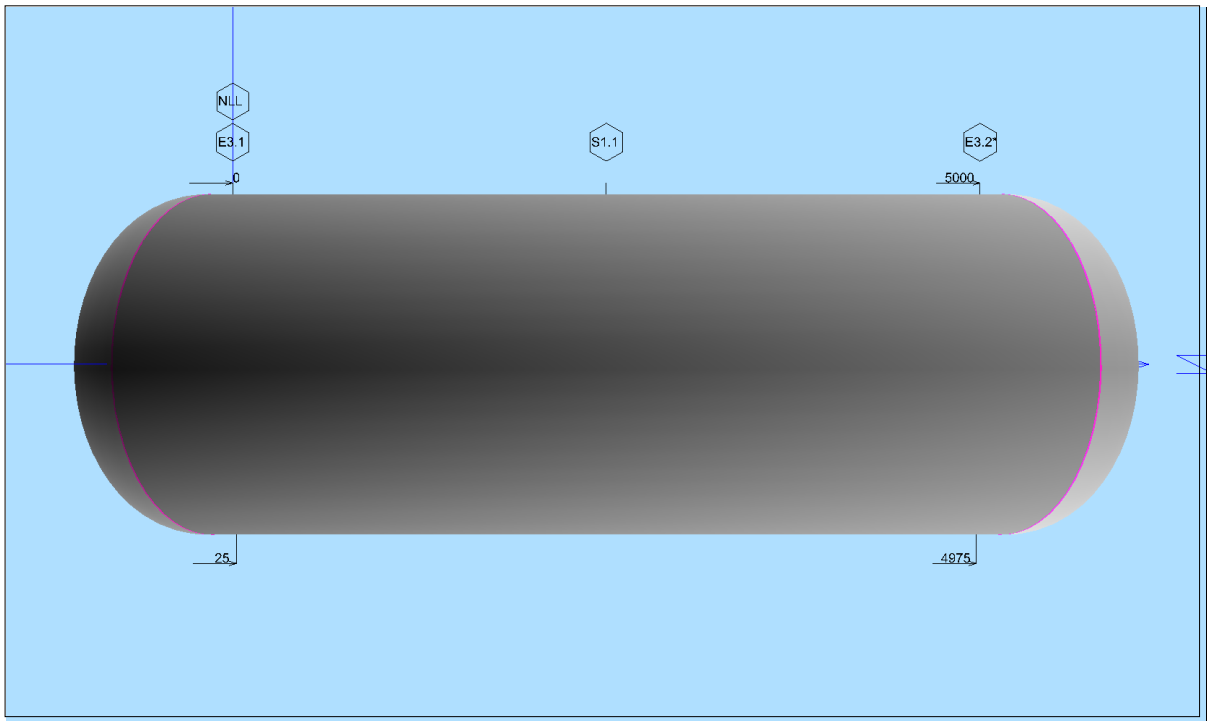
Company Name -

Client :UPI Vessel Tag No.:No.1

Visual Vessel Design by Hexagon AB,Ver:19.0 Operator :Fekete Rev.:A

(0) Drawing

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



History of Revisions

Rev	ID	Component Type	Comp. Description	DATE & TIME
A	E3.1	Torispherical End	LAVE	06 Aug. 2020 14:42
A	E3.2*	Torispherical End	PRAVE	06 Aug. 2020 14:42
A	S1.1	Cylindrical Shell	PLAST	06 Aug. 2020 14:42

A First Issue Fekete 06 Aug. 2020 14:32

Design Data & Process Information

Description	Units	Design Data
Process Card		General Design Data
Design Code & Specifications		EN13445 TG = 3b
Internal Design Pressure (MPa)	MPa	0.6
External Design Pressure (MPa)	MPa	
Hydrotest Pressure (MPa)	MPa	
Maximum Design Temperature ('C)	'C	150
Minimum Design Temperature ('C)	'C	20
Operating Temperature ('C)	'C	
Corrosion Allowance (mm)	mm	1
Content of Vessel		
Specific Density of Oper.Liq		1
Normal Liquid Level NLL (mm)	mm	1100

