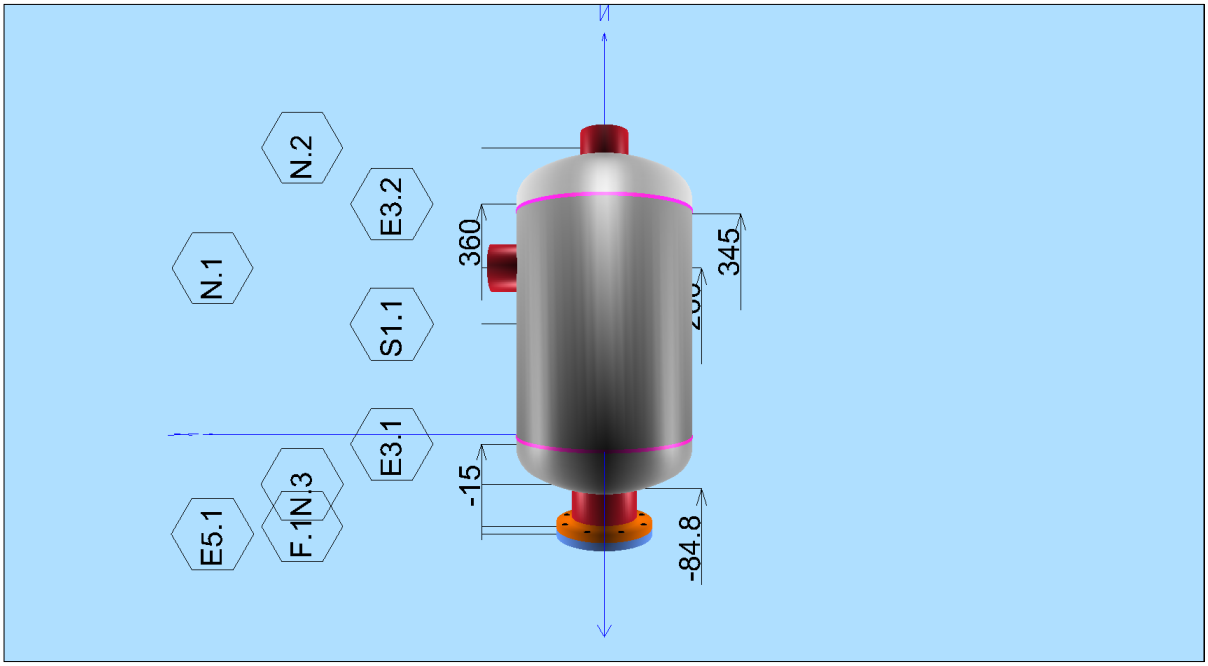
(0) Drawing

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	0.5
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-Bottom Head	3.300	9.277	4.261	0.005	4.261	9.271
E3.2	Torispherical End-Upper Head	3.300	9.277	4.261	0.001	4.261	9.276
E5.1	Bolted Flat End-Cover Flange	3.300	7.082	4.261	0.006	4.261	7.076
F.1	RT - Flange-Ring Flange	3.300	7.197	NA	0.006	NA	7.191
N.1	Nozzle,Seamless Pipe-Inlet	3.300	6.558	NA	0.003	NA	6.554
N.2	Nozzle,Seamless Pipe-Outlet	3.300	7.726	NA	0.000	NA	7.726
N.3	Nozzle,Seamless Pipe-Float Shell	3.300	6.856	NA	0.006	NA	6.851
S1.1	Cylindrical Shell-Shell	3.300	10.164	4.156	0.005	4.156	10.159

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) ....: 6.5542 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) ...: 6.5576 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-Bottom Head	3.300	9.277	4.261	0.002	4.261	9.275
E3.2	Torispherical End-Upper Head	3.300	9.277	4.261	0.003	4.261	9.273
E5.1	Bolted Flat End-Cover Flange	3.300	7.082	4.261	0.002	4.261	7.080
F.1	RT - Flange-Ring Flange	3.300	7.197	NA	0.002	NA	7.195
N.1	Nozzle,Seamless Pipe-Inlet	3.300	6.558	NA	0.001	NA	6.556
N.2	Nozzle,Seamless Pipe-Outlet	3.300	7.726	NA	0.002	NA	7.724
N.3	Nozzle,Seamless Pipe-Float Shell	3.300	6.856	NA	0.002	NA	6.854
S1.1	Cylindrical Shell-Shell	3.300	10.164	4.156	0.003	4.156	10.160

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) ....: 6.5564 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) ...: 6.5576 MPa

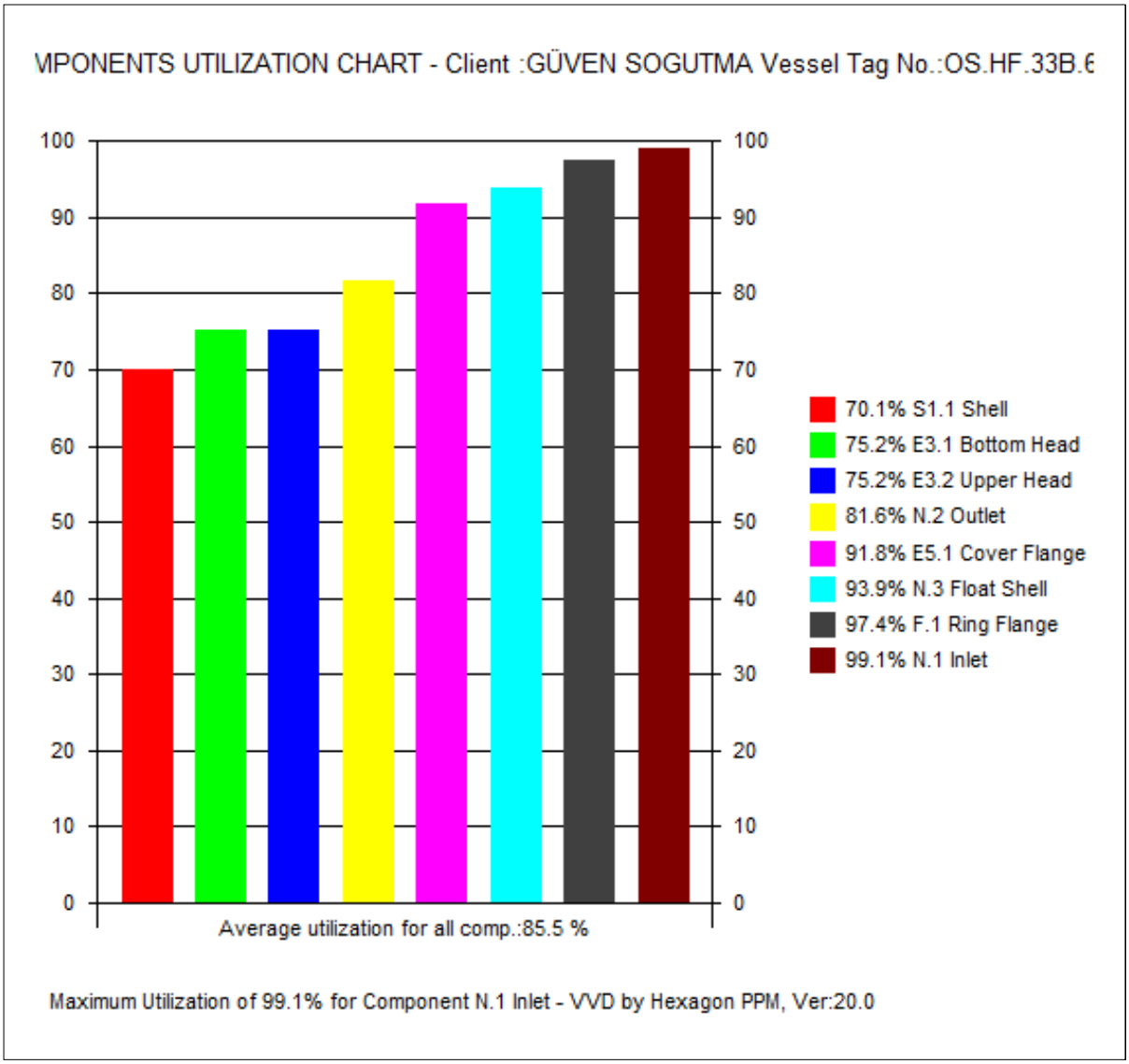
Note : Other components may limit Ptlim than the ones checked above.

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=3.3000 MPa, c=0.5 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 % 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        273.00 mm
LENGTH OF CYLINDRICAL PART OF SHELL.....:Lcyl      345.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en        4.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:          10.00 %
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)
=273*3.3/(2*202.67*1+3.3)=                                  2.2046 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =2.2+0.5+0.45=                    3.1546 mm

Analysis Thickness
ea = en - c - NegDev =4.5-0.5-0.45=                         3.5500 mm
```

»7.4.1 Cond.of Applicabilty emin/De=0.0081 <= 0.16« » OK«

Internal Pressure emina=3.15 <= en=4.5[mm]	70.1%	OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

