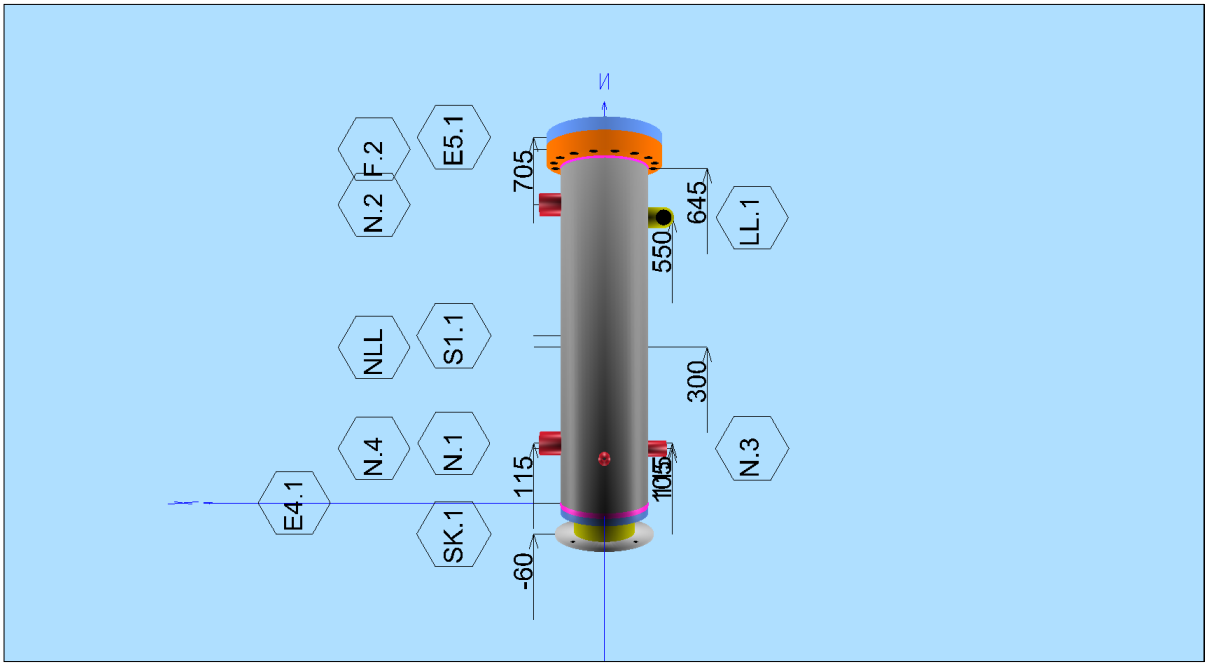
(0) Drawing

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



Design Data & Process Information

Description	Units	Design Data
Process Card		General Design Data
Design Code & Specifications		EN13445 TG = 3b
Internal Design Pressure (MPa)	MPa	13
External Design Pressure (MPa)	MPa	
Hydrotest Pressure (MPa)	MPa	
Maximum Design Temperature ('C)	'C	130
Minimum Design Temperature ('C)	'C	-20
Operating Temperature ('C)	'C	
Corrosion Allowance (mm)	mm	0.5
Content of Vessel		
Specific Density of Oper.Liq		1.2
Normal Liquid Level NLL (mm)	mm	300

Test Pressure

TEST PRESSURE OF VESSEL - NEW & COLD - VERTICAL

```
Design Pressure.........................:    13.000 MPa
Design Temperature......................:   130.0 C
```

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
E4.1	Welded Flat End-Flat End	13.004	27.502	16.496	0.007	16.496	27.495
E5.1	Bolted Flat End-Cover Flange	13.000	27.192	16.496	0.000	16.496	27.192
F.2	RT - Flange-Shell Flange	13.000	22.460	16.496	0.001	16.496	22.459
N.1	Nozzle,Seamless Pipe-Inlet	13.002	24.194	NA	0.007	NA	24.187
N.2	Nozzle,Seamless Pipe-Outlet	13.000	24.194	NA	0.002	NA	24.191
N.3	Nozzle,Seamless Pipe-Safety Valve	13.002	25.054	NA	0.005	NA	25.049

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
N.4	Nozzle,Seamless Pipe-Oil Return	13.002	25.745	NA	0.006	NA	25.739
S1.1	Cylindrical Shell-Shell	13.004	26.605	16.370	0.007	16.370	26.598

PtReq = MAX(MIN(PtTop), 1.43*p)= 18.5900 MPa (EN13445-5, 10.2.3.3.1-1 & 2)

HYDRO-TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Hydro Test) ......: 18.5900 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Hydro Test) ....: 22.4594 MPa

PNEUMATIC TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..: 18.5937 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...: 22.4600 MPa

Note : Other components may limit Ptlim than the ones checked above.

TEST PRESSURE OF VESSEL - NEW & COLD - HORIZONTAL

Design Pressure.....: 13.000 MPa
Design Temperature.....: 130.0 C

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
E4.1	Welded Flat End-Flat End	13.004	27.502	16.496	0.001	16.496	27.500
E5.1	Bolted Flat End-Cover Flange	13.000	27.192	16.496	0.003	16.496	27.190
F.2	RT - Flange-Shell Flange	13.000	22.460	16.496	0.002	16.496	22.458
N.1	Nozzle,Seamless Pipe-Inlet	13.002	24.194	NA	0.001	NA	24.193
N.2	Nozzle,Seamless Pipe-Outlet	13.000	24.194	NA	0.001	NA	24.193
N.3	Nozzle,Seamless Pipe-Safety Valve	13.002	25.054	NA	0.003	NA	25.051
N.4	Nozzle,Seamless Pipe-Oil Return	13.002	25.745	NA	0.002	NA	25.743
S1.1	Cylindrical Shell-Shell	13.004	26.605	16.370	0.002	16.370	26.603

PtReq = MAX(MIN(PtTop), 1.43*p)= 18.5900 MPa (EN13445-5, 10.2.3.3.1-1 & 2)
PhydOper = 0.0037 MPa PhydTest = 0.0028 MPa
PtReq = PtReq + (PhydOper-PhydTest) (EN13445-5, 10.2.3.3.1-3)

HYDRO-TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Hydro Test) ......: 18.5910 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Hydro Test) ....: 22.4577 MPa

PNEUMATIC TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..: 18.5947 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...: 22.4600 MPa

Note : Other components may limit Ptlim than the ones checked above.

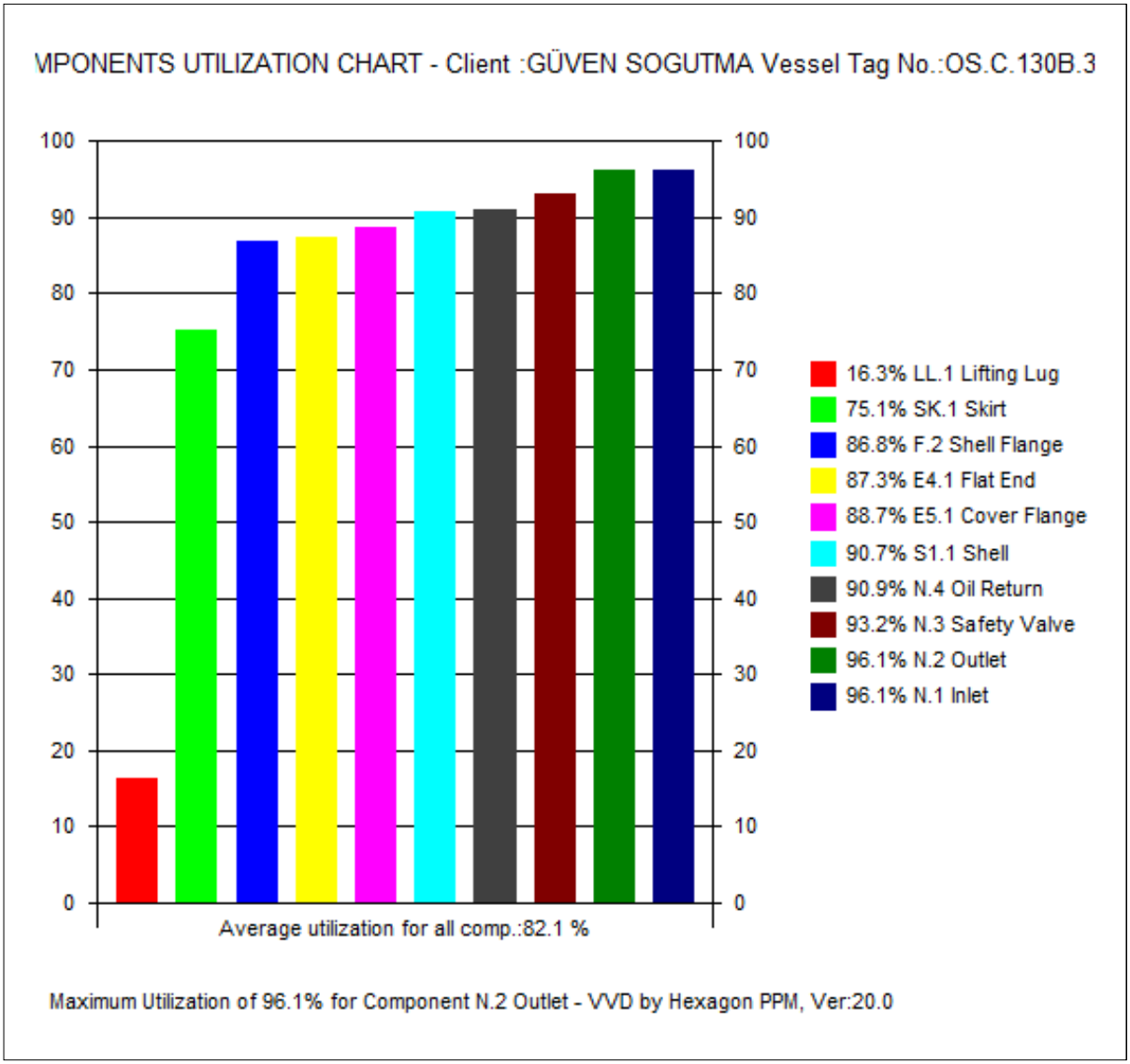
NOMENCLATURE:
Pdesign- is the design pressure including liquid head at the part under consideration.
PtMax - is the maximum allowed test pressure determined at the part under consideration.
PtMin - is the required test pressure determined at the part under consideration.
Wat.Head - is the water head 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.

Utilization Chart

Utilization Chart



INPUT DATA

COMPONENT ATTACHMENT/LOCATION

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 100°C, P=13.0000 MPa, c=0.5 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG        1.2000
LIQUID HEAD.....:LH        300.00 mm
```

SHELL DATA

```
CYLINDER FABRICATION: Welded Pipe
WELD JOINT COEFFICIENT: Testing Group  1   (z=1.0)
NEGATIVE TOLERANCE: Negative tolerance specified in % of nominal thickness
EN 10217-3:2002/A1:05, 1.0565 P355NH welded tube, HT:N THK<=20mm 100'C
Rm=490 Rp=355 Rpt=304 f=202.67 f20=204.17 ftest=338.1 E=206067(N/mm2) ro=7.85
OUTSIDE DIAMETER OF SHELL.....:De        168.30 mm
LENGTH OF CYLINDRICAL PART OF SHELL.....:Lcyl      645.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en        7.1000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:          10.00 %
Calculate minimum shell thickness due to internal pressure at different elevations
with steps of 1000 mm.: NO
Split shell into several shell courses and include welding information: NO
```

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 = De * P / (2 * f * z + P)                                   (7.4-2)
=168.3*13./(2*202.67*1+13.)=                              5.2313 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =5.23+0.5+0.71=                  6.4413 mm

Analysis Thickness
ea = en - c - NegDev =7.1-0.5-0.71=                        5.8900 mm
```

»7.4.1 Cond.of Applicabilty emin/De=0.0311 <= 0.16« » OK«

Internal Pressure emina=6.44 <= en=7.1[mm]	90.7%	OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

```
Inside Diameter of Shell
Di = De - 2 * ea =168.3-2*5.89=                            156.52 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(168.3+156.52)/2=                      162.41 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
MAWPHC = 2 * f * z * ea / Dm =2*202.67*1*5.89/162.41=       14.70 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)
MAWPNC = 2 * f20 * z * (ea + c) / Dm
=2*204.17*1*(5.89+0.5)/162.41=                            16.07 MPa
```

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

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*338.1*1*(5.89+0.5)/162.41=                             26.60 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*13*204.17/202.67= 16.37 MPa

Ptmin = 1.43 * Pd =1.43*13= 18.59 MPa

Test Pressure Ptmin=18.59 <= Ptmax=26.6[MPa]	69.8%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Inside Radius of Shell
ris = Di / 2 (9.5-3) =156.52/2= 78.26 mm
Length of Shell Contributing to Reinforcement
Is = Sqr((2 * ris + ea) * ea) (9.5-2)
=Sqr((2*78.26+5.89)*5.89)= 30.93 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*156.52,(5.89*30.93*(202.67-0.5*13.)/13.-78.26*30.93)/(0.5*78.26+0.5*5.89))= = 7.7885 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr((2 * ris + ea) * ea) (9.5-18)
=0.15*Sqr((2*78.26+5.89)*5.89)= 4.6393 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(7.79,4.64)= 7.7885 mm

CALCULATION SUMMARY

7.4.2 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

Required Minimum Shell Thickness Excl.Allow. emin :
emin = De * P / (2 * f * z + P) (7.4-2)
=168.3*13./(2*202.67*1+13.)= 5.2313 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =5.23+0.5+0.71= 6.4413 mm

Internal Pressure emina=6.44 <= en=7.1[mm]	90.7%	OK

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

Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*338.1*1*(5.89+0.5)/162.41= 26.60 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*13*204.17/202.67= 16.37 MPa

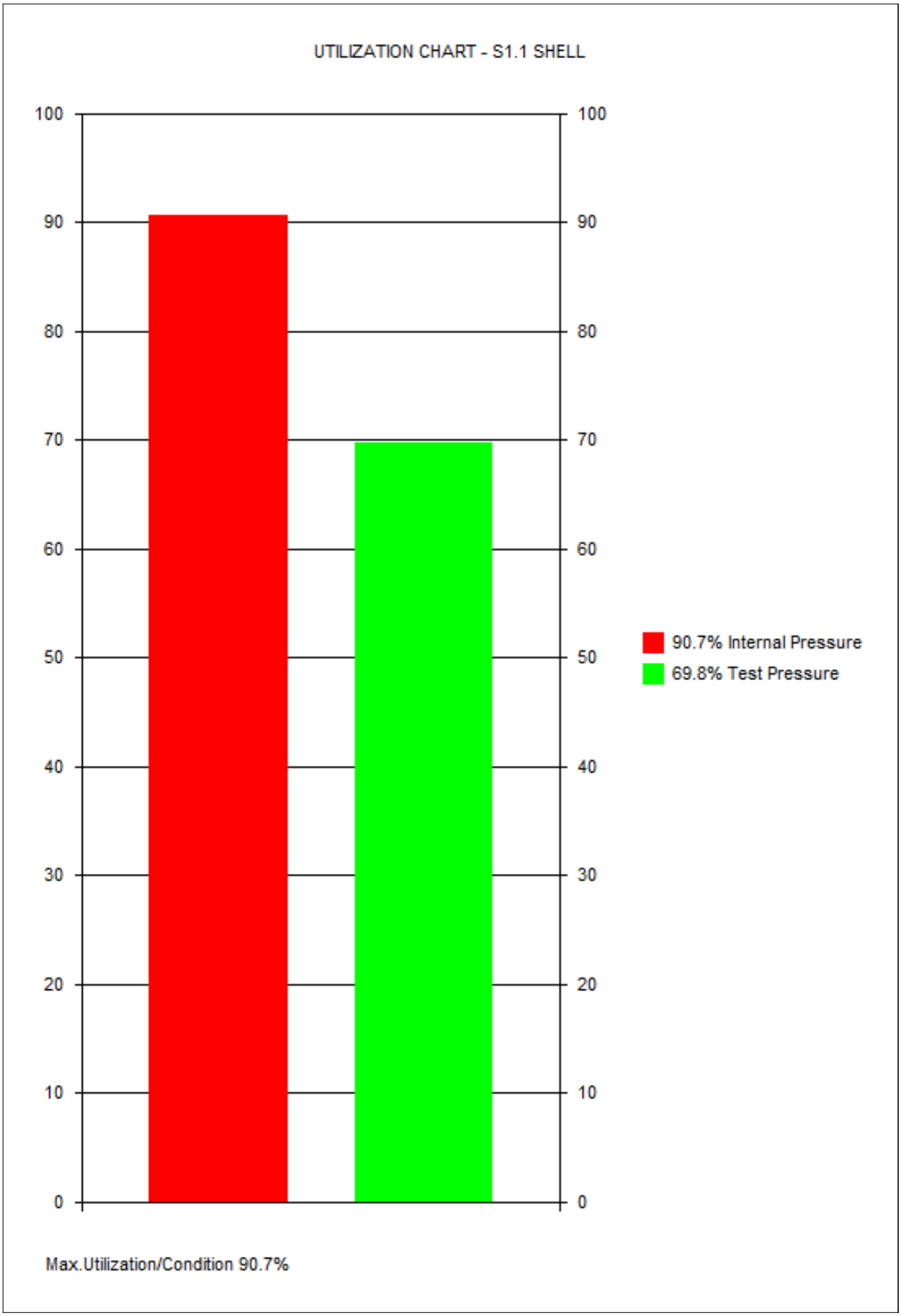
Ptmin = 1.43 * Pd =1.43*13= 18.59 MPa

Test Pressure Ptmin=18.59 <= Ptmax=26.6[MPa]	69.8%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(7.79,4.64)= 7.7885 mm

Volume:0.0124 m3 Weight:18.2 kg (SG= 7.85)


UTILIZATION CHART - S1.1 SHELL
100
90
80
70
60
50
40
30
20
10
0
90.7% Internal Pressure
69.8% Test Pressure
Max.Utilization/Condition 90.7%

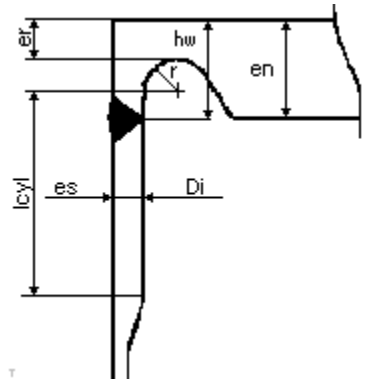
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

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

GENERAL DESIGN DATA

```
PROCESS CARD: General Design Data : Temp= 100°C, P=13.0000 MPa, c=0.5 mm
SPECIFIC DENSITY OF OPERATING LIQUID.................:SG        1.2000
LIQUID HEAD..........................................:LH        300.00 mm
Check Deflection of Cover to TEMA RCB-9-21(multipass units): NO
Shape of Cover: Circular
Stayed Flat Plate to section 20.2: NO
Circular flat ends with radial reinforcement ribs to section 21: NO
```




```
TYPE OF FLAT WELDED END: Flat end with relief groove
```

DATA FOR CYLINDRICAL SHELL SECTION

```
CYLINDER DIAMETER: Base Design on Cylinder Outside Diameter
OUTSIDE DIAMETER OF SHELL............................:De        168.30 mm
NOMINAL WALL THICKNESS (uncorroded)..................:esn       7.1000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE................:th        0.7100 mm
LENGTH OF CYLINDRICAL PART OF END....................:Lc        645.00 mm
EN 10217-3:2002/A1:05, 1.0565 P355NH welded tube, HT:N THK<=20mm 100'C
Rm=490 Rp=355 Rpt=304 fs=202.67 fs20=204.17 fstest=338.1 E=206067(N/mm2) ro=7.85
```

DATA FOR END/BLIND FLANGE

```
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en         18.00 mm
NOMINAL THK.OF END UNDER RELIEF GROOVE(uncorroded)..:ern        13.00 mm
INSIDE RADIUS OF RELIEF GROOVE.....................:rd        5.0000 mm
Exclude option in 10.4.4.4, no fatigue analysis will be performed.: NO
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=40mm 100'C
Rm=510 Rp=345 Rpt=314 f=209.33 f20=212.5 ftest=328.57 E=206067(N/mm2) ro=7.85
```

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

```
Di = De - 2 * (esn - c) =168.3-2*(7.1-0.5)=                    155.10 mm

Minimum thk.of cylinder section due to pressure only, esmin
esmin = P * Di / (2 * fs - P)
=13.*155.1/(2*202.67-13.)=                                    5.1406 mm

Length of cylindrical shell contributing to junction strength Icyl
Icyl = Sqr(( Di + es) * es) (10.4-2) =Sqr((155.1+5.89)*5.89)=    30.79 mm

Analysis Thickness of a Uniform Cyl. Shell es
es = (esn - c - th) * MIN( Lc, Icyl) / Icyl
```

```
=(7.1-0.5-0.71)*MIN(645,30.79)/30.79=                    5.8900 mm

Minimum allowable design stress fmin
fmin = Min( f , fs ) =Min(209.33,202.67)=                 202.67 N/mm2
```

10.4.5 FLAT END WITH RELIEF GROOVE

```
Minimum required groove radius rdmin
rdmin = Max( 0.25 * es , 5) =Max(0.25*5.89,5)=            5.0000 mm
```

»Groove Radius Size rd=5 >= rdmin=5[mm] (10.4.2.4)« » OK«

»Groove Radius Location ern+rd=18 <= en=18[mm] (10.4.2.4)« » OK«

```
Minimum required thickness at bottom of groove excl.corrosion ermin
ermin = Max( es , es * (fs / f))
=Max(5.89,5.89*(202.67/209.33))=                         5.8900 mm

Minimum thickness at bottom of groove incl.corr. er
er = ermin + c =5.89+0.5=                                 6.3900 mm
```

Thickness Check ern=13 >= e=6.39[mm]	49.1%	OK

```
Factor C1 from fig.10.4.4(es/Di=0.0380) (p/f=0.0642)    C1 =0.3939
Factor C2 from fig.10.4.5(es/Di=0.0380) (p/fmin=0.0642) C2 =0.4941
```

10.4.4 MINIMUM THICKNESS OF FLAT END e

```
emin1 = C1 * Di * Sqr( P / f)                                (10.4-12)
=0.3939*155.1*Sqr(13./209.33)=                           15.23 mm
emin2 = C2 * Di * Sqr( P / fmin)                             (10.4-10)
=0.4941*155.1*Sqr(13./202.67)=                           19.41 mm
NOTE: The design has been based on emin1 only, it is required to perform
a simplified assessment of the fatigue life of the flat end to shell junction a
ccording to section 17 using etta=                       = 3.83 (ref. 10.4.4.4).
Minimum thickness excluding corrosion emin
emin = MAX( emin1 ) =MAX(15.23)=                          15.23 mm

Minimum thickness including corrosion e
e = emin + c =15.23+0.5=                                  15.73 mm
```

Thickness Check en=18 >= e=15.73[mm]	87.3%	OK

PRESSURE CALCULATIONS

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax = f * (ea / (C1 * Di)) ^ 2
=212.5*(18/(0.402*155.1))^2=                             17.71 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Pmax = f * (ea / (C1 * Di)) ^ 2
=209.33*(17.5/(0.4006*155.1))^2=                         16.61 MPa
```

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

```
Pmax = f * (ea / (C1 * Di)) ^ 2
=328.57*(18/(0.4011*155.1))^2=                           27.50 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*13*212.5/209.33=         16.50 MPa