Weight & Volume of Vessel

ID	No.	Wt-UnFinish.	Wt-Finished	Tot.Volume	Test.Liq.Wt	Oper.Liq.Wt
E3.1	1	298.0 kg	298.0 kg	1.467 m3	1467.0 kg	1480.7 kg
E3.2*	1	298.0 kg	298.0 kg	1.467 m3	1467.0 kg	1480.7 kg
S1.1	1	1874.0 kg	1874.0 kg	18.612 m3	18612.0 kg	18577.8 kg
Total	**3**	**2470.0 kg**	**2470.0 kg**	**21.546 m3**	**21546.0 kg**	**21539.2 kg**

Weight Summary/Condition	Weights
Empty Weight of Vessel incl. 5% Contingency	2594 kg / 2.6 Tons
Total Test Weight of Vessel (Testing with Water)	24140 kg / 24.1 Tons
Total Operating Weight of Vessel	24133 kg / 24.1 Tons

Center of Gravity

ID	X-Empty	Y-Empty	Z-Empty	X-Test	Y-Test	Z-Test	X-Oper	Y-Oper	Z-Oper
E3.1	0	0	-338	0	0	-193	0	0	-582
E3.2*	0	0	5338	0	0	5193	0	0	5582
S1.1	0	0	2500	0	0	2500	0	0	2500

CENTER OF GRAVITY AT CONDITIONS BELOW	X	Y	Z
Empty Vessel	0	0	2500
Test Condition of Vessel (Testing with Water)	0	0	2500
Operating Condition of Vessel	0	0	2500

Max. Allowable Pressure MAWP

ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
E3.1	Torispherical End	LAVE	0.022 MPa	0.903 MPa	0.655 MPa
E3.2*	Torispherical End	PRAVE	0.022 MPa	0.903 MPa	0.655 MPa
S1.1	Cylindrical Shell	PLAST	0.022 MPa	0.905 MPa	0.670 MPa
	MAWP			**0.903 MPa**	**0.655 MPa**

Note : Other components may limit the MAWP than the ones checked above.
Note : The value for MAWP is at top of vessel, with static liquid head subtracted.

Test Pressure

TEST PRESSURE OF VESSEL - NEW & COLD - HORIZONTAL

Design Pressure.....: 0.600 MPa
Design Temperature.....: 150.0 C

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
E3.1	Torispherical End-LAVE	0.622	1.365	0.862	0.011	0.862	1.355
E3.2*	Torispherical End-PRAVE	0.622	1.365	0.862	0.022	0.862	1.344
S1.1	Cylindrical Shell-PLAST	0.622	1.610	0.862	0.022	0.862	1.589

PtReq = MAX(MIN(PtTop), 1.43*p)= 0.8618 MPa (EN13445-5, 10.2.3.3.1-1 & 2)

HYDRO-TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Hydro Test) .....: 0.8618 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Hydro Test) .....: 1.3438 MPa

PNEUMATIC TEST

```
REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ..:     0.8834 MPa
MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...:     1.3654 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.
```

Bill of Materials

ID	No	Description	Component Dimensions	Material Standard
E3.1	1	Torispherical End-LAVE	De= 2200, wt= 7, h= 564.81, R= 1760, r= 338.8, Not Applicable	ID 1, EN 10028-2:2017, 1.0425 P265GH plate and strip, HT:N
E3.2*	1	Torispherical End-PRAVE	De= 2200, wt= 7, h= 564.81, R= 1760, r= 338.8, Not Applicable	ID 1, EN 10028-2:2017, 1.0425 P265GH plate and strip, HT:N
S1.1	1	Cylindrical Shell-PLAST	De= 2200, en= 7, L= 4950	ID 1, EN 10028-2:2017, 1.0425 P265GH plate and strip, HT:N

Notes, Warning & Error Messages

ID & Comp. Description	Notes/Warnings/Error Messages
S1.1 Cylindrical Shell PLAST	
-	NOTE: PLATE TO SPEC. EN-10028 NORMALLY PERMITS A NEGATIVE TOLERANCE OF 0.3 mm(EN 10029 Class B).

