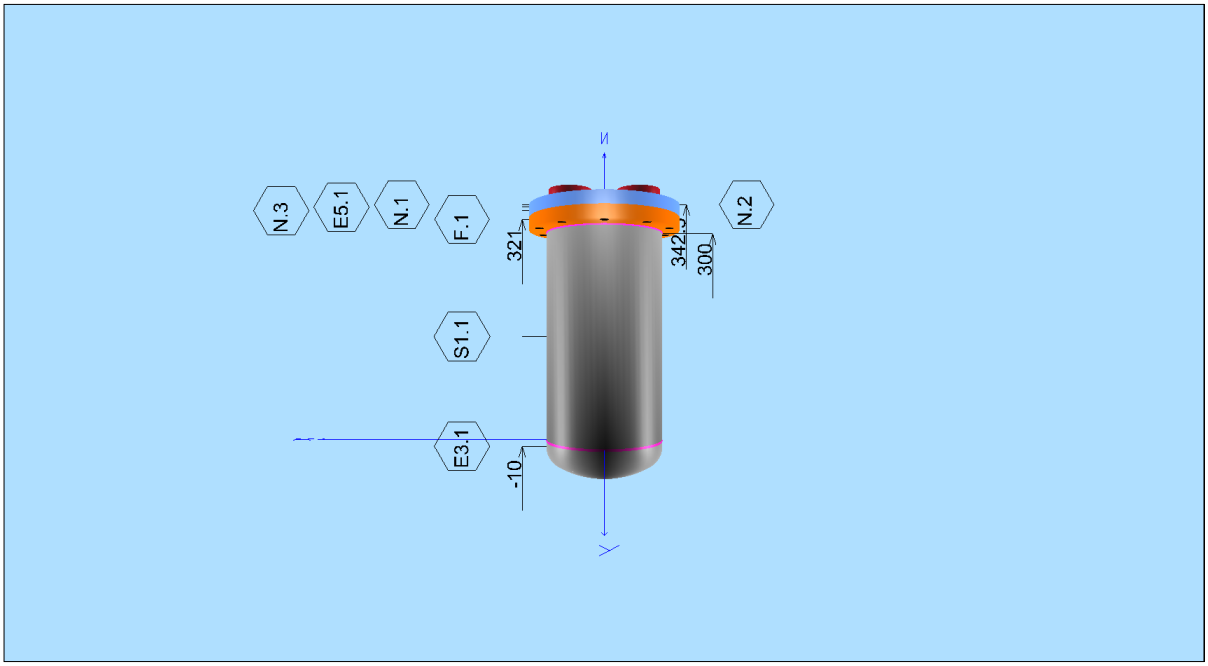
(0) Drawing

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	3.3
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
Content of Vessel		
Specific Density of Oper.Liq		
Normal Liquid Level NLL (mm)	mm	

Test Pressure

TEST PRESSURE OF VESSEL - NEW & COLD - VERTICAL

Design Pressure.....: 3.300 MPa
Design Temperature.....: 130.0 C

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
E3.1	Torispherical End-End	3.300	6.710	4.386	0.004	4.386	6.706
E5.1	Bolted Flat End-Cover Flange	3.300	8.405	4.187	0.000	4.187	8.405
F.1	RT - Flange-Shell Flange	3.300	5.887	4.187	0.001	4.187	5.886
N.1	Nozzle,Seamless Pipe-Inlet	3.300	6.511	NA	0.000	NA	6.511
N.2	Nozzle,Seamless Pipe-Outlet	3.300	6.511	NA	0.000	NA	6.511
N.3	Nozzle,Seamless Pipe-Sae 3/8"	3.300	7.617	NA	0.000	NA	7.617
S1.1	Cylindrical Shell-Shell	3.300	10.012	4.297	0.004	4.297	10.009

PtReq = MAX(MIN(PtTop), 1.43*p)= 4.7190 MPa (EN13445-5, 10.2.3.3.1-1 & 2)

HYDRO-TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Hydro Test) ......:     4.7190 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Hydro Test) .......:     5.8864 MPa
```

PNEUMATIC TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..:     4.7190 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...:     5.8870 MPa

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

TEST PRESSURE OF VESSEL - NEW & COLD - HORIZONTAL

```
Design Pressure.........................:     3.300 MPa
Design Temperature......................:   130.0 C
```

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
E3.1	Torispherical End-End	3.300	6.710	4.386	0.001	4.386	6.709
E5.1	Bolted Flat End-Cover Flange	3.300	8.405	4.187	0.002	4.187	8.403
F.1	RT - Flange-Shell Flange	3.300	5.887	4.187	0.002	4.187	5.885
N.1	Nozzle,Seamless Pipe-Inlet	3.300	6.511	NA	0.001	NA	6.511
N.2	Nozzle,Seamless Pipe-Outlet	3.300	6.511	NA	0.002	NA	6.510
N.3	Nozzle,Seamless Pipe-Sae 3/8"	3.300	7.617	NA	0.002	NA	7.616
S1.1	Cylindrical Shell-Shell	3.300	10.012	4.297	0.002	4.297	10.010

```
PtReq = MAX(MIN(PtTop), 1.43*p)=  4.7190 MPa (EN13445-5, 10.2.3.3.1-1 & 2)
```

HYDRO-TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Hydro Test) ......:     4.7190 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Hydro Test) .......:     5.8849 MPa
```

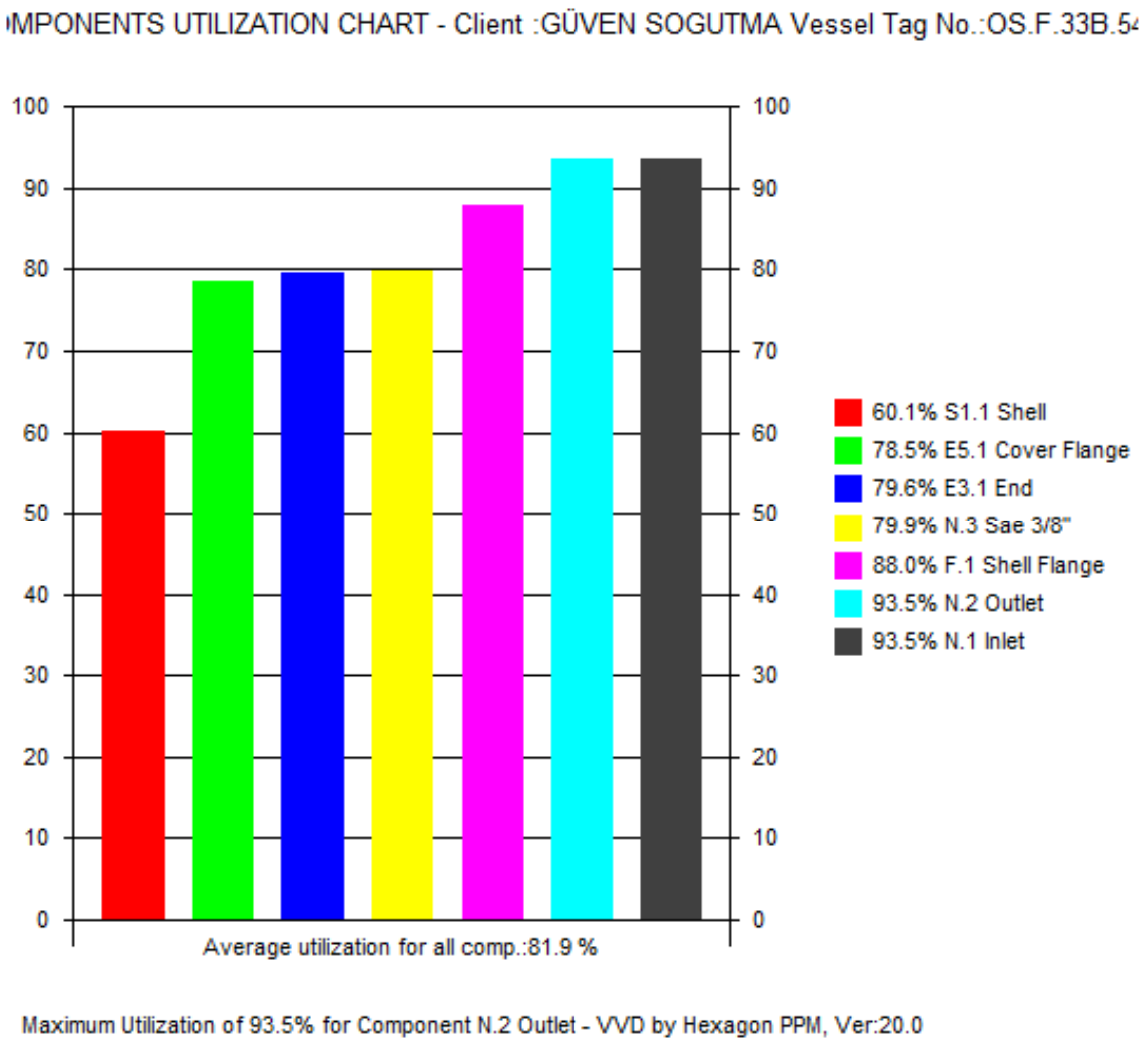
PNEUMATIC TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..:     4.7190 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...:     5.8870 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
```


MPONENTS UTILIZATION CHART - Client :GÜVEN SOGUTMA Vessel Tag No.:OS.F.33B.5
100
90
80
70
60
50
40
30
20
10
0
Average utilization for all comp.:81.9 %
60.1% S1.1 Shell
78.5% E5.1 Cover Flange
79.6% E3.1 End
79.9% N.3 Sae 3/8"
88.0% F.1 Shell Flange
93.5% N.2 Outlet
93.5% N.1 Inlet
Maximum Utilization of 93.5% for Component N.2 Outlet - VVD by Hexagon PPM, Ver:20.0

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=3.3000 MPa, c=0.0 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG          0.00
LIQUID HEAD.....:LH          0.00 mm
```

SHELL DATA

```
CYLINDER FABRICATION: Welded Pipe
WELD JOINT COEFFICIENT: Testing Group  1   (z=1.0)
NEGATIVE TOLERANCE: Negative tolerance specified in mm
EN 10216-3:2013, 1.0565 P355NH seamless tube, HT:N THK<=50mm 100'C
Rm=490 Rp=335 Rpt=294 f=196 f20=204.17 ftest=319.05 E=206067(N/mm2) ro=7.85
OUTSIDE DIAMETER OF SHELL.....:De        168.30 mm
LENGTH OF CYLINDRICAL PART OF SHELL.....:Lcyl      300.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en        3.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th        0.4000 mm
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*3.3/(2*196*1+3.3)=                                  1.4050 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =1.4+0+0.4=                       1.8050 mm

Analysis Thickness
ea = en - c - NegDev =3-0-0.4=                              2.6000 mm
```

