*(54+3.7+4)))/3=                12.65 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                 (16.10-15)
=(344.63*3.7^2*200/(0.3823*58.03))=                         42.53 kN
```

Loads in Cyl.Shell Fvi=12.65 <= Fimax=42.53[kN]	29.7%	OK

Bracket Baseplate Minimum Thickness

```
tbmin = MAX( tbBending , tbBearing) =MAX(8.25,5.07)=          8.2516 mm
```

Bracket Baseplate Thickness tbmin=8.25 <= ec=10[mm]	82.5%	OK
Gusset/Rib Plate trmin=1.13 <= er=8[mm]	14.1%	OK
Total Stresses in Weld Case A SigwTotx=29.18 <= z*fb=221[N/mm2]	13.2%	OK
Total Stresses in Weld Case B SigwTotB=34.42 <= z*fb=221[N/mm2]	15.5%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=15.11 <= z*fs=225.25[N/mm2]	6.7%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=20.39 <= z*fs=225.25[N/mm2]	9.0%	OK

LOAD CASE NO: 2 - LC4 SHUT DOWN

Axial Stresses in the Leg Siga=2.27 <= fl=156.67[N/mm2]	1.4%	OK
Combined Stresses in the Leg Sigc=8.66 <= 1.5*fl=235.[N/mm2]	3.6%	OK
Deflection in the Legs Defl=0.0033 <= DeflMax=7.35[mm]	0.0%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0164 <= 1.0=1	1.6%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(3667.39+4*7007.85/(1100+2*(54+3.7+4)))/3=            1.2301 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                (16.10-15)
=(299.81*3.7^2*200/(0.3823*58.54))=                     36.68 kN
```

Loads in Cyl.Shell Fvi=1.23 <= Fimax=36.68[kN]	3.3%	OK

Bracket Baseplate Minimum Thickness

```
tbmin = MAX( tbBending , tbBearing) =MAX(3.15,1.94)=          3.1521 mm
```

Bracket Baseplate Thickness tbmin=3.15 <= ec=10[mm]	31.5%	OK
Gusset/Rib Plate trmin=0.1713 <= er=8[mm]	2.1%	OK
Total Stresses in Weld Case A SigwTotx=2.86 <= z*fb=147.33[N/mm2]	1.9%	OK
Total Stresses in Weld Case B SigwTotB=3.36 <= z*fb=147.33[N/mm2]	2.2%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=1.47 <= z*fs=153.[N/mm2]	0.9%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=1.99 <= z*fs=153.[N/mm2]	1.3%	OK

LOAD CASE NO: 3 - LC5 INSTALLATION

Axial Stresses in the Leg Siga=2.27 <= fl=156.67[N/mm2]	1.4%	OK
Combined Stresses in the Leg Sigc=8.66 <= 1.5*fl=235.[N/mm2]	3.6%	OK
Deflection in the Legs Defl=0.0021 <= DeflMax=7.35[mm]	0.0%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0163 <= 1.0=1	1.6%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(3667.39+4*6653.83/(1100+2*(54+3.7+4)))/3=            1.2297 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                (16.10-15)
=(299.81*3.7^2*200/(0.3823*58.34))=                     36.80 kN
```

Loads in Cyl.Shell Fvi=1.23 <= Fimax=36.8[kN]	3.3%	OK

Bracket Baseplate Minimum Thickness

```
tbmin = MAX( tbBending , tbBearing) =MAX(3.15,1.94)=          3.1516 mm
```

Bracket Baseplate Thickness tbmin=3.15 <= ec=10[mm]	31.5%	OK
Gusset/Rib Plate trmin=0.1688 <= er=8[mm]	2.1%	OK
Total Stresses in Weld Case A SigwTotx=2.85 <= z*fb=147.33[N/mm2]	1.9%	OK

Total Stresses in Weld Case B SigwTotB=3.35 <= z*fb=147.33[N/mm2]	2.2%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=1.47 <= z*fs=153.[N/mm2]	0.9%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=1.99 <= z*fs=153.[N/mm2]	1.2%	OK

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

Axial Stresses in the Leg Siga=3.82 <= fl=123.2[N/mm2]	3.1%	OK
Combined Stresses in the Leg Sigc=14.55 <= 1.5*fl=184.8[N/mm2]	7.8%	OK
Deflection in the Legs Defl=0.0033 <= DeflMax=7.35[mm]	0.0%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.0274 <= 1.0=1	2.7%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(6175.15+4*5593.02/(1100+2*(54+3.7+4)))/3=              2.0645 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                (16.10-15)
=(221.46*3.7^2*200/(0.3823*58.32))=                      27.19 kN
```