```
Inside Diameter of Shell
Di = De - 2 * ea =273-2*3.55=                               265.90 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(273+265.9)/2=                          269.45 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
MAWPHC = 2 * f * z * ea / Dm =2*202.67*1*3.55/269.45=       5.3403 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)
MAWPNC = 2 * f20 * z * (ea + c) / Dm
=2*204.17*1*(3.55+0.5)/269.45=                              6.1376 MPa
```

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

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*338.1*1*(3.55+0.5)/269.45=                               10.16 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*204.17/202.67= 4.1555 MPa

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

Test Pressure Ptmin=4.72 <= Ptmax=10.16[MPa]	46.4%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Inside Radius of Shell
ris = Di / 2 (9.5-3) =265.9/2= 132.95 mm
Length of Shell Contributing to Reinforcement
Is = Sqr((2 * ris + ea) * ea) (9.5-2)
=Sqr((2*132.95+3.55)*3.55)= 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*265.9,(3.55*30.93*(202.67-0.5*3.3)/3.3-132.95*30.93)/(0.5*132.95+0
.5*3.55))= = 37.75 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr((2 * ris + ea) * ea) (9.5-18)
=0.15*Sqr((2*132.95+3.55)*3.55)= 4.6392 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(37.75,4.64)= 37.75 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)
=273*3.3/(2*202.67*1+3.3)= 2.2046 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =2.2+0.5+0.45= 3.1546 mm

Internal Pressure emina=3.15 <= en=4.5[mm]	70.1%	OK

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

Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*338.1*1*(3.55+0.5)/269.45= 10.16 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*204.17/202.67= 4.1555 MPa

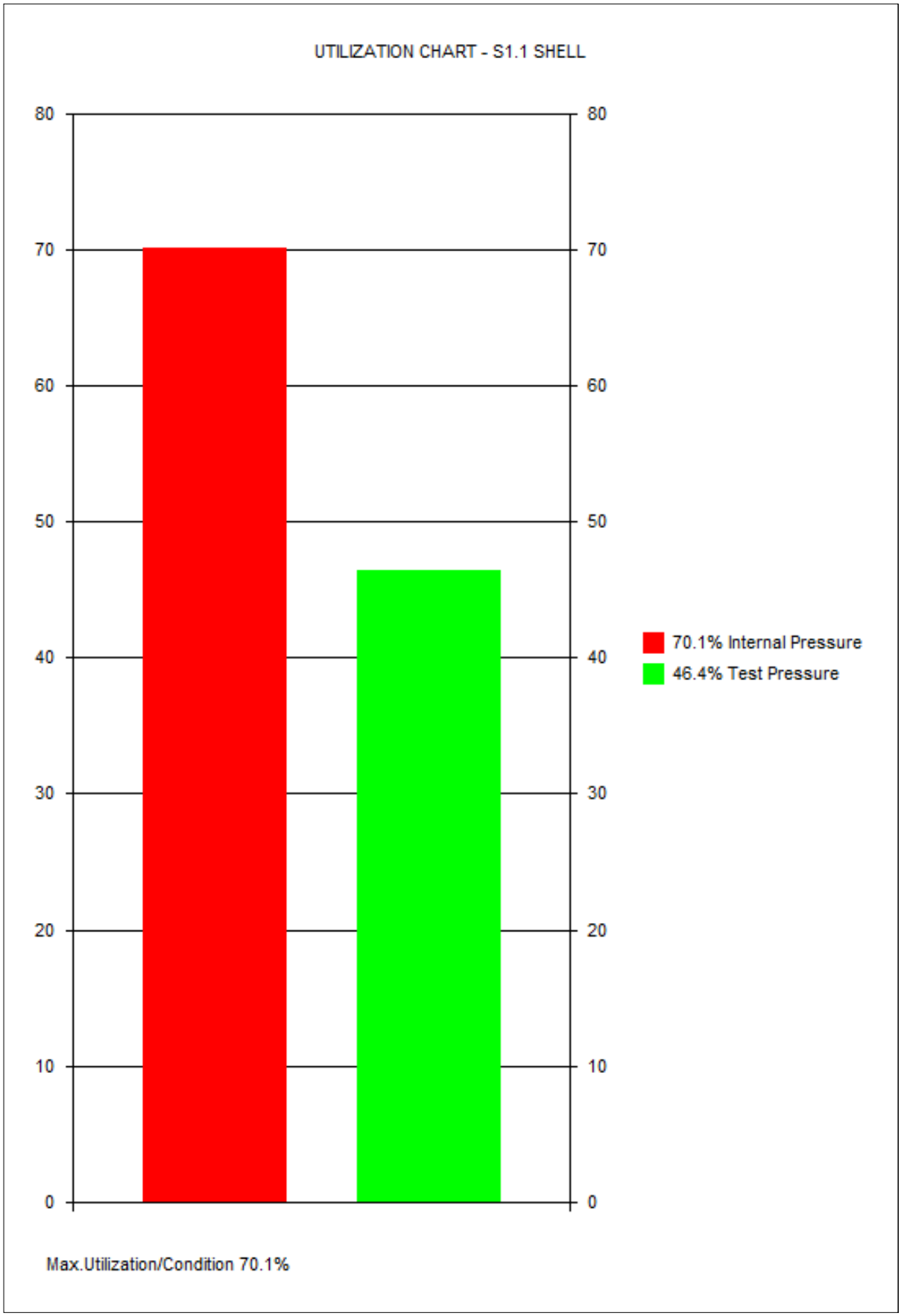
Ptmin = 1.43 * Pd =1.43*3.3= 4.7190 MPa

Test Pressure Ptmin=4.72 <= Ptmax=10.16[MPa]	46.4%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(37.75,4.64)= 37.75 mm

Volume:0.0192 m3 Weight:10.3 kg (SG= 7.85)


UTILIZATION CHART - S1.1 SHELL
80
70
60
50
40
30
20
10
0
70.1% Internal Pressure
46.4% Test Pressure
Max.Utilization/Condition 70.1%

INPUT DATA

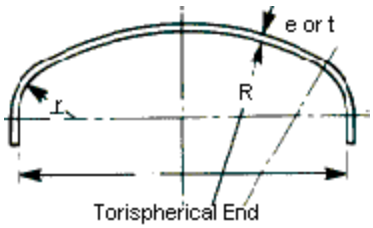
COMPONENT ATTACHMENT/LOCATION

```
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= 130°C, P=3.3000 MPa, c=0.5 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        273.00 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl       15.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en        4.0000 mm
Include calculation of forming during fabrication to EN13445-4 Section 9.: NO
```

MATERIAL DATA FOR END

```
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=16mm 130'C
Rm=510 Rp=355 Rpt=308.6 f=205.73 f20=212.5 ftest=338.1 E=203868(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*218.4/(2*205.73*1-0.5*3.3)=                          1.7587 mm

fb = Rpt / 1.5 * 1.6 (7.5-5) =308.6/1.5*1.6=                329.17 N/mm2
Required Thickness of Knuckle to Avoid Plastic Buckling
eb = (0.75*R+0.2*Di)*((P/(111*fb)*(Di/r)^0.825)^(0.667)           (7.5-3)
=(0.75*218.4+0.2*266)*((3.3/(111*329.17)*(266/42.042)^0.825)^(0.667)
=   1.2018 mm
```

```
7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(2.21/218.4,0.04)=      0.0101
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0101)=                     1.9953
X = r / Di (7.5-11) =42.042/268.58=                          0.1565
```

```
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                                (7.5-12)
=1.006-1/(6.2+(90*0.0101)^4)=                              0.8608
Beta01 = N*(-0.1833*Z^3+1.0383*Z^2-1.2943*Z+0.837)                  (7.5-15)
=0.8608*(-0.1833*2.^3+1.0383*2.^2-1.2943*2.+0.837)=        0.8023
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*0.0101-82.5*0.0101^2))=           0.5054
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)               (7.5-16)
=10*((0.2-0.1565)*0.8023+(0.1565-0.1)*0.5054)=             0.6344
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * P * (0.75 * R + 0.2 * Di) / f                           (7.5-2)
=0.6344*3.3*(0.75*218.4+0.2*268.58)/205.73=                2.2136 mm
```

NOTE 3, since ey(2.2) > 0.005*Di(1.3) it is NOT necessary to calculate/consider eb.

```
Required Minimum End Thickness Excl.Allow. emin :
emin = emin =2.21=                                          2.2136 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =2.21+0.5+0.3=                        3.0100 mm
```

Internal Pressure emina=3.01 <= en=4[mm]	75.2%	OK

```
Analysis Thickness
ea = en - c - th =4-0.5-0.3=                                3.2000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =273-2*(4-0.5)=                      266.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(273+266)/2=                            269.50 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(266*2.21)=            4.8531 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*266/(2*205.73*1-3.3)=                                 2.1506 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =2.15+0.5=                                 2.6500 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=42.042 <= 0.2 * Di=53.2[mm] « » OK«
»Geometry Check r=42.042 >= 0.06 * Di=15.96[mm] « » OK«
»Geometry Check r=42.042 >= 2*e[mm] « » OK«
»Geometry Check e=2.21 <= 0.08*De=21.84[mm] « » OK«
»Geometry Check ea=3.2 >= 0.001*De=0.273[mm] « » OK«
»Geometry Check R=218.4 <= De=273[mm] « » OK«

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                (7.5-6)
=2*212.5*1*3.7/(217.9+0.5*3.7)=                            7.1559 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                      (7.5-7)
=212.5*3.7/(0.5925*(0.75*217.9+0.2*266))=                  6.1262 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                   (7.5-8)
=111*378.67*(3.7/(0.75*217.9+0.2*266))^1.5*(42.042/266)^0.825=    20.48 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*212.5*1/(266+3.7)=                                  5.8306 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=5.83=                                                     5.8306 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                (7.5-6)
=2*205.73*1*3.2/(218.4+0.5*3.2)=                           5.9849 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                      (7.5-7)
=205.73*3.2/(0.6009*(0.75*218.4+0.2*266))=                 5.0490 MPa
```

```
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                    (7.5-8)
=111*329.17*(3.2/(0.75*218.4+0.2*266))^1.5*(42.042/266)^0.825=    14.28 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.2*205.73*1/(266+3.2)=                                        4.8911 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=4.89=                                                            4.8911 MPa
```

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

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                 (7.5-6)
=2*338.1*1*3.7/(217.9+0.5*3.7)=                                   11.39 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                       (7.5-7)
=338.1*3.7/(0.5925*(0.75*217.9+0.2*266))=                         9.7471 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                    (7.5-8)
=111*540.95*(3.7/(0.75*217.9+0.2*266))^1.5*(42.042/266)^0.825=    29.26 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*338.1*1/(266+3.7)=                                         9.2768 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=9.28=                                                            9.2768 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*212.5/205.73=                4.2607 MPa

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

Test Pressure Ptmin=4.72 <= Ptmax=9.28[MPa]	50.8%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =218.4=                                           218.40 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea)                                       (9.5-2)
=Sqr((2*218.4+3.2)*3.2)=                                          37.52 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*266,(3.2*37.52*(205.73-0.5*3.3)/3.3-218.4*37.52)/(0.5*218.4+0.5*3.
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*218.4+3.2)*3.2)=                                     5.6285 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(0,5.63)=                           5.6285 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 =2.21=                                                2.2136 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =2.21+0.5+0.3=                              3.0100 mm
```

Internal Pressure emina=3.01 <= en=4[mm]	75.2%	OK

```
Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =2.15+0.5=                                       2.6500 mm
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=5.83=                                                            5.8306 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=4.89= 4.8911 MPa

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

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=9.28= 9.2768 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*212.5/205.73= 4.2607 MPa

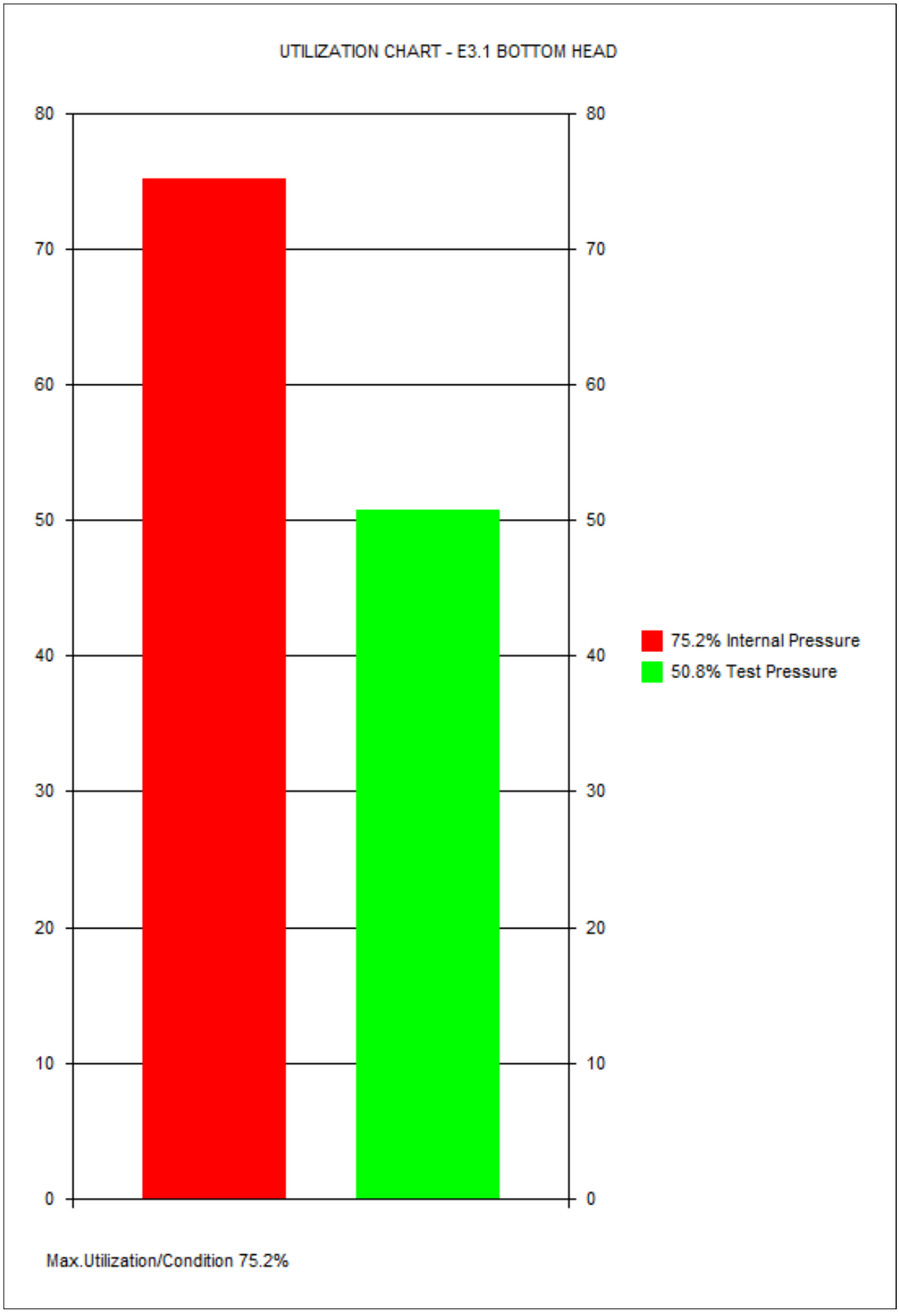
Ptmin = 1.43 * Pd =1.43*3.3= 4.7190 MPa

Test Pressure Ptmin=4.72 <= Ptmax=9.28[MPa]	50.8%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(0,5.63)= 5.6285 mm

Volume:0.0033 m3 Weight:2.9 kg (SG= 7.85)


UTILIZATION CHART - E3.1 BOTTOM HEAD
80
70
60
50
40
30
20
10
0
75.2% Internal Pressure
50.8% Test Pressure
Max.Utilization/Condition 75.2%

INPUT DATA

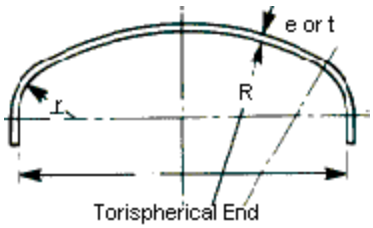
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    Shell
Location: Along z-axis z1=  345
```