TOTAL No. OF ERRORS/WARNINGS : 0

Maximum Component Utilization - Umax

ID	Comp.Type	Umax(%)	Limited by
E3.1	Torispherical End	93.7%	Internal Pressure
E3.2*	Torispherical End	93.7%	Internal Pressure
S1.1	Cylindrical Shell	91.3%	Internal Pressure

```
Component with highest utilization     Umax = 93.7% E3.1     LAVE

Average utilization of all components Umean= 92.9%
```

11 Material Data/Mechanical Properties

Material Data/Mechanical Properties

ID	Material Name	Temp	Rm	Rp	Rpt	f_d	f20	ftest	E-mod	Note
1	EN 10028-2:2017, 1.0425 P265GH plate and strip, HT:N TG3, CS, Mat.Group:1.1, , Max.T= 16mm, SG=7.85	150	410	265	223	148.7	170.8	252.4	202384	

Notation:
Thickness in mm, stress in N/mm2, temperature in deg.C
TG : Test Group 1 to 4
Max.T: Maximum thickness for this stress set, 0 or 999 = No limit specified
S/C : CS = Carbon Steel, SS = Stainless Steel
SG : SG = Specific Gravity (Water = 1.0)
Rm : MIN.TENSILE STRENGTH at ambient temp.
Rp : MIN. PROOF STRENGTH at ambient temp.
Rpt : MIN. PROOF STRENGTH at calc.temp.
f_d : DESIGN STRESS at calc.temp.
f20 : DESIGN STRESS at ambient temp.
GRP : 1.1 = Steels with a specified minimum specified yield strength ReH <= 275 N/mm2
GRP : 1.0 = Steels with a specified minimum yield strength ReH <= 460 N/mm2 a and with analysis in %:C <= 0,25, Si <= 0,60, Mn <= 1,70, Mo <= 0,70b, S <= 0,045, P <= 0,045, Cu <= 0,40b, Ni <= 0,5b, Cr <= 0,3 (0,4 for castings)b, Nb <= 0,05, V <= 0,12b, Ti <= 0,05
HT : N = normalised

Comp.Location in Global Coord.System

ID	Comp. Type	X	Y	Z	Teta	Phi	ConnID
E3.1	Torispherical End	0	0	25	0.0	0.0	S1.1
E3.2*	Torispherical End	0	0	4975	0.0	0.0	S1.1
S1.1	Cylindrical Shell	0	0	25	0.0	0.0	

The report above shows the location of the connecting point (x, y and z) for each component referenced to the coordinate system of the connecting component (ConnID). The connecting point (x, y and z) is always on the center axis of rotational symmetry for the component under consideration, i.e. the connecting point for a nozzle connected to a cylindrical shell will be at the intersection of the nozzle center axis and the mid thickness of the shell referenced to the shell s coordinate system. In addition the orientation of the the center axis of the component is given by the two angles Teta and Phi, where Teta is the angle between the center axis of the two components and Phi is the orientation in the x-y plane
The basis for the coordinate system used by the software is a right handed coordinate system with the z-axis as the center axis of rotational geometry for the components, and Teta as the Polar Angle and Phi as the Azimuthal Angle

Impact Test Requirements

Table :

ID-Description	Material Name	en(mm)	eB(mm)	Re(N/mm2)	f/fd
E3.1 LAVE - End	EN 10028-2:2017, 1.0425 P265GH plate and strip, HT:N	7.0	7.0	265.0	0.94
E3.2* PRAVE - End	EN 10028-2:2017, 1.0425 P265GH plate and strip, HT:N	7.0	7.0	265.0	0.94
S1.1 PLAST - Shell	EN 10028-2:2017, 1.0425 P265GH plate and strip, HT:N	7.0	7.0	265.0	0.91