Loads in Cyl.Shell Fvi=2.06 <= Fimax=27.19[kN]	7.5%	OK

Bracket Baseplate Minimum Thickness

```
tbmin = MAX( tbBending , tbBearing) =MAX(4.52,2.78)=       4.5235 mm
```

Bracket Baseplate Thickness tbmin=4.52 <= ec=10[mm]	45.2%	OK
Gusset/Rib Plate trmin=0.3473 <= er=8[mm]	4.3%	OK
Total Stresses in Weld Case A SigwTotx=4.78 <= z*fb=120.06[N/mm2]	3.9%	OK
Total Stresses in Weld Case B SigwTotB=5.63 <= z*fb=120.06[N/mm2]	4.6%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=2.47 <= z*fs=125.38[N/mm2]	1.9%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=3.34 <= z*fs=125.38[N/mm2]	2.6%	OK

LOAD CASE NO: 5 - OPER.SEISMIC

Axial Stresses in the Leg Siga=4.76 <= fl=235[N/mm2]	2.0%	OK
Combined Stresses in the Leg Sigc=68.16 <= 1.5*fl=352.5[N/mm2]	19.3%	OK
Deflection in the Legs Defl=2.97 <= DeflMax=7.35[mm]	40.4%	OK
Buckling of Leg NFd/Nbrd+K1*MFm/Mbrd=0.4322 <= 1.0=1	43.2%	OK

16.10.4 APPLIED FORCES

```
Fvi = (FV + 4 * MA / (Di + 2 * (a1 + ea + e2))) / n
=(6175.15+4*9.7952E05/(1100+2*(54+3.7+4)))/3=            3.1259 kN
```

16.10.5 LOAD LIMITS OF THE SHELL

```
Fimax = (Sigball * ea ^ 2 * b3 / (K17 * a1eq))                    (16.10-15)
=(347.44*3.7^2*200/(0.3823*246.29))=                      10.10 kN
```

Loads in Cyl.Shell Fvi=3.13 <= Fimax=10.1[kN]	30.9%	OK

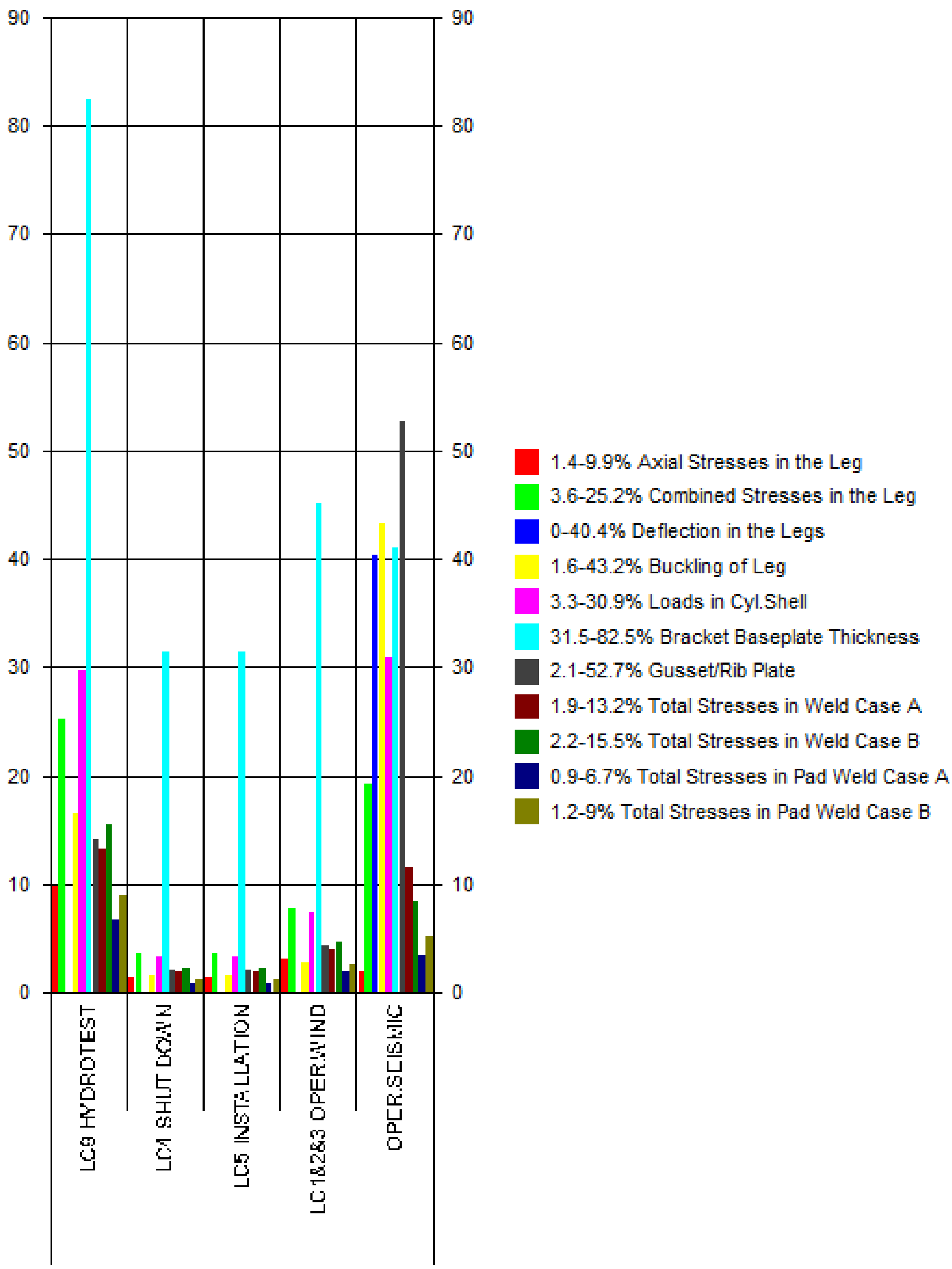
Bracket Baseplate Minimum Thickness

```
tbmin = MAX( tbBending , tbBearing) =MAX(4.1,2.52)=          4.1027 mm
```