»7.4.1 Cond.of Applicabilty emin/De=0.0083 <= 0.16« » OK«

Internal Pressure emina=1.8 <= en=3[mm]	60.1%	OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

```
Inside Diameter of Shell
Di = De - 2 * ea =168.3-2*2.6=                              163.10 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(168.3+163.1)/2=                        165.70 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
MAWPHC = 2 * f * z * ea / Dm =2*196*1*2.6/165.7=            6.1509 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)
MAWPNC = 2 * f20 * z * (ea + c) / Dm
=2*204.17*1*(2.6+0)/165.7=                                 6.4073 MPa
```

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

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*319.05*1*(2.6+0)/165.7=                                 10.01 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*3.3*204.17/196= 4.2969 MPa

Ptmin = 1.43 * Pd =1.43*3.3= 4.7190 MPa

Test Pressure Ptmin=4.72 <= Ptmax=10.01[MPa]	47.1%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Inside Radius of Shell
ris = Di / 2 (9.5-3) =163.1/2= 81.55 mm
Length of Shell Contributing to Reinforcement
Is = Sqr((2 * ris + ea) * ea) (9.5-2)
=Sqr((2*81.55+2.6)*2.6)= 20.76 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*163.1,(2.6*20.76*(196-0.5*3.3)/3.3-81.55*20.76)/(0.5*81.55+0.5*2.6
))= = 35.31 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr((2 * ris + ea) * ea) (9.5-18)
=0.15*Sqr((2*81.55+2.6)*2.6)= 3.1134 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(35.31,3.11)= 35.31 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*3.3/(2*196*1+3.3)= 1.4050 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =1.4+0+0.4= 1.8050 mm

Internal Pressure emina=1.8 <= en=3[mm]	60.1%	OK

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

Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*319.05*1*(2.6+0)/165.7= 10.01 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*3.3*204.17/196= 4.2969 MPa

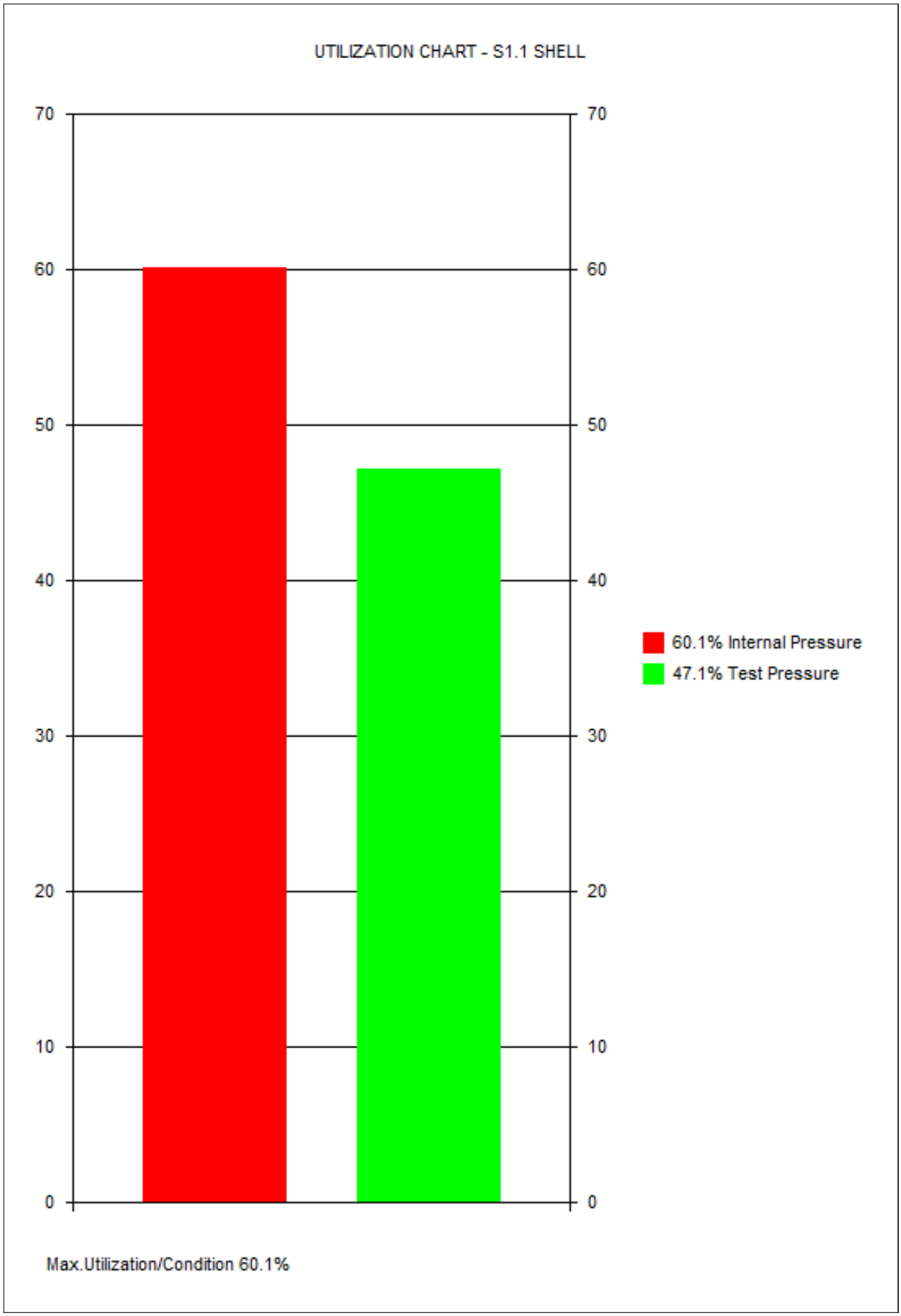
Ptmin = 1.43 * Pd =1.43*3.3= 4.7190 MPa

Test Pressure Ptmin=4.72 <= Ptmax=10.01[MPa]	47.1%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(35.31,3.11)= 35.31 mm

Volume:0.0063 m3 Weight:3.7 kg (SG= 7.85)


UTILIZATION CHART - S1.1 SHELL
70
60
50
40
30
20
10
0
60.1% Internal Pressure
47.1% Test Pressure
Max.Utilization/Condition 60.1%

INPUT DATA

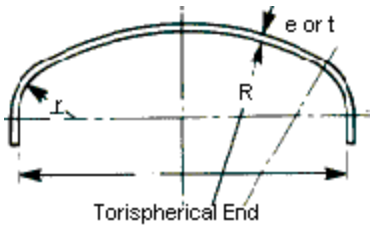
COMPONENT ATTACHMENT/LOCATION

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

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 100°C, P=3.3000 MPa, c=0.0 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG          0.00
LIQUID HEAD.....:LH          0.00 mm
```

DIMENSIONS OF END




```
Type of Torispherical End: Dished End KORBBOGEN DIN 28013-28014/SMS 482
WELD JOINT COEFFICIENT: Unwelded Component(z=1.0)
OUTSIDE DIAMETER OF CYLINDRICAL FLANGE OF END.......:De        168.30 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl       10.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en        2.5000 mm
Include calculation of forming during fabrication to EN13445-4 Section 9.: NO
```

MATERIAL DATA FOR END

```
EN 10028-2:2017, 1.0425 P265GH plate and strip, HT:N THK<=16mm 100'C
Rm=410 Rp=265 Rpt=241 f=160.67 f20=170.83 ftest=252.38 E=206067(N/mm2) ro=7.85
Material & Delivery Form: Cold Spun Seamless Austenitic Stainless Steel
```

NOZZLES IN KNUCKLE REGION TO SECTION 7.7

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

```
Required Thickness of End to Limit Membrane Stress in Central Part
es = P * R / (2 * f * z - 0.5 * P)                                  (7.5-1)
=3.3*134.64/(2*160.67*1-0.5*3.3)=                          1.3898 mm

fb = Rpt / 1.5 * 1.6 (7.5-5) =241/1.5*1.6=                   257.07 N/mm2
Required Thickness of Knuckle to Avoid Plastic Buckling
eb = (0.75*R+0.2*Di)*((P/(111*fb)*(Di/r)^0.825)^(0.667)             (7.5-3)
=(0.75*134.64+0.2*163.3)*((3.3/(111*257.07)*(163.3/25.92)^0.825)^(0.667)
=   0.8708 mm

7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(1.68/134.64,0.04)=      0.0125
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0125)=                      1.9031
X = r / Di (7.5-11) =25.92/164.93=                            0.1571
```

```
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                              (7.5-12)
=1.006-1/(6.2+(90*0.0125)^4)=                          0.8778
Beta01 = N*(-0.1833*Z^3+1.0383*Z^2-1.2943*Z+0.837)                (7.5-15)
=0.8778*(-0.1833*1.9^3+1.0383*1.9^2-1.2943*1.9+0.837)=     0.7645
Beta02 = MAX( 0.5, 0.95 * (0.56 - 1.94 * Y - 82.5 * Y ^ 2))       (7.5-17)
=MAX(0.5,0.95*(0.56-1.94*0.0125-82.5*0.0125^2))=           0.5000
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)             (7.5-16)
=10*((0.2-0.1571)*0.7645+(0.1571-0.1)*0.5)=                0.6134
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * P * (0.75 * R + 0.2 * Di) / f                         (7.5-2)
=0.6134*3.3*(0.75*134.64+0.2*164.93)/160.67=               1.6877 mm
```

NOTE 3, since ey(1.7) > 0.005*Di(0.8) it is NOT necessary to calculate/consider eb.