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 130°C, P=3.3000 MPa, c=0.5 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        273.00 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl       15.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th        0.3000 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en        4.0000 mm
Include calculation of forming during fabrication to EN13445-4 Section 9.: NO
```

MATERIAL DATA FOR END

```
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=16mm 130'C
Rm=510 Rp=355 Rpt=308.6 f=205.73 f20=212.5 ftest=338.1 E=203868(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*218.4/(2*205.73*1-0.5*3.3)=                          1.7587 mm

fb = Rpt / 1.5 * 1.6 (7.5-5) =308.6/1.5*1.6=                329.17 N/mm2
Required Thickness of Knuckle to Avoid Plastic Buckling
eb = (0.75*R+0.2*Di)*((P/(111*fb)*(Di/r)^0.825)^(0.667)           (7.5-3)
=(0.75*218.4+0.2*266)*((3.3/(111*329.17)*(266/42.042)^0.825)^(0.667)
=   1.2018 mm

7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(2.21/218.4,0.04)=     0.0101
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0101)=                    1.9953
X = r / Di (7.5-11) =42.042/268.58=                         0.1565
```

```
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                                  (7.5-12)
=1.006-1/(6.2+(90*0.0101)^4)=                              0.8608
Beta01 = N*(-0.1833*Z^3+1.0383*Z^2-1.2943*Z+0.837)                    (7.5-15)
=0.8608*(-0.1833*2.^3+1.0383*2.^2-1.2943*2.+0.837)=        0.8023
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*0.0101-82.5*0.0101^2))=           0.5054
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)                 (7.5-16)
=10*((0.2-0.1565)*0.8023+(0.1565-0.1)*0.5054)=             0.6344
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * P * (0.75 * R + 0.2 * Di) / f                             (7.5-2)
=0.6344*3.3*(0.75*218.4+0.2*268.58)/205.73=                2.2136 mm
```

NOTE 3, since ey(2.2) > 0.005*Di(1.3) it is NOT necessary to calculate/consider eb.

```
Required Minimum End Thickness Excl.Allow. emin :
emin = emin =2.21=                                          2.2136 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =2.21+0.5+0.3=                        3.0100 mm
```

Internal Pressure emina=3.01 <= en=4[mm]	75.2%	OK

```
Analysis Thickness
ea = en - c - th =4-0.5-0.3=                                3.2000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =273-2*(4-0.5)=                      266.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(273+266)/2=                            269.50 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(266*2.21)=            4.8531 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*266/(2*205.73*1-3.3)=                                 2.1506 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =2.15+0.5=                                 2.6500 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=42.042 <= 0.2 * Di=53.2[mm] « » OK«
»Geometry Check r=42.042 >= 0.06 * Di=15.96[mm] « » OK«
»Geometry Check r=42.042 >= 2*e[mm] « » OK«
»Geometry Check e=2.21 <= 0.08*De=21.84[mm] « » OK«
»Geometry Check ea=3.2 >= 0.001*De=0.273[mm] « » OK«
»Geometry Check R=218.4 <= De=273[mm] « » OK«

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                  (7.5-6)
=2*212.5*1*3.7/(217.9+0.5*3.7)=                            7.1559 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                        (7.5-7)
=212.5*3.7/(0.5925*(0.75*217.9+0.2*266))=                  6.1262 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                     (7.5-8)
=111*378.67*(3.7/(0.75*217.9+0.2*266))^1.5*(42.042/266)^0.825=    20.48 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*212.5*1/(266+3.7)=                                  5.8306 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=5.83=                                                     5.8306 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                  (7.5-6)
=2*205.73*1*3.2/(218.4+0.5*3.2)=                           5.9849 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                        (7.5-7)
=205.73*3.2/(0.6009*(0.75*218.4+0.2*266))=                 5.0490 MPa
```

```
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                    (7.5-8)
=111*329.17*(3.2/(0.75*218.4+0.2*266))^1.5*(42.042/266)^0.825=    14.28 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.2*205.73*1/(266+3.2)=                                        4.8911 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=4.89=                                                            4.8911 MPa
```

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

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                 (7.5-6)
=2*338.1*1*3.7/(217.9+0.5*3.7)=                                   11.39 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                       (7.5-7)
=338.1*3.7/(0.5925*(0.75*217.9+0.2*266))=                         9.7471 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                    (7.5-8)
=111*540.95*(3.7/(0.75*217.9+0.2*266))^1.5*(42.042/266)^0.825=    29.26 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*3.7*338.1*1/(266+3.7)=                                         9.2768 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=9.28=                                                            9.2768 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*212.5/205.73=                4.2607 MPa

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

Test Pressure Ptmin=4.72 <= Ptmax=9.28[MPa]	50.8%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =218.4=                                           218.40 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea)                                       (9.5-2)
=Sqr((2*218.4+3.2)*3.2)=                                          37.52 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*266,(3.2*37.52*(205.73-0.5*3.3)/3.3-218.4*37.52)/(0.5*218.4+0.5*3.
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*218.4+3.2)*3.2)=                                     5.6285 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(0,5.63)=                           5.6285 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 =2.21=                                                2.2136 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =2.21+0.5+0.3=                              3.0100 mm
```

Internal Pressure emina=3.01 <= en=4[mm]	75.2%	OK

```
Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =2.15+0.5=                                       2.6500 mm
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=5.83=                                                            5.8306 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=4.89= 4.8911 MPa

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

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=9.28= 9.2768 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*212.5/205.73= 4.2607 MPa

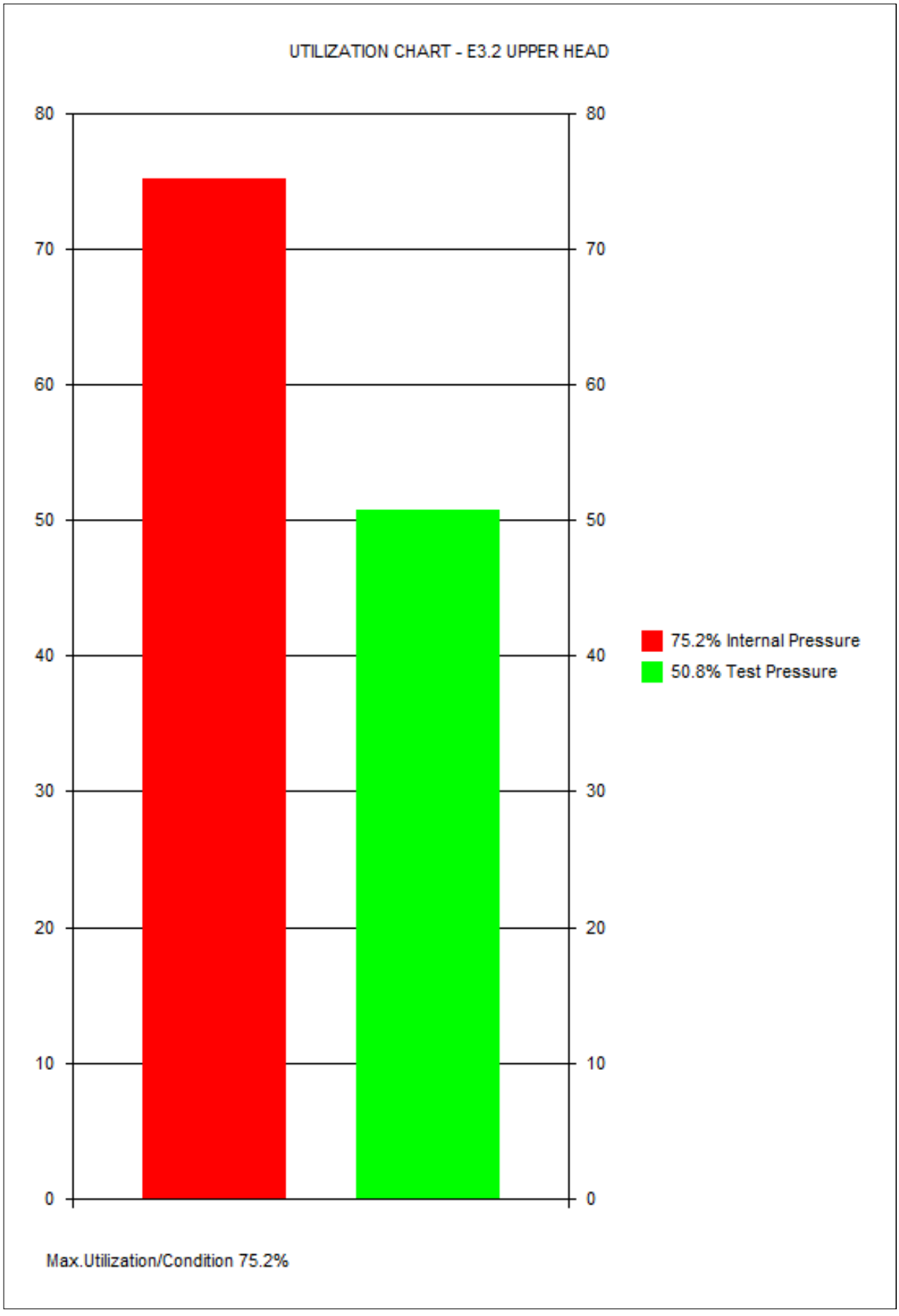
Ptmin = 1.43 * Pd =1.43*3.3= 4.7190 MPa

Test Pressure Ptmin=4.72 <= Ptmax=9.28[MPa]	50.8%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(0,5.63)= 5.6285 mm

Volume:0.0033 m3 Weight:2.9 kg (SG= 7.85)


UTILIZATION CHART - E3.2 UPPER HEAD
80
70
60
50
40
30
20
10
0
75.2% Internal Pressure
50.8% Test Pressure
Max.Utilization/Condition 75.2%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