Ptmin = 1.43 * Pd =1.43*13=                               18.59 MPa
```

Test Pressure Ptmin=18.59 <= Ptmax=27.5[MPa]	67.5%	OK

CALCULATION SUMMARY

10.4.5 FLAT END WITH RELIEF GROOVE

Minimum thickness at bottom of groove incl.corr. er
er = ermin + c =5.89+0.5= 6.3900 mm

Thickness Check ern=13 >= e=6.39[mm]	49.1%	OK

10.4.4 MINIMUM THICKNESS OF FLAT END e

Minimum thickness including corrosion e
e = emin + c =15.23+0.5= 15.73 mm

Thickness Check en=18 >= e=15.73[mm]	87.3%	OK

PRESSURE CALCULATIONS

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

Pmax = f * (ea / (C1 * Di)) ^ 2
=212.5*(18/(0.402*155.1))^2= 17.71 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax = f * (ea / (C1 * Di)) ^ 2
=209.33*(17.5/(0.4006*155.1))^2= 16.61 MPa

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

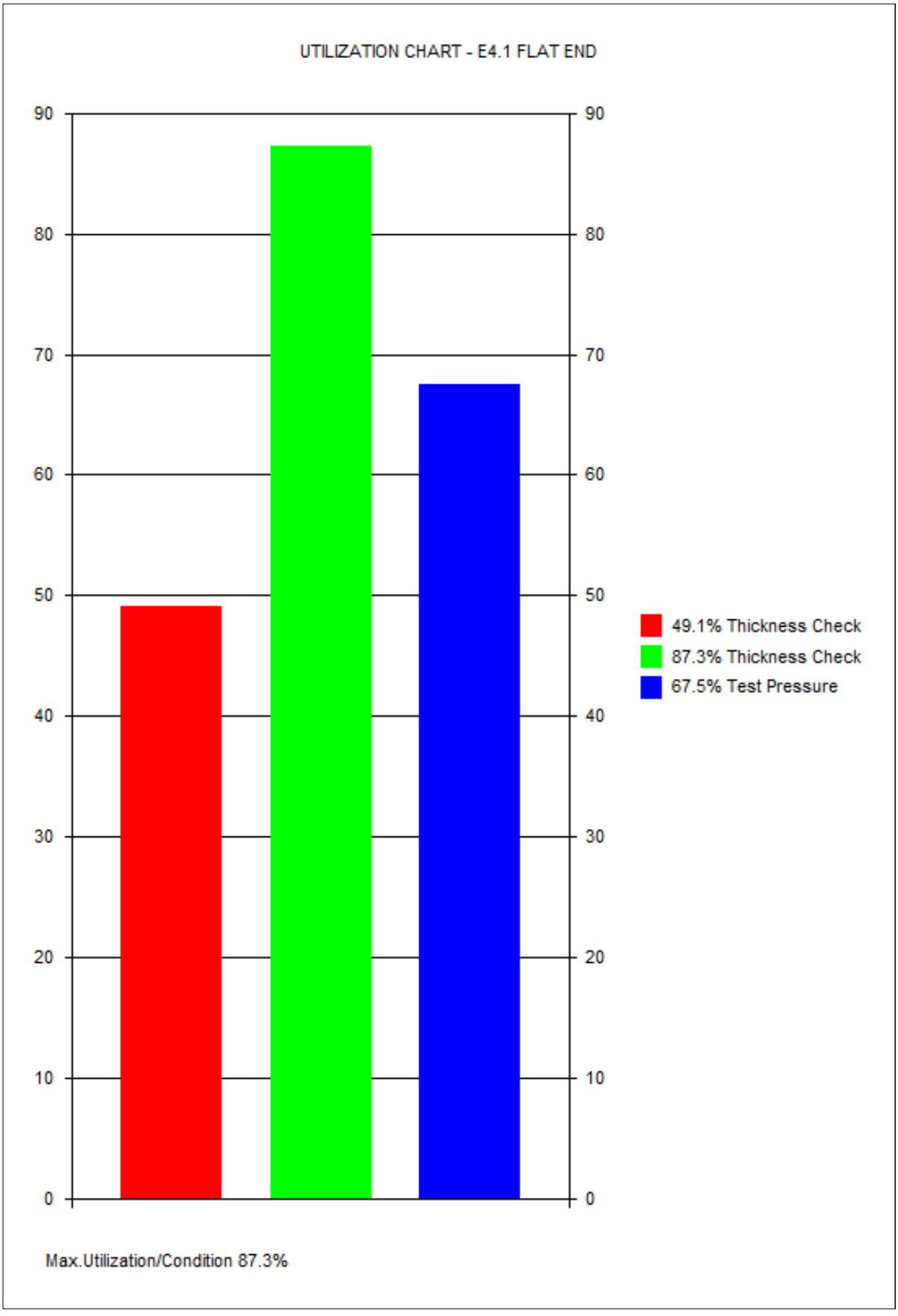
Pmax = f * (ea / (C1 * Di)) ^ 2
=328.57*(18/(0.4011*155.1))^2= 27.50 MPa

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*13*212.5/209.33= 16.50 MPa
Ptmin = 1.43 * Pd =1.43*13= 18.59 MPa

Test Pressure Ptmin=18.59 <= Ptmax=27.5[MPa]	67.5%	OK

Volume:0.00 m3 Weight:3 kg (SG= 7.85)


UTILIZATION CHART - E4.1 FLAT END
90
80
70
60
50
40
30
20
10
0
49.1% Thickness Check
87.3% Thickness Check
67.5% Test Pressure
Max.Utilization/Condition 87.3%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

```
Attachment: F.2     RT - Flange          Shell Flange                  S1.1
Location: Along z-axis z1=  682
```

GENERAL DESIGN DATA

```
PROCESS CARD: General Design Data : Temp= 100°C, P=13.0000 MPa, c=0.5 mm
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG        1.2000
LIQUID HEAD.....:LH          0.00 mm
Check Deflection of Cover to TEMA RCB-9-21(multipass units): NO
Shape of Cover: Circular
Stayed Flat Plate to section 20.2: NO
Circular flat ends with radial reinforcement ribs to section 21: NO
```

DATA FOR MATING FLANGE (F.2)

```
TYPE OF BLIND FLANGE: Blind flange with full face gasket
OUTSIDE DIAMETER OF FLANGE.....:A         223.00 mm
BOLT-CIRCLE DIAMETER.....:C         195.00 mm
NUMBER OF BOLTS.....:n          16.00
DIAMETER OF BOLT HOLES IN FLANGE.....:d          16.00 mm
GASKET FACTOR.....:m         0.2500
```

DATA FOR BLIND FLANGE

```
NOMINAL THICKNESS OF HEAD/END (uncorroded).....:en          23.00 mm
THICKNESS OF FLANGE(uncorroded).....:e          23.00 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=40mm 100'C
Rm=510 Rp=345 Rpt=314 f=209.33 f20=212.5 ftest=328.57 E=206067(N/mm2) ro=7.85
```

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

10.5.3.1 MINIMUM THICKNESS OF FLAT END WITH FULL FACE GASKET e

```
Minimum thickness excluding corrosion emin
emin = 0.41 * C * Sqr( P / f)                                   (10.5-7)
=0.41*195*Sqr(13/209.33)=                              19.92 mm

Minimum thickness including allowance e
e = emin + c =19.92+0.5=                                20.42 mm
```

End Thickness en=23 >= e=20.42[mm]	88.7%	OK

10.5.3.2 MINIMUM THICKNESS OF FLANGED EXTENSION e1

```
e1 = 0.8 * emin (10.5-8) =0.8*19.92=                    15.94 mm
```

Flanged Extension Thk. eb=23 >= e1=15.94[mm]	69.3%	OK

PRESSURE CALCULATIONS

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax = f * (ea / (0.41 * C)) ^ 2
=212.5*(23/(0.41*195))^2=                              17.59 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Pmax = f * (ea / (0.41 * C)) ^ 2
=209.33*(22.5/(0.41*195))^2=                           16.58 MPa
```

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

```
Pmax = f * (ea / (0.41 * C)) ^ 2
=328.57*(23/(0.41*195))^2=                                  27.19 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*13*212.5/209.33=           16.50 MPa
Ptmin = 1.43 * Pd =1.43*13=                                 18.59 MPa
```

Test Pressure Ptmin=18.59 <= Ptmax=27.19[MPa]	68.3%	OK

CALCULATION SUMMARY

10.5.3.1 MINIMUM THICKNESS OF FLAT END WITH FULL FACE GASKET e

```
Minimum thickness including allowance e
e = emin + c =19.92+0.5=                                    20.42 mm
```

End Thickness en=23 >= e=20.42[mm]	88.7%	OK

10.5.3.2 MINIMUM THICKNESS OF FLANGED EXTENSION e1

```
e1 = 0.8 * emin (10.5-8) =0.8*19.92=                        15.94 mm
```

Flanged Extension Thk. eb=23 >= e1=15.94[mm]	69.3%	OK

PRESSURE CALCULATIONS

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax = f * (ea / (0.41 * C)) ^ 2
=212.5*(23/(0.41*195))^2=                                   17.59 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Pmax = f * (ea / (0.41 * C)) ^ 2
=209.33*(22.5/(0.41*195))^2=                                16.58 MPa
```

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

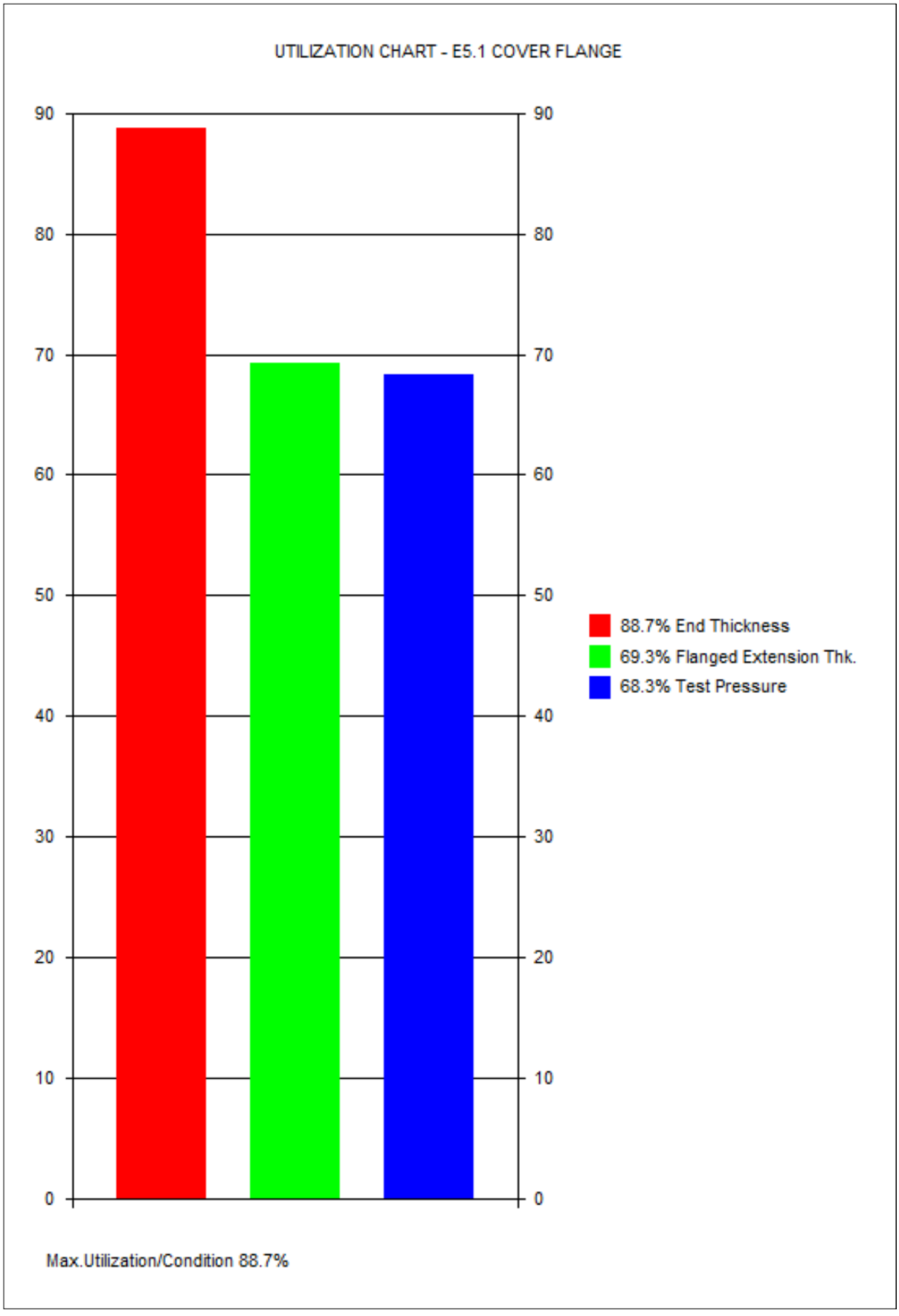
```
Pmax = f * (ea / (0.41 * C)) ^ 2
=328.57*(23/(0.41*195))^2=                                  27.19 MPa
```

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*13*212.5/209.33=           16.50 MPa
Ptmin = 1.43 * Pd =1.43*13=                                 18.59 MPa
```

Test Pressure Ptmin=18.59 <= Ptmax=27.19[MPa]	68.3%	OK

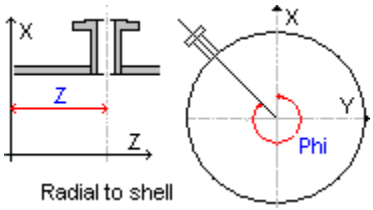
Volume:0.00 m3 Weight:7 kg (SG= 7.85)


UTILIZATION CHART - E5.1 COVER FLANGE
90
80
70
60
50
40
30
20
10
0
88.7% End Thickness
69.3% Flanged Extension Thk.
68.3% Test Pressure
Max.Utilization/Condition 88.7%

INPUT DATA

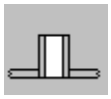
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    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          115.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi     0.00 Degr.
```

GENERAL DESIGN DATA



```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 100°C, P=13.0000 MPa, c=0.5 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.............:SG         1.2000
LIQUID HEAD.....................................:LH         185.00 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         168.30 mm
NOMINAL WALL THICKNESS (uncorroded).............:en         7.1000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...........:th         0.7100 mm
EN 10217-3:2002/A1:05, 1.0565 P355NH welded tube, HT:N THK<=20mm 100'C
Rm=490 Rp=355 Rpt=304 fs=202.67 f20=204.17 ftest=338.1 E=206067(N/mm2) ro=7.85
```

NOZZLE MATERIAL DATA

```
Delivery Form: Seamless Pipe
EN 10216-2:2013, 1.0425 P265GH seamless tube, HT:N THK<=16mm 100'C
Rm=410 Rp=265 Rpt=226 fb=150.67 f20=170.83 ftest=252.38 E=206067(N/mm2) ro=7.85
```

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        44.50 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       8.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:           12.50 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.............:ho         40.00 mm
```

WELDING DATA

```
Nozzle/Pad to Shell Welding Area: User Specified Fillet Weld Throat Dimensions
OUTWARD NOZZLE WELD, THROAT DIMENSION...............:mo        5.0000 mm
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE PhiC(OBLIQUE IN TRANSVERSE.CROSS SECT.)Fig.9.5-2:PhiC      0.00 Degr.
ANGLE PhiL(OBLIQUE IN LONG.CROSS SECT.)Fig.9.5-1....:PhiL        0.00 Degr.
```

DATA FOR REINFORCEMENT PAD

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

LIMITS OF REINFORCEMENT

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness eas
eas = en - c - th =7.1-0.5-0.71=                          5.8900 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =8-0.5-1=                         6.5000 mm
Inside Radius of Curvature
ris = De / 2 - eas (9.5-3) =168.3/2-5.89=                  78.26 mm
dib = deb - 2 * eab =44.5-2*6.5=                           31.50 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=13.*44.5/(2*150.67*1+13.)=                             1.8400 mm
Allowable Stresses
fob = Min( fs, fb) (9.5-8) =Min(202.67,150.67)=             150.67 N/mm2
```

GEOMETRIC LIMITATIONS

»Check Max.Diameter of Nozzle dib/(2*ris)=0.2013 <= 1.00=1[mm] «» OK«

Min.Nozzle Thk. ebp=1.84 <= eab=6.5[mm]	28.3%	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*78.26+5.89)*5.89)=                                  30.93 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =5.89*30.93=                        182.17 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((44.5-6.5)*6.5,)40)=                               15.72 mm
Set In Nozzle
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =6.5*(15.72+0+5.89)=  140.44 mm2
```

Area of Welds Afw

```
Afw = mo ^ 2 =5^2=                                           25.00 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*31.5*(15.72+5.89)=  340.30 mm2

Cyl.Shell in the Longitudinal Section Aps
ApsL = ris * (Is + a) (9.5-94) =78.26*(30.93+22.25)=        4161.78 mm2

Cyl.Shell in the Transverse Cross Section Aps
ApsT = 0.5 * ris ^ 2 * (Is + a ) / (0.5 * eas + ris)              (9.5-105)
=0.5*78.26^2*(30.93+22.54)/(0.5*5.89+78.26)=              2016.29 mm2

Aps = MAX( ApsL ApsT) =MAX(4161.78,2016.29)=                4161.78 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =13.*(4161.78+340.3)=      58.54 kN

pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                            (9.5-7)
=13.*(2016.29+340.3+0.5*0)=                                 30.64 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(58536.9,30640.87)=         58.54 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)
=(182.17+25)*(202.67-0.5*13.)+0*(0-0.5*13.)+140.44*(150.67-0.5*13.)
=    60.89 kN
```

Nozzle Reinforcement pAAval=60.89 >= pAReq=58.54[kN]	96.1%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))     (9.5-10)
=(182.17+25)*202.67+140.44*150.67/((4161.78+340.3)+0.5*(182.17+25+140.44+0)
)=                                                          =    13.50 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                  24.19 MPa

Weight of Nozzle: .3628kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=1.84 <= eab=6.5[mm]	28.3%	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*78.26+5.89)*5.89)=                                  30.93 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((44.5-6.5)*6.5,)40)=                               15.72 mm
```

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =13.*(4161.78+340.3)=       58.54 kN

pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                            (9.5-7)
=13.*(2016.29+340.3+0.5*0)=                                 30.64 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(58536.9,30640.87)=          58.54 kN
```

Pressure Area Available pA(aval.)

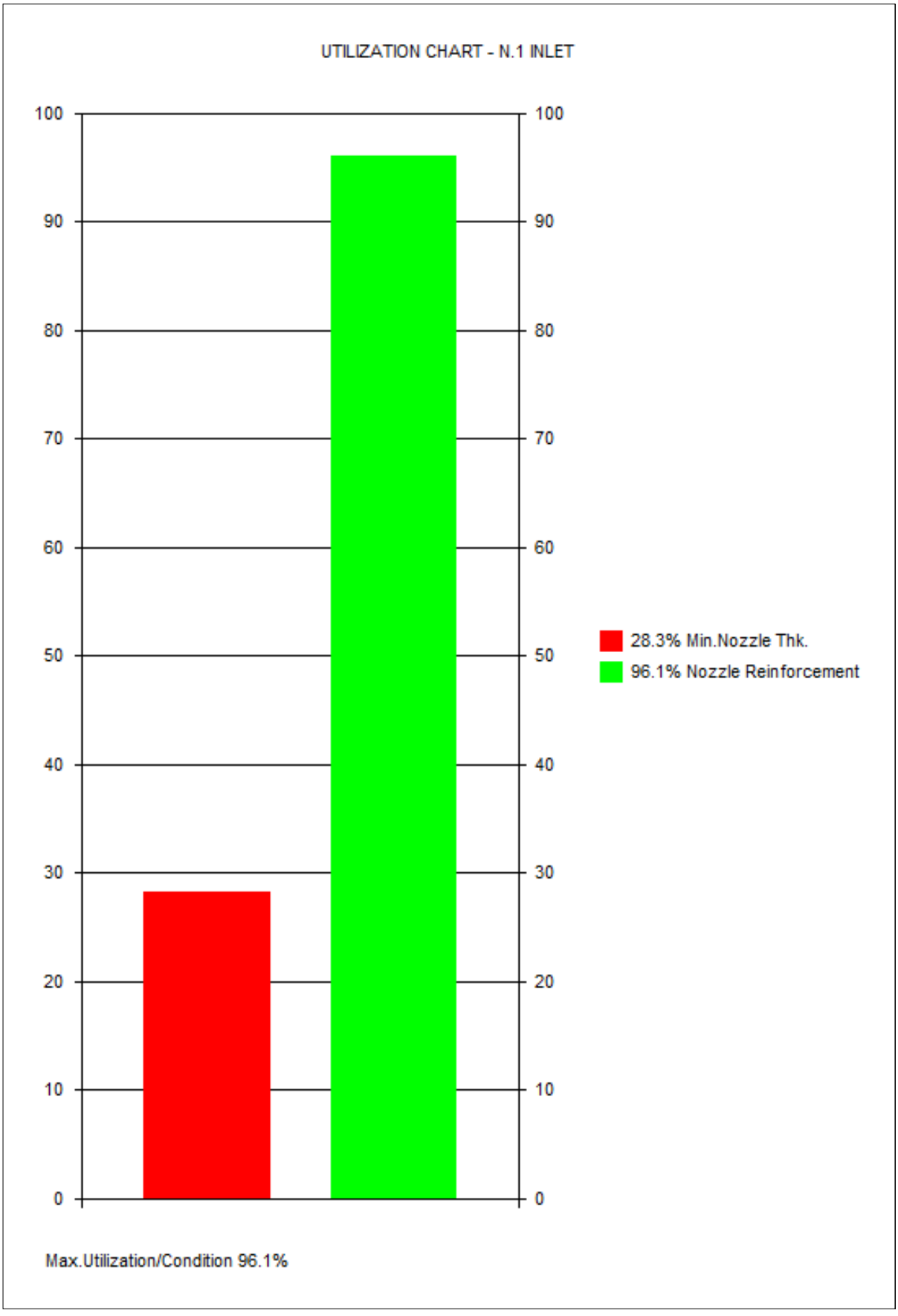
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)      (9.5-7)
=(182.17+25)*(202.67-0.5*13.)+0*(0-0.5*13.)+140.44*(150.67-0.5*13.)
=    60.89 kN
```

Nozzle Reinforcement pAAval=60.89 >= pAReq=58.54[kN]	96.1%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))     (9.5-10)
=(182.17+25)*202.67+140.44*150.67/((4161.78+340.3)+0.5*(182.17+25+140.44+0)
)=                                                          =    13.50 MPa
```

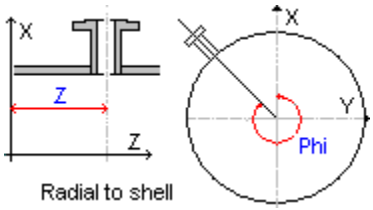
Volume:0.00 m3 Weight:0.4 kg (SG= 7.85)


UTILIZATION CHART - N.1 INLET
100
90
80
70
60
50
40
30
20
10
0
28.3% Min.Nozzle Thk.
96.1% Nozzle Reinforcement
Max.Utilization/Condition 96.1%

INPUT DATA

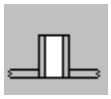
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    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          575.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi     0.00 Degr.
```

GENERAL DESIGN DATA



```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 100°C, P=13.0000 MPa, c=0.5 mm, Pext=0.0000 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         168.30 mm
NOMINAL WALL THICKNESS (uncorroded).....:en         7.1000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th         0.7100 mm
EN 10217-3:2002/A1:05, 1.0565 P355NH welded tube, HT:N THK<=20mm 100'C
Rm=490 Rp=355 Rpt=304 fs=202.67 f20=204.17 ftest=338.1 E=206067(N/mm2) ro=7.85
```

NOZZLE MATERIAL DATA

```
Delivery Form: Seamless Pipe
EN 10216-2:2013, 1.0425 P265GH seamless tube, HT:N THK<=16mm 100'C
Rm=410 Rp=265 Rpt=226 fb=150.67 f20=170.83 ftest=252.38 E=206067(N/mm2) ro=7.85
```

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        44.50 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       8.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:           12.50 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.............:ho         40.00 mm
```

WELDING DATA

```
Nozzle/Pad to Shell Welding Area: User Specified Fillet Weld Throat Dimensions
OUTWARD NOZZLE WELD, THROAT DIMENSION...............:mo        5.0000 mm
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE PhiC(OBLIQUE IN TRANSVERSE.CROSS SECT.)Fig.9.5-2:PhiC      0.00 Degr.
ANGLE PhiL(OBLIQUE IN LONG.CROSS SECT.)Fig.9.5-1....:PhiL        0.00 Degr.
```

DATA FOR REINFORCEMENT PAD

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

LIMITS OF REINFORCEMENT

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness eas
eas = en - c - th =7.1-0.5-0.71=                          5.8900 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =8-0.5-1=                         6.5000 mm
Inside Radius of Curvature
ris = De / 2 - eas (9.5-3) =168.3/2-5.89=                  78.26 mm
dib = deb - 2 * eab =44.5-2*6.5=                           31.50 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=13*44.5/(2*150.67*1+13)=                                1.8400 mm
Allowable Stresses
fob = Min( fs, fb) (9.5-8) =Min(202.67,150.67)=             150.67 N/mm2
```

GEOMETRIC LIMITATIONS

»Check Max.Diameter of Nozzle dib/(2*ris)=0.2013 <= 1.00=1[mm] «» OK«

Min.Nozzle Thk. ebp=1.84 <= eab=6.5[mm]	28.3%	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*78.26+5.89)*5.89)=                                  30.93 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =5.89*30.93=                        182.17 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((44.5-6.5)*6.5,)40)=                               15.72 mm
Set In Nozzle
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =6.5*(15.72+0+5.89)=  140.44 mm2
```

Area of Welds Afw

```
Afw = mo ^ 2 =5^2=                                           25.00 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*31.5*(15.72+5.89)=   340.30 mm2

Cyl.Shell in the Longitudinal Section Aps
ApsL = ris * (Is + a) (9.5-94) =78.26*(30.93+22.25)=        4161.78 mm2

Cyl.Shell in the Transverse Cross Section Aps
ApsT = 0.5 * ris ^ 2 * (Is + a ) / (0.5 * eas + ris)              (9.5-105)
=0.5*78.26^2*(30.93+22.54)/(0.5*5.89+78.26)=              2016.29 mm2

Aps = MAX( ApsL ApsT) =MAX(4161.78,2016.29)=                4161.78 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =13*(4161.78+340.3)=       58.53 kN

pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                            (9.5-7)
=13*(2016.29+340.3+0.5*0)=                                  30.64 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(58527.,30635.69)=          58.53 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)
=(182.17+25)*(202.67-0.5*13)+0*(0-0.5*13)+140.44*(150.67-0.5*13)=    60.89 kN
```

Nozzle Reinforcement pAAval=60.89 >= pAReq=58.53[kN]	96.1%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))     (9.5-10)
=(182.17+25)*202.67+140.44*150.67/((4161.78+340.3)+0.5*(182.17+25+140.44+0)
)=                                                          =    13.50 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                  24.19 MPa

Weight of Nozzle: .3628kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=1.84 <= eab=6.5[mm]	28.3%	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*78.26+5.89)*5.89)=                                  30.93 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((44.5-6.5)*6.5,)40)=                               15.72 mm
```

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =13*(4161.78+340.3)=        58.53 kN

pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                            (9.5-7)
=13*(2016.29+340.3+0.5*0)=                                  30.64 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(58527.,30635.69)=           58.53 kN
```

Pressure Area Available pA(aval.)