```
Required Minimum End Thickness Excl.Allow. emin :
emin = emin =1.69=                                          1.6877 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =1.69+0+0.3=                          1.9900 mm
```

Internal Pressure emina=1.99 <= en=2.5[mm]	79.6%	OK

```
Analysis Thickness
ea = en - c - th =2.5-0-0.3=                                2.2000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =168.3-2*(2.5-0)=                    163.30 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(168.3+163.3)/2=                        165.80 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(163.3*1.69)=          3.3202 mm
Since Lcyl > Llim, Required Thickness of Straight Cylindrical Flange to 7.4.2
Minimum Thickness of Straight Flange Excl. Allow.
ecyl = P * Di / (2 * f * z - P)                                   (7.4-1)
=3.3*163.3/(2*160.67*1-3.3)=                               1.6944 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =1.69+0=                                   1.6900 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=25.92 <= 0.2 * Di=32.66[mm] « » OK«
»Geometry Check r=25.92 >= 0.06 * Di=9.8[mm] « » OK«
»Geometry Check r=25.92 >= 2*e=3.38[mm] « » OK«
»Geometry Check e=1.69 <= 0.08*De=13.46[mm] « » OK«
»Geometry Check ea=2.2 >= 0.001*De=0.1683[mm] « » OK«
»Geometry Check R=134.64 <= De=168.3[mm] « » OK«

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                              (7.5-6)
=2*170.83*1*2.2/(134.64+0.5*2.2)=                          5.5374 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                    (7.5-7)
=170.83*2.2/(0.5931*(0.75*134.64+0.2*163.3))=              4.7420 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                 (7.5-8)
=111*282.67*(2.2/(0.75*134.64+0.2*163.3))^1.5*(25.92/163.3)^0.825=    14.52 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*2.2*170.83*1/(163.3+2.2)=                               4.5417 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=4.54=                                                     4.5417 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                              (7.5-6)
=2*160.67*1*2.2/(134.64+0.5*2.2)=                          5.2081 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                    (7.5-7)
=160.67*2.2/(0.5931*(0.75*134.64+0.2*163.3))=              4.4599 MPa
```

```
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                    (7.5-8)
=111*257.07*(2.2/(0.75*134.64+0.2*163.3))^1.5*(25.92/163.3)^0.825=    13.20 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*2.2*160.67*1/(163.3+2.2)=                                  4.2716 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=4.27=                                                        4.2716 MPa
```

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

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                 (7.5-6)
=2*252.38*1*2.2/(134.64+0.5*2.2)=                             8.1809 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                       (7.5-7)
=252.38*2.2/(0.5931*(0.75*134.64+0.2*163.3))=                 7.0057 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                    (7.5-8)
=111*403.81*(2.2/(0.75*134.64+0.2*163.3))^1.5*(25.92/163.3)^0.825=    20.74 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*2.2*252.38*1/(163.3+2.2)=                                  6.7098 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=6.71=                                                        6.7098 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*3.3*170.83/160.67=           4.3858 MPa

Ptmin = 1.43 * Pd =1.43*3.3=                                   4.7190 MPa
```

Test Pressure Ptmin=4.72 <= Ptmax=6.71[MPa]	70.3%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =134.64=                                       134.64 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea)                                       (9.5-2)
=Sqr((2*134.64+2.2)*2.2)=                                     24.44 mm
Maximum Diameter of Unreinforced Opening in Shell Checked to Rules in Section 9
dmax1 = (ea*Is*(f-0.5*P)/P-ris*Is)/(0.5*ris+0.5*ea)                  (9.5-7,22,23)
=(2.2*24.44*(160.67-0.5*3.3)/3.3-134.64*24.44)/(0.5*134.64+0.5*2.2)
=     0.00 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr(( 2 * ris + ea) * ea)                             (9.5-18)
=0.15*Sqr((2*134.64+2.2)*2.2)=                                3.6658 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(0,3.67)=                        3.6658 mm
```

CALCULATION SUMMARY

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

```
Required Minimum End Thickness Excl.Allow. emin :
emin = emin =1.69=                                             1.6877 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =1.69+0+0.3=                             1.9900 mm
```

Internal Pressure emina=1.99 <= en=2.5[mm]	79.6%	OK

```
Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =1.69+0=                                      1.6900 mm
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=4.54=                                                        4.5417 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=4.27= 4.2716 MPa

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

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=6.71= 6.7098 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*3.3*170.83/160.67= 4.3858 MPa

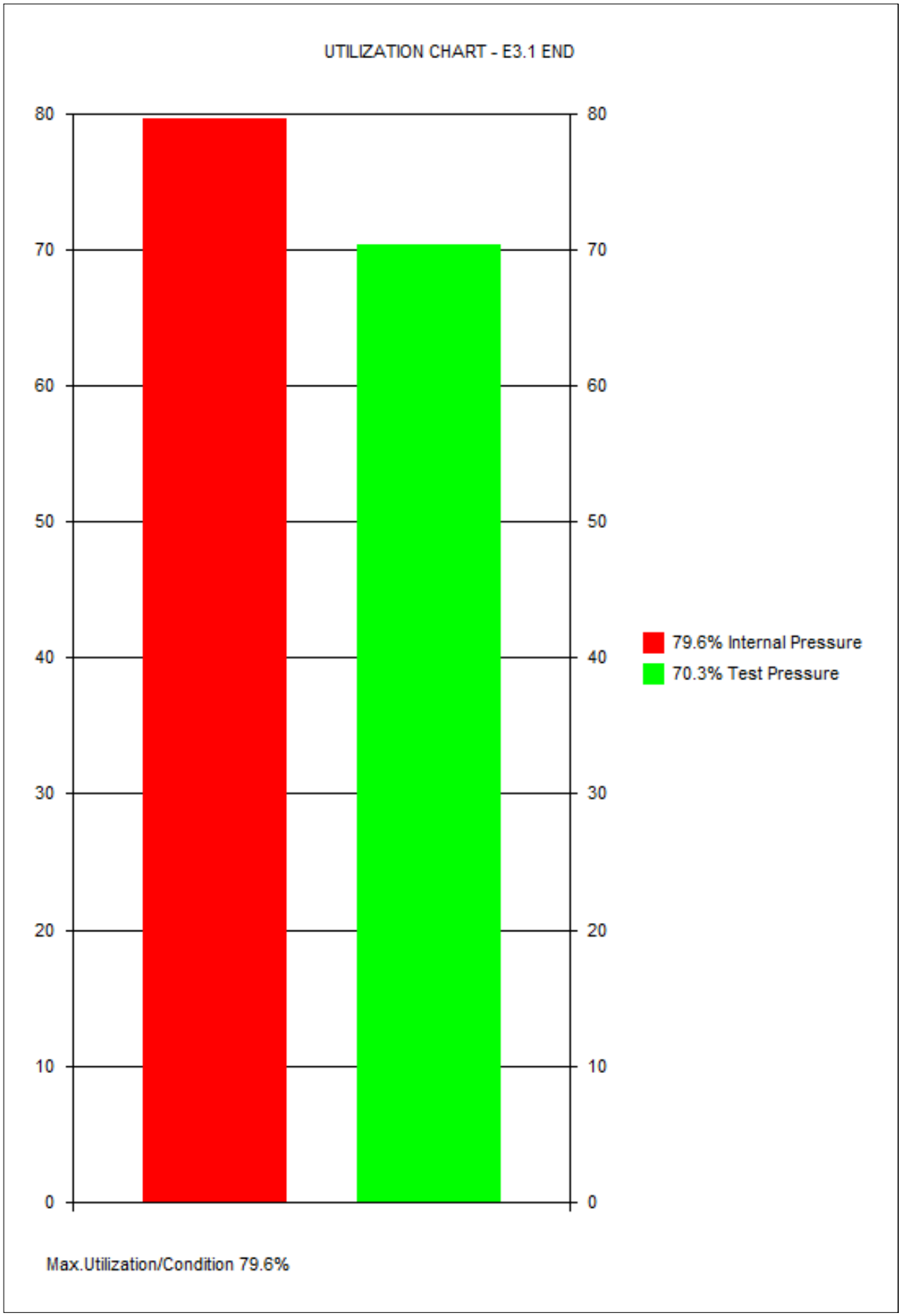
Ptmin = 1.43 * Pd =1.43*3.3= 4.7190 MPa

Test Pressure Ptmin=4.72 <= Ptmax=6.71[MPa]	70.3%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(0,3.67)= 3.6658 mm

Volume:0.0007900 m3 Weight:0.7 kg (SG= 7.85)


UTILIZATION CHART - E3.1 END
80
70
60
50
40
30
20
10
0
79.6% Internal Pressure
70.3% Test Pressure
Max.Utilization/Condition 79.6%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

```
Attachment: F.1     RT - Flange          Shell Flange                  S1.1
Location: Along z-axis z1=  321
```

GENERAL DESIGN DATA

```
PROCESS CARD: General Design Data : Temp= 100°C, P=3.3000 MPa, c=0.0 mm
SPECIFIC DENSITY OF OPERATING LIQUID.................:SG          0.00
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.1)

```
TYPE OF BLIND FLANGE: Blind flange with gasket entirely within the bolt circle.
OUTSIDE DIAMETER OF FLANGE...........................:A         218.00 mm
BOLT-CIRCLE DIAMETER.................................:C         193.00 mm
NUMBER OF BOLTS......................................:n          10.00
DIAMETER OF BOLT HOLES IN FLANGE.....................:d          12.00 mm
FLANGE DESIGN BOLT LOAD FOR ASSEMBLY CONDITION.......:W         103.78 kN
DIAMETER AT LOCATION OF GASKET LOAD REACTION.........:G         167.50 mm
GASKET FACTOR........................................:m         2.0000
EFFECTIVE GASKET SEATING WIDTH.......................:b         2.5000 mm
```

DATA FOR BLIND FLANGE

```
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en          18.00 mm
THICKNESS OF FLANGE(uncorroded).....................:e          18.00 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

10.5.2.1 MINIMUM THICKNESS OF BLIND FLANGE WITHIN GASKET e

```
Mean Bolt Pitch
tB = PI * C / n =3.14*193/10=                                  60.63 mm
Cf = MAX(Sqr(tB/(2*db+6*(eb-c)/(0.5+m))),1)                        (10.5-4)
=MAX(Sqr(60.63/(2*10.8+6*(18-0)/(0.5+2))),1)=            1.0000
Bolting Up Conditions
ea = Sqr( Cf * 3 * (C - G) / (PI * G) * (W / f20))                 (10.5-2)
=Sqr(1*3*(193-167.5)/(3.14*167.5)*(103.78/212.5))=       8.4261 mm

Operating Conditions
eP = Sqr((0.31*G^2+3*Cf*(G/4+2*b*m)*(C-G))*P/f)                    (10.5-3)
=Sqr((0.31*167.5^2+3*1*(167.5/4+2*2.5*2)*(193-167.5))*3.3/209.33)=    14.13 mm

Minimum thickness excluding corrosion emin
emin = Max( eA , eP ) (10.5-1) =Max(8.43,14.13)=           14.13 mm

Minimum thickness including allowance e
e = emin + c =14.131+0=                                    14.13 mm
```