```
Attachment: F.1     RT - Flange          Ring Flange                    N.3
Location: Along z-axis z1= -59.3
```

GENERAL DESIGN DATA

```
PROCESS CARD: General Design Data : Temp= 130°C, P=3.3000 MPa, c=0.5 mm
SPECIFIC DENSITY OF OPERATING LIQUID.................:SG          0.00
LIQUID HEAD..........................................:LH        144.10 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         149.00 mm
BOLT-CIRCLE DIAMETER.................................:C         130.00 mm
NUMBER OF BOLTS......................................:n         8.0000
DIAMETER OF BOLT HOLES IN FLANGE.....................:d          10.00 mm
FLANGE DESIGN BOLT LOAD FOR ASSEMBLY CONDITION.......:W          46.21 kN
DIAMETER AT LOCATION OF GASKET LOAD REACTION.........:G          98.50 mm
GASKET FACTOR........................................:m         2.0000
EFFECTIVE GASKET SEATING WIDTH.......................:b         2.0000 mm
```

DATA FOR BLIND FLANGE

```
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en          11.50 mm
THICKNESS OF FLANGE(uncorroded).....................:e           11.50 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=16mm 130'C
Rm=510 Rp=355 Rpt=308.6 f=205.73 f20=212.5 ftest=338.1 E=203868(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*130/8=                                  51.05 mm
Cf = MAX(Sqr(tB/(2*db+6*(eb-c)/(0.5+m))),1)                        (10.5-4)
=MAX(Sqr(51.05/(2*9+6*(11.5-0.5)/(0.5+2))),1)=          1.0723
Bolting Up Conditions
ea = Sqr( Cf * 3 * (C - G) / (PI * G) * (W / f20))                 (10.5-2)
=Sqr(1.07*3*(130-98.5)/(3.14*98.5)*(46.21/212.5))=      8.4385 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*98.5^2+3*1.07*(98.5/4+2*2*2)*(130-98.5))*3.3/205.73)=    10.06 mm

Minimum thickness excluding corrosion emin
emin = Max( eA , eP ) (10.5-1) =Max(8.44,10.06)=          10.06 mm

Minimum thickness including allowance e
e = emin + c =10.063+0.5=                                 10.56 mm
```

End Thickness en=11.5 >= e=10.563[mm]	91.8%	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*1.07*(98.5/4+2*2*2)*(130-98.5)*3.3/205.73)=      7.2821 mm

e1 = Max( eA , eP1 ) (10.5-5) =Max(8.44,7.28)=            8.4390 mm
```

Flanged Extension Thk. eb=11.5 >= e1=8.439[mm]	73.3%	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))
=11.5^2*212.5/(0.31*98.5^2+3*1.07*(98.5/4+2*2*2)*(130-98.5))=   4.4512 MPa

Pmax2 = e1^2*f/(3*Cf*(G/4+2*b*m)*(C-G))
=11.5^2*212.5/(3*1.07*(98.5/4+2*2*2)*(130-98.5))=          8.5008 MPa

Pmax = MIN( Pmax1 , Pmax2) =MIN(4.45,8.5)=                  4.4512 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))
=11^2*205.73/(0.31*98.5^2+3*1.07*(98.5/4+2*2*2)*(130-98.5))=   3.9428 MPa

Pmax2 = e1^2*f/(3*Cf*(G/4+2*b*m)*(C-G))
=11^2*205.73/(3*1.07*(98.5/4+2*2*2)*(130-98.5))=           7.5299 MPa

Pmax = MIN( Pmax1 , Pmax2) =MIN(3.94,7.53)=                 3.9428 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))
=11.5^2*338.1/(0.31*98.5^2+3*1.07*(98.5/4+2*2*2)*(130-98.5))=   7.0821 MPa

Pmax2 = e1^2*f/(3*Cf*(G/4+2*b*m)*(C-G))
=11.5^2*338.1/(3*1.07*(98.5/4+2*2*2)*(130-98.5))=          13.53 MPa

Pmax = MIN( Pmax1 , Pmax2) =MIN(7.08,13.53)=                7.0821 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*212.5/205.73=         4.2607 MPa

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

Test Pressure Ptmin=4.72 <= Ptmax=7.08[MPa]	66.6%	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(8.44,10.06)=            10.06 mm

Minimum thickness including allowance e
e = emin + c =10.063+0.5=                                   10.56 mm
```

End Thickness en=11.5 >= e=10.563[mm]	91.8%	OK

10.5.2.2 MINIMUM THICKNESS OF FLANGED EXTENSION e1

```
e1 = Max( eA , eP1 ) (10.5-5) =Max(8.44,7.28)=              8.4390 mm
```

Flanged Extension Thk. eb=11.5 >= e1=8.439[mm]	73.3%	OK

PRESSURE CALCULATIONS

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax = MIN( Pmax1 , Pmax2) =MIN(4.45,8.5)=                  4.4512 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax = MIN(Pmax1 , Pmax2) =MIN(3.94,7.53)= 3.9428 MPa

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

Pmax = MIN(Pmax1 , Pmax2) =MIN(7.08,13.53)= 7.0821 MPa

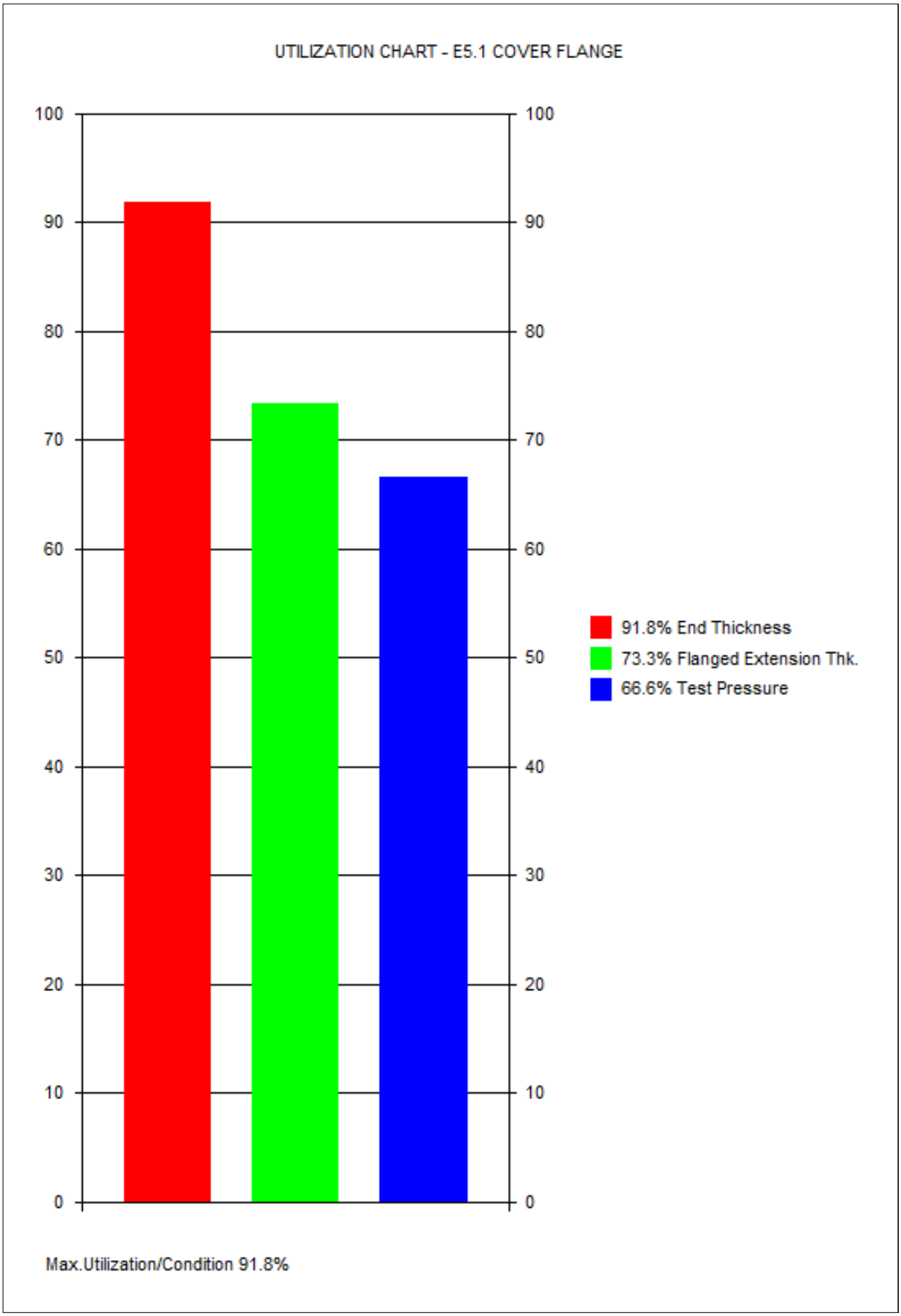
EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE:Ptmin

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*3.3*212.5/205.73= 4.2607 MPa

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

Test Pressure Ptmin=4.72 <= Ptmax=7.08[MPa]	66.6%	OK

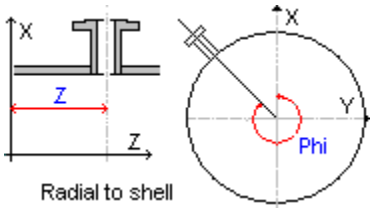
Volume:0.00 m3 Weight:1 kg (SG= 7.85)


UTILIZATION CHART - E5.1 COVER FLANGE
100
90
80
70
60
50
40
30
20
10
0
91.8% End Thickness
73.3% Flanged Extension Thk.
66.6% Test Pressure
Max.Utilization/Condition 91.8%

INPUT DATA

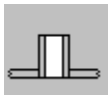
COMPONENT ATTACHMENT/LOCATION

```
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         260.00 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= 130°C, P=3.3000 MPa, c=0.5 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
Include Nozzle Load Calculation: NO
```

SHELL DATA (S1.1)

```
Shell Type: Cylindrical Shell
OUTSIDE DIAMETER OF SHELL.......................:De        273.00 mm
NOMINAL WALL THICKNESS (uncorroded).............:en        4.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...........:th        0.4500 mm
EN 10217-3:2019, 1.0565 P355NH welded tube, HT:N THK<=20mm 130'C
Rm=490 Rp=355 Rpt=292 fs=194.67 f20=204.17 ftest=338.1 E=203868(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 130'C
Rm=410 Rp=265 Rpt=218.2 fb=145.47 f20=170.83 ftest=252.38 E=203868(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        74.50 mm
NOMINAL NOZZLE THICKNESS (uncorroded)...............:enb       5.0000 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: Exclude Area of Nozzle to Shell Weld
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE PhiC(OBLIQUE IN TRANSVERSE.CROSS SECT.)Fig.9.5-2:PhiC      0.00 Degr.
ANGLE PhiL(OBLIQUE IN LONG.CROSS SECT.)Fig.9.5-1....:PhiL        0.00 Degr.
```

DATA FOR REINFORCEMENT PAD

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

LIMITS OF REINFORCEMENT

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness eas
eas = en - c - th =4.5-0.5-0.45=                          3.5500 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =5-0.5-0.625=                     3.8750 mm
Inside Radius of Curvature
ris = De / 2 - eas (9.5-3) =273/2-3.55=                   132.95 mm
dib = deb - 2 * eab =74.5-2*3.875=                         66.75 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=3.3*74.5/(2*145.47*1+3.3)=                             0.8400 mm
Allowable Stresses
fob = Min( fs, fb) (9.5-8) =Min(194.67,145.47)=            145.47 N/mm2
```