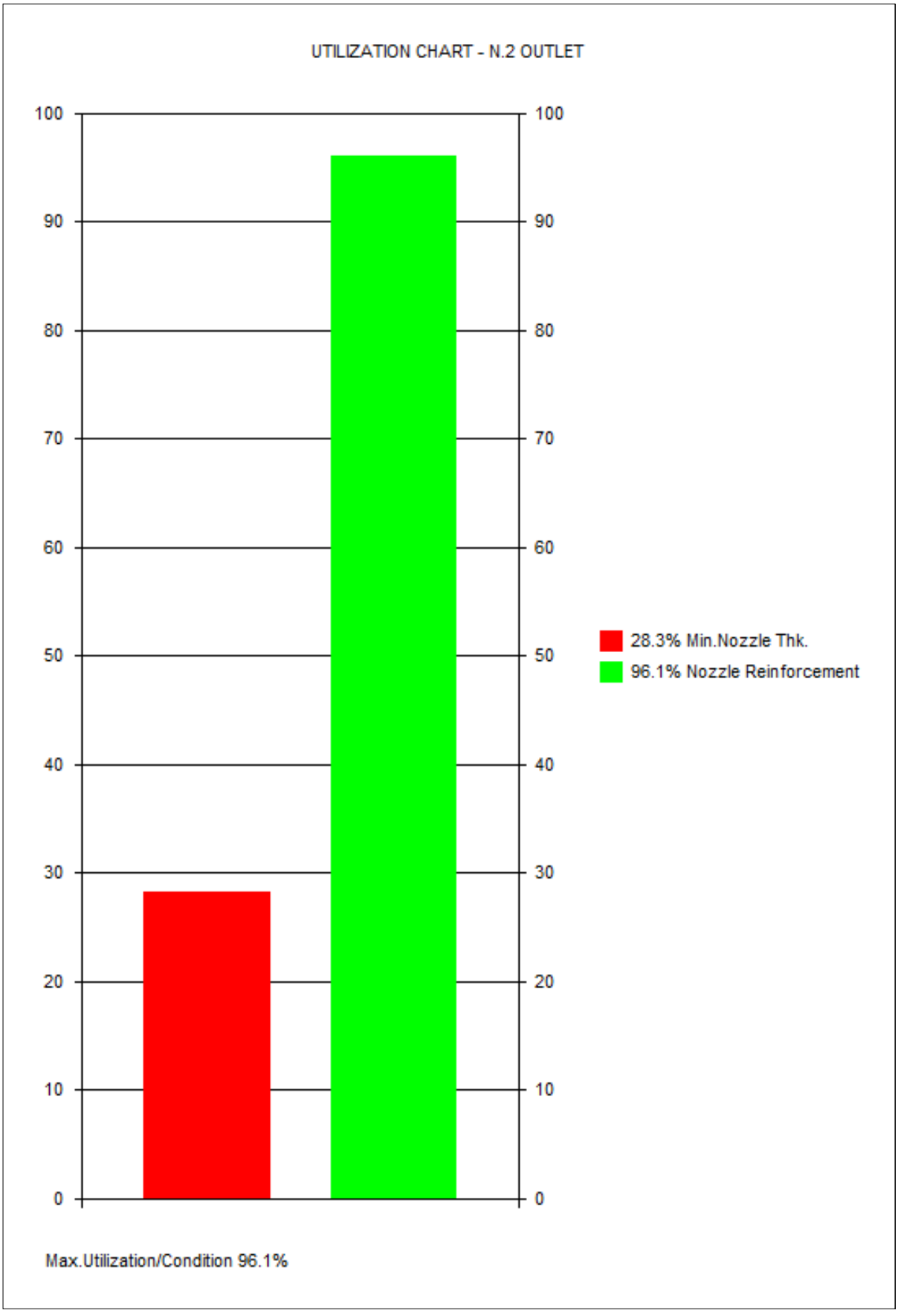
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)       (9.5-7)
=(182.17+25)*(202.67-0.5*13)+0*(0-0.5*13)+140.44*(150.67-0.5*13)=     60.89 kN
```

Nozzle Reinforcement pAAval=60.89 >= pAReq=58.53[kN]	96.1%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))      (9.5-10)
=(182.17+25)*202.67+140.44*150.67/((4161.78+340.3)+0.5*(182.17+25+140.44+0)
)=                                                          =     13.50 MPa
```

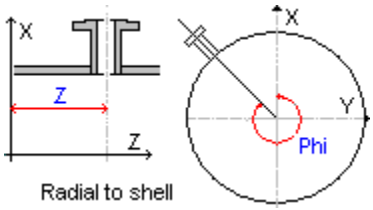
Volume:0.00 m3 Weight:0.4 kg (SG= 7.85)


UTILIZATION CHART - N.2 OUTLET
100
90
80
70
60
50
40
30
20
10
0
28.3% Min.Nozzle Thk.
96.1% Nozzle Reinforcement
Max.Utilization/Condition 96.1%

INPUT DATA

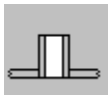
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    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         105.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi   180.00 Degr.
```

GENERAL DESIGN DATA



```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 100°C, P=13.0000 MPa, c=0.5 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.............:SG        1.2000
LIQUID HEAD.....................................:LH        195.00 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        168.30 mm
NOMINAL WALL THICKNESS (uncorroded).............:en        7.1000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...........:th        0.7100 mm
EN 10217-3:2002/A1:05, 1.0565 P355NH welded tube, HT:N THK<=20mm 100'C
Rm=490 Rp=355 Rpt=304 fs=202.67 f20=204.17 ftest=338.1 E=206067(N/mm2) ro=7.85
```

NOZZLE MATERIAL DATA

```
Delivery Form: Seamless Pipe
EN 10216-2:2013, 1.0425 P265GH seamless tube, HT:N THK<=16mm 100'C
Rm=410 Rp=265 Rpt=226 fb=150.67 f20=170.83 ftest=252.38 E=206067(N/mm2) ro=7.85
```

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        30.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       7.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:           12.50 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.............:ho         35.00 mm
```

WELDING DATA

```
Nozzle/Pad to Shell Welding Area: User Specified Fillet Weld Throat Dimensions
OUTWARD NOZZLE WELD, THROAT DIMENSION...............:mo        3.5000 mm
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE PhiC(OBLIQUE IN TRANSVERSE.CROSS SECT.)Fig.9.5-2:PhiC      0.00 Degr.
ANGLE PhiL(OBLIQUE IN LONG.CROSS SECT.)Fig.9.5-1....:PhiL        0.00 Degr.
```

DATA FOR REINFORCEMENT PAD

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

LIMITS OF REINFORCEMENT

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness eas
eas = en - c - th =7.1-0.5-0.71=                          5.8900 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =7-0.5-0.875=                     5.6250 mm
Inside Radius of Curvature
ris = De / 2 - eas (9.5-3) =168.3/2-5.89=                  78.26 mm
dib = deb - 2 * eab =30-2*5.625=                           18.75 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=13.*30/(2*150.67*1+13.)=                                1.2400 mm
Allowable Stresses
fob = Min( fs, fb) (9.5-8) =Min(202.67,150.67)=             150.67 N/mm2
```

GEOMETRIC LIMITATIONS

»Check Max.Diameter of Nozzle dib/(2*ris)=0.1198 <= 1.00=1[mm] «» OK«

Min.Nozzle Thk. ebp=1.24 <= eab=5.625[mm]	22.0%	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*78.26+5.89)*5.89)=                                  30.93 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =5.89*30.93=                        182.17 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((30-5.625)*5.625,)35)=                             11.71 mm
Set In Nozzle
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =5.625*(11.71+0+5.89)=    99.00 mm2
```

Area of Welds Afw

```
Afw = mo ^ 2 =3.5^2=                                         12.25 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*18.75*(11.71+5.89)=   164.99 mm2

Cyl.Shell in the Longitudinal Section Aps
ApsL = ris * (Is + a) (9.5-94) =78.26*(30.93+15)=           3594.39 mm2

Cyl.Shell in the Transverse Cross Section Aps
ApsT = 0.5 * ris ^ 2 * (Is + a ) / (0.5 * eas + ris)               (9.5-105)
=0.5*78.26^2*(30.93+15.09)/(0.5*5.89+78.26)=              1735.29 mm2

Aps = MAX( ApsL ApsT) =MAX(3594.39,1735.29)=                3594.39 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =13.*(3594.39+164.99)=      48.88 kN

pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                            (9.5-7)
=13.*(1735.29+164.99+0.5*0)=                                24.71 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(48880.68,24708.02)=         48.88 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)
=(182.17+12.25)*(202.67-0.5*13.)+0*(0-0.5*13.)+99.*(150.67-0.5*13.)
=    52.41 kN
```

Nozzle Reinforcement pAAval=52.41 >= pAReq=48.88[kN]	93.2%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))      (9.5-10)
=(182.17+12.25)*202.67+99.*150.67/((3594.39+164.99)+0.5*(182.17+12.25+99.+0
))=                                                         =    13.91 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                  25.05 MPa

Weight of Nozzle: .173kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=1.24 <= eab=5.625[mm]	22.0%	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*78.26+5.89)*5.89)=                                  30.93 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((30-5.625)*5.625,)35)=                             11.71 mm
```

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =13.*(3594.39+164.99)=      48.88 kN
pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                            (9.5-7)
=13.*(1735.29+164.99+0.5*0)=                                24.71 kN
pAReq = MAX( pAReqL, pAReqT) =MAX(48880.68,24708.02)=         48.88 kN
```

Pressure Area Available pA(aval.)

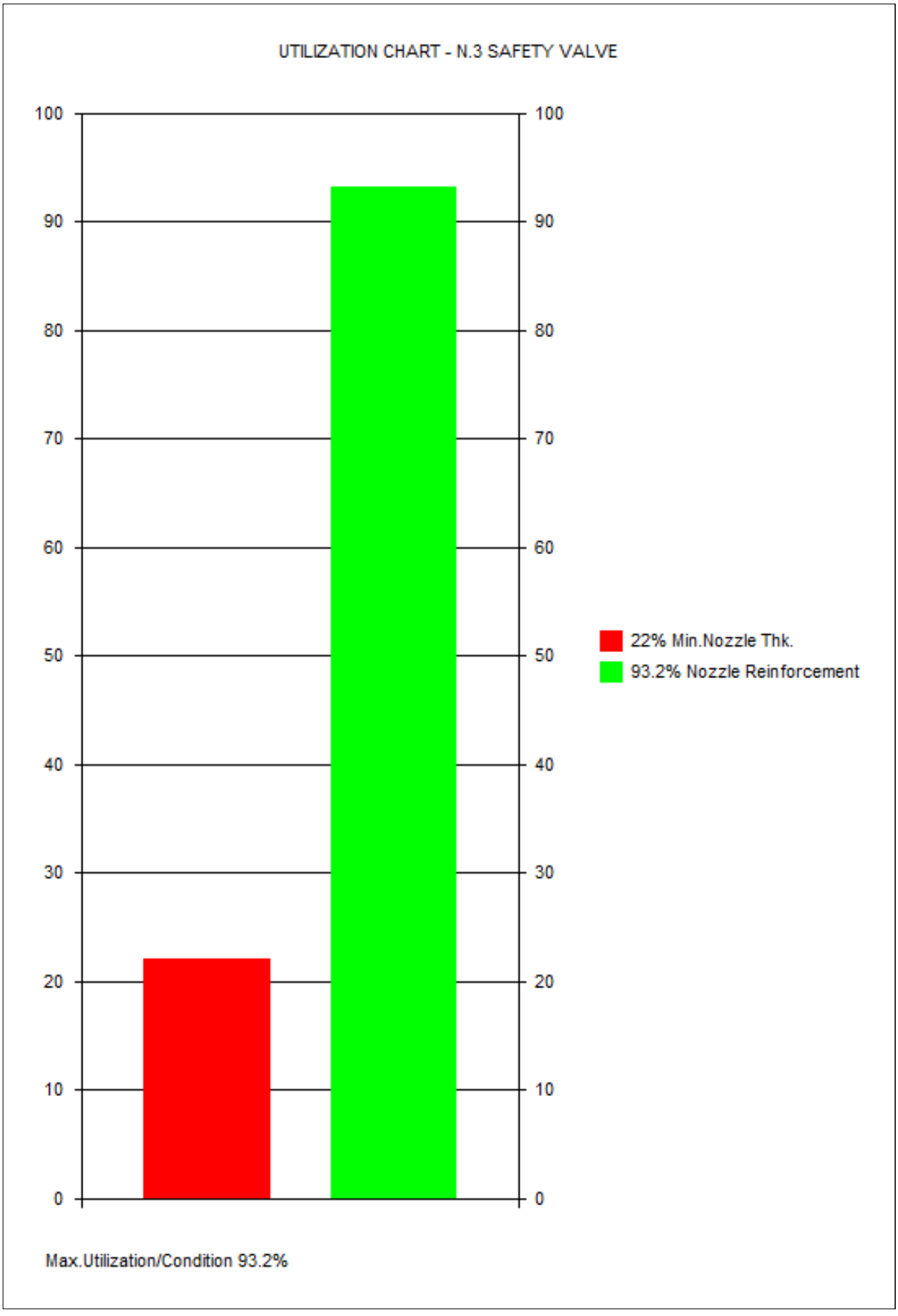
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)       (9.5-7)
=(182.17+12.25)*(202.67-0.5*13.)+0*(0-0.5*13.)+99.*(150.67-0.5*13.)
=    52.41 kN
```

Nozzle Reinforcement pAAval=52.41 >= pAReq=48.88[kN]	93.2%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))      (9.5-10)
=(182.17+12.25)*202.67+99.*150.67/((3594.39+164.99)+0.5*(182.17+12.25+99.+0
))=                                                         =     13.91 MPa
```

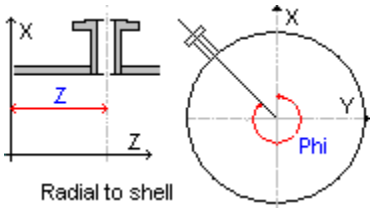
Volume:0.00 m3 Weight:0.2 kg (SG= 7.85)


UTILIZATION CHART - N.3 SAFETY VALVE
100
90
80
70
60
50
40
30
20
10
0
22% Min.Nozzle Thk.
93.2% Nozzle Reinforcement
Max.Utilization/Condition 93.2%

INPUT DATA

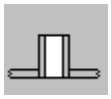
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    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         105.00 mm
Angle of Rotation of nozzle axis projected in the x-y plane:Phi    90.00 Degr.
```

GENERAL DESIGN DATA



```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 100°C, P=13.0000 MPa, c=0.5 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.............:SG        1.2000
LIQUID HEAD.....................................:LH        195.00 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        168.30 mm
NOMINAL WALL THICKNESS (uncorroded).............:en        7.1000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...........:th        0.7100 mm
EN 10217-3:2002/A1:05, 1.0565 P355NH welded tube, HT:N THK<=20mm 100'C
Rm=490 Rp=355 Rpt=304 fs=202.67 f20=204.17 ftest=338.1 E=206067(N/mm2) ro=7.85
```

NOZZLE MATERIAL DATA

```
Delivery Form: Seamless Pipe
EN 10216-2:2013, 1.0425 P265GH seamless tube, HT:N THK<=16mm 100'C
Rm=410 Rp=265 Rpt=226 fb=150.67 f20=170.83 ftest=252.38 E=206067(N/mm2) ro=7.85
```

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        20.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       5.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:           12.50 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.............:ho         23.00 mm
```

WELDING DATA

```
Nozzle/Pad to Shell Welding Area: User Specified Fillet Weld Throat Dimensions
OUTWARD NOZZLE WELD, THROAT DIMENSION...............:mo        3.5000 mm
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE PhiC(OBLIQUE IN TRANSVERSE.CROSS SECT.)Fig.9.5-2:PhiC      0.00 Degr.
ANGLE PhiL(OBLIQUE IN LONG.CROSS SECT.)Fig.9.5-1....:PhiL        0.00 Degr.
```

DATA FOR REINFORCEMENT PAD

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

LIMITS OF REINFORCEMENT

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness eas
eas = en - c - th =7.1-0.5-0.71=                          5.8900 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =5.5-0.5-0.6875=                  4.3125 mm
Inside Radius of Curvature
ris = De / 2 - eas (9.5-3) =168.3/2-5.89=                  78.26 mm
dib = deb - 2 * eab =20-2*4.3125=                          11.38 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=13.*20/(2*150.67*1+13.)=                                0.8300 mm
Allowable Stresses
fob = Min( fs, fb) (9.5-8) =Min(202.67,150.67)=             150.67 N/mm2
```

GEOMETRIC LIMITATIONS

»Check Max.Diameter of Nozzle dib/(2*ris)=0.0727 <= 1.00=1[mm] «» OK«

Min.Nozzle Thk. ebp=0.83 <= eab=4.3125[mm]	19.2%	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*78.26+5.89)*5.89)=                                  30.93 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =5.89*30.93=                        182.17 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((20-4.3125)*4.3125,)23)=                          8.2251 mm
Set In Nozzle
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =4.3125*(8.23+0+5.89)=    60.87 mm2
```

Area of Welds Afw

```
Afw = mo ^ 2 =3.5^2=                                        12.25 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*11.375*(8.23+5.89)=    80.28 mm2

Cyl.Shell in the Longitudinal Section Aps
ApsL = ris * (Is + a) (9.5-94) =78.26*(30.93+10)=           3203.09 mm2

Cyl.Shell in the Transverse Cross Section Aps
ApsT = 0.5 * ris ^ 2 * (Is + a ) / (0.5 * eas + ris)               (9.5-105)
=0.5*78.26^2*(30.93+10.03)/(0.5*5.89+78.26)=              1544.42 mm2

Aps = MAX( ApsL ApsT) =MAX(3203.09,1544.42)=                3203.09 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =13.*(3203.09+80.28)=       42.69 kN

pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                            (9.5-7)
=13.*(1544.42+80.28+0.5*0)=                                 21.12 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(42691.4,21124.89)=          42.69 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)
=(182.17+12.25)*(202.67-0.5*13.)+0*(0-0.5*13.)+60.87*(150.67-0.5*13.)
=    46.92 kN
```

Nozzle Reinforcement pAAval=46.92 >= pAReq=42.69[kN]	90.9%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))      (9.5-10)
=(182.17+12.25)*202.67+60.87*150.67/((3203.09+80.28)+0.5*(182.17+12.25+60.8
7+0))=                                                      =    14.24 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                  25.74 MPa

Weight of Nozzle: .0605kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.83 <= eab=4.3125[mm]	19.2%	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*78.26+5.89)*5.89)=                                  30.93 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                                (9.5-76)
=MIN(Sqr((20-4.3125)*4.3125,)23)=                           8.2251 mm
```

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =13.*(3203.09+80.28)=       42.69 kN

pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                              (9.5-7)
=13.*(1544.42+80.28+0.5*0)=                                  21.12 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(42691.4,21124.89)=          42.69 kN
```

Pressure Area Available pA(aval.)

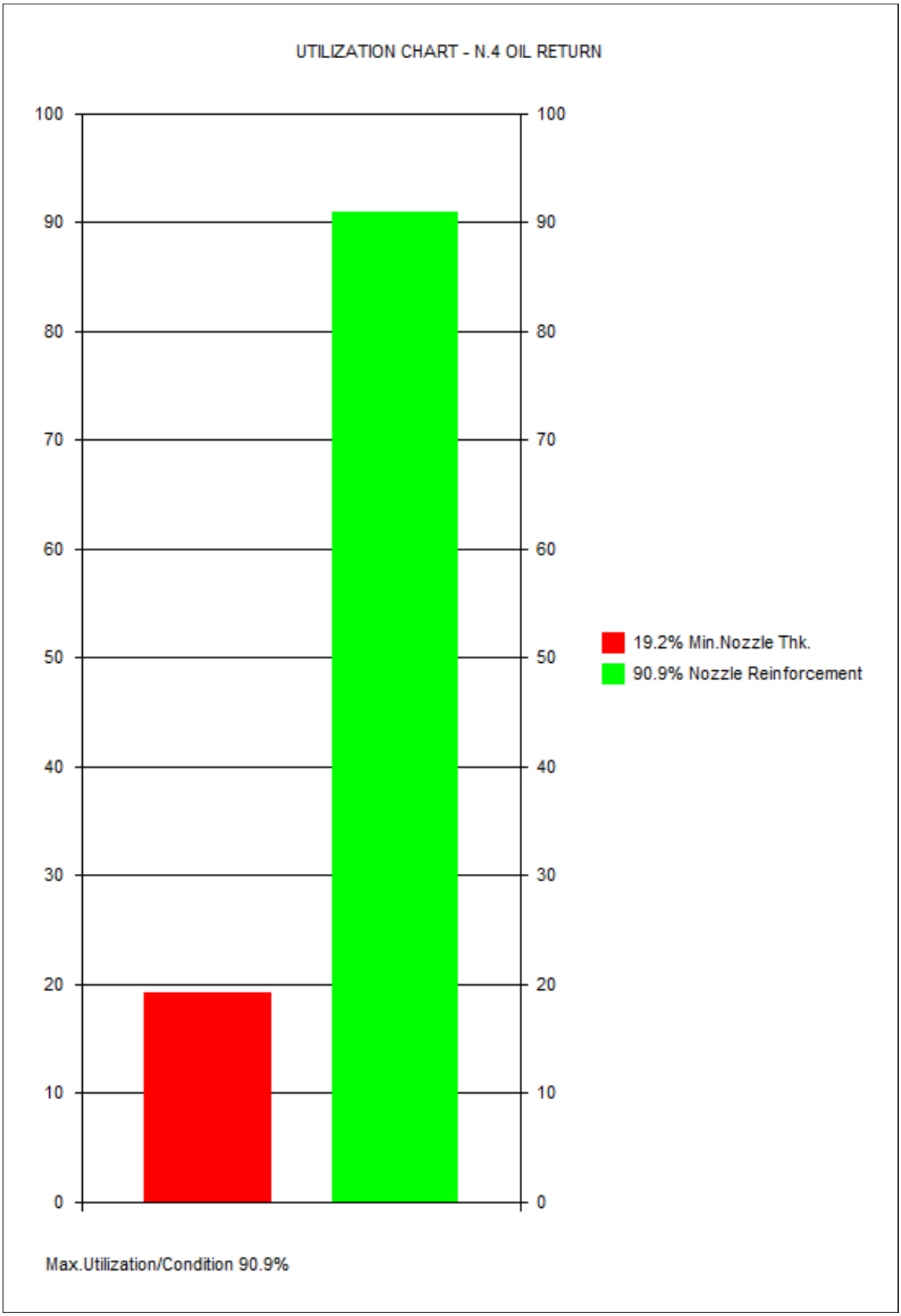
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)       (9.5-7)
=(182.17+12.25)*(202.67-0.5*13.)+0*(0-0.5*13.)+60.87*(150.67-0.5*13.)
=    46.92 kN
```

Nozzle Reinforcement pAAval=46.92 >= pAReq=42.69[kN]	90.9%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))      (9.5-10)
=(182.17+12.25)*202.67+60.87*150.67/((3203.09+80.28)+0.5*(182.17+12.25+60.8
7+0))=                                                       =    14.24 MPa
```

Volume:0.00 m3 Weight:0.1 kg (SG= 7.85)


UTILIZATION CHART - N.4 OIL RETURN
100
90
80
70
60
50
40
30
20
10
0
19.2% Min.Nozzle Thk.
90.9% Nozzle Reinforcement
Max.Utilization/Condition 90.9%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

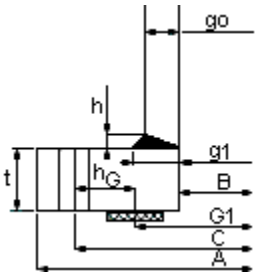
```
Attachment: S1.1    Cylindrical Shell    Shell
Location: Along z-axis z1=  645
Flange Design Method: Section 11 - Taylor Forge
```

GENERAL DESIGN DATA

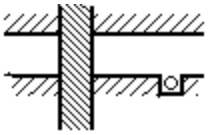
```
PROCESS CARD: General Design Data : Temp= 100°C, P=13.0000 MPa, c=0.5 mm
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG        1.2000
LIQUID HEAD.....:LH          0.00 mm
B: Pressure loading: Flange under internal pressure
EXTERNAL LOADS ON FLANGE  (PD5500 ENQ 5500/123): NO
SPECIFY BOLT LOADS FROM 2nd./MATING FLANGE: NO
```

TYPE OF FLANGE AND GASKET FACING

```
A: Flange Standard: User Specified Flanges
```




```
C: Flange Type: RT  Ring Type(Smooth or Stepped bore)
```



```
D: Flange Facing (Sketch/Description):
7   Full faced flanges with metal to metal contact(O-rings)
```

SHELL/NOZZLE DATA

```
SHELL/NOZZLE SIZE & COMMENT: S1.1
EN 10217-3:2002/A1:05, 1.0565 P355NH welded tube, HT:N THK<=20mm 100'C
Rm=490 Rp=355 Rpt=304 fs=202.67 fs20=204.17 ftest=338.1 E=206067(N/mm2) ro=7.85
OUTSIDE DIAMETER OF SHELL/NOZZLE .....:Do        168.30 mm
WALL THICKNESS OF NOZZLE/SHELL(uncorroded).....:s1        7.1000 mm
```

FLANGE DATA

```
FLANGE HUB: Flange With Hub
DESIGN METHOD: A) INTEGRAL FLANGE METHOD
FLANGE BORE: Stepped
INSIDE DIAMETER OF FLANGE corroded.....:B         161.00 mm
OUTSIDE DIAMETER OF FLANGE.....:A         223.00 mm
THICKNESS OF FLANGE(uncorroded).....:e          32.00 mm
THICKNESS OF FLANGE AT REDUCED SECTION.....:er         27.00 mm
CORROSION ALLOWANCE FOR FLANGE FACE.....:cf          0.00 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=40mm 100'C
Rm=510 Rp=345 Rpt=314 SFO=209.33 SFA=212.5 ftest=328.57 E=206067(N/mm2) ro=7.85
```