Bracket Baseplate Thickness tbmin=4.1 <= ec=10[mm]	41.0%	OK
Gusset/Rib Plate trmin=4.22 <= er=8[mm]	52.7%	OK
Total Stresses in Weld Case A SigwTotx=25.65 <= z*fb=221[N/mm2]	11.6%	OK
Total Stresses in Weld Case B SigwTotB=18.65 <= z*fb=221[N/mm2]	8.4%	OK
Total Stresses in Pad Weld Case A SigwTotPadx=7.87 <= z*fs=225.25[N/mm2]	3.4%	OK
Total Stresses in Pad Weld Case B SigwTotPadB=11.65 <= z*fs=225.25[N/mm2]	5.1%	OK

Volume:0.00 m3 Weight:33.2 kg (SG= 7.93)

UTILIZATION CHART - SB.1



Max.Utilization/Condition 82.5% CASE:LC9 HYDROTEST

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

SUMMARY OF CALCULATION RESULTS :
No. of Nozzles Considered :  5
No. of Permutations ......:  4
No. of Nozzle Pairs Classified as Groups ...............: 1
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.1    N.2        209      162     338 No  ---N/A--- ---N/A---  N/A  N/A
2 N.1    N.6        105      162     202 Yes     18485     88008  21%  OK
3 N.2    N.6        438      162     535 No  ---N/A--- ---N/A---  N/A  N/A
Max.test pressure Ptmax= 1.731 for Nozzle Group: N.1 - N.6 Located in:E3.1   T

EN13445 - 9.6 MULTIPLE OPENINGS
GO.1                                  20 June 2019 12:12
Nozzles on Component :S1.1   Cylindrical Shell   Main Shell
NOMENCLATURE :
Distance(mm); Lb = Center Dist.between the pair of Nozzles
Distance(mm); s = Dist.between OD of Nozzles = Lb-a1-a2 ; Iso = Iso1+Iso2
Pres.Area(N); pAreq.= Pressure Area Required, pAaval = Pressure Area Available
Status (---); N/A = Not a Group, OK = Sufficient Reinf., ADD = Add reinf.