Table Continued

ID-Description	Ts(C)	TR(C)	TR+Ts	TKVPWHT	TKVAW	Comments
E3.1 LAVE - End	0.0	20.0	20.0	20	20	Fig.B.2-1 KV >= 27 J(PWHT). Fig.B.2-2 KV >= 27 J(AW).
E3.2* PRAVE - End	0.0	20.0	20.0	20	20	Fig.B.2-1 KV >= 27 J(PWHT). Fig.B.2-2 KV >= 27 J(AW).

ID-Description	Ts(C)	TR(C)	TR+Ts	TKVPWHT	TKVAW	Comments
S1.1 PLAST - Shell	0.0	20.0	20.0	20	20	Fig.B.2-1 KV >= 27 J(PWHT). Fig.B.2-2 KV >= 27 J(AW).

EN13445-2 Annex B, Requirements for Prevention of Brittle Fracture
B.2.3 Method 2 - Code of practice developed from fracture mechanics

NOMENCLATURE:
en - Nominal thickness of component under consideration(including corr. allow.).
eB - Reference thickness of component under consideration from Table B.4-1.
Re - Minimum specified yield strength at room temperature.
AW - As Welded condition.
PWHT - Post Weld Heat Treatment.
f/fd - Ratio in Table B.2-12, f=membrane stress, fd=allowable stress.
TR - Design Reference Temperature.
Ts - Temperature adjustment according to Table B.2-12.
NOTE: - Ts, the temperature adjustment according to Table B.2-12 has been based on the design conditions. If a reduced pressure exist at low temperature further adjustment may be possible.
KV&TKV - Parent material, welds and HAZs shall meet the impact energy KV at the impact temperature TKV.
TKVPWHT- Material impact test temperature for PWHT condition from Figure B.2-1, 3, 5 or 7, and required impact energy 27J, 40J or 60J.
TKVAW - Material impact test temperature for AW condition from Figure B.2-2, 4, 6, 8, 9, 10 or 11, and required impact energy 27J or 40J.
NOTE 1:- Steel designation unknown, this method is only applicable for ferritic steels(C, CMn and fine grain) and 1.5% to 5% Ni-alloy steels.

NDT - Requirements for Test Group :3b

Table EN13445-5, 6.6.2-1:

Weld ID	Weld Category	Weld Type	RT or UT	MT or PT
1	Full Penetration butt weld	Longitudinal joints	10%	0
2a	Full Penetration butt weld	Circumferential joints on a shell	5%(c	0
2b	Full Penetration butt weld	Circumferential joints on a shell with backing strip (k)	NA	100%
2c	Full Penetration butt weld	Circumferential joggle joint (k)	NA	100%
3a	Full Penetration butt weld	Circumferential joints on a nozzle di > 150 mm and e > 16 mm	5%(c	10%(d)
3b	Full Penetration butt weld	Circumferential joints on a nozzle di > 150 mm and e > 16 mm with backing strip (k)	NA	100%
4	Full Penetration butt weld	Circumferential joints on a nozzle with di <= 150 mm or e <= 16mm	0	5%
5	Full Penetration butt weld	All welds in spheres, heads and hemispherical heads to shells	10%	0
6	Full Penetration butt weld	Assembly of a conical shell with a cylindrical shell without a knuckle(large end of cone) (q, r)	10%	100%
7	Full Penetration butt weld	Assembly of a conical shell with a cylindrical shell without a knuckle(small end of cone)	10%	10%(d)
8a	Circumferential lapped joints (k)	General application shell to head	NA	NA
8b	Circumferential lapped joints (k)	Bellows to shell e <= 8 mm	0 %	10%
9	Assembly of a flat head or a tubesheet, with a cylindrical shell Assembly of a flange or a collar with a shell	With full penetration	5%	10%(d)
10	Assembly of a flat head or a tubesheet, with a cylindrical shell Assembly of a flange or a collar with a shell	With partial penetration if a>16 mm (a as defined in figure 6.6.2-1)(j)	NA	10%
11	Assembly of a flat head or a tubesheet, with a cylindrical shell Assembly of a flange or a collar with a shell	With partial penetration if a<=16 mm (a as defined in figure 6.6.2-1) (j)	NA	10%
12	Assembly of a flange or a collar with a nozzle	With full penetration	5%	10%(d)
13	Assembly of a flange or a collar with a nozzle	With partial penetration (j)	NA	10%
14	Assembly of a flange or a collar with a nozzle	With full or partial penetration di <= 150 mm and e <= 16 mm j	0	10%