DATA FOR FLANGE HUB

```
LENGTH OF HUB.....................................:h          5.0000 mm
THICKNESS OF HUB AT BACK OF FLANGE corroded.......:g1          10.00 mm
THICKNESS OF HUB AT SMALL END      corroded.......:go         5.0000 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=16mm 100'C
Rm=510 Rp=355 Rpt=323 SHO=212.5 SHA=212.5 ftest=338.1 E=206067(N/mm2) ro=7.85
```

BOLTING DATA

```
BOLTING TORQUE CALCULATION: NO
NOMINAL BOLTING SIZE & COMMENT: M14x2    ;
EFFECTIVE BOLT AREA per bolt.....................:Ae        115.00 mm2
RECOMMENDED MINIMUM BOLT CENTER TO EDGE CLEARANCE...:Bce     17.50 mm
RECOMMENDED MINIMUM BOLT CENTER/RADIAL CLEARANCE....:Bcr     21.50 mm
DIAMETER OF BOLT HOLES IN FLANGE.................:d         16.00 mm
NUMBER OF BOLTS...................................:n         16.00
BOLT-CIRCLE DIAMETER..............................:C        195.00 mm
EN 10269:2013, 2.4668 NiCr19Fe19Nb5Mo3 bar, bolt, HT:P THK<=160mm 100'C
Rm=1230 Rp=1030 Rpt=1000 Sb=307.5 Sa=307.5 ftest=461.25 E=193180(N/mm2) ro=7.93
```

GASKET DATA

```
Table H-1 Gasket factors m & y   Facing:
Rubber O-rings 75-85  BS and IRH m=0.25  Y=1.4   2 7
DIAMETER AT LOCATION OF GASKET LOAD REACTION........:G        161.00 mm
```

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

FLANGE LOADS

```
HD = 0.785 * B ^ 2 * p =0.785*161^2*13=                  264.52 kN
H = 0.785 * G ^ 2 * p =0.785*161^2*13=                   264.52 kN
HT = H - HD =2.6452E05-2.6452E05=                          0.00 kN
```

MOMENT ARMS

```
hD = (C - B - g1) / 2 =(195-161-10)/2=                    12.00 mm
hT = (2 * C - G - B) / 4 =(2*195-161-161)/4=              17.00 mm
hR = (A - C) / 2 (11.10-1) =(223-195)/2=                  14.00 mm
```

FLANGE MOMENTS

```
MR = HD * hD + HT * hT (11.10-2) =2.6452E05*12+0*17=     3174.29 Nm

HR = MR / hR (11.10-3) =3174.29/14=                       226.73 kN
```

BOLT LOADS

```
Operating condition
Wop = H + HR (11.10-5) =2.6452E05+2.2673E05=              491.26 kN

Bolting up condition
Wamb = 0 (11.10-4) =0=                                      0.00 kN
```

BOLTING AREA

```
Am1 = Wop / Sb =4.9126E05/307.5=                         1597.59 mm2

Am2 = Wamb / Sa =0/307.5=                                   0.00 mm2

Required Bolting Area Am
Am = MAX( Am1 , Am2) =MAX(1597.59,0)=                    1597.59 mm2

Available Bolting Area Ab
Ab (num.bolts*root area) = n * Ae =16*115=               1840.00 mm2
```

Bolting Area Check Ab=1840 >= Am=1597.59[mm2]	86.8%	OK

BOLT SPACING

Actual Bolt Pitch
Boltp = 2 * (C / 2) * Sqr(1 - (Cos(PI / n)) ^ 2)
=2*(195/2)*Sqr(1-(Cos(3.14/16))^2)= 38.04 mm

MINIMUM FLANGE THICKNESS

Minimum Flange Thickness Excl. Corr.
emin = Sqr(6 * MR / (f * (PI * C - n * d))) (11.10-6)
=Sqr(6*3174.29/(209.33*(3.14*195-16*16)))= 15.97 mm

Required Flange Thk. e=27 >= emin=15.97[mm]	59.1%	OK

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*13*212.5/209.33= 16.50 MPa

Ptmin = 1.43 * Pd =1.43*13= 18.59 MPa

Test Pressure Ptmin=18.59 <= Ptmax=22.46[MPa]	82.7%	OK

PRESSURE AND TORQUE SUMMARY

Table PRESSURE AND TORQUE SUMMARY FOR F.2 :

Description	Temp(C)	P(MPa)	Limited By	Min.Req.Total Bolt Force(kN)
Design Pressure(corroded)	100	13.00	Bolting Area Check	491.26
Max.Allow.Pressure(corroded)	100	15.08	Bolting Area Check	566.08
Max.Allow.Pressure(corroded)	Ambient	15.08	Bolting Area Check	566.08
Max.Allow.Test Pressure(corroded)	Ambient	22.46	Bolting Area Check	848.77
Required Test Pressure	Ambient	16.50	Bolting Area Check	580.03

The nominal Force and Torque values are based on the following bolting up method:

CALCULATION SUMMARY

BOLTING AREA

Bolting Area Check Ab=1840 >= Am=1597.59[mm2]	86.8%	OK

MINIMUM FLANGE THICKNESS

Minimum Flange Thickness Excl. Corr.
emin = Sqr(6 * MR / (f * (PI * C - n * d))) (11.10-6)
=Sqr(6*3174.29/(209.33*(3.14*195-16*16)))= 15.97 mm

Required Flange Thk. e=27 >= emin=15.97[mm]	59.1%	OK

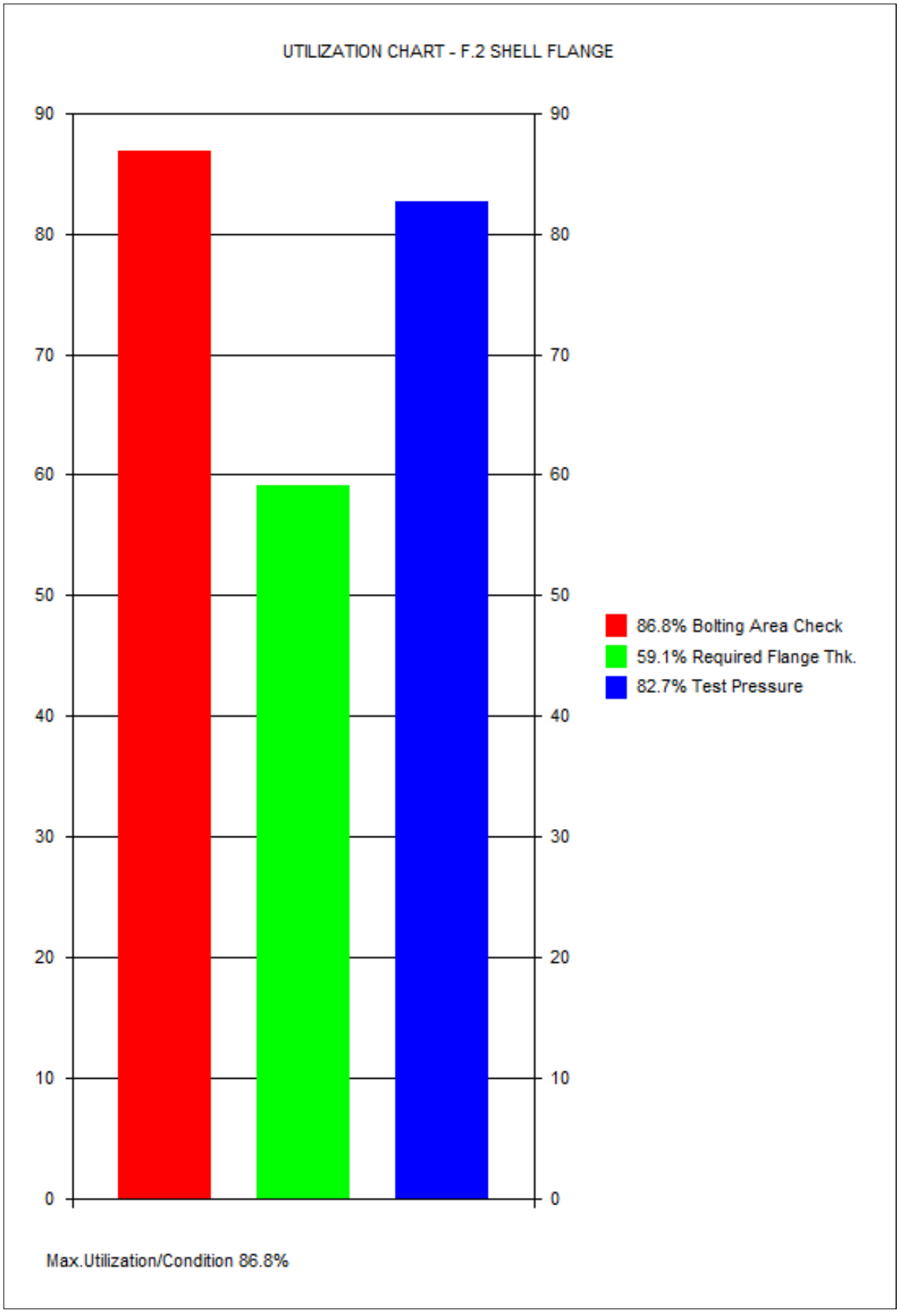
EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*13*212.5/209.33= 16.50 MPa

Ptmin = 1.43 * Pd =1.43*13= 18.59 MPa

Test Pressure Ptmin=18.59 <= Ptmax=22.46[MPa]	82.7%	OK

Volume:0.0006991 m3 Weight:4 kg (SG= 7.85)


UTILIZATION CHART - F.2 SHELL FLANGE
90
80
70
60
50
40
30
20
10
0
86.8% Bolting Area Check
59.1% Required Flange Thk.
82.7% Test Pressure
Max.Utilization/Condition 86.8%

INPUT DATA

SKIRT DATA

```
Skirt is connected to component: S1.1
SELECT TYPE OF SHAPE: Shape A - Skirt connection via support in cylinder area
MEAN SKIRT DIAMETER AT TOP.....................:Dz        114.00 mm
MEAN SKIRT DIAMETER AT BOTTOM..................:Dzb       114.00 mm
NOMINAL THICKNESS OF SKIRT.....................:ez        3.0000 mm
EN 10025-2:2005, 1.0038 S235JR Flat/Long Products THK<=16mm 50'C
Rm=360 Rp=235 Rpt=235 fz=78.33 fz20=78.33 ftest=117.5  (N/mm2)
NOTE: A PARTICULAR MATERIAL APPRAISAL(PMA) MAY BE REQUIRED FOR THIS MATERIAL.
Select a different material for lower part of skirt: NO
HEIGHT OF SUPPORT RING BETWN.SKIRT AND SHELL.....:h           0.00 mm
MODULUS OF ELASTICITY at design temp............:E      2,0607E05 N/mm2
SAFETY FACTOR (1.0 carbon and 1.25 austenitic steels):s     1.0000
```

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         10.00 m/s
WIND FORCE/VESSEL SHAPE/DRAG COEFFICIENT.......:Cf        0.7000
Check Wind Induced Vibration to EN13445 Section 22.10: YES
Seismic Load: YES
Type of Seismic Load: Uniform Building Code UBC 1997
Seismic Zone Factor (Table 16-I): Zone 4,  Z=0.4
Site Coefficient for Soil Profile (Table 16-Q): SC Very Dense Soil and Soft 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         70.00 %
Acceleration Loads: NO
Blast Pressure Load: NO
```

EXTERNAL LOAD BEARING COMPONENTS

Table COMPONENTS:

Description	ID	Do1(mm)	Do2(mm)	L(mm)	Thk(mm)	z1(mm)	z2(mm)	A(m2)	Sp.Dens.
Shell	S1.1	168.3	168.3	645	7.1	0	645	0.11	7.85
Shell Flange	F.2	168.3	223	37	7.1	645	682	0.01	7.85
Cover Flange	E5.1	223	1	23	23	682	705	0	7.85

Table COMPONENTS Continued

Description	Weight(kg)	Vol(m3)	Material Name	fd	fa	fcd	fca	E-Module
Shell	18.2	0.012	EN 10217-3:2002/A1:05, 1.0565	202.7	204.2	191.1	221.9	206067.6
Shell Flange	4	0.001	EN 10028-2:2017, 1.0473 P355GH	209.3	212.5	194.8	213.1	206067.6
Cover Flange	7	0	EN 10028-2:2017, 1.0473 P355GH	209.3	212.5	202.4	221.9	206067.6

Table COMPONENTS Continued

Description	S	Thinning(mm)	E20-Module	Pemax
Shell	1	0.71	211770.7	0
Shell Flange	1	0	211770.7	0
Cover Flange	1	0	211770.7	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	LC6&7&8 Oper.Seismic
Wind Load	0
Seismic	1.0
Blast Load	0
Acceleration	0

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	18.59	0	0	11.7
Ext.Pressure(MPa)	Pe	0	0	0	0
Temperature D/A	T	A	D	A	D
Corrosion (mm)	c	0	0.5	0.5	0.5
Stress M-Factor :	mf	1.425	1	1	1
Liquid Level (mm)	LL	FULL	EMPTY	EMPTY	300
Sp.Gravity (Liq.)	SG	1	0	0	1.2
Max.Deflection d/200	d	1	1	1	1

Table LOAD CASE FACTORS Continued

Description	LC6&7&8 Oper.Seismic
Int.Pressure(MPa)	11.7
Ext.Pressure(MPa)	0
Temperature D/A	D
Corrosion (mm)	0.5
Stress M-Factor :	1.425
Liquid Level (mm)	300
Sp.Gravity (Liq.)	1.2
Max.Deflection d/200	1

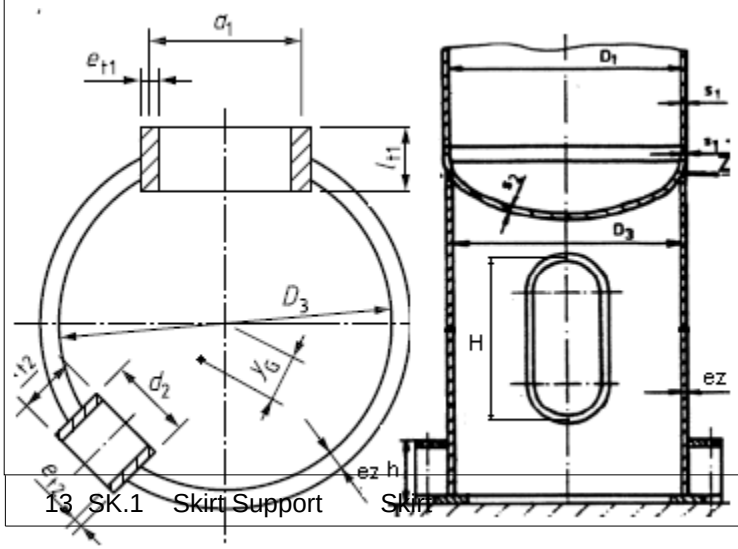
SKIRT OPENINGS

Table DATA FOR SKIRT OPENINGS:

Opening ID.	Dia./Width(mm)	Center z-value(mm)	Angle(degr.)	Height(H)(mm)
Inspection Opening	0	0	0	0

Table DATA FOR SKIRT OPENINGS Continued

Opening ID.	Reinf.thk.(eti)(mm)	Reinf.Length(lti)(mm)
Inspection Opening	0	



VESSEL DATA

```
MEAN SHELL DIAMETER.................................:DB        162.41 mm
THICKNESS OF VESSEL WALL (uncorroded)...............:eB        5.8900 mm
EN 10217-3:2002/A1:05, 1.0565 P355NH welded tube, HT:N THK<=20mm 100'C
Rm=490 Rp=355 Rpt=304 fB=202.67 fB20=204.17 ftest=338.1 E=206067(N/mm2) ro=7.85
```

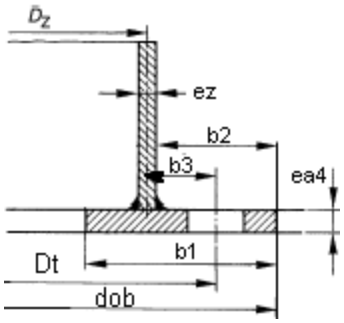
ANCHOR BOLT DATA

```
NUMBER OF BOLTS.....................................:n         4.0000
EFFECTIVE BOLT AREA per bolt........................:Ae         36.60 mm2
Bolting Size/Comment: M8x1.25  ;
5.6 -2  DIN 267 THK<=30mm 100'C
Rm=500 Rp=300 Rpt=250 Sa=83.33 Sb=100 ftest=150  (N/mm2)
NOTE: A PARTICULAR MATERIAL APPRAISAL(PMA) MAY BE REQUIRED FOR THIS MATERIAL.
Allowable Bolt Material Stress Based On::
Apply Safety Factors of 2.0625 on tensile- and 1.65 on yield-stress at room temp.
```

Allowable stresses for anchor bolts: Sa = 181.8, Sb = 181.8

```
ANCHOR BOLTS FRICTION COEFFICIENT: Normal/Average Conditions  μ=0.20
ANCHOR BOLTS ASSEMBLY FACTOR(RECOMMENDED VALUE 0.5).:Phi       0.5000
```

DATA FOR SKIRT BASE




```
SELECT TYPE OF BASE: Skirt with base ring only
OUTSIDE DIAMETER OF BASE PLATE.....................:dob       190.00 mm
NOMINAL THICKNESS OF BASE PLATE....................:ea4       5.0000 mm
TOTAL WIDTH OF BASE PLATE RING.....................:b1         70.00 mm
DIAMETER OF BOLT HOLE IN BASE PLATE RING...........:dtb       8.5000 mm
Skirt base design temperature......................:Tb        100.00 'C
EN 10028-2:2017, 1.0345 P235GH plate and strip, HT:N THK<=16mm 100'C
Rm=360 Rp=235 Rpt=214 fc1=142.67 fc20=150 ftest=223.81 E=206067(N/mm2) ro=7.85
DIST.BETWEEN SKIRT OD AND CENTERLINE OF ANCHOR BOLTS:b3         23.00 mm
ALLOWABLE FOUNDATION BEARING PRESSURE..............:Fba       7.4000 N/mm2
```

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(705--60)=                    765.00 mm
```

Uniform Building Code 1997

```
Ca (from UBC Table 16Q) = ==                                 0.4000
Cv (from UBC Table 16R) = ==                                 0.5600
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 - LC6&7&8 OPER.SEISMIC

```
Tnat = MIN( TRay , Cz * TnatA)
=MIN(0.0078,1.3*0.0399)=                                    0.0078 s
The total design base shear is given by the following formulas(rigid vessel
T<0.06):
V = 0.7 * Ca * I * W (34-1) =0.7*0.4*1*50.32=                14.09 kg
Shear force at bottom of vessel V
V = V * 9.81 / 1.4 =14.09*9.81/1.4=                         0.0987 kN

Ft = 0 since T < 0.7 s
```

VESSEL DEFLECTION LOAD CASE NO: 1 - LC9 HYDROTEST

ID	z(mm)	I(m4)	E-Mod.(N/mm2)	F Shear(kN)	Moment(kNm)	Deflection(mm)
SK	-60	0.6366	211771	0.00	0.002	0.000
S1.1	0	0.1170	211771	0.00	0.000	0.000
S1.1	0	0.1170	211771	0.00	0.002	0.000
F.2	645	0.1170	211771	0.00	0.000	0.000
E5.1	682	1.2139	211771	0.00	0.000	0.000

»LC9 HYDROTEST, Max.deflection over 200mm length dallow=1 >= dactual=6.259E-05[mm] «» OK«

```
Between z1= 508 and z2= 705 in component:E5.1
Deflection at top of vessel  :    0.0 mm
```

VESSEL DEFLECTION LOAD CASE NO: 2 - LC4 SHUT DOWN

ID	z(mm)	I(m4)	E-Mod.(N/mm2)	F Shear(kN)	Moment(kNm)	Deflection(mm)
SK	-60	0.6366	206070	0.01	0.003	0.000
S1.1	0	0.1098	206068	0.00	0.000	0.000
S1.1	0	0.1098	206068	0.01	0.002	0.000
F.2	645	0.1098	206068	0.00	0.000	0.000
E5.1	682	1.2139	206068	0.00	0.000	0.000

»LC4 SHUT DOWN, Max.deflection over 200mm length dallow=1 >= dactual=1.0323E-04[mm] «» OK«

```
Between z1= 484 and z2= 682 in component:F.2
Deflection at top of vessel  :    0.0 mm
```

VESSEL DEFLECTION LOAD CASE NO: 3 - LC5 INSTALLATION

ID	z(mm)	I(m4)	E-Mod.(N/mm2)	F Shear(kN)	Moment(kNm)	Deflection(mm)
SK	-60	0.6366	211771	0.00	0.002	0.000
S1.1	0	0.1098	211771	0.00	0.000	0.000
S1.1	0	0.1098	211771	0.00	0.002	0.000
F.2	645	0.1098	211771	0.00	0.000	0.000
E5.1	682	1.2139	211771	0.00	0.000	0.000

»LC5 INSTALLATION, Max.deflection over 200mm length dallow=1 >= dactual=7.1617E-05[mm] «» OK«

```
Between z1= 508 and z2= 705 in component:E5.1
Deflection at top of vessel  :    0.0 mm
```

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

ID	z(mm)	I(m4)	E-Mod.(N/mm2)	F Shear(kN)	Moment(kNm)	Deflection(mm)
SK	-60	0.6366	206070	0.01	0.003	0.000
S1.1	0	0.1098	206068	0.00	0.000	0.000
S1.1	0	0.1098	206068	0.01	0.002	0.000
F.2	645	0.1098	206068	0.00	0.000	0.000
E5.1	682	1.2139	206068	0.00	0.000	0.000

»LC1&2&3 OPER.WIND, Max.deflection over 200mm length dallow=1 >= dactual=1.0323E-04[mm] «» OK«

```
Between z1= 484 and z2= 682 in component:F.2
Deflection at top of vessel  :    0.0 mm
```

VESSEL DEFLECTION LOAD CASE NO: 5 - LC6&7&8 OPER.SEISMIC

ID	z(mm)	I(m4)	E-Mod.(N/mm2)	F Shear(kN)	Moment(kNm)	Deflection(mm)
SK	-60	0.6366	206070	0.10	0.054	0.000
S1.1	0	0.1098	206068	0.00	0.000	0.000
S1.1	0	0.1098	206068	0.10	0.050	0.000
F.2	645	0.1098	206068	0.04	0.002	0.006
E5.1	682	1.2139	206068	0.03	0.000	0.007

»LC6&7&8 OPER.SEISMIC, Max.deflection over 200mm length dallow=1 >= dactual=0.0023[mm] «» OK«

Between z1= 484 and z2= 682 in component:F.2
Deflection at top of vessel : 0.0 mm

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	0.0086 s	116.63 Hz
LOAD CASE NO: 2 - LC4 SHUT DOWN	0.0078 s	128.88 Hz
LOAD CASE NO: 3 - LC5 INSTALLATION	0.0077 s	130.65 Hz
LOAD CASE NO: 4 - LC1&2&3 OPER.WIND	0.0078 s	127.98 Hz
LOAD CASE NO: 5 - LC6&7&8 OPER.SEISMIC	0.0078 s	127.98 Hz

EN13445 Section 22.10.2 - Criteria for Vortex Shedding

The effect of vortex shedding need not be investigated when at least one of the following conditions is met:
h/Dc13 < 15, Vcr > 1.25*vm, 0.004*me/(ro*Dc13^2) > 0.8 for oper.cond and 1.1 for erection cond.

LOAD CASE	Dc13(mm)	me(kg/m)	Vm(m/s)	Vcr(m/s)	h/Dc13	0.004*me/(ro*Dc13^2)	Status
NO: 1 - LC9 HYDROTEST	167.19	90.72	10.00	108.33	4.58	10.18	OK
NO: 2 - LC4 SHUT DOWN	167.19	69.34	10.00	119.71	4.58	7.78	OK
NO: 3 - LC5 INSTALLATION	167.19	69.34	10.00	121.36	4.58	7.78	OK
NO: 4 - LC1&2&3 OPER.WIND	167.19	69.34	10.00	118.87	4.58	7.78	OK

Nomenclature:
h = Total height above ground level =0.7650 m
Dc13 = Average diameter(including insulation) of upper third of height of column.
me = Eqvivalent mass per unit length of the upper third of height of column.
vcrit = Critical wind velocity for mode 1.
vm = 10 minute mean wind velocity with a 0.02 annual risk of beeing exceeded at elevation 0.6375 m above ground level.

22.10 Vortex Shedding - Forces and Moments

Load Case	Sc	K	Kw	clat	yF,max(mm)	Force(kN)	Moment(kNm)
LC9 Hydrotest	203.58	0.1300	0.6000	0.00	0.00	0.00	0.00
LC4 Shut Down	46.68	0.1300	0.6000	0.00	0.00	0.00	0.00
LC5 Installation	46.68	0.1300	0.6000	0.00	0.00	0.00	0.00
LC1&2&3 Oper.Wind	155.61	0.1300	0.6000	0.00	0.00	0.00	0.00

16.12.4.4 CHECK OF LARGEST OPENING IN SKIRT(at z= 0)

Half angle of the opening
Delta = ArcSin(d / D3) (16.12-72) =ArcSin(0/111)= 0.00 rad
Area of Reinforcement of opening
At = 2 * eti * lti =2*0*0= 0.00 mm2