End Thickness en=18 >= e=14.131[mm]	78.5%	OK

10.5.2.2 MINIMUM THICKNESS OF FLANGED EXTENSION e1

```
eP1 = Sqr( 3 * Cf * (G / 4 + 2 * b * m) * (C - G) * P / f)         (10.5-6)
=Sqr(3*1*(167.5/4+2*2.5*2)*(193-167.5)*3.3/209.33)=      7.9095 mm

e1 = Max( eA , eP1 ) (10.5-5) =Max(8.43,7.91)=             8.4260 mm
```

Flanged Extension Thk. eb=18 >= e1=8.426[mm]	46.8%	OK

PRESSURE CALCULATIONS

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax1 = ea^2*f/(0.31*G^2+3*Cf*(G/4+2*b*m)*(C-G))
=18^2*212.5/(0.31*167.5^2+3*1*(167.5/4+2*2.5*2)*(193-167.5))=   5.4359 MPa

Pmax2 = e1^2*f/(3*Cf*(G/4+2*b*m)*(C-G))
=18^2*212.5/(3*1*(167.5/4+2*2.5*2)*(193-167.5))=            17.35 MPa

Pmax = MIN( Pmax1 , Pmax2) =MIN(5.44,17.35)=                 5.4359 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Pmax1 = ea^2*f/(0.31*G^2+3*Cf*(G/4+2*b*m)*(C-G))
=18^2*209.33/(0.31*167.5^2+3*1*(167.5/4+2*2.5*2)*(193-167.5))=   5.3548 MPa

Pmax2 = e1^2*f/(3*Cf*(G/4+2*b*m)*(C-G))
=18^2*209.33/(3*1*(167.5/4+2*2.5*2)*(193-167.5))=            17.09 MPa

Pmax = MIN( Pmax1 , Pmax2) =MIN(5.35,17.09)=                 5.3548 MPa
```

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

```
Pmax1 = ea^2*f/(0.31*G^2+3*Cf*(G/4+2*b*m)*(C-G))
=18^2*328.57/(0.31*167.5^2+3*1*(167.5/4+2*2.5*2)*(193-167.5))=   8.4050 MPa

Pmax2 = e1^2*f/(3*Cf*(G/4+2*b*m)*(C-G))
=18^2*328.57/(3*1*(167.5/4+2*2.5*2)*(193-167.5))=            26.83 MPa

Pmax = MIN( Pmax1 , Pmax2) =MIN(8.41,26.83)=                 8.4050 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*3.3*212.5/209.33=          4.1875 MPa

Ptmin = 1.43 * Pd =1.43*3.3=                                 4.7190 MPa
```

Test Pressure Ptmin=4.72 <= Ptmax=8.41[MPa]	56.1%	OK

CALCULATION SUMMARY

10.5.2.1 MINIMUM THICKNESS OF BLIND FLANGE WITHIN GASKET e

```
Minimum thickness excluding corrosion emin
emin = Max( eA , eP ) (10.5-1) =Max(8.43,14.13)=              14.13 mm

Minimum thickness including allowance e
e = emin + c =14.131+0=                                       14.13 mm
```

End Thickness en=18 >= e=14.131[mm]	78.5%	OK

10.5.2.2 MINIMUM THICKNESS OF FLANGED EXTENSION e1

```
e1 = Max( eA , eP1 ) (10.5-5) =Max(8.43,7.91)=                8.4260 mm
```

Flanged Extension Thk. eb=18 >= e1=8.426[mm]	46.8%	OK

PRESSURE CALCULATIONS

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax = MIN( Pmax1 , Pmax2) =MIN(5.44,17.35)=                 5.4359 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax = MIN(Pmax1 , Pmax2) =MIN(5.35,17.09)= 5.3548 MPa

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

Pmax = MIN(Pmax1 , Pmax2) =MIN(8.41,26.83)= 8.4050 MPa

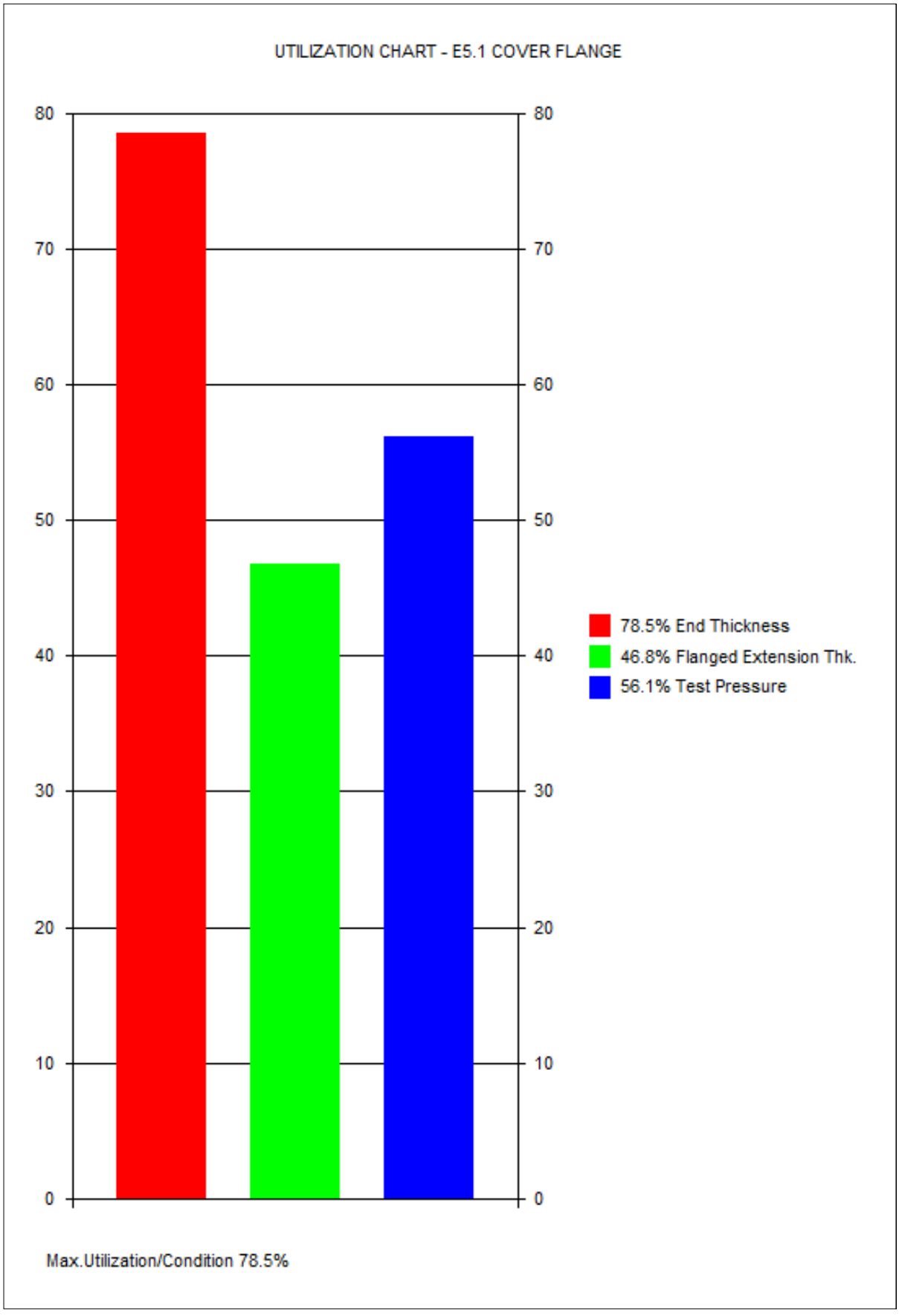
EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*3.3*212.5/209.33= 4.1875 MPa

Ptmin = 1.43 * Pd =1.43*3.3= 4.7190 MPa

Test Pressure Ptmin=4.72 <= Ptmax=8.41[MPa]	56.1%	OK

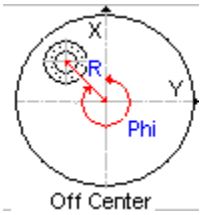
Volume:0.00 m3 Weight:5 kg (SG= 7.85)


UTILIZATION CHART - E5.1 COVER FLANGE
80
70
60
50
40
30
20
10
0
78.5% End Thickness
46.8% Flanged Extension Thk.
56.1% Test Pressure
Max.Utilization/Condition 78.5%

INPUT DATA

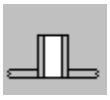
COMPONENT ATTACHMENT/LOCATION

```
Attachment: E5.1    Bolted Flat End      Cover Flange                    F.1
Connect this nozzle to the nozzle neck of another nozzle: NO
```




```
Orientation & Location of Nozzle: Radial to End (Off Center)
Angle of Rotation of nozzle axis projected in the x-y plane:Phi     0.00 Degr.
Distance between Center of End and Center of Nozzle.:R          50.00 mm
```

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=3.3000 MPa, c=0.0 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.................:SG          0.00
LIQUID HEAD.........................................:LH          0.00 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
```

SHELL DATA (E5.1)

```
Shell Type: Bolted Flat End
INSIDE DIAMETER OF SHELL/GASKET LOAD REACTION.......:Di        167.50 mm
NOMINAL WALL THICKNESS (uncorroded).................:en         18.00 mm
REQUIRED THICKNESS OF UNPIERCED END(corroded).......:eo         14.13 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=40mm 100'C
Rm=510 Rp=345 Rpt=314 fs=209.33 f20=212.5 ftest=328.57 E=206067(N/mm2) ro=7.85
```

NOZZLE MATERIAL DATA

```
Delivery Form: Seamless Pipe
EN 10217-2:2002/A1:05, 1.0345 P235GH welded tube, HT:N THK<=16mm 100'C
Rm=360 Rp=235 Rpt=198 fb=132 f20=150 ftest=223.81 E=206067(N/mm2) ro=7.85
```

NOZZLE DIMENSIONAL DATA

```
Attachment: Set On Nozzle
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER.............................:deb         62.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb        5.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:           10.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.............:ho          25.00 mm
```

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 =18-0= 18.00 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =5-0-0.5= 4.5000 mm
dib = deb - 2 * eab =62-2*4.5= 53.00 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=3.3*62/(2*132*1+3.3)= 0.7700 mm