GEOMETRIC LIMITATIONS

»Check Max.Diameter of Nozzle dib/(2*ris)=0.251 <= 1.00=1[mm] «» OK«

Min.Nozzle Thk. ebp=0.84 <= eab=3.875[mm]	21.6%	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*132.95+3.55)*3.55)=                                  30.93 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =3.55*30.93=                         109.79 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                                (9.5-76)
=MIN(Sqr((74.5-3.875)*3.875,)40)=                            16.54 mm
Set In Nozzle
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =3.875*(16.54+0+3.55)=    77.86 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*66.75*(16.54+3.55)=   670.60 mm2

Cyl.Shell in the Longitudinal Section Aps
ApsL = ris * (Is + a) (9.5-94) =132.95*(30.93+37.25)=        9064.28 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*132.95^2*(30.93+37.74)/(0.5*3.55+132.95)=             4504.68 mm2

Aps = MAX( ApsL ApsT) =MAX(9064.28,4504.68)=                 9064.28 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =3.3*(9064.28+670.6)=       32.13 kN

pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                              (9.5-7)
=3.3*(4504.68+670.6+0.5*0)=                                  17.08 kN

pAReq = MAX( pAReqL, pAReqT) =MAX(32125.11,17078.45)=        32.13 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)
=(109.79+0)*(194.67-0.5*3.3)+0*(0-0.5*3.3)+77.86*(145.47-0.5*3.3)=     32.39 kN
```

Nozzle Reinforcement pAAval=32.39 >= pAReq=32.13[kN]	99.1%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))       (9.5-10)
=(109.79+0)*194.67+77.86*145.47/((9064.28+670.6)+0.5*(109.79+0+77.86+0))
=    3.3270 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                  6.5576 MPa

Weight of Nozzle: .4273kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.84 <= eab=3.875[mm]	21.6%	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*132.95+3.55)*3.55)=                                  30.93 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                                (9.5-76)
=MIN(Sqr((74.5-3.875)*3.875,)40)=                            16.54 mm
```

Pressure Area Required pA(req.)

```
pAReqL = P * (ApsL + Apb) (9.5-7) =3.3*(9064.28+670.6)=      32.13 kN
pAReqT = P * (ApsT + Apb + 0.5 * Apphi)                        (9.5-7)
=3.3*(4504.68+670.6+0.5*0)=                                 17.08 kN
pAReq = MAX( pAReqL, pAReqT) =MAX(32125.11,17078.45)=       32.13 kN
```

Pressure Area Available pA(aval.)

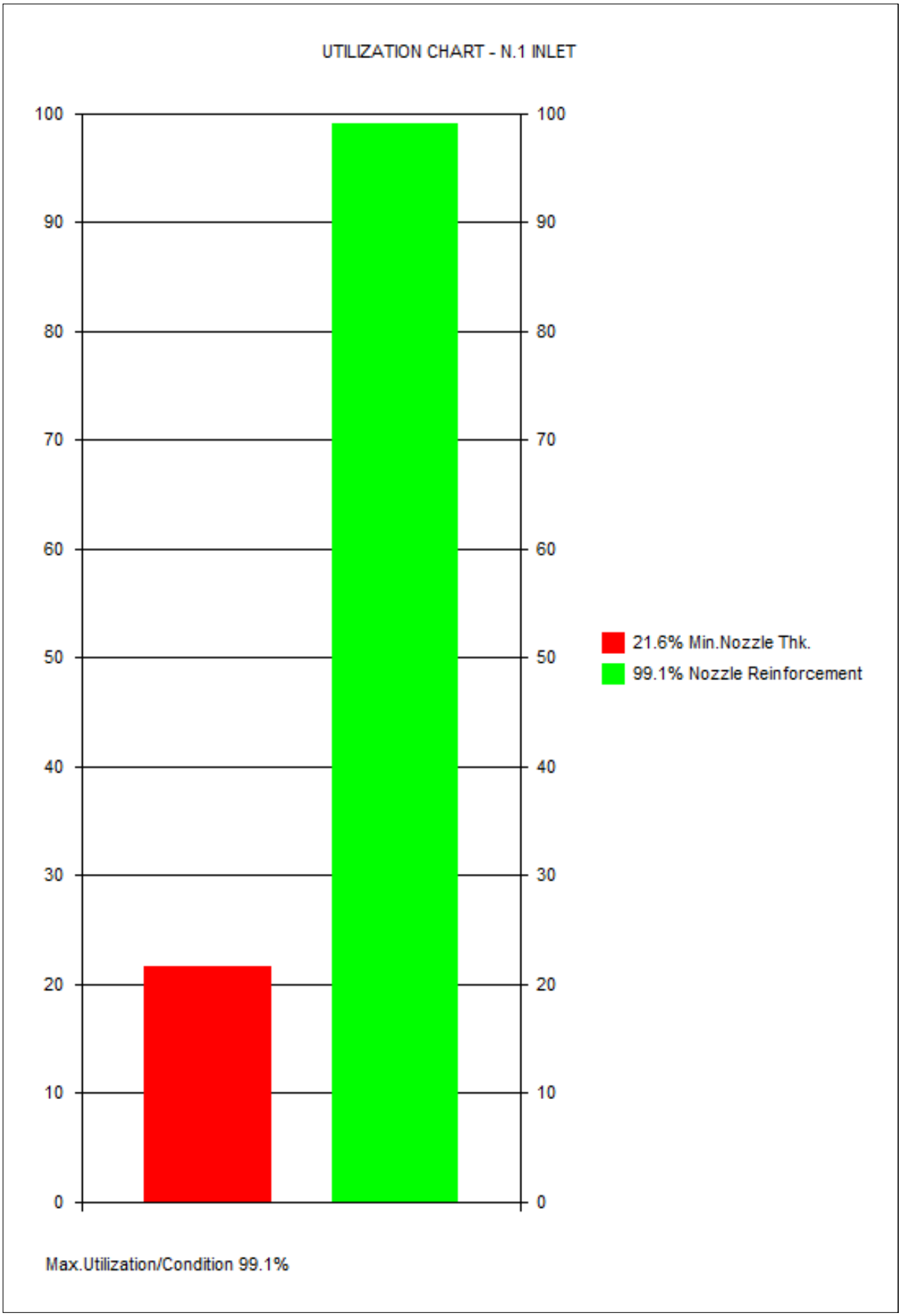
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)      (9.5-7)
=(109.79+0)*(194.67-0.5*3.3)+0*(0-0.5*3.3)+77.86*(145.47-0.5*3.3)=    32.39 kN
```

Nozzle Reinforcement pAAval=32.39 >= pAReq=32.13[kN]	99.1%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((ApsL+Apb)+0.5*(Afs+Afw+Afb+Afp))     (9.5-10)
=(109.79+0)*194.67+77.86*145.47/((9064.28+670.6)+0.5*(109.79+0+77.86+0))
=   3.3270 MPa
```

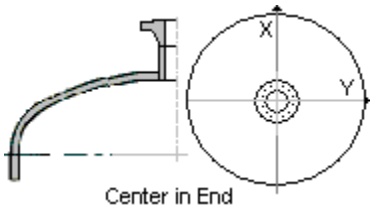
Volume:0.0001000 m3 Weight:0.4 kg (SG= 7.85)


UTILIZATION CHART - N.1 INLET
100
90
80
70
60
50
40
30
20
10
0
21.6% Min.Nozzle Thk.
99.1% Nozzle Reinforcement
Max.Utilization/Condition 99.1%

INPUT DATA

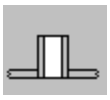
COMPONENT ATTACHMENT/LOCATION

```
Attachment: E3.2    Torispherical End    Upper Head                    S1.1
Connect this nozzle to the nozzle neck of another nozzle: NO
```




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

GENERAL DESIGN DATA



```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 130°C, P=3.3000 MPa, c=0.5 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
Include Nozzle Load Calculation: NO
```

SHELL DATA (E3.2)

```
Shell Type: Torispherical End
OUTSIDE DIAMETER OF SHELL............................:De        273.00 mm
NOMINAL WALL THICKNESS (uncorroded)..................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE................:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)...................:R         218.40 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=16mm 130'C
Rm=510 Rp=355 Rpt=308.6 fs=205.73 f20=212.5 ftest=338.1 E=203868(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 130'C
Rm=410 Rp=265 Rpt=218.2 fb=145.47 f20=170.83 ftest=252.38 E=203868(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        74.50 mm
NOMINAL NOZZLE THICKNESS (uncorroded)................:enb       5.0000 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: Exclude Area of Nozzle to Shell Weld
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE BETWN.BRANCH AXIS AND A LINE NORMAL TO MAIN BODY:Phi       0.00 Degr.
```

DATA FOR REINFORCEMENT PAD

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

LIMITS OF REINFORCEMENT

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness eas
eas = en - c - th =4-0.5-0.3=                                3.2000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =5-0.5-0.625=                        3.8750 mm
ris = R (9.5-4) =218.4=                                      218.40 mm
dib = deb - 2 * eab =74.5-2*3.875=                            66.75 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=3.3*74.5/(2*145.47*1+3.3)=                                0.8400 mm
Allowable Stresses
fob = Min( fs, fb) (9.5-8) =Min(205.73,145.47)=               145.47 N/mm2
```

GEOMETRIC LIMITATIONS

»Check Max.Diameter of Nozzle dib/De=0.2445 <= 0.60=0.6[mm] (9.4.5.3)«» OK«

Min.Nozzle Thk. ebp=0.84 <= eab=3.875[mm]	21.6%	OK

»Location in End to Fig.9.5-4 L=99.25 >= De/10=27.3[mm] « » OK«

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

```
Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*218.4+3.2)*3.2)=                                    37.52 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =3.2*37.52=                          120.07 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                              (9.5-76)
=MIN(Sqr((74.5-3.875)*3.875,)40)=                           16.54 mm
Set In Nozzle
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =3.875*(16.54+0+3.2)=    76.50 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*66.75*(16.54+3.2)=   658.92 mm2

Spherical Shell/End on any Section Aps
Aps = 0.5 * ris ^ 2 * (Is + a) / (0.5 * eas + ris)                (9.5-105)
=0.5*218.4^2*(37.52+37.43)/(0.5*3.2+218.4)=              8125.41 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                             (9.5-7)
=3.3*(8125.41+658.92+0.5*0)=                                  28.99 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)
=(120.07+0)*(205.73-0.5*3.3)+0*(0-0.5*3.3)+76.5*(145.47-0.5*3.3)=    35.51 kN
```

Nozzle Reinforcement pAAval=35.51 >= pAReq=28.99[kN]	81.6%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp)) (9.5-10)
=(120.07+0)*205.73+76.5*145.47/((8125.41+658.92+0.5*0)+0.5*(120.07+0+76.5+0
))=                                                           =   4.0339 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                    7.7263 MPa

Weight of Nozzle: .4045kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.84 <= eab=3.875[mm]	21.6%	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*218.4+3.2)*3.2)=                                      37.52 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                             (9.5-76)
=MIN(Sqr((74.5-3.875)*3.875,)40)=                             16.54 mm
```