```
Area of Skirt
As = (PI - Delta) * D3 * ea3 =(3.14-0)*111*3=                1046.15 mm2
Total Area of Available Skirt
A4 = As + At (16.12-73) =1046.15+0=                          1046.15 mm2
yt = 0.5 * D3 * Cos( Delta) + ht - 0.5 * lti
=0.5*111*Cos(0)+0-0.5*0=                                     55.50 mm
Distance between neutral axis and centre of gravity
yG = (0.5 * D3 * ea3 * d - 2 * lti * eti * yt) / A4                  (16.12-74)
=(0.5*111*3*0-2*0*0*55.5)/1046.15=                            0.00 mm
Maximum distance between centre of gravity and outer edge of section 4-4
ymax = MAX( 0.5 * D3 * Cos( Delta) + ht + yG 0.5 * D3 - yG)
=MAX(0.5*111*Cos(0)+0+0,0.5*111-0)=                          55.50 mm
Is = (PI-Delta-Sin(Delta)*Cos(Delta))*ea3*(0.5*D3)^3
=(3.14-0-Sin(0)*Cos(0))*3*(0.5*111)^3=                    1,6112E06 mm4
Section modulus of the cross section at section 4-4
W4 = (Is+At*(yt^2+lti^2/12)-A4*yG^2)/ymax                            (16.12-75)
=(1.6112E06+0*(55.5^2+0^2/12)-1046.15*0^2)/55.5=           29030.67 mm3
Weakening Factor for Area
Psi1 = MIN( 1, A4 / Aunperf) =MIN(1,1046.15/1074.42)=          0.9737
Weakening Factor for Elastic Section Modulus
Psi2 = MIN( 1, W4 / Wunperf)
=MIN(1,29030.67/29856.61)=                                   0.9723
```

16.12.4 WEAK AREAS IN SKIRT DUE TO OPENING/MULTIPLE OPENINGS

Z-Loc.(mm)	Skirt Mean D(mm)	Area A4(mm2)	Sect.Mod.W4(mm3)	eps(mm)	No.Open.	psi1	psi2
-60	114	1074	29857	0.000	0	1.000	1.000
-20	114	1074	29857	0.000	0	1.000	1.000

```
eps = displacement of neutral axis at elevation z.
No.Open. = number of openings considered at elevation z.
psi1 = area reduction of skirt = actual area / area of unpierced skirt.
psi2 = section modulus reduction of skirt = actual value/value of unpierced skirt.
NOTE: Top and bottom of skirt is always checked as skirt diameter, skirt material,
calculation temperature, allowable stress and moments may vary from top to bottom
of skirt.
```

Note: Skirt is pierced and has a minimum section modulus at z= 0mm

REACTION FORCES & MOMENTS AT SKIRT BASE

LOAD CASE	Fx(kN)	Fy(kN)	Fz(kN)	Mx(kNm)	My(kNm)	Mz(kNm)
LC9 HYDROTEST	0.00	0.00	-0.51	0.00	0.00	0.00
LC4 SHUT DOWN	0.01	0.00	-0.37	0.00	0.00	0.00
LC5 INSTALLATION	0.00	0.00	-0.37	0.00	0.00	0.00
LC1&2&3 OPER.WIND	0.01	0.00	-0.43	0.00	0.00	0.00
LC6&7&8 OPER.SEISMIC	0.10	0.00	-0.50	0.00	0.05	0.00

LOAD CASE NO: 1 - LC9 HYDROTEST

Summation of Total Loads for Load Case : LC9 HYDROTEST

```
Fz (Force in Vertical Direction)= ==                          -0.5128 kN
Fx (Force in X-Direction)= ==                                 0.0034 kN
Fy (Force in Y-Direction)= ==                                   0.00 kN
Fs=SQR(Fx^2 + Fy^2))(Tot.Force in Hor.Plane)= ==              0.0034 kN
Moments at top of skirt at elevation of shell/skirt connection.
Mx (Moment around the X-Axis)= ==                             -0.8814 kNmm
My (Moment around the Y-Axis)= ==                             1.3129 kNmm
M1=SQR(Mx^2+My^2)(Moment in XY Plane)= ==                     1.5813 kNmm
Mt (Moment around the z-axis)= ==                             0.0128 kNmm
Moments at elevation at bottom of skirt.
Mx4 (Moment around the X-Axis)= ==                            -0.8814 kNmm
My4 (Moment around the Y-Axis)= ==                            1.4509 kNmm
M4=SQR(Mx4^2+My4^2)(Moment in XY Plane)= ==                   1.6976 kNmm
FF (Weight of Content of Vessel)= ==                          0.1282 kN
dFg (Weight of Vessel Below Section 2-2)= (16.12-3) ==    2,7655E-04 kN
```

16.12.6.1 Verification of Membrane Stresses

```
Fzp = Fz + 4 * M1 / Dz (16.12-1) =-512.8+4*1.58/114=        -457.29 N
Fzq = Fz - 4 * M1 / Dz (16.12-2) =-512.8-4*1.58/114=        -568.26 N
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                  (16.14-15)
=1.21*2.1177E05*5.89/(355*162.41)=                    26.18
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                          (16.14-16)
=0.83/Sqr(1+0.005*162.41/5.89)=                       0.7781
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                     (16.14-19)
=(1-0.4123/(0.7781*26.18)^0.6)/1.05=                  0.8880
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =355*0.888=          315.25 N/mm2
```

Stresses in section 1-1 (internal pressure)

```
Membrane Stress(Sect.1-1)
Sig1pm = (Fzp+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(-457.29+0.2766+128.19)/(3.14*162.41*5.89)+18.59*162.41/(4*5.89)
=   128.04 N/mm2

Sig1qm = (Fzq+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(-568.26+0.2766+128.19)/(3.14*162.41*5.89)+18.59*162.41/(4*5.89)
=   128.00 N/mm2
```

Membrane Stress(Pint)(Sect.1-1) Sig1pm=128.04 <= fB=338.1[N/mm2]	37.8%	OK
Membrane Stress(Pint)(Sect.1-1) ABS(Sig1qm)=128. <= fB=338.1[N/mm2]	37.8%	OK

Stresses in section 1-1 (external pressure)

```
Membrane Stress(Sect.1-1)
Sig1pmext = (Fzp+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(-457.29+0.2766+128.19)/(3.14*162.41*5.89)-0*162.41/(4*5.89)=   -0.1094 N/mm2

Sig1qmext = (Fzq+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(-568.26+0.2766+128.19)/(3.14*162.41*5.89)-0*162.41/(4*5.89)=   -0.1463 N/mm2
```

Compr.Stress(Pext)(Sect.1-1) Sig1pmext=0.1094 <= Sigcall=315.25[N/mm2]	0.0%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.1463 <= Sigcall=315.25[N/mm2]	0.0%	OK

```
Membrane Stress(Sect.2-2)
Sig2pm = Sig2qm=(FF+dFg)/(PI*DB*eB)+p*DB/(4*eB)
=(128.19+0.2766)/(3.14*162.41*5.89)+18.59*162.41/(4*5.89)=   128.19 N/mm2
```

Membrane Stress(Sect.2-2) ABS(Sig2pm)=128.19 <= fB=338.1[N/mm2]	37.9%	OK

```
Membrane Stress(Sect.3-3)
Sig3pm = Fzp / (PI * Dz * ez) =-457.29/(3.14*114*3)=        -0.4256 N/mm2
Sig3qm = Fzq / (PI * Dz * ez) =-568.26/(3.14*114*3)=        -0.5289 N/mm2
```

Membrane Stress(Sect.3-3) ABS(Sig3pm)=0.4256 <= fz=117.5[N/mm2]	0.3%	OK
Membrane Stress(Sect.3-3) ABS(Sig3qm)=0.5289 <= fz=117.5[N/mm2]	0.4%	OK

16.12.6.2 Bending Stresses

```
a) Structural Shape A - figure 16.12-1
Total Bending Moments at Verification Points p and q:
Mp = 0.5 * (Dz - DB) * Fzp (16.12-18) =0.5*(114-162.41)*-457.29= 11068.67 Nmm
Mq = 0.5 * (Dz - DB) * Fzq (16.12-19) =0.5*(114-162.41)*-568.26= 13754.70 Nmm
e1pm = ((Fzp + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-7)
=((-457.29+0.2766+128.19)/(3.14*162.41)+18.59*162.41/4)/338.1=   2.2306 mm
e1qm = ((Fzq + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-8)
=((-568.26+0.2766+128.19)/(3.14*162.41)+18.59*162.41/4)/338.1=   2.2299 mm
e2m = ((dFg + FF) / (PI * DB) + p * DB / 4) / fB                   (16.12-11)
=((0.2766+128.19)/(3.14*162.41)+18.59*162.41/4)/338.1=     2.2332 mm
e3pm = (Fzp / (PI * Dz)) / fB                                      (16.12-11)
=(-457.29/(3.14*114))/338.1=                                -0.0038 mm
e3qm = (Fzq / (PI * Dz)) / fB                                      (16.12-11)
=(-568.26/(3.14*114))/338.1=                                -0.0047 mm
Total Section Modulus of the Support Ring at Verification Point
Wp = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1pm^2-e2m^2)*DB+0.5*(e2m^2-e3pm^2)*Dz)
(16.12-20)
=3.14/4*((114+3-162.41-5.89)*0^2+(2*5.89^2-2.23^2-2.23^2)*162.41+0.5*(2.23^
2--0.0038^2)*114)=                                          =  7802.86 mm3
Wq = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1qm^2-e2m^2)*DB+0.5*(e2m^2-e3qm^2)*Dz)
(16.12-21)
=3.14/4*((114+3-162.41-5.89)*0^2+(2*5.89^2-2.23^2-2.23^2)*162.41+0.5*(2.23^
2--0.0047^2)*114)=                                          =  7803.23 mm3
```

16.12.6.3 Total Stresses and Strength Conditions

a) Structural Shape A

1) Location p ABS(Mp)/Wp=1.42 <= fT=117.5[N/mm2] (16.12-44)	1.2%	OK
2) Location q ABS(Mq)/Wq=1.76 <= fT=117.5[N/mm2] (16.12-45)	1.5%	OK

16.12.7 Verification of Skirt (Section 4-4)

Note: Skirt is pierced and has a minimum section modulus at z= 0mm

Verification of Skirt at Bottom(no openings) at Elevation z = -60 mm

```
Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*512.77=                                    0.00 kNmm
Membrane Stress(Sect.4-4/z=-60)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(1697.62+0)/29856.61-512.77/1074.43=                    -0.4204 N/mm2
Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(1697.62+0)/29856.61-512.77/1074.43=                 -0.5341 N/mm2
```

Membrane Stress(Sect.4-4/z=-60) Sig4pm=0.4204 <= fz=117.5[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=0.5341 <= fz=117.5[N/mm2]	0.4%	OK

```
Compressive Stresses in Skirt(Sect.4-4/z=-60)
Sig4c = - F4 / A4 =-512.77/1074.43=                          -0.4773 N/mm2
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                     (16.14-15)
=1.21*206070*3/(235*114)=                                  27.92
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                             (16.14-16)
=0.83/Sqr(1+0.005*114/3)=                                 0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                        (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.05=                      0.8896
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.8896=               209.06 N/mm2
```

Compr.Stress Limits (4-4/z=-60) Sig4c=0.4773 <= Sigcall=209.06[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*209.06= 224.62 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall (16.14-3)
=3.14/4*114^2*3*209.06= 6.4017 kNm

Stability of skirt(Sect.4-4/z=-60)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max) (16.12-70)
=512.77/(1*2.2462E05)+(ABS(1697.62)+512.77*0)/(1*6.4017E06)= 0.0025

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0025 <= 1=1	0.2%	OK

Verification of Skirt at Top(no openings) at Elevation z = -20 mm

Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*512.77= 0.00 kNmm
Membrane Stress(Sect.4-4/z=-20)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(1581.32+0)/29856.61-512.77/1074.43= -0.4243 N/mm2

Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(1581.32+0)/29856.61-512.77/1074.43= -0.5302 N/mm2

Membrane Stress(Sect.4-4/z=-20) Sig4pm=0.4243 <= fz=117.5[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=0.5302 <= fz=117.5[N/mm2]	0.4%	OK

Compressive Stresses in Skirt(Sect.4-4/z=-20)
Sig4c = - F4 / A4 =-512.77/1074.43= -0.4773 N/mm2

16.14.8 COMPRESSIVE STRESS LIMITS

K = 1.21 * E * ea / (Sige * D) (16.14-15)
=1.21*206070*3/(235*114)= 27.92
alfa = 0.83 / Sqr(1 + 0.005 * D / ea) (16.14-16)
=0.83/Sqr(1+0.005*114/3)= 0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.05= 0.8896
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.8896= 209.06 N/mm2

Compr.Stress Limits (4-4/z=-20) Sig4c=0.4773 <= Sigcall=209.06[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*209.06= 224.62 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall (16.14-3)
=3.14/4*114^2*3*209.06= 6.4017 kNm

Stability of skirt(Sect.4-4/z=-20)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max) (16.12-70)
=512.77/(1*2.2462E05)+(ABS(1581.32)+512.77*0)/(1*6.4017E06)= 0.0025

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.0025 <= 1=1	0.2%	OK

SKIRT BASE DESIGN

```
Wsk = F4 / (PI * Dzb) =512.77/(3.14*114)=                    1.4318 N/mm
Msk = 4 * M4 / (PI * Dzb ^ 2) =4*1.7/(3.14*114^2)=           0.1663 N/mm
Outer radial width of bearing plate/base plate
b2 = (dob - (Dzb + ez)) / 2 =(190-(114+3))/2=                 36.50 mm
```

16.12.5 Anchor Bolt Design

```
Bolt Circle Diameter
d = Dzb + ea3 + 2 * b3 =114+3+2*23=                          163.00 mm
Mean Diameter of Bearing Ring/Base Plate
DCR = dob - b1 =190-70=                                      120.00 mm
Inside Diameter of Bearing Ring/Base Plate
D3 = dob - 2 * b1 =190-2*70=                                  50.00 mm
Pre-tensioning of bolts FA
FA = Phi * Ae * fdAnchor (16.12.80) =0.5*36.6*181.82=       3327.27 N
Maximum anchor bolt force FB
FB = (4 * M5 / d - F5) / n (16.12.77) =(4*1697.62/163-512.77)/4=  -117.78 N
Required minimum torque(per bolt).
Mt = μ * FA * 1.1 * SQR( 4 * Ae / PI)                                (16.12-81)
=0.2*3327.27*1.1*SQR(4*36.6/3.14)=                          4.9970 Nm
Design anchor bolt load FBd
FBd = MAX( FA , FB) (16.12.83) =MAX(3327.27,-117.78)=       3327.27 N
Required Bolting Area
Aemin = MAX( FB , 0) / fdAnchor
=MAX(-117.78,0)/181.82=                                       0.00 mm2
```

Anchor Bolt Area Aemin=0 <= Ae=36.6[mm2]	0.0%	OK

```
Spacing between anchor bolts
b8 = PI * (Dzb + ea3 + 2 * b3) / n
=3.14*(114+3+2*23)/4=                                       128.02 mm
Design load on concrete FCd
FCd = MAX( 4 * M5 / DCR + F5 , FA * n)
=MAX(4*1697.62/120+512.77,3327.27*4)=                     13309.09 N
Foundation Bearing Pressure on concrete below base ring
Sigc = FCd / (PI * DCR * b1) (16.12-86) =13309.09/(3.14*120*70)=   0.5043 N/mm2
```

Foundation Bearing Pressure(concrete) Sigc=0.5043 <= fcd/1.35=5.48[N/mm2] (16.12-86)	9.2%	OK

16.12.5.4.3 Checks for type 1 - Simple Bearing Plate

```
Required minimum analysis thickness of bearing plate (FB <= 0)
ea4min = b2 * SQR( 3 * SigC / f4)                                    (16.12-90b)
=36.5*SQR(3*0.5043/223.81)=                                 3.0011 mm
```

Min.Thk.of Base Ring ea4min=3. <= eR=5[mm]	60.0%	OK

LOAD CASE NO: 2 - LC4 SHUT DOWN

Summation of Total Loads for Load Case : LC4 SHUT DOWN

```
Fz (Force in Vertical Direction)= ==                         -0.3672 kN
Fx (Force in X-Direction)= ==                                 0.0063 kN
Fy (Force in Y-Direction)= ==                                   0.00 kN
Fs=SQR(Fx^2 + Fy^2))(Tot.Force in Hor.Plane)= ==              0.0063 kN
Moments at top of skirt at elevation of shell/skirt connection.
Mx (Moment around the X-Axis)= ==                            -0.8814 kNmm
My (Moment around the Y-Axis)= ==                             2.2874 kNmm
M1=SQR(Mx^2+My^2)(Moment in XY Plane)= ==                     2.4513 kNmm
Mt (Moment around the z-axis)= ==                             0.0235 kNmm
Moments at elevation at bottom of skirt.
Mx4 (Moment around the X-Axis)= ==                            -0.8814 kNmm
My4 (Moment around the Y-Axis)= ==                            2.5403 kNmm
M4=SQR(Mx4^2+My4^2)(Moment in XY Plane)= ==                   2.6889 kNmm
```

```
FF (Weight of Content of Vessel)= ==                          0.00 kN
dFg (Weight of Vessel Below Section 2-2)= (16.12-3) ==    2,5707E-04 kN
```

16.12.6.1 Verification of Membrane Stresses

```
Fzp = Fz + 4 * M1 / Dz (16.12-1) =-367.2+4*2.45/114=        -281.16 N
Fzq = Fz - 4 * M1 / Dz (16.12-2) =-367.2-4*2.45/114=        -453.18 N
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                    (16.14-15)
=1.21*2.0607E05*5.39/(304*162.41)=                          27.22
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                            (16.14-16)
=0.83/Sqr(1+0.005*162.41/5.39)=                           0.7738
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                       (16.14-19)
=(1-0.4123/(0.7738*27.22)^0.6)/1.5=                       0.6225
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =304*0.6225=              189.24 N/mm2
```

Stresses in section 1-1 (internal pressure)

```
Membrane Stress(Sect.1-1)
Sig1pm = (Fzp+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(-281.16+0.2571+0)/(3.14*162.41*5.39)+0*162.41/(4*5.39)=   -0.1021 N/mm2

Sig1qm = (Fzq+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(-453.18+0.2571+0)/(3.14*162.41*5.39)+0*162.41/(4*5.39)=   -0.1647 N/mm2
```

Compr.Stress(Pint)(Sect.1-1) Sig1pm=0.1021 <= Sigcall=189.24[N/mm2]	0.0%	OK
Compr.Stress(Pint)(Sect.1-1) Sig1qm=0.1647 <= Sigcall=189.24[N/mm2]	0.0%	OK

Stresses in section 1-1 (external pressure)

```
Membrane Stress(Sect.1-1)
Sig1pmext = (Fzp+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(-281.16+0.2571+0)/(3.14*162.41*5.39)-0*162.41/(4*5.39)=   -0.1021 N/mm2

Sig1qmext = (Fzq+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(-453.18+0.2571+0)/(3.14*162.41*5.39)-0*162.41/(4*5.39)=   -0.1647 N/mm2
```

Compr.Stress(Pext)(Sect.1-1) Sig1pmext=0.1021 <= Sigcall=189.24[N/mm2]	0.0%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.1647 <= Sigcall=189.24[N/mm2]	0.0%	OK

```
Membrane Stress(Sect.2-2)
Sig2pm = Sig2qm=(FF+dFg)/(PI*DB*eB)+p*DB/(4*eB)
=(0+0.2571)/(3.14*162.41*5.39)+0*162.41/(4*5.39)=       9,3477E-05 N/mm2
```

Membrane Stress(Sect.2-2) ABS(Sig2pm)=9.3477E-05 <= fB=202.67[N/mm2]	0.0%	OK

```
Membrane Stress(Sect.3-3)
Sig3pm = Fzp / (PI * Dz * ez) =-281.16/(3.14*114*3)=        -0.2617 N/mm2

Sig3qm = Fzq / (PI * Dz * ez) =-453.18/(3.14*114*3)=        -0.4218 N/mm2
```

Membrane Stress(Sect.3-3) ABS(Sig3pm)=0.2617 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.3-3) ABS(Sig3qm)=0.4218 <= fz=78.33[N/mm2]	0.5%	OK

16.12.6.2 Bending Stresses

```
a) Structural Shape A - figure 16.12-1
Total Bending Moments at Verification Points p and q:
Mp = 0.5 * (Dz - DB) * Fzp (16.12-18) =0.5*(114-162.41)*-281.16=  6805.43 Nmm
Mq = 0.5 * (Dz - DB) * Fzq (16.12-19) =0.5*(114-162.41)*-453.18= 10969.23 Nmm
e1pm = ((Fzp + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-7)
=((-281.16+0.2571+0)/(3.14*162.41)+0*162.41/4)/202.67=     -0.0027 mm
e1qm = ((Fzq + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-8)
=((-453.18+0.2571+0)/(3.14*162.41)+0*162.41/4)/202.67=     -0.0044 mm
e2m = ((dFg + FF) / (PI * DB) + p * DB / 4) / fB                   (16.12-11)
=((0.2571+0)/(3.14*162.41)+0*162.41/4)/202.67=          2,486E-06 mm
e3pm = (Fzp / (PI * Dz)) / fB                                      (16.12-11)
=(-281.16/(3.14*114))/202.67=                              -0.0039 mm
e3qm = (Fzq / (PI * Dz)) / fB                                      (16.12-11)
=(-453.18/(3.14*114))/202.67=                              -0.0062 mm
Total Section Modulus of the Support Ring at Verification Point
Wp = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1pm^2-e2m^2)*DB+0.5*(e2m^2-e3pm^2)*Dz)
(16.12-20)
=3.14/4*((114+3-162.41-5.39)*0^2+(2*5.39^2--0.0027^2-2.486E-06^2)*162.41+0.
5*(2.486E-06^2--0.0039^2)*114)=                                =  7411.57 mm3

Wq = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1qm^2-e2m^2)*DB+0.5*(e2m^2-e3qm^2)*Dz)
(16.12-21)
=3.14/4*((114+3-162.41-5.39)*0^2+(2*5.39^2--0.0044^2-2.486E-06^2)*162.41+0.
5*(2.486E-06^2--0.0062^2)*114)=                                =  7411.56 mm3
```

16.12.6.3 Total Stresses and Strength Conditions

```
a) Structural Shape A
```

1) Location p ABS(Mp)/Wp=0.9182 <= fT=78.33[N/mm2] (16.12-44)	1.1%	OK
2) Location q ABS(Mq)/Wq=1.48 <= fT=78.33[N/mm2] (16.12-45)	1.8%	OK

16.12.7 Verification of Skirt (Section 4-4)

```
Note: Skirt is pierced and has a minimum section modulus at z=  0mm
```

Verification of Skirt at Bottom(no openings) at Elevation z = -60 mm

```
Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*367.17=                                    0.00 kNmm
Membrane Stress(Sect.4-4/z=-60)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(2688.88+0)/29856.61-367.17/1074.43=                    -0.2517 N/mm2

Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(2688.88+0)/29856.61-367.17/1074.43=                 -0.4318 N/mm2
```

Membrane Stress(Sect.4-4/z=-60) Sig4pm=0.2517 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=0.4318 <= fz=78.33[N/mm2]	0.5%	OK

```
Compressive Stresses in Skirt(Sect.4-4/z=-60)
Sig4c = - F4 / A4 =-367.17/1074.43=                        -0.3417 N/mm2
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                     (16.14-15)
=1.21*206070*3/(235*114)=                                  27.92
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                             (16.14-16)
=0.83/Sqr(1+0.005*114/3)=                                  0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                        (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.5=                        0.6227
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.6227=              146.34 N/mm2
```

Compr.Stress Limits (4-4/z=-60) Sig4c=0.3417 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

```
Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*146.34=    157.23 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall                          (16.14-3)
=3.14/4*114^2*3*146.34=                                  4.4812 kNm

Stability of skirt(Sect.4-4/z=-60)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max)  (16.12-70)
=367.17/(1*1.5723E05)+(ABS(2688.88)+367.17*0)/(1*4.4812E06)=    0.0029
```

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0029 <= 1=1	0.2%	OK

Verification of Skirt at Top(no openings) at Elevation z = -20 mm

```
Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*367.17=                                    0.00 kNmm
Membrane Stress(Sect.4-4/z=-20)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(2451.32+0)/29856.61-367.17/1074.43=                    -0.2596 N/mm2

Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(2451.32+0)/29856.61-367.17/1074.43=                 -0.4238 N/mm2
```

Membrane Stress(Sect.4-4/z=-20) Sig4pm=0.2596 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=0.4238 <= fz=78.33[N/mm2]	0.5%	OK

```
Compressive Stresses in Skirt(Sect.4-4/z=-20)
Sig4c = - F4 / A4 =-367.17/1074.43=                      -0.3417 N/mm2
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                  (16.14-15)
=1.21*206070*3/(235*114)=                                 27.92
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                          (16.14-16)
=0.83/Sqr(1+0.005*114/3)=                                 0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                     (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.5=                       0.6227
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.6227=            146.34 N/mm2
```

Compr.Stress Limits (4-4/z=-20) Sig4c=0.3417 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

```
Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*146.34=    157.23 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall                          (16.14-3)
=3.14/4*114^2*3*146.34=                                  4.4812 kNm

Stability of skirt(Sect.4-4/z=-20)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max)  (16.12-70)
=367.17/(1*1.5723E05)+(ABS(2451.32)+367.17*0)/(1*4.4812E06)=    0.0029
```

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.0029 <= 1=1	0.2%	OK

SKIRT BASE DESIGN

```
Wsk = F4 / (PI * Dzb) =367.17/(3.14*114)=                    1.0252 N/mm
Msk = 4 * M4 / (PI * Dzb ^ 2) =4*2.69/(3.14*114^2)=          0.2634 N/mm
Outer radial width of bearing plate/base plate
b2 = (dob - (Dzb + ez)) / 2 =(190-(114+3))/2=                 36.50 mm
```

16.12.5 Anchor Bolt Design