Min.Nozzle Thk. ebp=0.77 <= eab=4.5[mm]	17.1%	OK

Limit of Reinforcement Along Nozzle
Ibo = MIN(0.8 * Sqr((dib + eab) * eab), ho) (10.6-8)
=MIN(0.8*Sqr((53+4.5)*4.5,)25)= 12.87 mm

TOTAL AREA OF REINFORCEMENT AVAILABLE IN THE NOZZLE A

A = Ibo * (eab - ebp) =12.87*(4.5-0.77)= 48.00 mm2
A = MIN(A , A * fb / fs) (10.6-7) =MIN(48.,48.*132/209.33)= 30.27 mm2

deq = dib - 2 * A / eas (10.6-5) =53-2*30.27/18= 49.64 mm

10.6 PIERCED CIRCULAR FLAT ENDS

Calculation Coefficient for Opening Reinforcement Y1 and Y2
Y2 = SQR(G / (G - deq)) (10.6-4) =SQR(167.5/(167.5-49.64))= 1.1921

Required Minimum Thickness of End due to Opening emin

emin = Y2 * eo + c (10.6-2) =1.19*14.13+0= 16.84 mm

Req.Unpierced End Thk. emin=16.84 <= en=18[mm]	93.5%	OK

Weight of Nozzle: .1757kg Pad: 0kg

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.77 <= eab=4.5[mm]	17.1%	OK

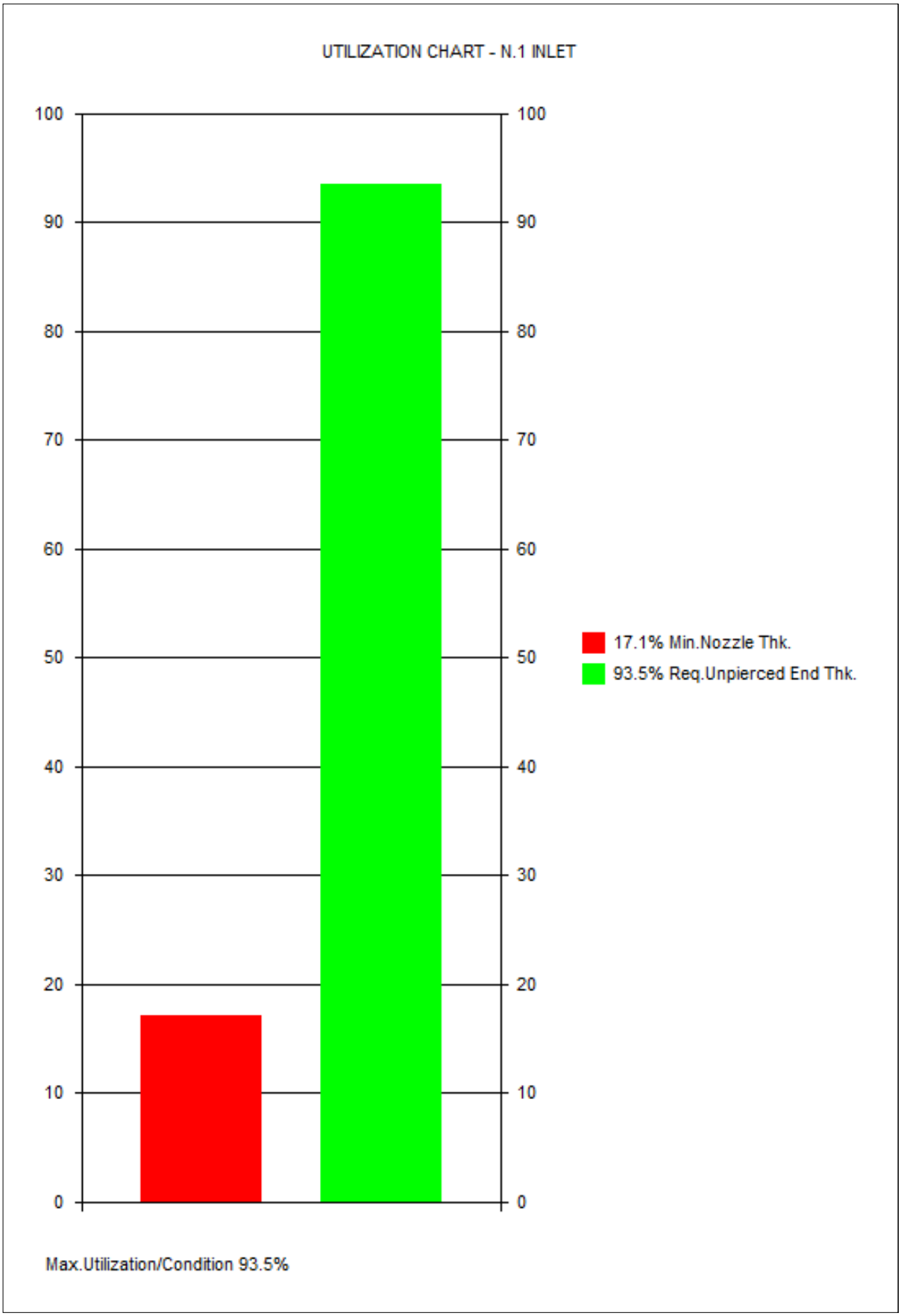
Limit of Reinforcement Along Nozzle
Ibo = MIN(0.8 * Sqr((dib + eab) * eab), ho) (10.6-8)
=MIN(0.8*Sqr((53+4.5)*4.5,)25)= 12.87 mm

Required Minimum Thickness of End due to Opening emin

emin = Y2 * eo + c (10.6-2) =1.19*14.13+0= 16.84 mm

Req.Unpierced End Thk. emin=16.84 <= en=18[mm]	93.5%	OK

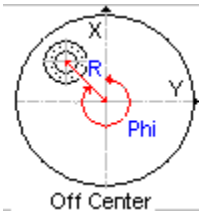
Volume:0.0001000 m3 Weight:0.2 kg (SG= 7.85)


UTILIZATION CHART - N.1 INLET
100
90
80
70
60
50
40
30
20
10
0
17.1% Min.Nozzle Thk.
93.5% Req.Unpierced End Thk.
Max.Utilization/Condition 93.5%

INPUT DATA

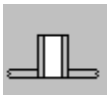
COMPONENT ATTACHMENT/LOCATION

```
Attachment: E5.1    Bolted Flat End      Cover Flange                  F.1
Connect this nozzle to the nozzle neck of another nozzle: NO
```




```
Orientation & Location of Nozzle: Radial to End (Off Center)
Angle of Rotation of nozzle axis projected in the x-y plane:Phi   180.00 Degr.
Distance between Center of End and Center of Nozzle.:R          50.00 mm
```

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=3.3000 MPa, c=0.0 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.................:SG          0.00
LIQUID HEAD.........................................:LH          0.00 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
```

SHELL DATA (E5.1)

```
Shell Type: Bolted Flat End
INSIDE DIAMETER OF SHELL/GASKET LOAD REACTION.......:Di        167.50 mm
NOMINAL WALL THICKNESS (uncorroded).................:en         18.00 mm
REQUIRED THICKNESS OF UNPIERCED END(corroded).......:eo         14.13 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=40mm 100'C
Rm=510 Rp=345 Rpt=314 fs=209.33 f20=212.5 ftest=328.57 E=206067(N/mm2) ro=7.85
```

NOZZLE MATERIAL DATA

```
Delivery Form: Seamless Pipe
EN 10217-2:2002/A1:05, 1.0345 P235GH welded tube, HT:N THK<=16mm 100'C
Rm=360 Rp=235 Rpt=198 fb=132 f20=150 ftest=223.81 E=206067(N/mm2) ro=7.85
```

NOZZLE DIMENSIONAL DATA