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                             (9.5-7)
=3.3*(8125.41+658.92+0.5*0)=                                  28.99 kN
```

Pressure Area Available pA(aval.)

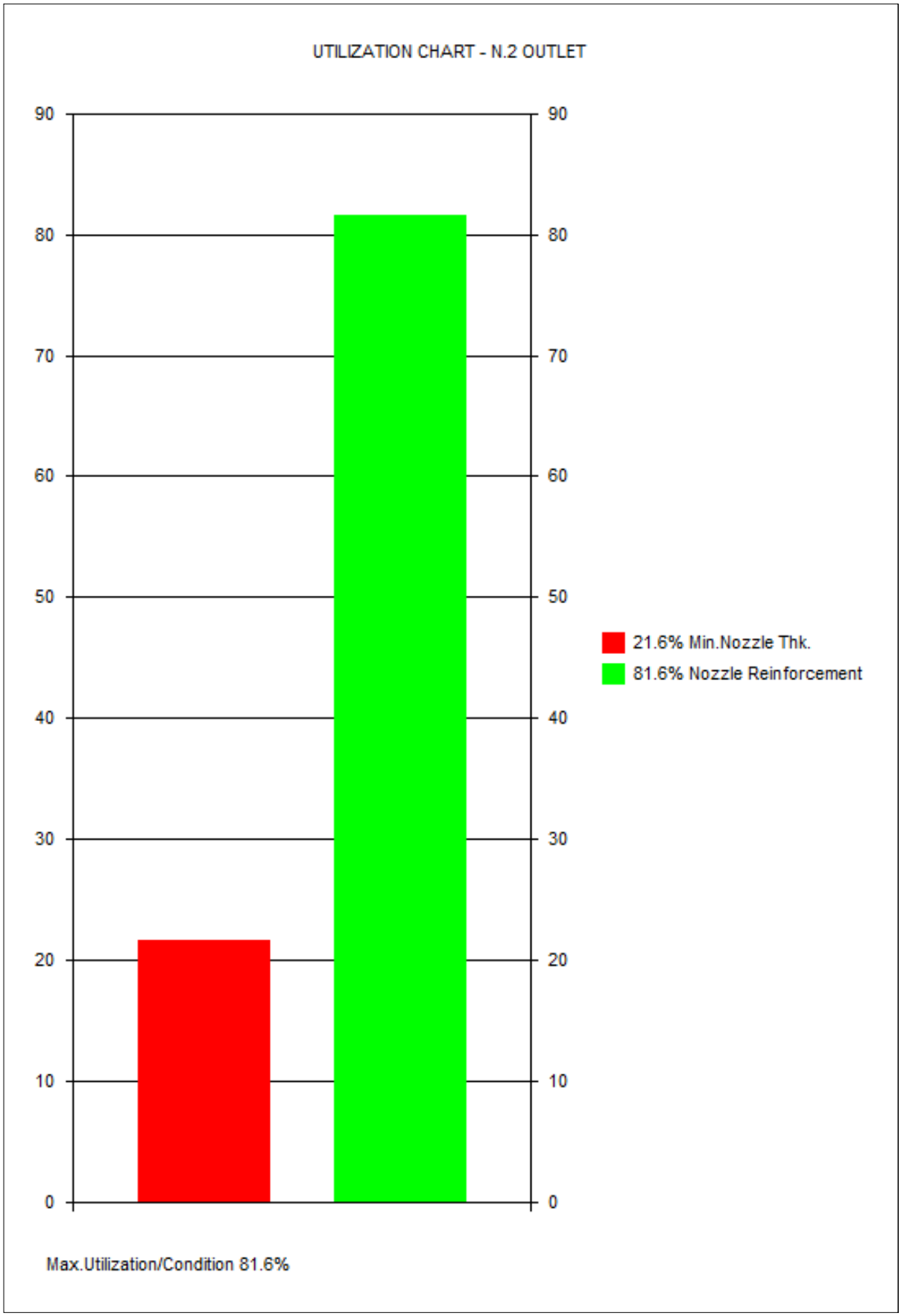
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)      (9.5-7)
=(120.07+0)*(205.73-0.5*3.3)+0*(0-0.5*3.3)+76.5*(145.47-0.5*3.3)=    35.51 kN
```

Nozzle Reinforcement pAAval=35.51 >= pAReq=28.99[kN]	81.6%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp)) (9.5-10)
=(120.07+0)*205.73+76.5*145.47/((8125.41+658.92+0.5*0)+0.5*(120.07+0+76.5+0
))=                                                           =   4.0339 MPa
```

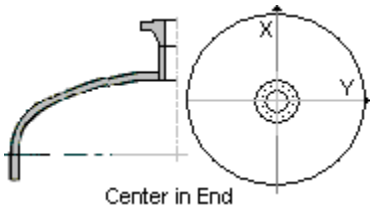
Volume:0.0001000 m3 Weight:0.4 kg (SG= 7.85)


UTILIZATION CHART - N.2 OUTLET
90
80
70
60
50
40
30
20
10
0
21.6% Min.Nozzle Thk.
81.6% Nozzle Reinforcement
Max.Utilization/Condition 81.6%

INPUT DATA

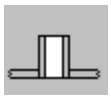
COMPONENT ATTACHMENT/LOCATION

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




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

GENERAL DESIGN DATA



```
Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 130°C, P=3.3000 MPa, c=0.5 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.................:SG          0.00
LIQUID HEAD.........................................:LH         84.84 mm
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
Include Nozzle Load Calculation: NO
```

SHELL DATA (E3.1)

```
Shell Type: Torispherical End
OUTSIDE DIAMETER OF SHELL............................:De        273.00 mm
NOMINAL WALL THICKNESS (uncorroded)..................:en        4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE................:th        0.3000 mm
INSIDE SPHERICAL RADIUS (corroded)...................:R         218.40 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=16mm 130'C
Rm=510 Rp=355 Rpt=308.6 fs=205.73 f20=212.5 ftest=338.1 E=203868(N/mm2) ro=7.85
```

NOZZLE MATERIAL DATA

```
Delivery Form: Seamless Pipe
EN 10217-3:2019, 1.0565 P355NH welded tube, HT:N THK<=20mm 130'C
Rm=490 Rp=355 Rpt=292 fb=194.67 f20=204.17 ftest=338.1 E=203868(N/mm2) ro=7.85
```

NOZZLE DIMENSIONAL DATA

```
Attachment: Protruding 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       101.60 mm
NOMINAL NOZZLE THICKNESS (uncorroded)................:enb       3.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE................:          10.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD..............:ho        40.00 mm
```

```
PROTRUDING MEASURED FROM SHELL ris (corroded).......:Ibi        20.00 mm
```

WELDING DATA

```
Nozzle/Pad to Shell Welding Area: User Specified Fillet Weld Throat Dimensions
OUTWARD NOZZLE WELD, THROAT DIMENSION..............:mo        2.2000 mm
INWARD NOZZLE WELD, THROAT DIMENSION...............:mi        2.2000 mm
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE BETWN.BRANCH AXIS AND A LINE NORMAL TO MAIN BODY:Phi       0.00 Degr.
```

DATA FOR REINFORCEMENT PAD

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

LIMITS OF REINFORCEMENT

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

```
Shell Analysis Thickness eas
eas = en - c - th =4-0.5-0.3=                          3.2000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev =3-0.5-0.3=                    2.2000 mm
ris = R (9.5-4) =218.4=                                218.40 mm
dib = deb - 2 * eab =101.6-2*2.2=                       97.20 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P)
=3.3*101.6/(2*194.67*1+3.3)=                         0.8500 mm
Allowable Stresses
fob = Min( fs, fb) (9.5-8) =Min(205.73,194.67)=         194.67 N/mm2
```

GEOMETRIC LIMITATIONS

»Check Max.Diameter of Nozzle dib/De=0.356 <= 0.60=0.6[mm] (9.4.5.3)«» OK«

Min.Nozzle Thk. ebp=0.85 <= eab=2.2[mm]	38.6%	OK

»Location in End to Fig.9.5-4 L=85.7 >= De/10=27.3[mm] « » OK«

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

```
Limit of Reinforcement Along Shell
Iso = Sqr(( 2 * ris + eas) * eas)
=Sqr((2*218.4+3.2)*3.2)=                              37.52 mm
Set In Nozzle
Afs = eas * Is (9.5-79) =3.2*37.52=                    120.07 mm2
```

Area of Nozzle Afb

```
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                        (9.5-76)
=MIN(Sqr((101.6-2.2)*2.2,)40)=                        14.79 mm
Limit of Reinforcement Along Nozzle (inside shell)
Ibi = Min( Ibi, 0.5 * Ibo) =Min(20,0.5*14.79)=          7.3939 mm
Set In Nozzle
```

```
Afb = eb * (Ibo + Ibi + eas) (9.5-78) =2.2*(14.79+7.39+3.2)=     55.84 mm2
```

Area of Welds Afw

```
Afw = mo ^ 2 + (mi - c) ^ 2 =2.2^2+(2.2-0.5)^2=              7.7300 mm2
```

Calculation of Pressure Loaded Areas

```
In the Nozzle Apb
Apb = 0.5 * dib * (Ibo + eas) (9.5-84) =0.5*97.2*(14.79+3.2)=    874.21 mm2

Spherical Shell/End on any Section Aps
Aps = 0.5 * ris ^ 2 * (Is + a) / (0.5 * eas + ris)                (9.5-105)
=0.5*218.4^2*(37.52+51.26)/(0.5*3.2+218.4)=                 9624.91 mm2
```

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                             (9.5-7)
=3.3*(9624.91+874.21+0.5*0)=                                  34.65 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)
=(120.07+7.73)*(205.73-0.5*3.3)+0*(0-0.5*3.3)+55.84*(194.67-0.5*3.3)
=    36.86 kN
```

Nozzle Reinforcement pAAval=36.86 >= pAReq=34.65[kN]	93.9%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp)) (9.5-10)
=(120.07+7.73)*205.73+55.84*194.67/((9624.91+874.21+0.5*0)+0.5*(120.07+7.73
+55.84+0))=                                                   =   3.5090 MPa
```

Max.Allowable Test Pressure Ptmax

```
Ptmax =  ==                                                    6.8565 MPa

Weight of Nozzle: .5106kg
```

CALCULATION SUMMARY

Min.Nozzle Thk. ebp=0.85 <= eab=2.2[mm]	38.6%	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*218.4+3.2)*3.2)=                                      37.52 mm
Limit of Reinforcement Along Nozzle (outside shell)
Ibo = MIN( Sqr(( deb - eb) * eb), ho)                             (9.5-76)
=MIN(Sqr((101.6-2.2)*2.2,)40)=                                14.79 mm
Limit of Reinforcement Along Nozzle (inside shell)
Ibi = Min( Ibi, 0.5 * Ibo) =Min(20,0.5*14.79)=                 7.3939 mm
```

Pressure Area Required pA(req.)

```
pAReq = P * (Aps + Apb + 0.5 * Apphi)                             (9.5-7)
=3.3*(9624.91+874.21+0.5*0)=                                  34.65 kN
```

Pressure Area Available pA(aval.)