```
Bolt Circle Diameter
d = Dzb + ea3 + 2 * b3 =114+3+2*23=                          163.00 mm
Mean Diameter of Bearing Ring/Base Plate
DCR = dob - b1 =190-70=                                      120.00 mm
Inside Diameter of Bearing Ring/Base Plate
D3 = dob - 2 * b1 =190-2*70=                                  50.00 mm
Pre-tensioning of bolts FA
FA = Phi * Ae * fdAnchor (16.12.80) =0.5*36.6*181.82=       3327.27 N
Maximum anchor bolt force FB
FB = (4 * M5 / d - F5) / n (16.12.77) =(4*2688.88/163-367.17)/4=   -75.30 N
Required minimum torque(per bolt).
Mt = μ * FA * 1.1 * SQR( 4 * Ae / PI)                                (16.12-81)
=0.2*3327.27*1.1*SQR(4*36.6/3.14)=                          4.9970 Nm
Design anchor bolt load FBd
FBd = MAX( FA , FB) (16.12.83) =MAX(3327.27,-75.3)=          3327.27 N
Required Bolting Area
Aemin = MAX( FB , 0) / fdAnchor =MAX(-75.3,0)/181.82=           0.00 mm2
```

Anchor Bolt Area Aemin=0 <= Ae=36.6[mm2]	0.0%	OK

```
Spacing between anchor bolts
b8 = PI * (Dzb + ea3 + 2 * b3) / n
=3.14*(114+3+2*23)/4=                                       128.02 mm
Design load on concrete FCd
FCd = MAX( 4 * M5 / DCR + F5 , FA * n)
=MAX(4*2688.88/120+367.17,3327.27*4)=                     13309.09 N
Foundation Bearing Pressure on concrete below base ring
Sigc = FCd / (PI * DCR * b1) (16.12-86) =13309.09/(3.14*120*70)=   0.5043 N/mm2
```

Foundation Bearing Pressure(concrete) Sigc=0.5043 <= fcd/1.35=5.48[N/mm2] (16.12-86)	9.2%	OK

16.12.5.4.3 Checks for type 1 - Simple Bearing Plate

```
Required minimum analysis thickness of bearing plate (FB <= 0)
ea4min = b2 * SQR( 3 * SigC / f4)                                    (16.12-90b)
=36.5*SQR(3*0.5043/142.67)=                                 3.7588 mm
```

Min.Thk.of Base Ring ea4min=3.76 <= eR=5[mm]	75.1%	OK

LOAD CASE NO: 3 - LC5 INSTALLATION

Summation of Total Loads for Load Case : LC5 INSTALLATION

```
Fz (Force in Vertical Direction)= ==                         -0.3672 kN
Fx (Force in X-Direction)= ==                                 0.0040 kN
Fy (Force in Y-Direction)= ==                                   0.00 kN
Fs=SQR(Fx^2 + Fy^2))(Tot.Force in Hor.Plane)= ==              0.0040 kN
Moments at top of skirt at elevation of shell/skirt connection.
Mx (Moment around the X-Axis)= ==                            -0.8814 kNmm
My (Moment around the Y-Axis)= ==                             1.5078 kNmm
M1=SQR(Mx^2+My^2)(Moment in XY Plane)= ==                     1.7465 kNmm
Mt (Moment around the z-axis)= ==                             0.0149 kNmm
Moments at elevation at bottom of skirt.
Mx4 (Moment around the X-Axis)= ==                            -0.8814 kNmm
My4 (Moment around the Y-Axis)= ==                            1.6687 kNmm
M4=SQR(Mx4^2+My4^2)(Moment in XY Plane)= ==                   1.8872 kNmm
FF (Weight of Content of Vessel)= ==                            0.00 kN
```

```
dFg (Weight of Vessel Below Section 2-2)= (16.12-3) ==    2,5707E-04 kN
```

16.12.6.1 Verification of Membrane Stresses

```
Fzp = Fz + 4 * M1 / Dz (16.12-1) =-367.2+4*1.75/114=        -305.89 N
Fzq = Fz - 4 * M1 / Dz (16.12-2) =-367.2-4*1.75/114=        -428.45 N
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                    (16.14-15)
=1.21*2.1177E05*5.39/(355*162.41)=                    23.96
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                            (16.14-16)
=0.83/Sqr(1+0.005*162.41/5.39)=                      0.7738
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                       (16.14-19)
=(1-0.4123/(0.7738*23.96)^0.6)/1.5=                  0.6190
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =355*0.619=          219.74 N/mm2
```

Stresses in section 1-1 (internal pressure)

```
Membrane Stress(Sect.1-1)
Sig1pm = (Fzp+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(-305.89+0.2571+0)/(3.14*162.41*5.39)+0*162.41/(4*5.39)=   -0.1111 N/mm2

Sig1qm = (Fzq+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(-428.45+0.2571+0)/(3.14*162.41*5.39)+0*162.41/(4*5.39)=   -0.1557 N/mm2
```

Compr.Stress(Pint)(Sect.1-1) Sig1pm=0.1111 <= Sigcall=219.74[N/mm2]	0.0%	OK
Compr.Stress(Pint)(Sect.1-1) Sig1qm=0.1557 <= Sigcall=219.74[N/mm2]	0.0%	OK

Stresses in section 1-1 (external pressure)

```
Membrane Stress(Sect.1-1)
Sig1pmext = (Fzp+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(-305.89+0.2571+0)/(3.14*162.41*5.39)-0*162.41/(4*5.39)=   -0.1111 N/mm2

Sig1qmext = (Fzq+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(-428.45+0.2571+0)/(3.14*162.41*5.39)-0*162.41/(4*5.39)=   -0.1557 N/mm2
```

Compr.Stress(Pext)(Sect.1-1) Sig1pmext=0.1111 <= Sigcall=219.74[N/mm2]	0.0%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.1557 <= Sigcall=219.74[N/mm2]	0.0%	OK

```
Membrane Stress(Sect.2-2)
Sig2pm = Sig2qm=(FF+dFg)/(PI*DB*eB)+p*DB/(4*eB)
=(0+0.2571)/(3.14*162.41*5.39)+0*162.41/(4*5.39)=       9,3477E-05 N/mm2
```

Membrane Stress(Sect.2-2) ABS(Sig2pm)=9.3477E-05 <= fB=204.17[N/mm2]	0.0%	OK

```
Membrane Stress(Sect.3-3)
Sig3pm = Fzp / (PI * Dz * ez) =-305.89/(3.14*114*3)=        -0.2847 N/mm2

Sig3qm = Fzq / (PI * Dz * ez) =-428.45/(3.14*114*3)=        -0.3988 N/mm2
```

Membrane Stress(Sect.3-3) ABS(Sig3pm)=0.2847 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.3-3) ABS(Sig3qm)=0.3988 <= fz=78.33[N/mm2]	0.5%	OK

16.12.6.2 Bending Stresses

```
a) Structural Shape A - figure 16.12-1
Total Bending Moments at Verification Points p and q:
Mp = 0.5 * (Dz - DB) * Fzp (16.12-18) =0.5*(114-162.41)*-305.89=  7404.03 Nmm
Mq = 0.5 * (Dz - DB) * Fzq (16.12-19) =0.5*(114-162.41)*-428.45= 10370.63 Nmm
e1pm = ((Fzp + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-7)
=((-305.89+0.2571+0)/(3.14*162.41)+0*162.41/4)/204.17=     -0.0029 mm
e1qm = ((Fzq + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-8)
=((-428.45+0.2571+0)/(3.14*162.41)+0*162.41/4)/204.17=     -0.0041 mm
e2m = ((dFg + FF) / (PI * DB) + p * DB / 4) / fB                   (16.12-11)
=((0.2571+0)/(3.14*162.41)+0*162.41/4)/204.17=          2,4678E-06 mm
e3pm = (Fzp / (PI * Dz)) / fB                                      (16.12-11)
=(-305.89/(3.14*114))/204.17=                              -0.0042 mm
e3qm = (Fzq / (PI * Dz)) / fB                                      (16.12-11)
=(-428.45/(3.14*114))/204.17=                              -0.0059 mm
Total Section Modulus of the Support Ring at Verification Point
Wp = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1pm^2-e2m^2)*DB+0.5*(e2m^2-e3pm^2)*Dz)
(16.12-20)
=3.14/4*((114+3-162.41-5.39)*0^2+(2*5.39^2--0.0029^2-2.4678E-06^2)*162.41+0
.5*(2.4678E-06^2--0.0042^2)*114)=                          =  7411.57 mm3
Wq = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1qm^2-e2m^2)*DB+0.5*(e2m^2-e3qm^2)*Dz)
(16.12-21)
=3.14/4*((114+3-162.41-5.39)*0^2+(2*5.39^2--0.0041^2-2.4678E-06^2)*162.41+0
.5*(2.4678E-06^2--0.0059^2)*114)=                          =  7411.56 mm3
```

16.12.6.3 Total Stresses and Strength Conditions

```
a) Structural Shape A
```

1) Location p ABS(Mp)/Wp=0.999 <= fT=78.33[N/mm2] (16.12-44)	1.2%	OK
2) Location q ABS(Mq)/Wq=1.4 <= fT=78.33[N/mm2] (16.12-45)	1.7%	OK

16.12.7 Verification of Skirt (Section 4-4)

```
Note: Skirt is pierced and has a minimum section modulus at z=  0mm
```

Verification of Skirt at Bottom(no openings) at Elevation z = -60 mm

```
Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*367.17=                                  0.00 kNmm
Membrane Stress(Sect.4-4/z=-60)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(1887.22+0)/29856.61-367.17/1074.43=                  -0.2785 N/mm2
Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(1887.22+0)/29856.61-367.17/1074.43=               -0.4049 N/mm2
```

Membrane Stress(Sect.4-4/z=-60) Sig4pm=0.2785 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=0.4049 <= fz=78.33[N/mm2]	0.5%	OK

```
Compressive Stresses in Skirt(Sect.4-4/z=-60)
Sig4c = - F4 / A4 =-367.17/1074.43=                     -0.3417 N/mm2
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                     (16.14-15)
=1.21*206070*3/(235*114)=                                27.92
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                             (16.14-16)
=0.83/Sqr(1+0.005*114/3)=                                0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                        (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.5=                      0.6227
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.6227=            146.34 N/mm2
```

Compr.Stress Limits (4-4/z=-60) Sig4c=0.3417 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*146.34= 157.23 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall (16.14-3)
=3.14/4*114^2*3*146.34= 4.4812 kNm

Stability of skirt(Sect.4-4/z=-60)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max) (16.12-70)
=367.17/(1*1.5723E05)+(ABS(1887.22)+367.17*0)/(1*4.4812E06)= 0.0028

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0028 <= 1=1	0.2%	OK

Verification of Skirt at Top(no openings) at Elevation z = -20 mm

Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*367.17= 0.00 kNmm
Membrane Stress(Sect.4-4/z=-20)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(1746.51+0)/29856.61-367.17/1074.43= -0.2832 N/mm2

Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(1746.51+0)/29856.61-367.17/1074.43= -0.4002 N/mm2

Membrane Stress(Sect.4-4/z=-20) Sig4pm=0.2832 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=0.4002 <= fz=78.33[N/mm2]	0.5%	OK

Compressive Stresses in Skirt(Sect.4-4/z=-20)
Sig4c = - F4 / A4 =-367.17/1074.43= -0.3417 N/mm2

16.14.8 COMPRESSIVE STRESS LIMITS

K = 1.21 * E * ea / (Sige * D) (16.14-15)
=1.21*206070*3/(235*114)= 27.92
alfa = 0.83 / Sqr(1 + 0.005 * D / ea) (16.14-16)
=0.83/Sqr(1+0.005*114/3)= 0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.5= 0.6227
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.6227= 146.34 N/mm2

Compr.Stress Limits (4-4/z=-20) Sig4c=0.3417 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*146.34= 157.23 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall (16.14-3)
=3.14/4*114^2*3*146.34= 4.4812 kNm

Stability of skirt(Sect.4-4/z=-20)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max) (16.12-70)
=367.17/(1*1.5723E05)+(ABS(1746.51)+367.17*0)/(1*4.4812E06)= 0.0027

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.0027 <= 1=1	0.2%	OK

SKIRT BASE DESIGN

```
Wsk = F4 / (PI * Dzb) =367.17/(3.14*114)=                    1.0252 N/mm
Msk = 4 * M4 / (PI * Dzb ^ 2) =4*1.89/(3.14*114^2)=          0.1849 N/mm
Outer radial width of bearing plate/base plate
b2 = (dob - (Dzb + ez)) / 2 =(190-(114+3))/2=                 36.50 mm
```

16.12.5 Anchor Bolt Design

```
Bolt Circle Diameter
d = Dzb + ea3 + 2 * b3 =114+3+2*23=                          163.00 mm
Mean Diameter of Bearing Ring/Base Plate
DCR = dob - b1 =190-70=                                      120.00 mm
Inside Diameter of Bearing Ring/Base Plate
D3 = dob - 2 * b1 =190-2*70=                                  50.00 mm
Pre-tensioning of bolts FA
FA = Phi * Ae * fdAnchor (16.12.80) =0.5*36.6*181.82=       3327.27 N
Maximum anchor bolt force FB
FB = (4 * M5 / d - F5) / n (16.12.77) =(4*1887.22/163-367.17)/4=   -80.21 N
Required minimum torque(per bolt).
Mt = μ * FA * 1.1 * SQR( 4 * Ae / PI)                                (16.12-81)
=0.2*3327.27*1.1*SQR(4*36.6/3.14)=                          4.9970 Nm
Design anchor bolt load FBd
FBd = MAX( FA , FB) (16.12.83) =MAX(3327.27,-80.21)=         3327.27 N
Required Bolting Area
Aemin = MAX( FB , 0) / fdAnchor =MAX(-80.21,0)/181.82=          0.00 mm2
```

Anchor Bolt Area Aemin=0 <= Ae=36.6[mm2]	0.0%	OK

```
Spacing between anchor bolts
b8 = PI * (Dzb + ea3 + 2 * b3) / n
=3.14*(114+3+2*23)/4=                                       128.02 mm
Design load on concrete FCd
FCd = MAX( 4 * M5 / DCR + F5 , FA * n)
=MAX(4*1887.22/120+367.17,3327.27*4)=                     13309.09 N
Foundation Bearing Pressure on concrete below base ring
Sigc = FCd / (PI * DCR * b1) (16.12-86) =13309.09/(3.14*120*70)=   0.5043 N/mm2
```

Foundation Bearing Pressure(concrete) Sigc=0.5043 <= fcd/1.35=5.48[N/mm2] (16.12-86)	9.2%	OK

16.12.5.4.3 Checks for type 1 - Simple Bearing Plate

```
Required minimum analysis thickness of bearing plate (FB <= 0)
ea4min = b2 * SQR( 3 * SigC / f4)                                    (16.12-90b)
=36.5*SQR(3*0.5043/150)=                                    3.6658 mm
```

Min.Thk.of Base Ring ea4min=3.67 <= eR=5[mm]	73.3%	OK

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

Summation of Total Loads for Load Case : LC1&2&3 OPER.WIND

```
Fz (Force in Vertical Direction)= ==                         -0.4335 kN
Fx (Force in X-Direction)= ==                                 0.0063 kN
Fy (Force in Y-Direction)= ==                                   0.00 kN
Fs=SQR(Fx^2 + Fy^2))(Tot.Force in Hor.Plane)= ==              0.0063 kN
Moments at top of skirt at elevation of shell/skirt connection.
Mx (Moment around the X-Axis)= ==                            -0.8814 kNmm
My (Moment around the Y-Axis)= ==                             2.2874 kNmm
M1=SQR(Mx^2+My^2)(Moment in XY Plane)= ==                     2.4513 kNmm
Mt (Moment around the z-axis)= ==                             0.0235 kNmm
Moments at elevation at bottom of skirt.
Mx4 (Moment around the X-Axis)= ==                            -0.8814 kNmm
My4 (Moment around the Y-Axis)= ==                            2.5403 kNmm
M4=SQR(Mx4^2+My4^2)(Moment in XY Plane)= ==                   2.6889 kNmm
FF (Weight of Content of Vessel)= ==                          0.0663 kN
```

```
dFg (Weight of Vessel Below Section 2-2)= (16.12-3) ==    2,5708E-04 kN
```

16.12.6.1 Verification of Membrane Stresses

```
Fzp = Fz + 4 * M1 / Dz (16.12-1) =-433.5+4*2.45/114=        -347.46 N
Fzq = Fz - 4 * M1 / Dz (16.12-2) =-433.5-4*2.45/114=        -519.49 N
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                    (16.14-15)
=1.21*2.0607E05*5.39/(304*162.41)=                        27.22
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                            (16.14-16)
=0.83/Sqr(1+0.005*162.41/5.39)=                           0.7738
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                       (16.14-19)
=(1-0.4123/(0.7738*27.22)^0.6)/1.5=                       0.6225
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =304*0.6225=             189.24 N/mm2
```

Stresses in section 1-1 (internal pressure)

```
Membrane Stress(Sect.1-1)
Sig1pm = (Fzp+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(-347.46+0.2571+66.31)/(3.14*162.41*5.39)+11.7*162.41/(4*5.39)=    88.03 N/mm2

Sig1qm = (Fzq+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(-519.49+0.2571+66.31)/(3.14*162.41*5.39)+11.7*162.41/(4*5.39)=    87.97 N/mm2
```

Membrane Stress(Pint)(Sect.1-1) Sig1pm=88.03 <= fB=202.67[N/mm2]	43.4%	OK
Membrane Stress(Pint)(Sect.1-1) ABS(Sig1qm)=87.97 <= fB=202.67[N/mm2]	43.4%	OK

Stresses in section 1-1 (external pressure)

```
Membrane Stress(Sect.1-1)
Sig1pmext = (Fzp+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(-347.46+0.2571+66.31)/(3.14*162.41*5.39)-0*162.41/(4*5.39)=   -0.1021 N/mm2

Sig1qmext = (Fzq+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(-519.49+0.2571+66.31)/(3.14*162.41*5.39)-0*162.41/(4*5.39)=   -0.1647 N/mm2
```

Compr.Stress(Pext)(Sect.1-1) Sig1pmext=0.1021 <= Sigcall=189.24[N/mm2]	0.0%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.1647 <= Sigcall=189.24[N/mm2]	0.0%	OK

```
Membrane Stress(Sect.2-2)
Sig2pm = Sig2qm=(FF+dFg)/(PI*DB*eB)+p*DB/(4*eB)
=(66.31+0.2571)/(3.14*162.41*5.39)+11.7*162.41/(4*5.39)=    88.16 N/mm2
```

Membrane Stress(Sect.2-2) ABS(Sig2pm)=88.16 <= fB=202.67[N/mm2]	43.4%	OK

```
Membrane Stress(Sect.3-3)
Sig3pm = Fzp / (PI * Dz * ez) =-347.46/(3.14*114*3)=        -0.3234 N/mm2

Sig3qm = Fzq / (PI * Dz * ez) =-519.49/(3.14*114*3)=        -0.4835 N/mm2
```

Membrane Stress(Sect.3-3) ABS(Sig3pm)=0.3234 <= fz=78.33[N/mm2]	0.4%	OK
Membrane Stress(Sect.3-3) ABS(Sig3qm)=0.4835 <= fz=78.33[N/mm2]	0.6%	OK

16.12.6.2 Bending Stresses

```
a) Structural Shape A - figure 16.12-1
Total Bending Moments at Verification Points p and q:
Mp = 0.5 * (Dz - DB) * Fzp (16.12-18) =0.5*(114-162.41)*-347.46=  8410.36 Nmm
Mq = 0.5 * (Dz - DB) * Fzq (16.12-19) =0.5*(114-162.41)*-519.49= 12574.16 Nmm
e1pm = ((Fzp + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-7)
=((-347.46+0.2571+66.31)/(3.14*162.41)+11.7*162.41/4)/202.67=   2.3412 mm
e1qm = ((Fzq + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-8)
=((-519.49+0.2571+66.31)/(3.14*162.41)+11.7*162.41/4)/202.67=   2.3396 mm
e2m = ((dFg + FF) / (PI * DB) + p * DB / 4) / fB                   (16.12-11)
=((0.2571+66.31)/(3.14*162.41)+11.7*162.41/4)/202.67=      2.3446 mm
e3pm = (Fzp / (PI * Dz)) / fB                                      (16.12-11)
=(-347.46/(3.14*114))/202.67=                                 -0.0048 mm
e3qm = (Fzq / (PI * Dz)) / fB                                      (16.12-11)
=(-519.49/(3.14*114))/202.67=                                 -0.0072 mm
Total Section Modulus of the Support Ring at Verification Point
Wp = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1pm^2-e2m^2)*DB+0.5*(e2m^2-e3pm^2)*Dz)
(16.12-20)
=3.14/4*((114+3-162.41-5.39)*0^2+(2*5.39^2-2.34^2-2.34^2)*162.41+0.5*(2.34^
2--0.0048^2)*114)=                                          =  6257.28 mm3

Wq = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1qm^2-e2m^2)*DB+0.5*(e2m^2-e3qm^2)*Dz)
(16.12-21)
=3.14/4*((114+3-162.41-5.39)*0^2+(2*5.39^2-2.34^2-2.34^2)*162.41+0.5*(2.34^
2--0.0072^2)*114)=                                          =  6258.27 mm3
```

16.12.6.3 Total Stresses and Strength Conditions

a) Structural Shape A

1) Location p ABS(Mp)/Wp=1.34 <= fT=78.33[N/mm2] (16.12-44)	1.7%	OK
2) Location q ABS(Mq)/Wq=2.01 <= fT=78.33[N/mm2] (16.12-45)	2.5%	OK

16.12.7 Verification of Skirt (Section 4-4)

Note: Skirt is pierced and has a minimum section modulus at z= 0mm

Verification of Skirt at Bottom(no openings) at Elevation z = -60 mm

```
Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*433.48=                                    0.00 kNmm
Membrane Stress(Sect.4-4/z=-60)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(2688.88+0)/29856.61-433.48/1074.43=                   -0.3134 N/mm2

Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(2688.88+0)/29856.61-433.48/1074.43=                -0.4935 N/mm2
```

Membrane Stress(Sect.4-4/z=-60) Sig4pm=0.3134 <= fz=78.33[N/mm2]	0.4%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=0.4935 <= fz=78.33[N/mm2]	0.6%	OK

```
Compressive Stresses in Skirt(Sect.4-4/z=-60)
Sig4c = - F4 / A4 =-433.48/1074.43=                          -0.4034 N/mm2
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                     (16.14-15)
=1.21*206070*3/(235*114)=                                  27.92
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                             (16.14-16)
=0.83/Sqr(1+0.005*114/3)=                                  0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                        (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.5=                        0.6227
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.6227=               146.34 N/mm2
```

Compr.Stress Limits (4-4/z=-60) Sig4c=0.4034 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

```
Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*146.34=    157.23 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall                          (16.14-3)
=3.14/4*114^2*3*146.34=                                  4.4812 kNm

Stability of skirt(Sect.4-4/z=-60)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max)  (16.12-70)
=433.48/(1*1.5723E05)+(ABS(2688.88)+433.48*0)/(1*4.4812E06)=    0.0034
```

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0034 <= 1=1	0.3%	OK

Verification of Skirt at Top(no openings) at Elevation z = -20 mm

```
Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*433.48=                                    0.00 kNmm
Membrane Stress(Sect.4-4/z=-20)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(2451.32+0)/29856.61-433.48/1074.43=                    -0.3213 N/mm2

Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(2451.32+0)/29856.61-433.48/1074.43=                 -0.4856 N/mm2
```

Membrane Stress(Sect.4-4/z=-20) Sig4pm=0.3213 <= fz=78.33[N/mm2]	0.4%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=0.4856 <= fz=78.33[N/mm2]	0.6%	OK

```
Compressive Stresses in Skirt(Sect.4-4/z=-20)
Sig4c = - F4 / A4 =-433.48/1074.43=                      -0.4034 N/mm2
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                  (16.14-15)
=1.21*206070*3/(235*114)=                                 27.92
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                          (16.14-16)
=0.83/Sqr(1+0.005*114/3)=                                 0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                     (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.5=                       0.6227
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.6227=            146.34 N/mm2
```

Compr.Stress Limits (4-4/z=-20) Sig4c=0.4034 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

```
Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*146.34=    157.23 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall                          (16.14-3)
=3.14/4*114^2*3*146.34=                                  4.4812 kNm

Stability of skirt(Sect.4-4/z=-20)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max)  (16.12-70)
=433.48/(1*1.5723E05)+(ABS(2451.32)+433.48*0)/(1*4.4812E06)=    0.0033
```

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.0033 <= 1=1	0.3%	OK

SKIRT BASE DESIGN

```
Wsk = F4 / (PI * Dzb) =433.48/(3.14*114)=                    1.2103 N/mm
Msk = 4 * M4 / (PI * Dzb ^ 2) =4*2.69/(3.14*114^2)=          0.2634 N/mm
Outer radial width of bearing plate/base plate
b2 = (dob - (Dzb + ez)) / 2 =(190-(114+3))/2=                 36.50 mm
```

16.12.5 Anchor Bolt Design