```
Attachment: Set On Nozzle
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER.............................:deb        62.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       5.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:          10.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.............:ho         25.00 mm
```

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 =18-0= 18.00 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =5-0-0.5= 4.5000 mm
dib = deb - 2 * eab =62-2*4.5= 53.00 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=3.3*62/(2*132*1+3.3)= 0.7700 mm

Min.Nozzle Thk. ebp=0.77 <= eab=4.5[mm]	17.1%	OK

Limit of Reinforcement Along Nozzle
Ibo = MIN(0.8 * Sqr((dib + eab) * eab), ho) (10.6-8)
=MIN(0.8*Sqr((53+4.5)*4.5,)25)= 12.87 mm

TOTAL AREA OF REINFORCEMENT AVAILABLE IN THE NOZZLE A

A = Ibo * (eab - ebp) =12.87*(4.5-0.77)= 48.00 mm2
A = MIN(A , A * fb / fs) (10.6-7) =MIN(48.,48.*132/209.33)= 30.27 mm2

deq = dib - 2 * A / eas (10.6-5) =53-2*30.27/18= 49.64 mm

10.6 PIERCED CIRCULAR FLAT ENDS

Calculation Coefficient for Opening Reinforcement Y1 and Y2
Y2 = SQR(G / (G - deq)) (10.6-4) =SQR(167.5/(167.5-49.64))= 1.1921

Required Minimum Thickness of End due to Opening emin

emin = Y2 * eo + c (10.6-2) =1.19*14.13+0= 16.84 mm

Req.Unpierced End Thk. emin=16.84 <= en=18[mm]	93.5%	OK

Weight of Nozzle: .1757kg Pad: 0kg

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.77 <= eab=4.5[mm]	17.1%	OK

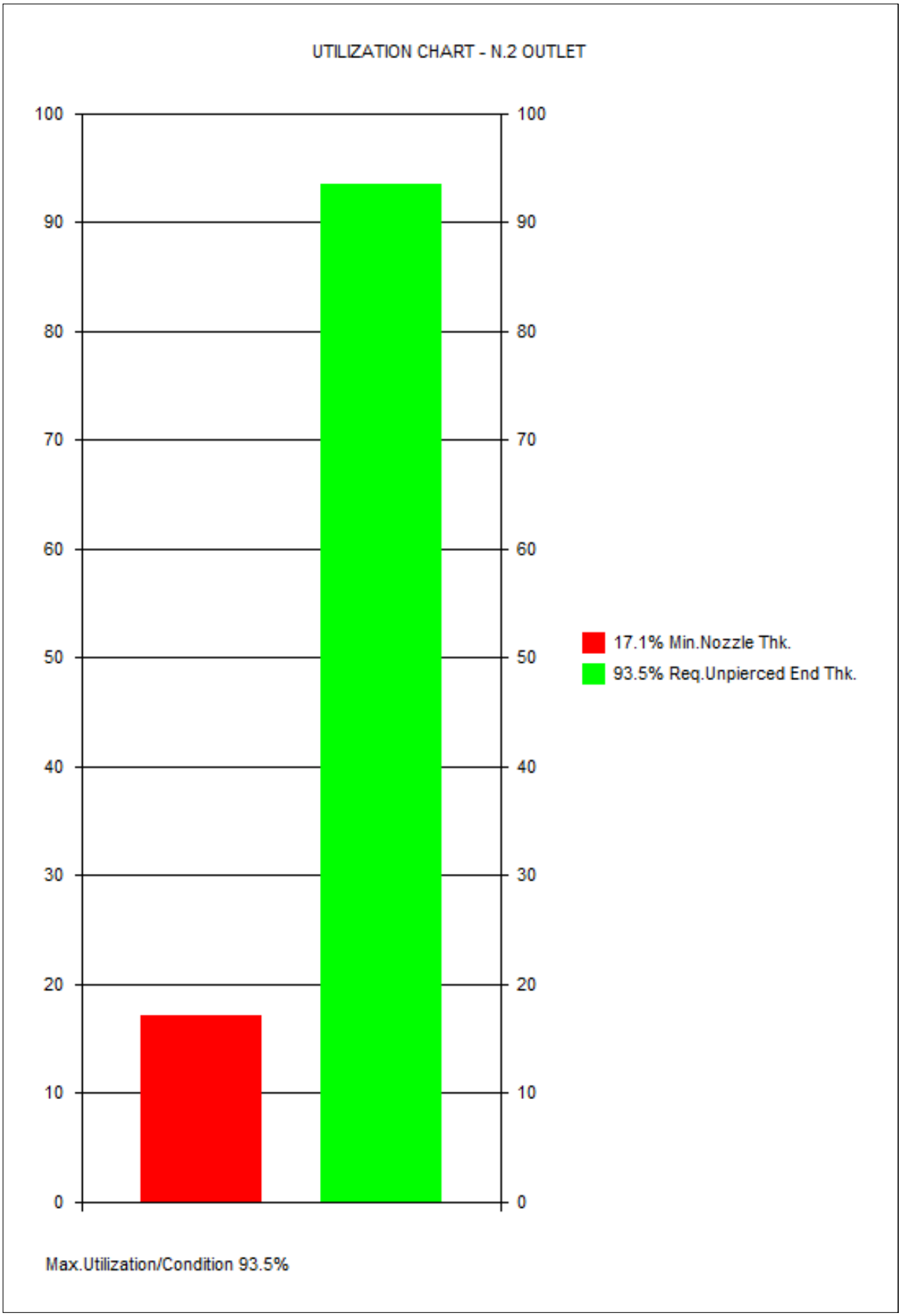
Limit of Reinforcement Along Nozzle
Ibo = MIN(0.8 * Sqr((dib + eab) * eab), ho) (10.6-8)
=MIN(0.8*Sqr((53+4.5)*4.5,)25)= 12.87 mm

Required Minimum Thickness of End due to Opening emin

emin = Y2 * eo + c (10.6-2) =1.19*14.13+0= 16.84 mm

Req.Unpierced End Thk. emin=16.84 <= en=18[mm]	93.5%	OK

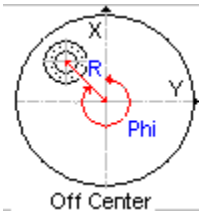
Volume:0.0001000 m3 Weight:0.2 kg (SG= 7.85)


UTILIZATION CHART - N.2 OUTLET
100
90
80
70
60
50
40
30
20
10
0
17.1% Min.Nozzle Thk.
93.5% Req.Unpierced End Thk.
Max.Utilization/Condition 93.5%

INPUT DATA

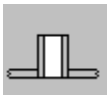
COMPONENT ATTACHMENT/LOCATION

```
Attachment: E5.1    Bolted Flat End      Cover Flange                  F.1
Connect this nozzle to the nozzle neck of another nozzle: NO
```




```
Orientation & Location of Nozzle: Radial to End (Off Center)
Angle of Rotation of nozzle axis projected in the x-y plane:Phi    90.00 Degr.
Distance between Center of End and Center of Nozzle.:R          50.00 mm
```

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=3.3000 MPa, c=0.0 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.................:SG          0.00
LIQUID HEAD.........................................:LH          0.00 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
```

SHELL DATA (E5.1)

```
Shell Type: Bolted Flat End
INSIDE DIAMETER OF SHELL/GASKET LOAD REACTION.......:Di        167.50 mm
NOMINAL WALL THICKNESS (uncorroded).................:en         18.00 mm
REQUIRED THICKNESS OF UNPIERCED END(corroded).......:eo         14.13 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=40mm 100'C
Rm=510 Rp=345 Rpt=314 fs=209.33 f20=212.5 ftest=328.57 E=206067(N/mm2) ro=7.85
```

NOZZLE MATERIAL DATA

```
Delivery Form: Seamless Pipe
EN 10217-2:2002/A1:05, 1.0345 P235GH welded tube, HT:N THK<=16mm 100'C
Rm=360 Rp=235 Rpt=198 fb=132 f20=150 ftest=223.81 E=206067(N/mm2) ro=7.85
```

NOZZLE DIMENSIONAL DATA

```
Attachment: Set On Nozzle
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER.............................:deb         17.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       5.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:           10.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.............:ho        8.0000 mm
```

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 =18-0= 18.00 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =5-0-0.5= 4.5000 mm
dib = deb - 2 * eab =17-2*4.5= 8.0000 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=3.3*17/(2*132*1+3.3)= 0.2100 mm

Min.Nozzle Thk. ebp=0.21 <= eab=4.5[mm]	4.6%	OK

Limit of Reinforcement Along Nozzle
Ibo = MIN(0.8 * Sqr((dib + eab) * eab), ho) (10.6-8)
=MIN(0.8*Sqr((8+4.5)*4.5,)8)= 6.0000 mm

TOTAL AREA OF REINFORCEMENT AVAILABLE IN THE NOZZLE A

A = Ibo * (eab - ebp) =6*(4.5-0.21)= 25.74 mm2
A = MIN(A , A * fb / fs) (10.6-7)
=MIN(25.74,25.74*132/209.33)= 16.23 mm2

deq = dib - 2 * A / eas (10.6-5) =8-2*16.23/18= 6.1965 mm

10.6 PIERCED CIRCULAR FLAT ENDS

Calculation Coefficient for Opening Reinforcement Y1 and Y2
Y2 = SQR(G / (G - deq)) (10.6-4) =SQR(167.5/(167.5-6.2))= 1.0190

Required Minimum Thickness of End due to Opening emin

emin = Y2 * eo + c (10.6-2) =1.02*14.13+0= 14.40 mm

Req.Unpierced End Thk. emin=14.4 <= en=18[mm]	79.9%	OK

Weight of Nozzle: .0118kg Pad: 0kg

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.21 <= eab=4.5[mm]	4.6%	OK

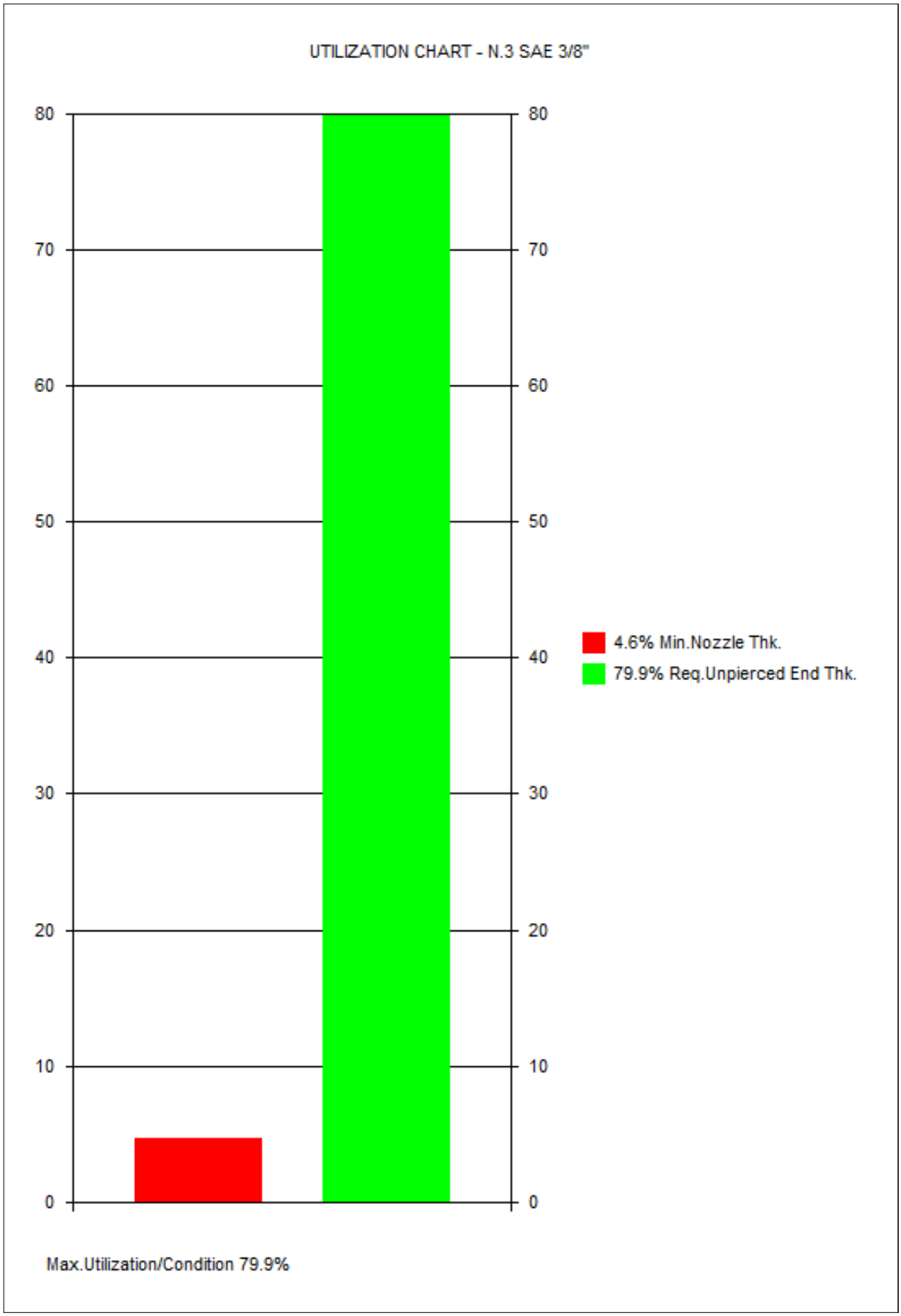
Limit of Reinforcement Along Nozzle
Ibo = MIN(0.8 * Sqr((dib + eab) * eab), ho) (10.6-8)
=MIN(0.8*Sqr((8+4.5)*4.5,)8)= 6.0000 mm