No.  Nozz1  Nozz2  ---s--- --Iso-- ---Lb-- Grp.-pAreq.-- -pAaval-- -U- -STS-
4 N.3    N.5       1745      128    1774 No  ---N/A--- ---N/A---  N/A  N/A
```

INPUT DATA

Extent of Nozzle Interaction Check

```
Select Extent of Nozzle Interaction Check:
Check All Components. ==> No. of Nozzles/Permutations : 5/ 4
```

GENERAL DESIGN DATA

```
CALCULATION TEMPERATURE.............................:Temp       90.00 °C
DESIGN PRESSURE.....................................:P         0.2037 MPa
INTERNAL CORROSION ALLOWANCE........................:c           0.00 mm
```

SHELL DATA

```
Nozzles on Component :E3.1   Torispherical End
OUTSIDE DIAMETER OF SHELL...........................:De       1110.00 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.1 Outlet

```
NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.............................:deb       129.00 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       0.1000 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        13.50 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:          1.3500 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.1 - N.6 Located in:E3.1 Torispherical End

Preliminary Calculations

```
Center Distance Between Nozzles Lb = ==                      201.72 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 =201.72-64.56-32.51=                        104.66 mm
ApLs = 0.5 * ris ^ 2 * Lb / (ris + 0.5 * eas)                      (9.6-5)
=0.5*888^2*201.72/(888+0.5*3.7)=                           89377.48 mm2

AfLs = (Lb - a1 - a2 + tn2 - c - dev2) * eas                       (9.6-7)
=(201.72-64.56-32.51+13.5-0-1.35)*3.7=                       432.18 mm2
```

Pressure Area Required pA(req.)

```
pAReq = P*(ApLs+Apb1+0.5*Apphi1+Apb2+0.5*Apphi2)                   (9.6-4)
=0.2037*(89377.48+1180.73+0.5*0+190+0.5*0)=                   18.49 kN
```

Pressure Area Available pA(aval.)

```
pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)
=0*(0-0.5*0.2037)+33.9*(135.07-0.5*0.2037)=                  4.5750 kN
pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)
=0*(0-0.5*0.2037)+135*(146.25-0.5*0.2037)=                    19.73 kN
pAAval = (AfLs+Afw1+Afw2)*(fs-0.5*P)+pANozz1+pANozz2               (9.6-4)
=(432.18+0+0)*(147.5-0.5*0.2037)+4574.96+19730.=              88.01 kN
```

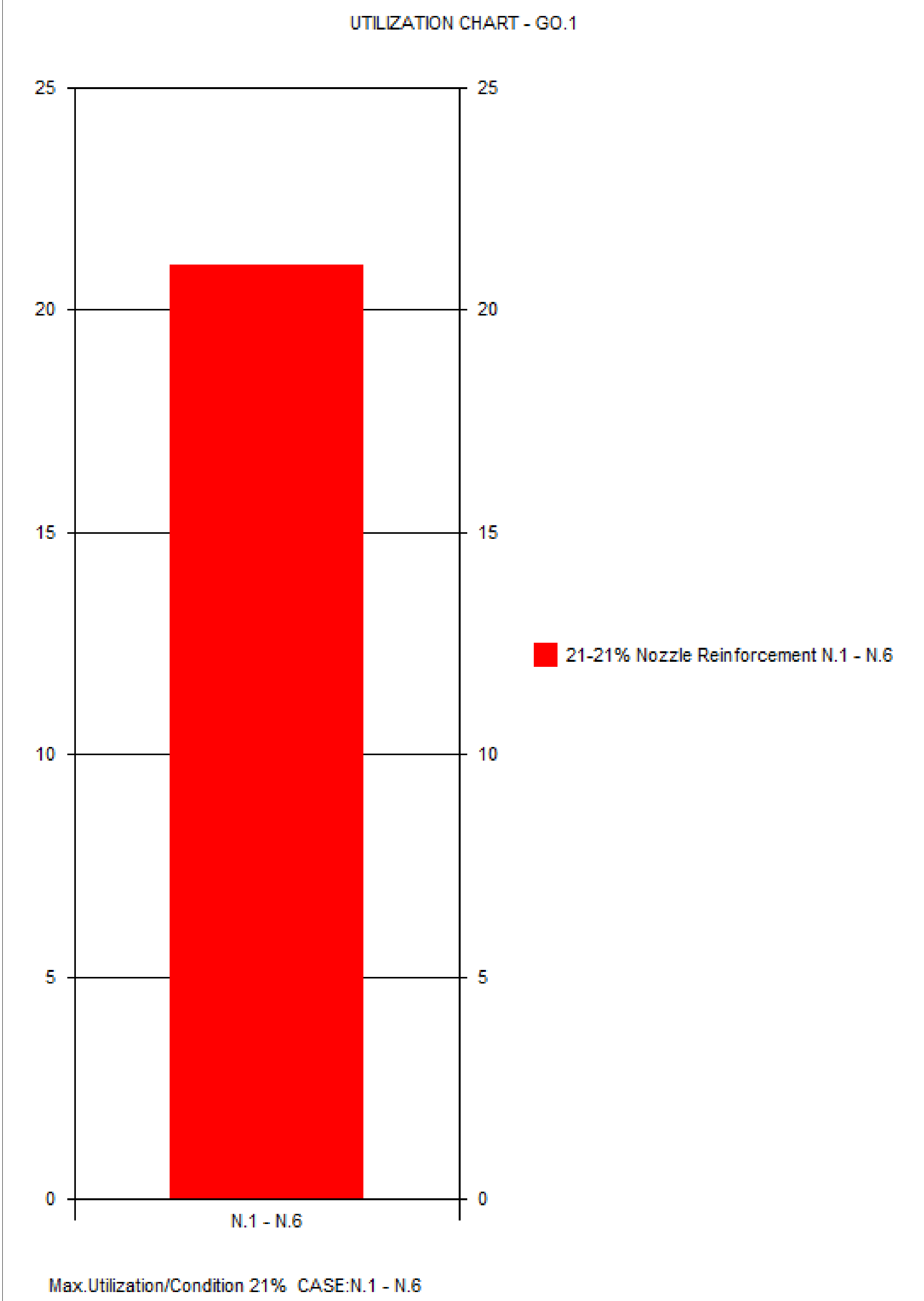
Nozzle Reinforcement N.1 - N.6 pAAval=88.01 >= pAReq=18.49[kN]	21.0%	OK