```
Bolt Circle Diameter
d = Dzb + ea3 + 2 * b3 =114+3+2*23=                          163.00 mm
Mean Diameter of Bearing Ring/Base Plate
DCR = dob - b1 =190-70=                                      120.00 mm
Inside Diameter of Bearing Ring/Base Plate
D3 = dob - 2 * b1 =190-2*70=                                  50.00 mm
Pre-tensioning of bolts FA
FA = Phi * Ae * fdAnchor (16.12.80) =0.5*36.6*181.82=       3327.27 N
Maximum anchor bolt force FB
FB = (4 * M5 / d - F5) / n (16.12.77) =(4*2688.88/163-433.48)/4=   -91.87 N
Required minimum torque(per bolt).
Mt = μ * FA * 1.1 * SQR( 4 * Ae / PI)                                (16.12-81)
=0.2*3327.27*1.1*SQR(4*36.6/3.14)=                          4.9970 Nm
Design anchor bolt load FBd
FBd = MAX( FA , FB) (16.12.83) =MAX(3327.27,-91.87)=         3327.27 N
Required Bolting Area
Aemin = MAX( FB , 0) / fdAnchor =MAX(-91.87,0)/181.82=          0.00 mm2
```

Anchor Bolt Area Aemin=0 <= Ae=36.6[mm2]	0.0%	OK

```
Spacing between anchor bolts
b8 = PI * (Dzb + ea3 + 2 * b3) / n
=3.14*(114+3+2*23)/4=                                       128.02 mm
Design load on concrete FCd
FCd = MAX( 4 * M5 / DCR + F5 , FA * n)
=MAX(4*2688.88/120+433.48,3327.27*4)=                     13309.09 N
Foundation Bearing Pressure on concrete below base ring
Sigc = FCd / (PI * DCR * b1) (16.12-86) =13309.09/(3.14*120*70)=   0.5043 N/mm2
```

Foundation Bearing Pressure(concrete) Sigc=0.5043 <= fcd/1.35=5.48[N/mm2] (16.12-86)	9.2%	OK

16.12.5.4.3 Checks for type 1 - Simple Bearing Plate

```
Required minimum analysis thickness of bearing plate (FB <= 0)
ea4min = b2 * SQR( 3 * SigC / f4)                                    (16.12-90b)
=36.5*SQR(3*0.5043/142.67)=                                 3.7588 mm
```

Min.Thk.of Base Ring ea4min=3.76 <= eR=5[mm]	75.1%	OK

LOAD CASE NO: 5 - LC6&7&8 OPER.SEISMIC

Summation of Total Loads for Load Case : LC6&7&8 OPER.SEISMIC

```
Fz (Force in Vertical Direction)= ==                        -0.5017 kN
Fx (Force in X-Direction)= ==                                0.0975 kN
Fy (Force in Y-Direction)= ==                                  0.00 kN
Fs=SQR(Fx^2 + Fy^2))(Tot.Force in Hor.Plane)= ==             0.0975 kN
Moments at top of skirt at elevation of shell/skirt connection.
Mx (Moment around the X-Axis)= ==                           -1.28 kNmm
My (Moment around the Y-Axis)= ==                            50.21 kNmm
M1=SQR(Mx^2+My^2)(Moment in XY Plane)= ==                    50.22 kNmm
Mt (Moment around the z-axis)= ==                           0.5749 kNmm
Moments at elevation at bottom of skirt.
Mx4 (Moment around the X-Axis)= ==                           -1.28 kNmm
My4 (Moment around the Y-Axis)= ==                            54.21 kNmm
M4=SQR(Mx4^2+My4^2)(Moment in XY Plane)= ==                  54.22 kNmm
FF (Weight of Content of Vessel)= ==                        0.0663 kN
```

```
dFg (Weight of Vessel Below Section 2-2)= (16.12-3) ==    2,6851E-04 kN
```

16.12.6.1 Verification of Membrane Stresses

```
Fzp = Fz + 4 * M1 / Dz (16.12-1) =-501.7+4*50.22/114=       1260.55 N
Fzq = Fz - 4 * M1 / Dz (16.12-2) =-501.7-4*50.22/114=      -2264.01 N
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                    (16.14-15)
=1.21*2.0607E05*5.39/(304*162.41)=                    27.22
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                            (16.14-16)
=0.83/Sqr(1+0.005*162.41/5.39)=                       0.7738
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                       (16.14-19)
=(1-0.4123/(0.7738*27.22)^0.6)/1.5=                   0.6225
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =304*0.6225=         189.24 N/mm2
```

Stresses in section 1-1 (internal pressure)

```
Membrane Stress(Sect.1-1)
Sig1pm = (Fzp+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(1260.55+0.2685+66.31)/(3.14*162.41*5.39)+11.7*162.41/(4*5.39)=    88.62 N/mm2

Sig1qm = (Fzq+dFg+FF)/(PI*DB*eB)+p*DB/(4*eB)
=(-2264.01+0.2685+66.31)/(3.14*162.41*5.39)+11.7*162.41/(4*5.39)
=    87.34 N/mm2
```

Membrane Stress(Pint)(Sect.1-1) Sig1pm=88.62 <= fB=288.8[N/mm2]	30.6%	OK
Membrane Stress(Pint)(Sect.1-1) ABS(Sig1qm)=87.34 <= fB=288.8[N/mm2]	30.2%	OK

Stresses in section 1-1 (external pressure)

```
Membrane Stress(Sect.1-1)
Sig1pmext = (Fzp+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(1260.55+0.2685+66.31)/(3.14*162.41*5.39)-0*162.41/(4*5.39)=   0.4826 N/mm2

Sig1qmext = (Fzq+dFg+FF)/(PI*DB*eB)-Pext*DB/(4*eB)
=(-2264.01+0.2685+66.31)/(3.14*162.41*5.39)-0*162.41/(4*5.39)=   -0.7990 N/mm2
```

Membrane Stress(Pext)(Sect.1-1) Sig1pmext=0.4826 <= fB=288.8[N/mm2]	0.1%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.799 <= Sigcall=227.09[N/mm2]	0.3%	OK

```
Membrane Stress(Sect.2-2)
Sig2pm = Sig2qm=(FF+dFg)/(PI*DB*eB)+p*DB/(4*eB)
=(66.31+0.2685)/(3.14*162.41*5.39)+11.7*162.41/(4*5.39)=    88.16 N/mm2
```

Membrane Stress(Sect.2-2) ABS(Sig2pm)=88.16 <= fB=288.8[N/mm2]	30.5%	OK

```
Membrane Stress(Sect.3-3)
Sig3pm = Fzp / (PI * Dz * ez) =1260.55/(3.14*114*3)=        1.1732 N/mm2

Sig3qm = Fzq / (PI * Dz * ez) =-2264.01/(3.14*114*3)=       -2.11 N/mm2
```

Membrane Stress(Sect.3-3) ABS(Sig3pm)=1.17 <= fz=111.62[N/mm2]	1.0%	OK
Membrane Stress(Sect.3-3) ABS(Sig3qm)=2.11 <= fz=111.62[N/mm2]	1.8%	OK

16.12.6.2 Bending Stresses

```
a) Structural Shape A - figure 16.12-1
Total Bending Moments at Verification Points p and q:
Mp = 0.5 * (Dz - DB) * Fzp (16.12-18) =0.5*(114-162.41)*1260.55= -30511.62 Nmm
Mq = 0.5 * (Dz - DB) * Fzq (16.12-19) =0.5*(114-162.41)*-2264.01= 54800.31 Nmm
e1pm = ((Fzp + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-7)
=((1260.55+0.2685+66.31)/(3.14*162.41)+11.7*162.41/4)/288.8=   1.6539 mm
e1qm = ((Fzq + dFg + FF) / (PI * DB) + p * DB / 4) / fB            (16.12-8)
=((-2264.01+0.2685+66.31)/(3.14*162.41)+11.7*162.41/4)/288.8=   1.6300 mm
e2m = ((dFg + FF) / (PI * DB) + p * DB / 4) / fB                   (16.12-11)
=((0.2685+66.31)/(3.14*162.41)+11.7*162.41/4)/288.8=       1.6453 mm
e3pm = (Fzp / (PI * Dz)) / fB                                      (16.12-11)
=(1260.55/(3.14*114))/288.8=                                0.0122 mm
e3qm = (Fzq / (PI * Dz)) / fB                                      (16.12-11)
=(-2264.01/(3.14*114))/288.8=                               -0.0219 mm
Total Section Modulus of the Support Ring at Verification Point
Wp = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1pm^2-e2m^2)*DB+0.5*(e2m^2-e3pm^2)*Dz)
(16.12-20)
=3.14/4*((114+3-162.41-5.39)*0^2+(2*5.39^2-1.65^2-1.65^2)*162.41+0.5*(1.65^
2-0.0122^2)*114)=                                             =  6838.53 mm3
Wq = PI/4*((Dz+ez-DB-eB)*h^2+(2*eB^2-e1qm^2-e2m^2)*DB+0.5*(e2m^2-e3qm^2)*Dz)
(16.12-21)
=3.14/4*((114+3-162.41-5.39)*0^2+(2*5.39^2-1.63^2-1.65^2)*162.41+0.5*(1.65^
2--0.0219^2)*114)=                                            =  6848.54 mm3
```

16.12.6.3 Total Stresses and Strength Conditions

a) Structural Shape A

1) Location p ABS(Mp)/Wp=4.46 <= fT=111.62[N/mm2] (16.12-44)	3.9%	OK
2) Location q ABS(Mq)/Wq=8. <= fT=111.62[N/mm2] (16.12-45)	7.1%	OK

16.12.7 Verification of Skirt (Section 4-4)

Note: Skirt is pierced and has a minimum section modulus at z= 0mm

Verification of Skirt at Bottom(no openings) at Elevation z = -60 mm

```
Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*501.73=                                   0.00 kNmm
Membrane Stress(Sect.4-4/z=-60)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(54220.32+0)/29856.61-501.73/1074.43=                   1.3490 N/mm2
Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(54220.32+0)/29856.61-501.73/1074.43=                -2.28 N/mm2
```

Membrane Stress(Sect.4-4/z=-60) Sig4pm=1.35 <= fz=111.62[N/mm2]	1.2%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=2.28 <= fz=111.62[N/mm2]	2.0%	OK

```
Compressive Stresses in Skirt(Sect.4-4/z=-60)
Sig4c = - F4 / A4 =-501.73/1074.43=                          -0.4670 N/mm2
```

16.14.8 COMPRESSIVE STRESS LIMITS

```
K = 1.21 * E * ea / (Sige * D)                                     (16.14-15)
=1.21*206070*3/(235*114)=                                   27.92
alfa = 0.83 / Sqr( 1 + 0.005 * D / ea)                             (16.14-16)
=0.83/Sqr(1+0.005*114/3)=                                   0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S                        (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.5=                         0.6227
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.6227=                146.34 N/mm2
```

Compr.Stress Limits (4-4/z=-60) Sig4c=0.467 <= Sigcall=175.61[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*146.34= 188.68 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall (16.14-3)
=3.14/4*114^2*3*146.34= 5.3774 kNm

Stability of skirt(Sect.4-4/z=-60)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max) (16.12-70)
=501.73/(1*1.8868E05)+(ABS(54220.32)+501.73*0)/(1*5.3774E06)= 0.0127

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0127 <= 1=1	1.2%	OK

Verification of Skirt at Top(no openings) at Elevation z = -20 mm

Additional Moment due to Displacement of Neutral Axis
dM4 = eps * F4 =0*501.73= 0.00 kNmm
Membrane Stress(Sect.4-4/z=-20)
Sig4pm = (M44 + dM4) / W4 - F4 / A4
=(50224.95+0)/29856.61-501.73/1074.43= 1.2152 N/mm2

Sig4qm = - 1 * (M44 + dM4) / W4 - F4 / A4
=-1*(50224.95+0)/29856.61-501.73/1074.43= -2.15 N/mm2

Membrane Stress(Sect.4-4/z=-20) Sig4pm=1.22 <= fz=111.62[N/mm2]	1.0%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=2.15 <= fz=111.62[N/mm2]	1.9%	OK

Compressive Stresses in Skirt(Sect.4-4/z=-20)
Sig4c = - F4 / A4 =-501.73/1074.43= -0.4670 N/mm2

16.14.8 COMPRESSIVE STRESS LIMITS

K = 1.21 * E * ea / (Sige * D) (16.14-15)
=1.21*206070*3/(235*114)= 27.92
alfa = 0.83 / Sqr(1 + 0.005 * D / ea) (16.14-16)
=0.83/Sqr(1+0.005*114/3)= 0.7609
delta = (1 - 0.4123 / (alfa * K) ^ 0.6) / S (16.14-19)
=(1-0.4123/(0.7609*27.92)^0.6)/1.5= 0.6227
Maximum Allowable Compressive Stress
Sigcall = Sige * delta (16.14-20) =235*0.6227= 146.34 N/mm2

Compr.Stress Limits (4-4/z=-20) Sig4c=0.467 <= Sigcall=175.61[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Maximum Compressive Force at Section 4-4
Fc4max = PI * D4 * ez * Sigcall (16.14-2) =3.14*114*3*146.34= 188.68 kN

Maximum Bending Moment at Section 4-4
M4max = PI / 4 * D4 ^ 2 * ez * Sigcall (16.14-3)
=3.14/4*114^2*3*146.34= 5.3774 kNm

Stability of skirt(Sect.4-4/z=-20)
StabilityFactor = F4/(Psi1*Fc4max)+(ABS(M44)+F4*eps)/(Psi2*M4max) (16.12-70)
=501.73/(1*1.8868E05)+(ABS(50224.95)+501.73*0)/(1*5.3774E06)= 0.0120

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.012 <= 1=1	1.1%	OK

SKIRT BASE DESIGN

```
Wsk = F4 / (PI * Dzb) =501.73/(3.14*114)=                    1.4009 N/mm
Msk = 4 * M4 / (PI * Dzb ^ 2) =4*54.22/(3.14*114^2)=         5.3121 N/mm
Outer radial width of bearing plate/base plate
b2 = (dob - (Dzb + ez)) / 2 =(190-(114+3))/2=                 36.50 mm
```

16.12.5 Anchor Bolt Design

```
Bolt Circle Diameter
d = Dzb + ea3 + 2 * b3 =114+3+2*23=                          163.00 mm
Mean Diameter of Bearing Ring/Base Plate
DCR = dob - b1 =190-70=                                      120.00 mm
Inside Diameter of Bearing Ring/Base Plate
D3 = dob - 2 * b1 =190-2*70=                                  50.00 mm
Pre-tensioning of bolts FA
FA = Phi * Ae * fdAnchor (16.12.80) =0.5*36.6*218.18=       3992.73 N
Maximum anchor bolt force FB
FB = (4 * M5 / d - F5) / n (16.12.77) =(4*54220.32/163-501.73)/4=   207.21 N
Required minimum torque(per bolt).
Mt = μ * FA * 1.1 * SQR( 4 * Ae / PI)                                (16.12-81)
=0.2*3992.73*1.1*SQR(4*36.6/3.14)=                          5.9964 Nm
Design anchor bolt load FBd
FBd = MAX( FA , FB) (16.12.83) =MAX(3992.73,207.21)=         3992.73 N
Required Bolting Area
Aemin = MAX( FB , 0) / fdAnchor =MAX(207.21,0)/218.18=        0.9497 mm2
```

Anchor Bolt Area Aemin=0.9497 <= Ae=36.6[mm2]	2.5%	OK

```
Spacing between anchor bolts
b8 = PI * (Dzb + ea3 + 2 * b3) / n
=3.14*(114+3+2*23)/4=                                       128.02 mm
Design load on concrete FCd
FCd = MAX( 4 * M5 / DCR + F5 , FA * n)
=MAX(4*54220.32/120+501.73,3992.73*4)=                    15970.91 N
Foundation Bearing Pressure on concrete below base ring
Sigc = FCd / (PI * DCR * b1) (16.12-86) =15970.91/(3.14*120*70)=   0.6052 N/mm2
```

Foundation Bearing Pressure(concrete) Sigc=0.6052 <= fcd/1.35=5.48[N/mm2] (16.12-86)	11.0%	OK

16.12.5.4.3 Checks for type 1 - Simple Bearing Plate

```
Required minimum analysis thickness of bearing plate (FB > 0)
ea4min = MAX(b2*SQR(3*SigC/f4),SQR(4*n*FB*b3/(PI*D3*f4)))          (16.12-90a)
=MAX(36.5*SQR(3*0.6052/203.3,)SQR(4*4*207.21*23/(3.14*50*203.3)))=   3.4493 mm
```

Min.Thk.of Base Ring ea4min=3.45 <= eR=5[mm]	68.9%	OK

CALCULATION SUMMARY

VESSEL DEFLECTION LOAD CASE NO: 1 - LC9 HYDROTEST

»LC9 HYDROTEST, Max.deflection over 200mm length dallow=1 >= dactual=6.259E-05[mm] «» OK«

```
Between z1= 508 and z2= 705 in component:E5.1
Deflection at top of vessel  :    0.0 mm
```

VESSEL DEFLECTION LOAD CASE NO: 2 - LC4 SHUT DOWN

»LC4 SHUT DOWN, Max.deflection over 200mm length dallow=1 >= dactual=1.0323E-04[mm] «» OK«

```
Between z1= 484 and z2= 682 in component:F.2
Deflection at top of vessel  :    0.0 mm
```

VESSEL DEFLECTION LOAD CASE NO: 3 - LC5 INSTALLATION

»LC5 INSTALLATION, Max.deflection over 200mm length dallow=1 >= dactual=7.1617E-05[mm] «» OK«

```
Between z1= 508 and z2= 705 in component:E5.1
Deflection at top of vessel  :    0.0 mm
```

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

»LC1&2&3 OPER.WIND, Max.deflection over 200mm length dallow=1 >= dactual=1.0323E-04[mm] «» OK«

```
Between z1= 484 and z2= 682 in component:F.2
Deflection at top of vessel  :    0.0 mm
```

VESSEL DEFLECTION LOAD CASE NO: 5 - LC6&7&8 OPER.SEISMIC

»LC6&7&8 OPER.SEISMIC, Max.deflection over 200mm length dallow=1 >= dactual=0.0023[mm] «» OK«

```
Between z1= 484 and z2= 682 in component:F.2
Deflection at top of vessel  :    0.0 mm
```

LOAD CASE NO: 1 - LC9 HYDROTEST

16.12.6.1 Verification of Membrane Stresses

Membrane Stress(Pint)(Sect.1-1) Sig1pm=128.04 <= fB=338.1[N/mm2]	37.8%	OK
Membrane Stress(Pint)(Sect.1-1) ABS(Sig1qm)=128. <= fB=338.1[N/mm2]	37.8%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1pmext=0.1094 <= Sigcall=315.25[N/mm2]	0.0%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.1463 <= Sigcall=315.25[N/mm2]	0.0%	OK
Membrane Stress(Sect.2-2) ABS(Sig2pm)=128.19 <= fB=338.1[N/mm2]	37.9%	OK
Membrane Stress(Sect.3-3) ABS(Sig3pm)=0.4256 <= fz=117.5[N/mm2]	0.3%	OK
Membrane Stress(Sect.3-3) ABS(Sig3qm)=0.5289 <= fz=117.5[N/mm2]	0.4%	OK

16.12.6.2 Bending Stresses

1) Location p ABS(Mp)/Wp=1.42 <= fT=117.5[N/mm2] (16.12-44)	1.2%	OK
2) Location q ABS(Mq)/Wq=1.76 <= fT=117.5[N/mm2] (16.12-45)	1.5%	OK

16.12.7 Verification of Skirt (Section 4-4)

Membrane Stress(Sect.4-4/z=-60) Sig4pm=0.4204 <= fz=117.5[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=0.5341 <= fz=117.5[N/mm2]	0.4%	OK
Compr.Stress Limits (4-4/z=-60) Sig4c=0.4773 <= Sigcall=209.06[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0025 <= 1=1	0.2%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4pm=0.4243 <= fz=117.5[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=0.5302 <= fz=117.5[N/mm2]	0.4%	OK
Compr.Stress Limits (4-4/z=-20) Sig4c=0.4773 <= Sigcall=209.06[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.0025 <= 1=1	0.2%	OK

SKIRT BASE DESIGN

Anchor Bolt Area Aemin=0 <= Ae=36.6[mm2]	0.0%	OK
Foundation Bearing Pressure(concrete) Sigc=0.5043 <= fcd/1.35=5.48[N/mm2] (16.12-86)	9.2%	OK

```
Required minimum analysis thickness of bearing plate (FB <= 0)
ea4min = b2 * SQR( 3 * SigC / f4)                              (16.12-90b)
=36.5*SQR(3*0.5043/223.81)=                              3.0011 mm
```

Min.Thk.of Base Ring ea4min=3. <= eR=5[mm]	60.0%	OK

LOAD CASE NO: 2 - LC4 SHUT DOWN

16.12.6.1 Verification of Membrane Stresses

Compr.Stress(Pint)(Sect.1-1) Sig1pm=0.1021 <= Sigcall=189.24[N/mm2]	0.0%	OK
Compr.Stress(Pint)(Sect.1-1) Sig1qm=0.1647 <= Sigcall=189.24[N/mm2]	0.0%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1pmext=0.1021 <= Sigcall=189.24[N/mm2]	0.0%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.1647 <= Sigcall=189.24[N/mm2]	0.0%	OK
Membrane Stress(Sect.2-2) ABS(Sig2pm)=9.3477E-05 <= fB=202.67[N/mm2]	0.0%	OK
Membrane Stress(Sect.3-3) ABS(Sig3pm)=0.2617 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.3-3) ABS(Sig3qm)=0.4218 <= fz=78.33[N/mm2]	0.5%	OK

16.12.6.2 Bending Stresses

1) Location p ABS(Mp)/Wp=0.9182 <= fT=78.33[N/mm2] (16.12-44)	1.1%	OK
2) Location q ABS(Mq)/Wq=1.48 <= fT=78.33[N/mm2] (16.12-45)	1.8%	OK

16.12.7 Verification of Skirt (Section 4-4)

Membrane Stress(Sect.4-4/z=-60) Sig4pm=0.2517 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=0.4318 <= fz=78.33[N/mm2]	0.5%	OK
Compr.Stress Limits (4-4/z=-60) Sig4c=0.3417 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0029 <= 1=1	0.2%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4pm=0.2596 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=0.4238 <= fz=78.33[N/mm2]	0.5%	OK
Compr.Stress Limits (4-4/z=-20) Sig4c=0.3417 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.0029 <= 1=1	0.2%	OK

SKIRT BASE DESIGN

Anchor Bolt Area Aemin=0 <= Ae=36.6[mm2]	0.0%	OK
Foundation Bearing Pressure(concrete) Sigc=0.5043 <= fcd/1.35=5.48[N/mm2] (16.12-86)	9.2%	OK

```
Required minimum analysis thickness of bearing plate (FB <= 0)
ea4min = b2 * SQR( 3 * SigC / f4)                              (16.12-90b)
=36.5*SQR(3*0.5043/142.67)=                              3.7588 mm
```

Min.Thk.of Base Ring ea4min=3.76 <= eR=5[mm]	75.1%	OK

LOAD CASE NO: 3 - LC5 INSTALLATION

16.12.6.1 Verification of Membrane Stresses

Compr.Stress(Pint)(Sect.1-1) Sig1pm=0.1111 <= Sigcall=219.74[N/mm2]	0.0%	OK
Compr.Stress(Pint)(Sect.1-1) Sig1qm=0.1557 <= Sigcall=219.74[N/mm2]	0.0%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1pmext=0.1111 <= Sigcall=219.74[N/mm2]	0.0%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.1557 <= Sigcall=219.74[N/mm2]	0.0%	OK
Membrane Stress(Sect.2-2) ABS(Sig2pm)=9.3477E-05 <= fB=204.17[N/mm2]	0.0%	OK
Membrane Stress(Sect.3-3) ABS(Sig3pm)=0.2847 <= fz=78.33[N/mm2]	0.3%	OK

Membrane Stress(Sect.3-3) ABS(Sig3qm)=0.3988 <= fz=78.33[N/mm2]	0.5%	OK

16.12.6.2 Bending Stresses

1) Location p ABS(Mp)/Wp=0.999 <= fT=78.33[N/mm2] (16.12-44)	1.2%	OK
2) Location q ABS(Mq)/Wq=1.4 <= fT=78.33[N/mm2] (16.12-45)	1.7%	OK

16.12.7 Verification of Skirt (Section 4-4)

Membrane Stress(Sect.4-4/z=-60) Sig4pm=0.2785 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=0.4049 <= fz=78.33[N/mm2]	0.5%	OK
Compr.Stress Limits (4-4/z=-60) Sig4c=0.3417 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0028 <= 1=1	0.2%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4pm=0.2832 <= fz=78.33[N/mm2]	0.3%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=0.4002 <= fz=78.33[N/mm2]	0.5%	OK
Compr.Stress Limits (4-4/z=-20) Sig4c=0.3417 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.0027 <= 1=1	0.2%	OK

SKIRT BASE DESIGN

Anchor Bolt Area Aemin=0 <= Ae=36.6[mm2]	0.0%	OK
Foundation Bearing Pressure(concrete) Sigc=0.5043 <= fcd/1.35=5.48[N/mm2] (16.12-86)	9.2%	OK