Required Minimum Thickness of End due to Opening emin

emin = Y2 * eo + c (10.6-2) =1.02*14.13+0= 14.40 mm

Req.Unpierced End Thk. emin=14.4 <= en=18[mm]	79.9%	OK

Volume:0.00 m3 Weight:0 kg (SG= 7.85)


UTILIZATION CHART - N.3 SAE 3/8"
80
70
60
50
40
30
20
10
0
4.6% Min.Nozzle Thk.
79.9% Req.Unpierced End Thk.
Max.Utilization/Condition 79.9%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

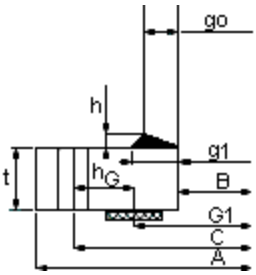
```
Attachment: S1.1    Cylindrical Shell    Shell
Location: Along z-axis z1=  300
Flange Design Method: Section 11 - Taylor Forge
```

GENERAL DESIGN DATA

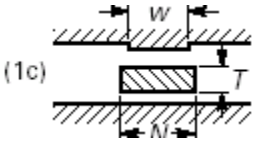
```
PROCESS CARD: General Design Data : Temp= 100°C, P=3.3000 MPa, c=0.0 mm
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG          0.00
LIQUID HEAD.....:LH          0.00 mm
B: Pressure loading: Flange under internal pressure
EXTERNAL LOADS ON FLANGE  (PD5500 ENQ 5500/123): NO
SPECIFY BOLT LOADS FROM 2nd./MATING 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): 1c  Tongue & Groove
```

SHELL/NOZZLE DATA

```
SHELL/NOZZLE SIZE & COMMENT: S1.1
EN 10216-3:2013, 1.0565 P355NH seamless tube, HT:N THK<=50mm 100'C
Rm=490 Rp=335 Rpt=294 fs=196 fs20=204.17 ftest=319.05 E=206067(N/mm2) ro=7.85
OUTSIDE DIAMETER OF SHELL/NOZZLE .....:Do        168.30 mm
WALL THICKNESS OF NOZZLE/SHELL(uncorroded).....:s1        3.0000 mm
```

FLANGE DATA

```
FLANGE HUB: Flange With Hub
REVERSE FLANGE: No (The bolts are located on the outside)
DESIGN METHOD: A) INTEGRAL FLANGE METHOD
FLANGE BORE: Stepped
INSIDE DIAMETER OF FLANGE corroded.....:B         162.50 mm
OUTSIDE DIAMETER OF FLANGE.....:A         218.00 mm
THICKNESS OF FLANGE(uncorroded).....:e          18.00 mm
THICKNESS OF FLANGE AT REDUCED SECTION.....:er          18.00 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         3.0000 mm
THICKNESS OF HUB AT BACK OF FLANGE corroded.....:g1        6.0000 mm
THICKNESS OF HUB AT SMALL END      corroded.....:go        3.0000 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

```
REDUCE SAFETY AGAINST ABUSE BY CAREFULLY CONTROLLING THE BOLTING-UP TORQUE: NO
BOLTING TORQUE CALCULATION: NO
NOMINAL BOLTING SIZE & COMMENT: M10x1.5  ;
EFFECTIVE BOLT AREA per bolt.....................:Ae         58.00 mm2
RECOMMENDED MINIMUM BOLT CENTER TO EDGE CLEARANCE...:Bce    14.00 mm
RECOMMENDED MINIMUM BOLT CENTER/RADIAL CLEARANCE....:Bcr    18.00 mm
DIAMETER OF BOLT HOLES IN FLANGE.................:d          12.00 mm
NUMBER OF BOLTS..................................:n          10.00
BOLT-CIRCLE DIAMETER.............................:C         193.00 mm
8.8  DIN 267 THK<=30mm 100'C
Rm=800 Rp=640 Rpt=590 Sb=196.67 Sa=200 ftest=300  (N/mm2)
NOTE: A PARTICULAR MATERIAL APPRAISAL(PMA) MAY BE REQUIRED FOR THIS MATERIAL.
```

GASKET DATA

```
Table H-1 Gasket factors m & y   Facing:
Mineral Fiber 3.2 mm thick       m=2.0   Y=11.0  2 1a,1b,1c,1d,4,5
OUTSIDE DIAMETER OF GASKET/RAISED FACE..............:Go        172.50 mm
GREATER VALUE OF INSIDE DIAMETER OF GASKET/FLANGE FACE:A1      162.50 mm
TEMA RGP-RCB-11.7 Include Additional Loads from Pass Partition Plate Gasket: NO
```

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

```
Large Diameter Stress Correction Factor K
k (D < 1000 mm) = 1 =1=                                          1.0000
```

GASKET DETAILS

```
b = MIN VALUE(2.52 * Sqr(bo), bo ) = ==                          2.5000 mm
```

FLANGE LOADS

```
HD = 0.785 * B ^ 2 * p =0.785*162.5^2*3.3=                        68.41 kN
H = 0.785 * G ^ 2 * p (11.5-5) =0.785*167.5^2*3.3=                72.68 kN
HG = (2 * PI * b * G * m) * p                                          (11.5-6)
=(2*3.14*2.5*167.5*2)*3.3=                                       17.37 kN
HT = H - HD (11.5-11) =72679.72-68405.39=                         4.2743 kN
```

MOMENT ARMS

```
hG = (C - G) / 2 (11.5-14) =(193-167.5)/2=                        12.75 mm
hD = (C - B) / 2 (11.5-13) =(193-162.5)/2=                        15.25 mm
hT = (2 * C - B - G) / 4 (11.5-15) =(2*193-162.5-167.5)/4=        14.00 mm
```

BOLT LOADS

```
Operating condition
Wop = H + HG (11.5-8) =72679.72+17365.15=                         90.04 kN

Bolting up condition
Wamb = PI * b * G * y (11.5-7) =3.14*2.5*167.5*11=                14.47 kN
```

BOLTING AREA

```
Am1 = Wop / Sb =90044.87/196.67=                                 457.85 mm2

Am2 = Wamb / Sa =14470.96/200=                                    72.35 mm2

Required Bolting Area Am
Am = MAX( Am1 , Am2) =MAX(457.85,72.35)=                         457.85 mm2

Available Bolting Area Ab
Ab (num.bolts*root area) = n * Ae =10*58=                        580.00 mm2
```

Bolting Area Check Ab=580 >= Am=457.85[mm2]	78.9%	OK

```
W = 0.5 * (Ab + Am) * Sa (11.5-16) =0.5*(580+457.85)*200=        103.78 kN
```

FLANGE MOMENTS

```
Mop = HD * hD + HT * hT + HG * hG                                  (11.5-18)
=68405.39*15.25+4274.33*14+17365.15*12.75=              1324.43 Nm

Mamb = W * hG (11.5-17) =1.0378E05*12.75=                1323.26 Nm

Bolt Spacing
Bs = C * PI / n =193*3.14/10=                              60.63 mm

Bolt Pitch Correction Factor
CF = MAX( Sqr( Bs / (2 * db + 6 * e / (m + 0.5))) , 1)             (11.5-20)
=MAX(Sqr(60.63/(2*10+6*18/(2+0.5))),1)=                  1.0000
Mo = Mop * CF / B (11.5-27) =1324.43*1/162.5=            8.1503 Nm/mm
Ma = Mamb * CF / B (11.5-26) =1323.26*1/162.5=           8.1431 Nm/mm
```

SHAPE CONSTANTS

```
K = A / B (11.5-21) =218/162.5=                          1.3415
lo = SQR( B * go) (11.5-22) =SQR(162.5*3)=                22.08
h/lo=  0.136  K=A/B=  1.342  g1/go=  2.000
VALUES FROM FIGURES 11.5-4 to 8
BetaT =    1.780  BetaZ =    3.501  BetaY =    6.764  BetaU =    7.433
BetaF=     0.900  BetaV =    0.410  phi =    3.044
lamda = (e*BetaF+lo)/(BetaT*lo)+e^3*BetaV/(BetaU*lo*go^2)
=(18*0.8997+22.08)/(1.78*22.08)+18^3*0.41/(7.433*22.08*3^2)=   2.5925
```

OPERATING CONDITION

```
M = Mo =8.15=                                            8.1503 Nm/mm
```

11.5.4.1 Flange Stresses with Flange Thickness e= 18 mm

```
Longitudinal Hub Stress
SigH = phi * M / (lamda * g1 ^ 2)                                  (11.5-32)
=3.04*8.15/(2.59*6^2)=                                  265.82 N/mm2

Radial Flange Stress
Sigr = (1.333 * e * BetaF + lo) * M / (lamda * e ^ 2 * lo)         (11.5-33)
=(1.333*18*0.8997+22.08)*8.15/(2.59*18^2*22.08)=         19.19 N/mm2

Tangential Flange Stress
SigTeta = BetaY*M/e^2-Sigr*(K^2+1)/(K^2-1)                         (11.5-34)
=6.764*8.15/18^2-19.19*(1.34^2+1)/(1.34^2-1)=           102.97 N/mm2
```

11.5.4.2 Stress Limits

Hub Stress k*SigH=265.82 <= 1.5 * MIN(f;fH)=314.[N/mm2] (11.5-90)	84.6%	OK
Radial Stress k*SigR=19.19 <= f=209.33[N/mm2] (11.5-91)	9.1%	OK
Tangential Stress k*SigTeta=102.97 <= f=209.33[N/mm2] (11.5-92)	49.1%	OK
Radial+Hub Stress 0.5*k*(SigH+SigR)=142.5 <= f=209.33[N/mm2] (11.5-93)	68.0%	OK
Tangential+Hub Stress 0.5*k*(SigH+SigTeta)=184.39 <= f=209.33[N/mm2] (11.5-94)	88.0%	OK

BOLTING UP CONDITION

```
M = Ma =8.14=                                            8.1431 Nm/mm
```

11.5.4.1 Flange Stresses with Flange Thickness e= 18 mm