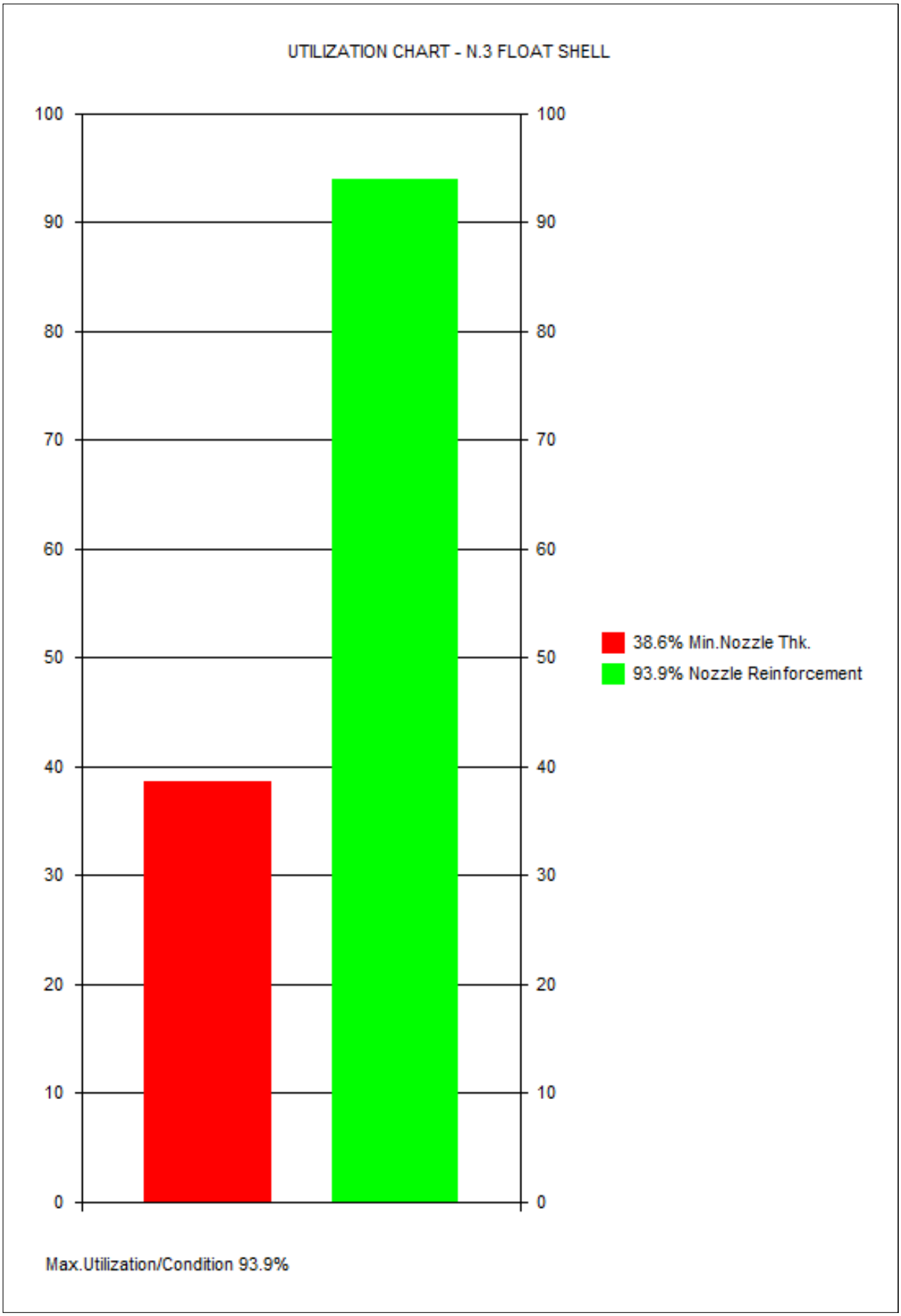
```
pAAval = (Afs+Afw)*(fs-0.5*P)+Afp*(fop-0.5*P)+Afb*(fob-0.5*P)      (9.5-7)
=(120.07+7.73)*(205.73-0.5*3.3)+0*(0-0.5*3.3)+55.84*(194.67-0.5*3.3)
=    36.86 kN
```

Nozzle Reinforcement pAAval=36.86 >= pAReq=34.65[kN]	93.9%	OK

Maximum Allowable Pressure Pmax

```
Pmax = (Afs+Afw)*fs+Afb*fob/((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp)) (9.5-10)
=(120.07+7.73)*205.73+55.84*194.67/((9624.91+874.21+0.5*0)+0.5*(120.07+7.73
+55.84+0))=                                                    =    3.5090 MPa
```

Volume:0.0003000 m3 Weight:0.5 kg (SG= 7.85)


UTILIZATION CHART - N.3 FLOAT SHELL
100
90
80
70
60
50
40
30
20
10
0
38.6% Min.Nozzle Thk.
93.9% Nozzle Reinforcement
Max.Utilization/Condition 93.9%

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

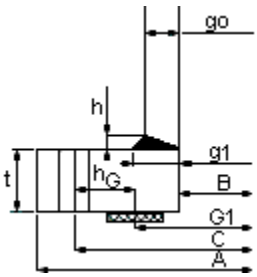
```
Attachment: N.3     Nozzle,Seamless Pipe Float Shell                    E3.1
Location: Along z-axis z1= -42
Flange Design Method: Section 11 - Taylor Forge
```

GENERAL DESIGN DATA

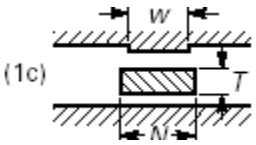
```
PROCESS CARD: General Design Data : Temp= 130°C, P=3.3000 MPa, c=0.5 mm
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG          0.00
LIQUID HEAD.....:LH        126.84 mm
B: Pressure loading: Flange under internal pressure
EXTERNAL LOADS ON FLANGE  (PD5500 ENQ 5500/123): NO
SPECIFY BOLT LOADS FROM 2nd./MATING 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: N.3
EN 10217-3:2019, 1.0565 P355NH welded tube, HT:N THK<=20mm 130'C
Rm=490 Rp=355 Rpt=292 fs=194.67 fs20=204.17 ftest=338.1 E=203868(N/mm2) ro=7.85
OUTSIDE DIAMETER OF SHELL/NOZZLE .....:Do        101.60 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: Smooth          .
OUTSIDE DIAMETER OF FLANGE.....:A         149.00 mm
THICKNESS OF FLANGE(uncorroded).....:e          11.00 mm
THICKNESS OF FLANGE AT REDUCED SECTION.....:er         11.00 mm
CORROSION ALLOWANCE FOR FLANGE FACE.....:cf          0.00 mm
EN 10028-2:2017, 1.0473 P355GH plate and strip, HT:N THK<=16mm 130'C
Rm=510 Rp=355 Rpt=308.6 SFO=205.73 SFA=212.5 ftest=338.1 E=203868(N/mm2) ro=7.85
```

DATA FOR FLANGE HUB

```
LENGTH OF HUB.....:h         6.0000 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 130'C
Rm=510 Rp=355 Rpt=308.6 SHO=205.73 SHA=212.5 ftest=338.1 E=203868(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: M8x1.5  ;
EFFECTIVE BOLT AREA per bolt.....................:Ae          36.60 mm2
RECOMMENDED MINIMUM BOLT CENTER TO EDGE CLEARANCE...:Bce      12.00 mm
RECOMMENDED MINIMUM BOLT CENTER/RADIAL CLEARANCE....:Bcr      16.00 mm
DIAMETER OF BOLT HOLES IN FLANGE.................:d          10.00 mm
NUMBER OF BOLTS..................................:n         8.0000
BOLT-CIRCLE DIAMETER.............................:C         130.00 mm
8.8  DIN 267 THK<=30mm 130'C
Rm=800 Rp=640 Rpt=575 Sb=191.67 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        102.50 mm
GREATER VALUE OF INSIDE DIAMETER OF GASKET/FLANGE FACE:A1      94.50 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 ) = ==                    2.0000 mm
```

FLANGE LOADS

```
HD = 0.785 * B ^ 2 * p =0.785*96.6^2*3.3=                   24.17 kN
H = 0.785 * G ^ 2 * p (11.5-5) =0.785*98.5^2*3.3=           25.13 kN
HG = (2 * PI * b * G * m) * p (11.5-6) =(2*3.14*2*98.5*2)*3.3=   8.1694 kN
HT = H - HD (11.5-11) =25133.68-24173.41=                   0.9603 kN
```

MOMENT ARMS

```
hG = (C - G) / 2 (11.5-14) =(130-98.5)/2=                   15.75 mm
hD = (C - B - g1) / 2 (11.5-12) =(130-96.6-6)/2=            13.70 mm
hT = (2 * C - B - G) / 4 (11.5-15) =(2*130-96.6-98.5)/4=    16.23 mm
```

BOLT LOADS

```
Operating condition
Wop = H + HG (11.5-8) =25133.68+8169.4=                     33.30 kN

Bolting up condition
Wamb = PI * b * G * y (11.5-7) =3.14*2*98.5*11=             6.8078 kN
```

BOLTING AREA

```
Am1 = Wop / Sb =33303.08/191.67=                            173.75 mm2

Am2 = Wamb / Sa =6807.83/200=                               34.04 mm2

Required Bolting Area Am
Am = MAX( Am1 , Am2) =MAX(173.75,34.04)=                    173.75 mm2

Available Bolting Area Ab
Ab (num.bolts*root area) = n * Ae =8*36.6=                  292.80 mm2
```

Bolting Area Check Ab=292.8 >= Am=173.75[mm2]	59.3%	OK

```
W = 0.5 * (Ab + Am) * Sa (11.5-16) =0.5*(292.8+173.75)*200=   46.66 kN
```

FLANGE MOMENTS

```
Mop = HD * hD + HT * hT + HG * hG                                   (11.5-18)
=24173.41*13.7+960.27*16.225+8169.4*15.75=                  475.42 Nm

Mamb = W * hG (11.5-17) =46655.22*15.75=                     734.82 Nm

Bolt Spacing
Bs = C * PI / n =130*3.14/8=                                  51.05 mm

Bolt Pitch Correction Factor
CF = MAX( Sqr( Bs / (2 * db + 6 * e / (m + 0.5))) , 1)              (11.5-20)
=MAX(Sqr(51.05/(2*8+6*11/(2+0.5))),1)=                      1.1000
Mo = Mop * CF / B (11.5-27) =475.42*1.1/96.6=                 5.4137 Nm/mm
Ma = Mamb * CF / B (11.5-26) =734.82*1.1/96.6=                8.3675 Nm/mm
```

SHAPE CONSTANTS

```
K = A / B (11.5-21) =149/96.6=                                  1.5424
lo = SQR( B * go) (11.5-22) =SQR(96.6*3)=                        17.02
h/lo=  0.352  K=A/B=  1.542  g1/go=  2.000
VALUES FROM FIGURES 11.5-4 to 8
BetaT =    1.692  BetaZ =    2.450  BetaY =    4.654  BetaU =    5.114
BetaF=     0.859  BetaV =    0.278  phi =    1.821
lamda = (e*BetaF+lo)/(BetaT*lo)+e^3*BetaV/(BetaU*lo*go^2)
=(11*0.8588+17.02)/(1.692*17.02)+11^3*0.2782/(5.114*17.02*3^2)=   1.3916
```