```
Required minimum analysis thickness of bearing plate (FB <= 0)
ea4min = b2 * SQR( 3 * SigC / f4)                          (16.12-90b)
=36.5*SQR(3*0.5043/150)=                          3.6658 mm
```

Min.Thk.of Base Ring ea4min=3.67 <= eR=5[mm]	73.3%	OK

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

16.12.6.1 Verification of Membrane Stresses

Membrane Stress(Pint)(Sect.1-1) Sig1pm=88.03 <= fB=202.67[N/mm2]	43.4%	OK
Membrane Stress(Pint)(Sect.1-1) ABS(Sig1qm)=87.97 <= fB=202.67[N/mm2]	43.4%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1pmext=0.1021 <= Sigcall=189.24[N/mm2]	0.0%	OK

Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.1647 <= Sigcall=189.24[N/mm2]	0.0%	OK
Membrane Stress(Sect.2-2) ABS(Sig2pm)=88.16 <= fB=202.67[N/mm2]	43.4%	OK
Membrane Stress(Sect.3-3) ABS(Sig3pm)=0.3234 <= fz=78.33[N/mm2]	0.4%	OK
Membrane Stress(Sect.3-3) ABS(Sig3qm)=0.4835 <= fz=78.33[N/mm2]	0.6%	OK

16.12.6.2 Bending Stresses

1) Location p ABS(Mp)/Wp=1.34 <= fT=78.33[N/mm2] (16.12-44)	1.7%	OK
2) Location q ABS(Mq)/Wq=2.01 <= fT=78.33[N/mm2] (16.12-45)	2.5%	OK

16.12.7 Verification of Skirt (Section 4-4)

Membrane Stress(Sect.4-4/z=-60) Sig4pm=0.3134 <= fz=78.33[N/mm2]	0.4%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=0.4935 <= fz=78.33[N/mm2]	0.6%	OK
Compr.Stress Limits (4-4/z=-60) Sig4c=0.4034 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0034 <= 1=1	0.3%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4pm=0.3213 <= fz=78.33[N/mm2]	0.4%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=0.4856 <= fz=78.33[N/mm2]	0.6%	OK
Compr.Stress Limits (4-4/z=-20) Sig4c=0.4034 <= Sigcall=146.34[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.0033 <= 1=1	0.3%	OK

SKIRT BASE DESIGN

Anchor Bolt Area Aemin=0 <= Ae=36.6[mm2]	0.0%	OK
Foundation Bearing Pressure(concrete) Sigc=0.5043 <= fcd/1.35=5.48[N/mm2] (16.12-86)	9.2%	OK

```
Required minimum analysis thickness of bearing plate (FB <= 0)
ea4min = b2 * SQR( 3 * SigC / f4)                              (16.12-90b)
=36.5*SQR(3*0.5043/142.67)=                              3.7588 mm
```

Min.Thk.of Base Ring ea4min=3.76 <= eR=5[mm]	75.1%	OK

LOAD CASE NO: 5 - LC6&7&8 OPER.SEISMIC

16.12.6.1 Verification of Membrane Stresses

Membrane Stress(Pint)(Sect.1-1) Sig1pm=88.62 <= fB=288.8[N/mm2]	30.6%	OK
Membrane Stress(Pint)(Sect.1-1) ABS(Sig1qm)=87.34 <= fB=288.8[N/mm2]	30.2%	OK
Membrane Stress(Pext)(Sect.1-1) Sig1pmext=0.4826 <= fB=288.8[N/mm2]	0.1%	OK
Compr.Stress(Pext)(Sect.1-1) Sig1qmext=0.799 <= Sigcall=227.09[N/mm2]	0.3%	OK
Membrane Stress(Sect.2-2) ABS(Sig2pm)=88.16 <= fB=288.8[N/mm2]	30.5%	OK
Membrane Stress(Sect.3-3) ABS(Sig3pm)=1.17 <= fz=111.62[N/mm2]	1.0%	OK
Membrane Stress(Sect.3-3) ABS(Sig3qm)=2.11 <= fz=111.62[N/mm2]	1.8%	OK

16.12.6.2 Bending Stresses

1) Location p ABS(Mp)/Wp=4.46 <= fT=111.62[N/mm2] (16.12-44)	3.9%	OK
2) Location q ABS(Mq)/Wq=8. <= fT=111.62[N/mm2] (16.12-45)	7.1%	OK

16.12.7 Verification of Skirt (Section 4-4)

Membrane Stress(Sect.4-4/z=-60) Sig4pm=1.35 <= fz=111.62[N/mm2]	1.2%	OK
Membrane Stress(Sect.4-4/z=-60) Sig4qm=2.28 <= fz=111.62[N/mm2]	2.0%	OK
Compr.Stress Limits (4-4/z=-60) Sig4c=0.467 <= Sigcall=175.61[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-60) StabilityFactor=0.0127 <= 1=1	1.2%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4pm=1.22 <= fz=111.62[N/mm2]	1.0%	OK
Membrane Stress(Sect.4-4/z=-20) Sig4qm=2.15 <= fz=111.62[N/mm2]	1.9%	OK
Compr.Stress Limits (4-4/z=-20) Sig4c=0.467 <= Sigcall=175.61[N/mm2]	0.2%	OK

Check of Skirt Stability/Weakening due to Openings in Skirt

Stability/Openings in skirt(Sect.4-4/z=-20) StabilityFactor=0.012 <= 1=1	1.1%	OK

SKIRT BASE DESIGN

Anchor Bolt Area Aemin=0.9497 <= Ae=36.6[mm2]	2.5%	OK
Foundation Bearing Pressure(concrete) Sigc=0.6052 <= fcd/1.35=5.48[N/mm2] (16.12-86)	11.0%	OK

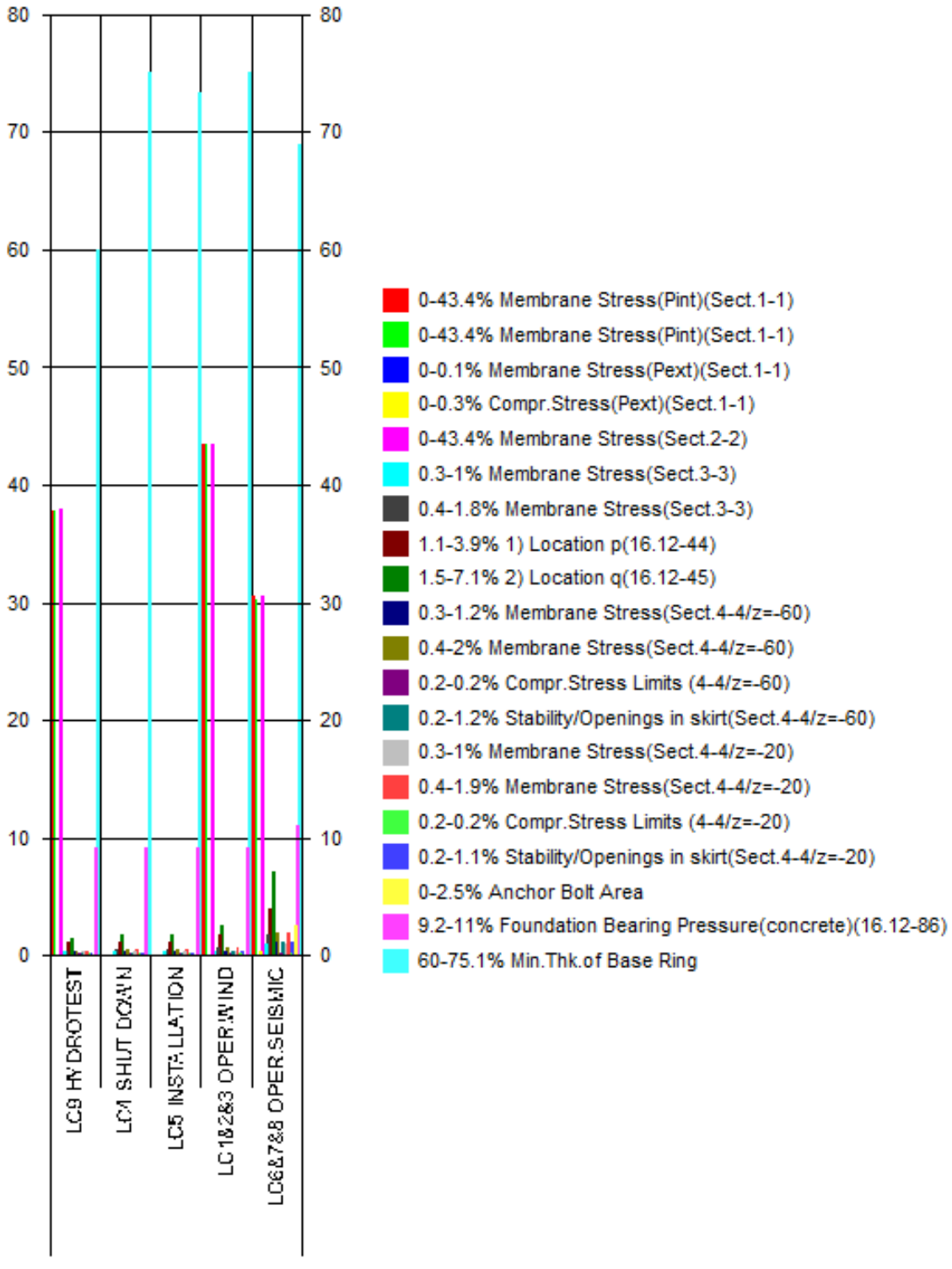
```
Required minimum analysis thickness of bearing plate (FB > 0)
ea4min = MAX(b2*SQR(3*SigC/f4),SQR(4*n*FB*b3/(PI*D3*f4)))          (16.12-90a)
=MAX(36.5*SQR(3*0.6052/203.3,)SQR(4*4*207.21*23/(3.14*50*203.3)))=   3.4493 mm
```

Min.Thk.of Base Ring ea4min=3.45 <= eR=5[mm]	68.9%	OK

Warning: Incorrect location along z-axis of opening in skirt for: InspectionOpening

Volume:0.00 m3 Weight:1.4 kg (SG= 7.849999)

UTILIZATION CHART - SK.1 SKIRT



Max.Utilization/Condition 75.1% CASE:LC4 SHUT DOWN

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

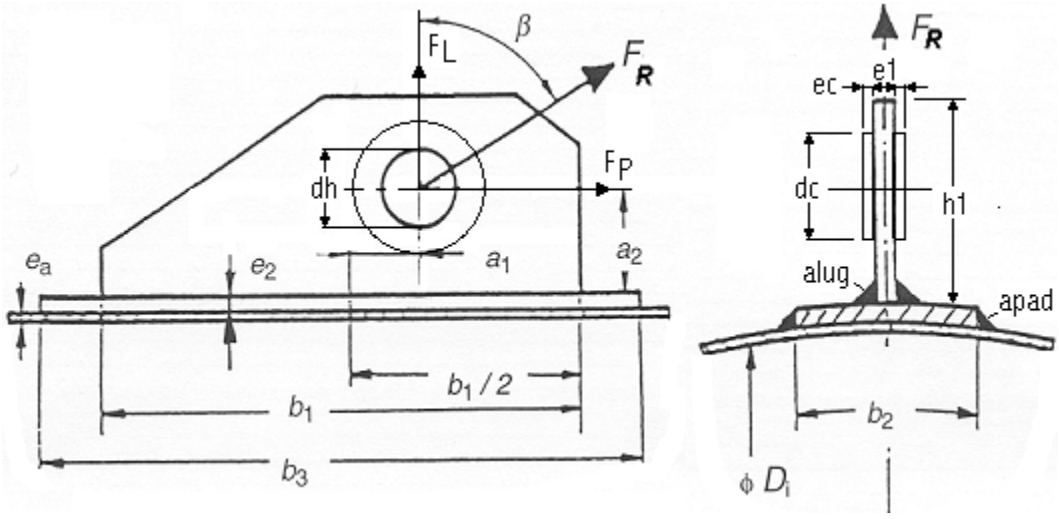
```
Attachment: S1.1    Cylindrical Shell    Shell
z-location of Lug at Loc.of Load Interaction.....:z         550.00 mm
Angular rotation of lug.........................:angle     180.00 degr.
Extent of Analysis: Check Lug and Loads in Shell
Load Orientation: Longitudinal Line Load
Type of Lifting Lug:
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 (S1.1)

```
Shell Type: Cylindrical Shell
OUTSIDE DIAMETER OF SHELL.......................:De        168.30 mm
NOMINAL WALL THICKNESS (uncorroded).............:en        7.1000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...........:th        0.7100 mm
INTERNAL CORROSION ALLOWANCE....................:c         0.5000 mm
EN 10217-3:2002/A1:05, 1.0565 P355NH welded tube, HT:N THK<=20mm 100'C
Rm=490 Rp=355 Rpt=304 f=202.67 f20=204.17 ftest=338.1 E=206067(N/mm2) ro=7.85
```

DATA FOR LIFTING LUG

```
Cheek Plates/Pad Eyes: Excluded
EN 10025-2:2005, 1.0045 S355JR Flat/Long Products THK<=16mm 50'C
Rm=470 Rp=355 Rpt=355 f=195.83 f20=195.83 ftest=338.1  (N/mm2)
NOTE: A PARTICULAR MATERIAL APPRAISAL(PMA) MAY BE REQUIRED FOR THIS MATERIAL.
Comment:
Exclude shell corrosion, only use lifting lug in uncorroded condition.: NO
LENGTH OF LIFTING LUG AT SHELL/PAD JUNCTION.....:b1         40.00 mm
HEIGHT OF LIFTING LUG...........................:h1         50.00 mm
THICKNESS OF LIFTING LUG........................:e1        5.0000 mm
DIAMETER OF HOLE IN LIFTING LUG.................:dh         30.00 mm
DISTANCE FROM LOAD TO SHELL OR REINFORCEMENT PAD....:a2     30.00 mm
```



DATA FOR REINFORCEMENT PAD

```
Reinforcement Pad: Excluded
```

WELDING DATA

```
Type of Weld - Lug to Pad/Shell: Double Sided Fillet Weld
WELD JOINT COEFFICIENT..........................:z         0.8500
WELD BETWEEN LUG AND PAD/SHELL, THROAT DIMENSION....:alug   2.0000 mm
```

LOAD DATA

Load Description	ID	Units	Load Case 1
Pressure	P	MPa	0
Not Applicable			0.5
Test Condition (Yes/No)			No
Temp.D=Design/A=Ambient	Temp		A
Maximum Force on Lug (at angle Beta)	FR	kN	0.6
Angle of Sling Leg From Vertical	Beta	degr.	45
Load Safety Factor	SL		1.5
Percentage Skew/Side Load	PS	%	0

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

Shell Analysis Thickness ea
ea = en - c - th =7.1-0.5-0.71= 5.8900 mm
Shell Inside Diameter
Di = De - 2 * (en - c) =168.3-2*(7.1-0.5)= 155.10 mm
16.6.3 Equivalent Shell Diameter
Deq = Di (16.6-1) =155.1= 155.10 mm
Lambda = b / SQR(Deq * ea) (16.6-13/17) =40/SQR(155.1*5.89)= 1.3234

16.7.3 CONDITIONS OF APPLICABILITY

»a) 0.001=.001 <= en/Deq=0.0458« » OK«
»a) en/Deq=0.0458 <= 0.05« » OK«

LOAD CASE NO: 1 - LOAD CASE 1

K2 (design condition) = == 1.2500
Normal Force Component
FL = SL * FR * Cos(beta) =1.5*600*Cos(45)= 0.6364 kN

Parallel Force Component
FP = SL * FR * Sin(beta) =1.5*600*Sin(45)= 0.6364 kN

Side/Skew Load - 0% Lateral Load
Fside = PS / 100 * SL * FR =0/100*1.5*600= 0.00 kN

External Moment Along Load Direction
ML = SL * FR * ((a2 + e2) * Sin(beta) - a1 * Cos(beta))
=1.5*600*((30+0)*Sin(45)-0*Cos(45))= 0.0191 kNm

External Moment in Transverse Load Direction
MT = Fside * (a2 + e2) =0*(30+0)= 0.00 kNm

Stresses in the Lug Foot/Across Baseline and at Weld

Tensional Stress in the Lug Foot
SigTension = FL / (e1 * b1) =636.4/(5*40)= 3.1820 N/mm2
Bending Stress due to FP
SigBendL = 6 * FP * a2 / (e1 * b1 ^ 2)
=6*636.4*30/(5*40^2)= 14.32 N/mm2
Bending Stress in Lug Plate due to Moment in Transverse Load Direction
SigBendT = 6 * Fside * a2 / (b1 * e1 ^ 2)
=6*0*30/(40*5^2)= 0.00 N/mm2
Shear Stress due to FP
TauL = FP / (b1 * e1) =636.4/(40*5)= 3.1820 N/mm2
Shear Stress in Transverse Load Direction
TauT = Fside / (b1 * e1) =0/(40*5)= 0.00 N/mm2
Effective Stress
Sige = SQR((SigTension+SigBendL+SigBendT)^2+3*(TauL^2+TauT^2))
=SQR((3.18+14.32+0)^2+3*(3.18^2+0^2))= 18.35 N/mm2

Effective Stress in the Lug Foot Sige=18.35 <= fl=195.83[N/mm2]	9.3%	OK

```
Bending Stress in Shell due to Moment in Transverse Load Direction
SigBendT2 = 6 * Fside * a2 / (b1 * ea ^ 2)
=6*0*30/(40*5.89^2)=                                    0.00 N/mm2
```

Bending Stress in Shell/Pad(Transverse Moment) SigBendT2=0 <= 1.5 * fs=306.25[N/mm2]	0.0%	OK

Double Fillet Weld between Lug and Pad/Shell(Bednar Chapter 10.3)

```
Weld Length
Lw = 2 * (e1 + b1) =2*(5+40)=                            90.00 mm
Section Modulus(around axis transverse to lug)
Zx = e1 * b1 + b1 ^ 2 / 3 =5*40+40^2/3=                 733.33 mm2
Section Modulus(around axis along lug)
Zy = b1 * e1 + e1 ^ 2 / 3 =40*5+5^2/3=                  208.33 mm2
Unit force due to FL
f1 = FL / Lw =636.4/90=                                 7.0711 N/mm
Unit force due to FP and Fside
f2 = SQR( FP ^ 2 + Fside ^ 2) / Lw
=SQR(636.4^2+0^2)/90=                                 7.0711 N/mm
Bending
f3 = MAX( ( FP * a2 - FL * a1) / Zx , Fside * a2 / Zy)
=MAX((636.4*30-636.4*0)/733.33,0*30/208.33)=            26.03 N/mm
Resultant Load
ftot = SQR(( f1 + f3) ^ 2 + f2 ^ 2)
=SQR((7.07+26.03)^2+7.07^2)=                            33.85 N/mm
Required Weld Size, Throat Dimension
alugmin = ftot / (z * fs) =33.85/(0.85*204.17)=          0.1951 mm
```

Required Lug Weld Size alugmin=0.1951 <= alug=2[mm]	9.7%	OK

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

```
TauTearOut = 3 * SL * FR / (e1 * 2 * (h1 - a2 - dh / 2))
=3*1.5*600/(5*2*(50-30-30/2))=                          54.00 N/mm2
```

Tear Out Stress TauTearOut=54 <= Re(lug)=355[N/mm2]	15.2%	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(1.5*600/(5*30))=                              58.05 N/mm2
```

Bearing Stress(pin in hole) SigBearing=58.05 <= Re(lug)=355[N/mm2]	16.3%	OK

16.6.7 - Global Circumferential Membrane Stress

```
Sigmy = P * Deq / (2 * ea) (16.6-11/12) =0*155.1/(2*5.89)=     0.00 N/mm2
```

16.6.8 - Single Line Loads

```
K13 = 1 / (1.2 * Sqr( 1 + 0.06 * Lambda ^ 2))                        (16.6-15)
=1/(1.2*Sqr(1+0.06*1.32^2))=                              0.7927
K14 = 1 / (0.6 * Sqr( 1 + 0.03 * Lambda ^ 2))                        (16.6-16)
=1/(0.6*Sqr(1+0.03*1.32^2))=                              1.6245
Ny1 = MIN( 0.08 * Lambda , 0.2) (16.6-14) =MIN(0.08*1.32,0.2)=   0.1059
Ny2 = Sigmy / (K2 * fs) (16.6-8) =0/(1.25*204.17)=             0.00
K1 from figure 16.6-1 =    1.464
Bending Limit Stress Sigball
Sigball = K1 * K2 * fs (16.6-6) =1.46*1.25*204.17=          373.62 N/mm2

Maximum Allowable Local Force FRmax
FRmax = Sigball*ea^2/(K13*Abs(Cos(beta))+K14*Abs(a2*Sin(beta)-a1*Cos(beta))/b1)
```

```
(16.7-4)
=373.62*5.89^2/(0.7927*Abs(Cos(0.7854))+1.62*Abs(30*Sin(0.7854)-0*Cos(0.785
4))/40)=                                                    =   9.1146 kN
```

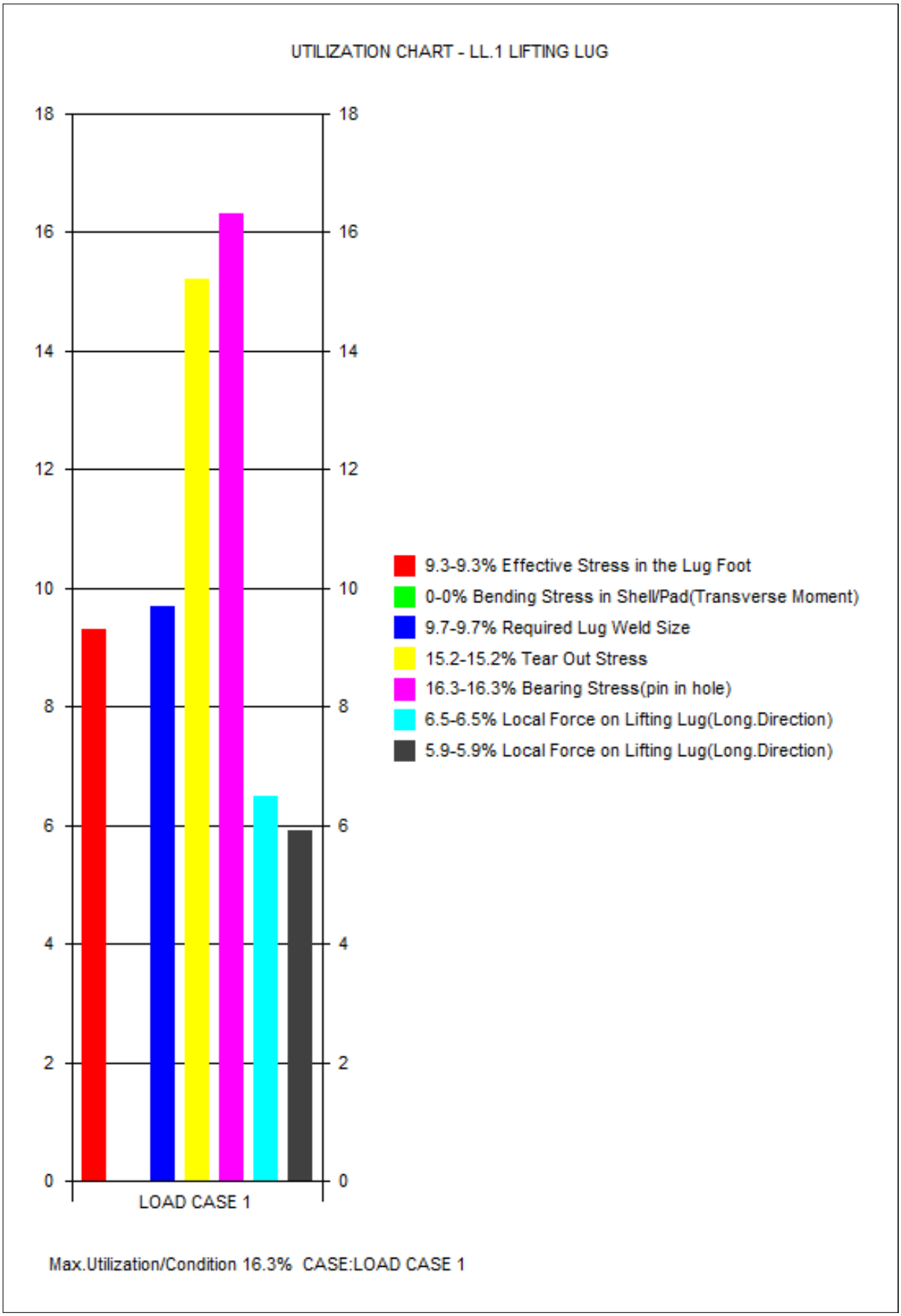
Local Force on Lifting Lug(Long.Direction) FR=0.6 <= FRmax=9.11[kN]	6.5%	OK
Local Force on Lifting Lug(Long.Direction) SL*FR=0.9 <= FRmax*(Sigballt/Sigball)=15.09[kN]	5.9%	OK

CALCULATION SUMMARY

LOAD CASE NO: 1 - LOAD CASE 1

Effective Stress in the Lug Foot Sige=18.35 <= fl=195.83[N/mm2]	9.3%	OK
Bending Stress in Shell/Pad(Transverse Moment) SigBendT2=0 <= 1.5 * fs=306.25[N/mm2]	0.0%	OK
Required Lug Weld Size alugmin=0.1951 <= alug=2[mm]	9.7%	OK
Tear Out Stress TauTearOut=54 <= Re(lug)=355[N/mm2]	15.2%	OK
Bearing Stress(pin in hole) SigBearing=58.05 <= Re(lug)=355[N/mm2]	16.3%	OK
Local Force on Lifting Lug(Long.Direction) FR=0.6 <= FRmax=9.11[kN]	6.5%	OK
Local Force on Lifting Lug(Long.Direction) SL*FR=0.9 <= FRmax*(Sigballt/Sigball)=15.09[kN]	5.9%	OK

Volume:0.00 m3 Weight:0.1 kg (SG= 7.85)


UTILIZATION CHART - LL.1 LIFTING LUG
18
16
14
12
10
8
6
4
2
0
LOAD CASE 1
9.3-9.3% Effective Stress in the Lug Foot
0-0% Bending Stress in Shell/Pad(Transverse Moment)
9.7-9.7% Required Lug Weld Size
15.2-15.2% Tear Out Stress
16.3-16.3% Bearing Stress(pin in hole)
6.5-6.5% Local Force on Lifting Lug(Long.Direction)
5.9-5.9% Local Force on Lifting Lug(Long.Direction)
Max.Utilization/Condition 16.3% CASE:LOAD CASE 1