```
Max.test pressure Ptmax= 1.731 for Nozzle Group: N.1 - N.6 Located in:E3.1
Torispherical End
==                                                            1.7310 MPa
```

CALCULATION SUMMARY

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

Nozzle Reinforcement N.1 - N.6 pAAval=88.01 >= pAReq=18.49[kN]	21.0%	OK


UTILIZATION CHART - GO.1
25
20
15
10
5
0
N.1 - N.6
21-21% Nozzle Reinforcement N.1 - N.6
Max.Utilization/Condition 21% CASE:N.1 - N.6

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

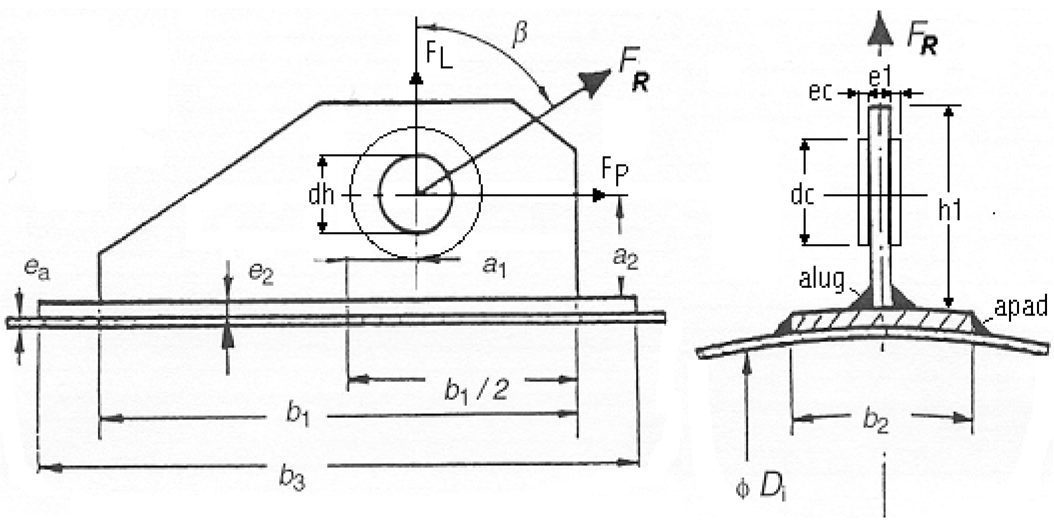
```
Attachment: E3.2    Torispherical End                                  S1.1
Off center radius of lug............................:R         430.00 mm
Angular rotation of lug.............................:angle       0.00 degr.
Extent of Analysis: Check Lug and Loads in Shell
Type of Lifting Lug:
Symmetric 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         888.00 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, 1.4307 X2CrNi18-9 C=Cold Rolled Strip, HT:A THK<=8mm 90'C,A>=35%
Rm=520 Rp=250 Rpt=189.63 f=141.25 f20=173.33 ftest=260 E=194028(N/mm2) ro=7.93
Comment:
LENGTH OF LIFTING LUG AT SHELL/PAD JUNCTION.........:b1        100.00 mm
HEIGHT OF LIFTING LUG...............................:h1        100.00 mm
THICKNESS OF LIFTING LUG............................:e1        5.0000 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         50.00 mm
LENGTH OF REINFORCEMENT PAD.........................:b3        130.00 mm
THICKNESS OF REINFORCEMENT PAD......................:e2        4.0000 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      1.0000 mm
```

LOAD DATA

Load Description	ID	Units	Ninoiyiea iaa?o?aiiinoe 1
Pressure	P	MPa	1
Not Applicable			1
Test Condition (Yes/No)			No
Temp.D=Design/A=Ambient	Temp		A
Maximum Force on Lug (at angle Beta)	FR	kN	2
Angle of Sling Leg From Vertical	Beta	degr.	45
Load Safety Factor	SL		2
Percentage Skew/Side Load	PS	%	1

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) =430= 888.00 mm
Lambda = b / SQR(Deq * ea) (16.6-13/17) =130/SQR(888*3.7)= 2.2680

16.7.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0045« » OK«
»a) en/Deq=0.0045 <= 0.05« » OK«
»16.7.3 b) e2=4 >= en=4[mm] « » OK«
»16.7.3 b) b3=130 <= 1.5*b1=150[mm] « » OK«

LOAD CASE NO: 1 - NINOI?IEA IAA?O?AIIINOE 1

K2 (design condition) = == 1.2500
Normal Force Component
FL = SL * FR * Cos(beta) =2*2000*Cos(45)= 2.8284 kN

Parallel Force Component
FP = SL * FR * Sin(beta) =2*2000*Sin(45)= 2.8284 kN

Side/Skew Load - 1% Lateral Load
Fside = PS / 100 * SL * FR =1/100*2*2000= 0.0400 kN

External Moment Along Load Direction
ML = SL * FR * ((a2 + e2) * Sin(beta) - a1 * Cos(beta))
=2*2000*((60+4)*Sin(45)-0*Cos(45))= 0.1810 kNm

External Moment in Transverse Load Direction
MT = Fside * (a2 + e2) =40*(60+4)= 0.0026 kNm

Stresses in the Lug Foot/Across Baseline and at Weld

Tensional Stress in the Lug Foot
SigTension = FL / (e1 * b1) =2828.43/(5*100)= 5.6569 N/mm2
Bending Stress due to FP
SigBendL = 6 * FP * a2 / (e1 * b1 ^ 2)
=6*2828.43*60/(5*100^2)= 20.36 N/mm2
Bending Stress in Lug Plate due to Moment in Transverse Load Direction
SigBendT = 6 * Fside * a2 / (b1 * e1 ^ 2)
=6*40*60/(100*5^2)= 5.7600 N/mm2
Shear Stress due to FP
TauL = FP / (b1 * e1) =2828.43/(100*5)= 5.6569 N/mm2
Shear Stress in Transverse Load Direction
TauT = Fside / (b1 * e1) =40/(100*5)= 0.0800 N/mm2
Effective Stress
Sige = SQR((SigTension+SigBendL+SigBendT)^2+3*(TauL^2+TauT^2))