OPERATING CONDITION

```
M = Mo =5.41=                                                 5.4137 Nm/mm
```

11.5.4.1 Flange Stresses with Flange Thickness e= 11 mm

```
Longitudinal Hub Stress
SigH = phi * M / (lamda * g1 ^ 2)                                   (11.5-32)
=1.82*5.41/(1.39*6^2)=                                      196.74 N/mm2

Radial Flange Stress
Sigr = (1.333 * e * BetaF + lo) * M / (lamda * e ^ 2 * lo)          (11.5-33)
=(1.333*11*0.8588+17.02)*5.41/(1.39*11^2*17.02)=             55.93 N/mm2

Tangential Flange Stress
SigTeta = BetaY*M/e^2-Sigr*(K^2+1)/(K^2-1)                          (11.5-34)
=4.654*5.41/11^2-55.93*(1.54^2+1)/(1.54^2-1)=                71.18 N/mm2
```

11.5.4.2 Stress Limits

Hub Stress k*SigH=196.74 <= 1.5 * MIN(f;fH)=308.59[N/mm2] (11.5-90)	63.7%	OK
Radial Stress k*SigR=55.93 <= f=205.73[N/mm2] (11.5-91)	27.1%	OK
Tangential Stress k*SigTeta=71.18 <= f=205.73[N/mm2] (11.5-92)	34.5%	OK
Radial+Hub Stress 0.5*k*(SigH+SigR)=126.33 <= f=205.73[N/mm2] (11.5-93)	61.4%	OK
Tangential+Hub Stress 0.5*k*(SigH+SigTeta)=133.96 <= f=205.73[N/mm2] (11.5-94)	65.1%	OK

BOLTING UP CONDITION

```
M = Ma =8.37=                                                 8.3675 Nm/mm
```

11.5.4.1 Flange Stresses with Flange Thickness e= 11 mm

```
Longitudinal Hub Stress
SigH = phi * M / (lamda * g1 ^ 2)                                   (11.5-32)
=1.82*8.37/(1.39*6^2)=                                      304.08 N/mm2

Radial Flange Stress
Sigr = (1.333 * e * BetaF + lo) * M / (lamda * e ^ 2 * lo)          (11.5-33)
=(1.333*11*0.8588+17.02)*8.37/(1.39*11^2*17.02)=             86.45 N/mm2
```

```
Tangential Flange Stress
SigTeta = BetaY*M/e^2-Sigr*(K^2+1)/(K^2-1)                    (11.5-34)
=4.654*8.37/11^2-86.45*(1.54^2+1)/(1.54^2-1)=          110.02 N/mm2
```

11.5.4.2 Stress Limits

Hub Stress k*SigH=304.08 <= 1.5 * MIN(f;fH)=318.75[N/mm2] (11.5-90)	95.3%	OK
Radial Stress k*SigR=86.45 <= f=212.5[N/mm2] (11.5-91)	40.6%	OK
Tangential Stress k*SigTeta=110.02 <= f=212.5[N/mm2] (11.5-92)	51.7%	OK
Radial+Hub Stress 0.5*k*(SigH+SigR)=195.26 <= f=212.5[N/mm2] (11.5-93)	91.8%	OK
Tangential+Hub Stress 0.5*k*(SigH+SigTeta)=207.05 <= f=212.5[N/mm2] (11.5-94)	97.4%	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*212.5/205.73=      4.2607 MPa
Ptmin = 1.43 * Pd =1.43*3.3=                            4.7190 MPa
```

Test Pressure Ptmin=4.72 <= Ptmax=7.197[MPa]	65.5%	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)	130	3.30	Tangential+Hub Stress	33.3
Max.Allow.Pressure(corroded)	130	3.54	Tangential+Hub Stress	35.7
Max.Allow.Pressure(corroded)	Ambient	3.70	Tangential+Hub Stress	37.3
Max.Allow.Test Pressure(corroded)	Ambient	7.20	Tangential+Hub Stress	72.63
Required Test Pressure	Ambient	4.26	Tangential+Hub Stress	43

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

CALCULATION SUMMARY

BOLTING AREA

Bolting Area Check Ab=292.8 >= Am=173.75[mm2]	59.3%	OK

OPERATING CONDITION

11.5.4.1 Flange Stresses with Flange Thickness e= 11 mm

```
Longitudinal Hub Stress
SigH = phi * M / (lamda * g1 ^ 2)                             (11.5-32)
=1.82*5.41/(1.39*6^2)=                                 196.74 N/mm2

Radial Flange Stress
Sigr = (1.333 * e * BetaF + lo) * M / (lamda * e ^ 2 * lo)    (11.5-33)
=(1.333*11*0.8588+17.02)*5.41/(1.39*11^2*17.02)=        55.93 N/mm2

Tangential Flange Stress
SigTeta = BetaY*M/e^2-Sigr*(K^2+1)/(K^2-1)                    (11.5-34)
=4.654*5.41/11^2-55.93*(1.54^2+1)/(1.54^2-1)=          71.18 N/mm2
```

11.5.4.2 Stress Limits

Hub Stress k*SigH=196.74 <= 1.5 * MIN(f;fH)=308.59[N/mm2] (11.5-90)	63.7%	OK
Radial Stress k*SigR=55.93 <= f=205.73[N/mm2] (11.5-91)	27.1%	OK
Tangential Stress k*SigTeta=71.18 <= f=205.73[N/mm2] (11.5-92)	34.5%	OK
Radial+Hub Stress 0.5*k*(SigH+SigR)=126.33 <= f=205.73[N/mm2] (11.5-93)	61.4%	OK
Tangential+Hub Stress 0.5*k*(SigH+SigTeta)=133.96 <= f=205.73[N/mm2] (11.5-94)	65.1%	OK

BOLTING UP CONDITION

11.5.4.1 Flange Stresses with Flange Thickness e= 11 mm

```
Longitudinal Hub Stress
SigH = phi * M / (lamda * g1 ^ 2)                              (11.5-32)
=1.82*8.37/(1.39*6^2)=                                  304.08 N/mm2

Radial Flange Stress
Sigr = (1.333 * e * BetaF + lo) * M / (lamda * e ^ 2 * lo)     (11.5-33)
=(1.333*11*0.8588+17.02)*8.37/(1.39*11^2*17.02)=         86.45 N/mm2

Tangential Flange Stress
SigTeta = BetaY*M/e^2-Sigr*(K^2+1)/(K^2-1)                     (11.5-34)
=4.654*8.37/11^2-86.45*(1.54^2+1)/(1.54^2-1)=           110.02 N/mm2
```

11.5.4.2 Stress Limits

Hub Stress k*SigH=304.08 <= 1.5 * MIN(f;fH)=318.75[N/mm2] (11.5-90)	95.3%	OK
Radial Stress k*SigR=86.45 <= f=212.5[N/mm2] (11.5-91)	40.6%	OK
Tangential Stress k*SigTeta=110.02 <= f=212.5[N/mm2] (11.5-92)	51.7%	OK
Radial+Hub Stress 0.5*k*(SigH+SigR)=195.26 <= f=212.5[N/mm2] (11.5-93)	91.8%	OK
Tangential+Hub Stress 0.5*k*(SigH+SigTeta)=207.05 <= f=212.5[N/mm2] (11.5-94)	97.4%	OK

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

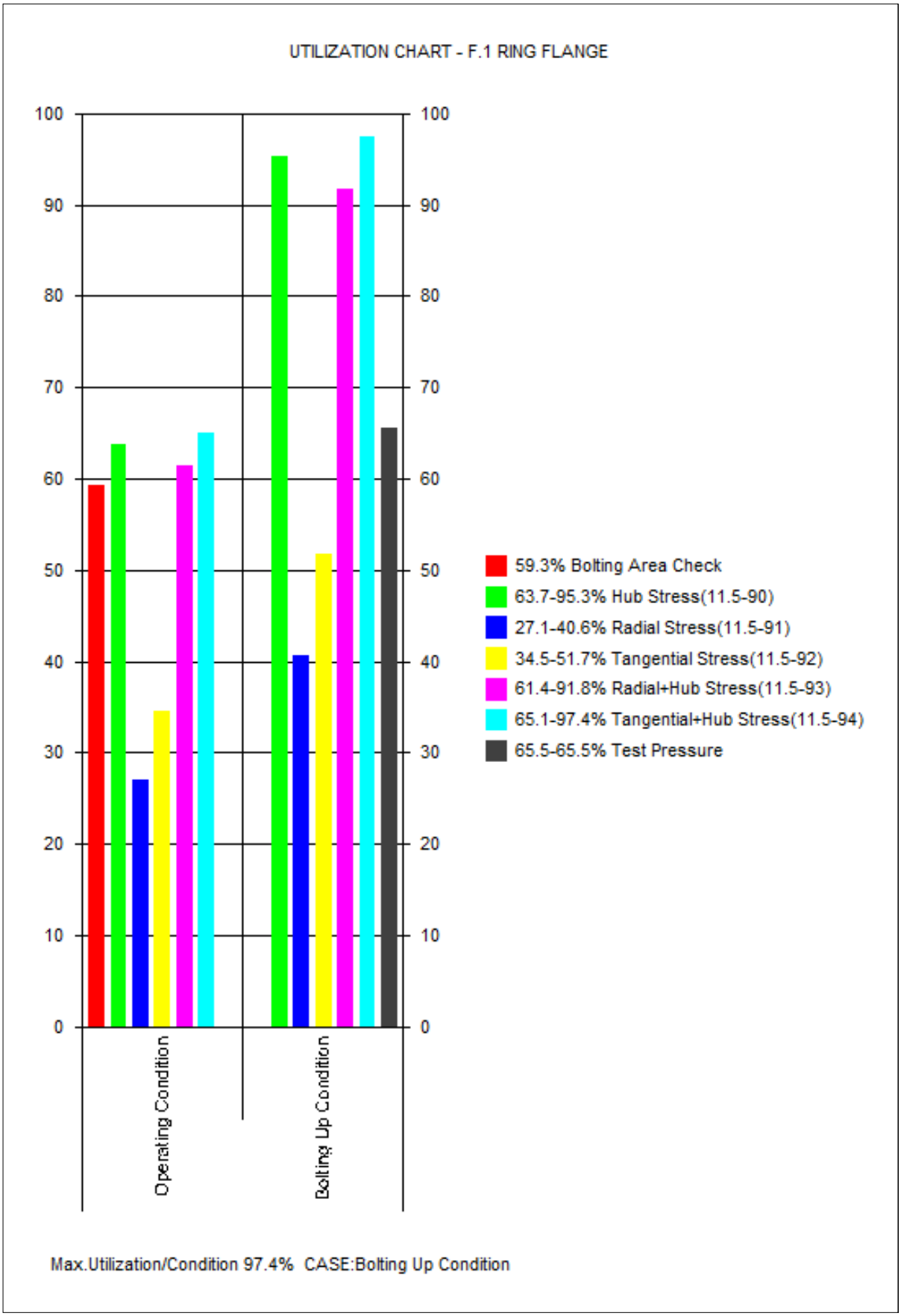
```
NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*3.3*212.5/205.73=      4.2607 MPa

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

Test Pressure Ptmin=4.72 <= Ptmax=7.197[MPa]	65.5%	OK

Warning: Invalid gasket location/dimension.

Volume:0.0001246 m3 Weight:0 kg (SG= 7.85)


UTILIZATION CHART - F.1 RING FLANGE
100
90
80
70
60
50
40
30
20
10
0
Operating Condition
Bolting Up Condition
59.3% Bolting Area Check
63.7-95.3% Hub Stress(11.5-90)
27.1-40.6% Radial Stress(11.5-91)
34.5-51.7% Tangential Stress(11.5-92)
61.4-91.8% Radial+Hub Stress(11.5-93)
65.1-97.4% Tangential+Hub Stress(11.5-94)
65.5-65.5% Test Pressure
Max.Utilization/Condition 97.4% CASE:Bolting Up Condition