```
Longitudinal Hub Stress
SigH = phi * M / (lamda * g1 ^ 2)                                  (11.5-32)
=3.04*8.14/(2.59*6^2)=                                  265.58 N/mm2

Radial Flange Stress
Sigr = (1.333 * e * BetaF + lo) * M / (lamda * e ^ 2 * lo)         (11.5-33)
=(1.333*18*0.8997+22.08)*8.14/(2.59*18^2*22.08)=         19.17 N/mm2
```

```
Tangential Flange Stress
SigTeta = BetaY*M/e^2-Sigr*(K^2+1)/(K^2-1)                    (11.5-34)
=6.764*8.14/18^2-19.17*(1.34^2+1)/(1.34^2-1)=          102.88 N/mm2
```

11.5.4.2 Stress Limits

Hub Stress k*SigH=265.58 <= 1.5 * MIN(f;fH)=318.75[N/mm2] (11.5-90)	83.3%	OK
Radial Stress k*SigR=19.17 <= f=212.5[N/mm2] (11.5-91)	9.0%	OK
Tangential Stress k*SigTeta=102.88 <= f=212.5[N/mm2] (11.5-92)	48.4%	OK
Radial+Hub Stress 0.5*k*(SigH+SigR)=142.38 <= f=212.5[N/mm2] (11.5-93)	67.0%	OK
Tangential+Hub Stress 0.5*k*(SigH+SigTeta)=184.23 <= f=212.5[N/mm2] (11.5-94)	86.6%	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*3.3*212.5/209.33=      4.1875 MPa
Ptmin = 1.43 * Pd =1.43*3.3=                            4.7190 MPa
```

Test Pressure Ptmin=4.72 <= Ptmax=5.887[MPa]	80.1%	OK

PRESSURE AND TORQUE SUMMARY

Table PRESSURE AND TORQUE SUMMARY FOR F.1 :

Description	Temp(C)	P(MPa)	Limited By	Min.Req.Total Bolt Force(kN)
Design Pressure(corroded)	100	3.30	Tangential+Hub Stress	90.04
Max.Allow.Pressure(corroded)	100	3.75	Tangential+Hub Stress	102.29
Max.Allow.Pressure(corroded)	Ambient	3.80	Tangential+Hub Stress	103.79
Max.Allow.Test Pressure(corroded)	Ambient	5.89	Tangential+Hub Stress	160.64
Required Test Pressure	Ambient	4.19	Tangential+Hub Stress	114.26

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

CALCULATION SUMMARY

BOLTING AREA

Bolting Area Check Ab=580 >= Am=457.85[mm2]	78.9%	OK

OPERATING CONDITION

11.5.4.1 Flange Stresses with Flange Thickness e= 18 mm

```
Longitudinal Hub Stress
SigH = phi * M / (lamda * g1 ^ 2)                             (11.5-32)
=3.04*8.15/(2.59*6^2)=                                 265.82 N/mm2

Radial Flange Stress
Sigr = (1.333 * e * BetaF + lo) * M / (lamda * e ^ 2 * lo)    (11.5-33)
=(1.333*18*0.8997+22.08)*8.15/(2.59*18^2*22.08)=        19.19 N/mm2

Tangential Flange Stress
SigTeta = BetaY*M/e^2-Sigr*(K^2+1)/(K^2-1)                    (11.5-34)
=6.764*8.15/18^2-19.19*(1.34^2+1)/(1.34^2-1)=          102.97 N/mm2
```

11.5.4.2 Stress Limits

Hub Stress k*SigH=265.82 <= 1.5 * MIN(f;fH)=314.[N/mm2] (11.5-90)	84.6%	OK
Radial Stress k*SigR=19.19 <= f=209.33[N/mm2] (11.5-91)	9.1%	OK
Tangential Stress k*SigTeta=102.97 <= f=209.33[N/mm2] (11.5-92)	49.1%	OK
Radial+Hub Stress 0.5*k*(SigH+SigR)=142.5 <= f=209.33[N/mm2] (11.5-93)	68.0%	OK
Tangential+Hub Stress 0.5*k*(SigH+SigTeta)=184.39 <= f=209.33[N/mm2] (11.5-94)	88.0%	OK

BOLTING UP CONDITION

11.5.4.1 Flange Stresses with Flange Thickness e= 18 mm

```
Longitudinal Hub Stress
SigH = phi * M / (lamda * g1 ^ 2)                              (11.5-32)
=3.04*8.14/(2.59*6^2)=                                  265.58 N/mm2

Radial Flange Stress
Sigr = (1.333 * e * BetaF + lo) * M / (lamda * e ^ 2 * lo)     (11.5-33)
=(1.333*18*0.8997+22.08)*8.14/(2.59*18^2*22.08)=         19.17 N/mm2

Tangential Flange Stress
SigTeta = BetaY*M/e^2-Sigr*(K^2+1)/(K^2-1)                     (11.5-34)
=6.764*8.14/18^2-19.17*(1.34^2+1)/(1.34^2-1)=           102.88 N/mm2
```

11.5.4.2 Stress Limits

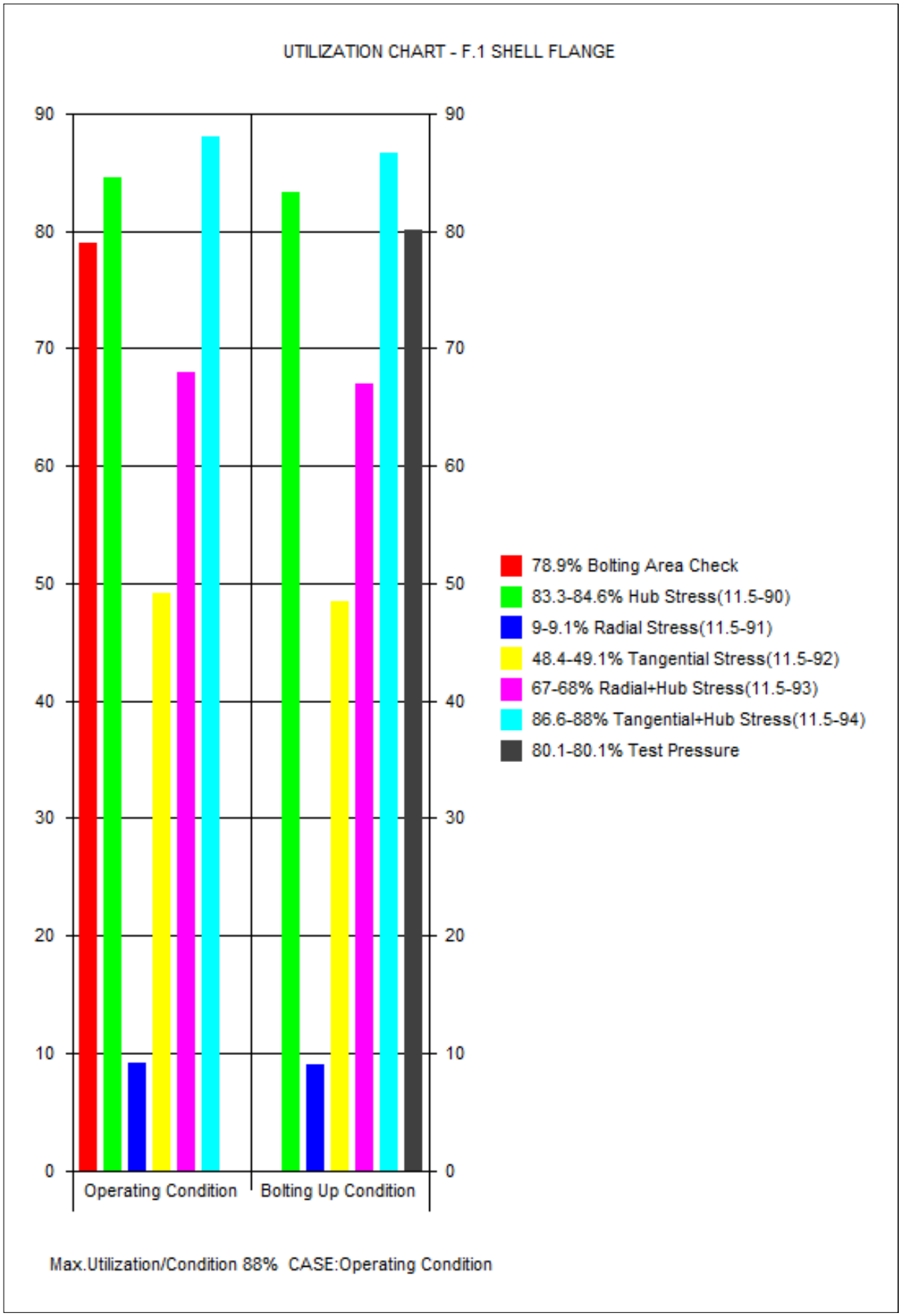
Hub Stress k*SigH=265.58 <= 1.5 * MIN(f;fH)=318.75[N/mm2] (11.5-90)	83.3%	OK
Radial Stress k*SigR=19.17 <= f=212.5[N/mm2] (11.5-91)	9.0%	OK
Tangential Stress k*SigTeta=102.88 <= f=212.5[N/mm2] (11.5-92)	48.4%	OK
Radial+Hub Stress 0.5*k*(SigH+SigR)=142.38 <= f=212.5[N/mm2] (11.5-93)	67.0%	OK
Tangential+Hub Stress 0.5*k*(SigH+SigTeta)=184.23 <= f=212.5[N/mm2] (11.5-94)	86.6%	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*3.3*212.5/209.33=      4.1875 MPa

Ptmin = 1.43 * Pd =1.43*3.3=                            4.7190 MPa
```

Test Pressure Ptmin=4.72 <= Ptmax=5.887[MPa]	80.1%	OK

Volume:0.0004345 m3 Weight:2 kg (SG= 7.85)


UTILIZATION CHART - F.1 SHELL FLANGE
90
80
70
60
50
40
30
20
10
0
Operating Condition
Bolting Up Condition
78.9% Bolting Area Check
83.3-84.6% Hub Stress(11.5-90)
9-9.1% Radial Stress(11.5-91)
48.4-49.1% Tangential Stress(11.5-92)
67-68% Radial+Hub Stress(11.5-93)
86.6-88% Tangential+Hub Stress(11.5-94)
80.1-80.1% Test Pressure
Max.Utilization/Condition 88% CASE:Operating Condition