```
=SQR((5.66+20.36+5.76)^2+3*(5.66^2+0.08^2))=                33.26 N/mm2
```

Effective Stress in the Lug Foot Sige=33.26 <= fl=173.33[N/mm2]	19.1%	OK

```
Bending Stress in Pad due to Moment in Transverse Load Direction
SigBendT2 = 6 * Fside * a2 / (b1 * e2 ^ 2)
=6*40*60/(100*4^2)=                                        9.0000 N/mm2
```

Bending Stress in Shell/Pad(Transverse Moment) SigBendT2=9 <= 1.5 * fs=270[N/mm2]	3.3%	OK
Effective Stress in Lug Weld Sige=33.26 <= z*MIN(fl,fs)=147.33[N/mm2]	22.5%	OK

Double Fillet Welds on Reinforcement Pad(Bednar Chapter 10.3)

```
Weld Length
Lwpad = 2 * (b2 + b3) =2*(50+130)=                           360.00 mm
Section Modulus(around axis transverse to lug)
Zxpad = b2 * b3 + b3 ^ 2 / 3 =50*130+130^2/3=              12133.33 mm2
Section Modulus(around axis along lug)
Zypad = b3 * b2 + b2 ^ 2 / 3 =130*50+50^2/3=                7333.33 mm2
Unit force due to FL
f1p = FL / Lwpad =2828.43/360=                               7.8567 N/mm
Unit force due to FP and Fside
f2p = SQR( FP ^ 2 + Fside ^ 2) / Lwpad
=SQR(2828.43^2+40^2)/360=                                  7.8575 N/mm
Bending
f3p = MAX((FP*a2-FL*a1)/Zxpad,Fside*a2/Zypad)
=MAX((2828.43*60-2828.43*0)/12133.33,40*60/7333.33)=        13.99 N/mm
Resultant Load
ftot = SQR(( f1p + f3p) ^ 2 + f2p ^ 2)
=SQR((7.86+13.99)^2+7.86^2)=                                23.21 N/mm
Required Weld Size, Throat Dimension
apadmin = fptot / (z * fs) =23.21/(0.85*180)=                0.1517 mm
```

Required Pad Weld Size apadmin=0.1517 <= apad=1[mm]	15.1%	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*2000/(5*2*(100-60-40/2))=                              60.00 N/mm2
```

Tear Out Stress TauTearOut=60 <= Re(lug)=250[N/mm2]	24.0%	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*2000/(5*40))=                                  105.99 N/mm2
```

Bearing Stress(pin in hole) SigBearing=105.99 <= Re(lug)=250[N/mm2]	42.3%	OK

16.6.7 - Global Circumferential Membrane Stress

```
Sigmy = P * Deq / (2 * ea) (16.6-11/12) =1*888/(2*3.7)=       120.00 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*2.27^2))=                               0.7285
K14 = 1 / (0.6 * Sqr( 1 + 0.03 * Lambda ^ 2))                      (16.6-16)
=1/(0.6*Sqr(1+0.03*2.27^2))=                               1.5513
K15 = MIN( 1 + 2.6 * (Deq / ea) ^ (0.3) * (b2 / Deq), 2)           (16.7-2)
=MIN(1+2.6*(888/3.7)^(0.3)*(50/888,)2)=                    1.7579
```

```
Ny1 = MIN( 0.08 * Lambda , 0.2) (16.6-14) =MIN(0.08*2.27,0.2)=   0.1814
Ny2 = Sigmy / (K2 * fs) (16.6-8) =120./(1.25*180)=            0.5333
K1 from figure 16.6-1 =     0.807
Bending Limit Stress Sigball
Sigball = K1 * K2 * fs (16.6-6) =0.8069*1.25*180=             181.56 N/mm2

Maximum Allowable Force FLmax
FLmax = K15 * Sigball * ea ^ 2 / K13                            (16.6-21)
=1.76*181.56*3.7^2/0.7285=                                5.9979 kN
```

Radial Force(in shell) FL=2.83 <= FLmax=6.[kN]	47.1%	OK

```
Maximum Allowable Moment MLmax
MLmax = K15 * Sigball * ea ^ 2 * b / K14                        (16.6-22)
=1.76*181.56*3.7^2*130/1.55=                              0.3662 kNm
```

Moment(in shell) ML=0.181 <= MLmax=0.3662[kNm]	49.4%	OK

16.6.9 COMBINED LOADS

```
Combined Loads(in shell)
Lcom = Abs( FL) / FLmax + Abs( ML) / MLmax                      (16.6-23)
=Abs(2828.43)/5997.85+Abs(1.8102E05)/3.6615E05=           0.9660
```

Combined Loads Lcom=0.966 <= 1.0=1	96.5%	OK

CALCULATION SUMMARY

LOAD CASE NO: 1 - NINOI?IEA IAA?O?AIIINOE 1

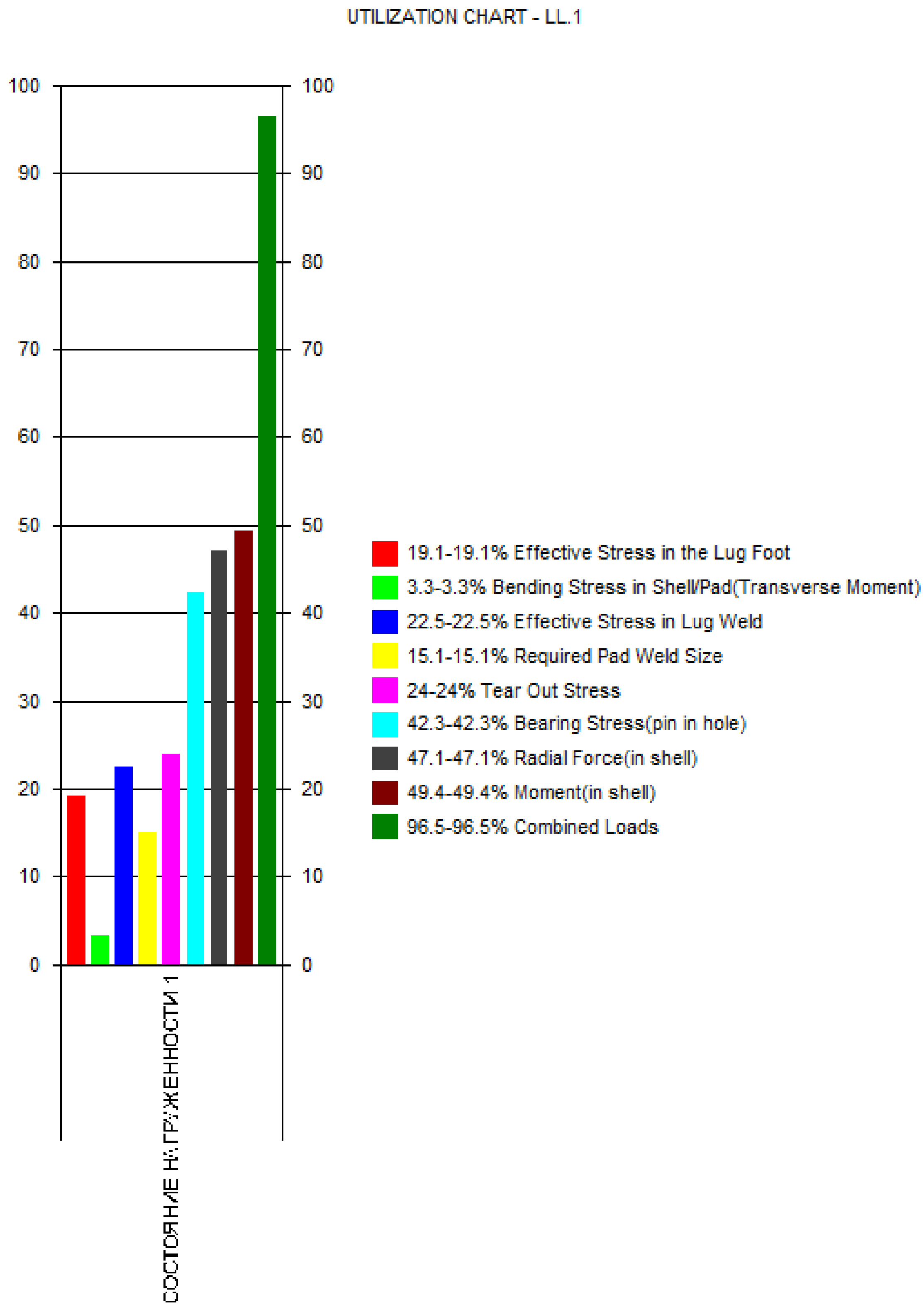
Effective Stress in the Lug Foot Sige=33.26 <= fl=173.33[N/mm2]	19.1%	OK
Bending Stress in Shell/Pad(Transverse Moment) SigBendT2=9 <= 1.5 * fs=270[N/mm2]	3.3%	OK
Effective Stress in Lug Weld Sige=33.26 <= z*MIN(fl,fs)=147.33[N/mm2]	22.5%	OK
Required Pad Weld Size apadmin=0.1517 <= apad=1[mm]	15.1%	OK
Tear Out Stress TauTearOut=60 <= Re(lug)=250[N/mm2]	24.0%	OK
Bearing Stress(pin in hole) SigBearing=105.99 <= Re(lug)=250[N/mm2]	42.3%	OK
Radial Force(in shell) FL=2.83 <= FLmax=6.[kN]	47.1%	OK
Moment(in shell) ML=0.181 <= MLmax=0.3662[kNm]	49.4%	OK

16.6.9 COMBINED LOADS

```
Combined Loads(in shell)
Lcom = Abs( FL) / FLmax + Abs( ML) / MLmax                      (16.6-23)
=Abs(2828.43)/5997.85+Abs(1.8102E05)/3.6615E05=           0.9660
```

Combined Loads Lcom=0.966 <= 1.0=1	96.5%	OK

Volume:0.00 m3 Weight:0.5 kg (SG= 7.929999)



Max.Utilization/Condition 96.5% CASE:СОСТОЯНИЕ НАГРУЖЕННОСТИ 1