Weld ID	Weld Category	Weld Type	RT or UT	MT or PT
15	Nozzle or branch (e)	With full penetration di > 150 mm and e > 16 mm	5%	10%(d)
16	Nozzle or branch (e)	With full penetration di <= 150 mm or e <= 16 mm	0	10%
17	Nozzle or branch (e)	With partial penetration for any di a > 16 mm (see figure 6.6.2-2)	NA	10%(d)
18	Nozzle or branch (e)	With partial penetration di > 150 mm a <= 16 mm (see figure 6.6.2-2)	0	10%
19	Nozzle or branch (e)	With partial penetration di <= 150 mm a <= 16 mm (see figure 6.6.2-2)	0	10%
20	Tube ends into tubesheet	-	-	10%
21	Permanent attachments (f)	With full penetration or partial penetration	10%(d)	10%(d)
22	Pressure retaining areas after removal of temporary attachments	-	-	100%
23	Cladding by welding	-	-	100%
24	Repairs	-	100 %	100%
19i	Nozzle or branch (e)	With reinforcing plate	0	5%
19j	Nozzle or branch (e)	Weld joint in reinforcing plate (s)	10%	0

The above requirements are for test group TG:3b
Notes:
(a): See figure 6.6.2-3 for an explanation on Weld ID.
(b): RT=Radiographic Testing, UT=Ultrasonic Testing, MT=Magnetic Particle Testing, PT=Penetrant Testing.
(c): 2 % if e <= 30mm and same WPS as longitudinal, for steel groups 1.1 and 8.1
(d): 10 % if e > 30 mm, 0 % if e <= 30 mm
(e): Percentage in the table refers to the aggregate weld length of all the nozzles see 6.6.2.5 b).
(f): No RT or UT for weld throat thickness <= 16 mm
(g): 10 % for steel groups 8.2, 9.1, 9.2, 9.3 and 10
(h): Volumetric testing if risks of cracks due to parent material or heat treatment
(i): For explanation of the reduction in NDT in testing group 2, see 6.6.1.2
(j): In exceptional cases or where the design or load bearing on the joint is critical, it may be necessary to employ both techniques (i.e. RT & UT, MT & PT). See table 6.6.3-1 for other circumstances for use of both techniques.
(k): For limitations of application see EN 13445-3, 5.7.3.2
(l): The percentage of surface examination refers to the percentage of length of the welds both on the inside and the outside.
(m): RT and UT are volumetric while MT and PT are surface testing. When referenced in this table both volumetric and surface are necessary to the extent shown.
(n): NA means 'Not Applicable'.
(o): In case of cyclic loading refer to Annex G.2.
(p): Annex A of EN 13445-3 gives design limitations on welds.
(q): Unless the design is such that the thickness at the weld exceeds 1.4*ej (see 7.6.6 of EN13445-3). In which case, use NDT of line 2a.
(r): For connections with knuckle, line 2a applies.
(s): Only MT or PT are applicable if the shell itself is used as backing.
NOTE: All testing groups require 100% visual inspection.
NOTE: G.2 In addition to the requirements of 6.6.2, all locations where the cumulative fatigue index D is greater than 0.8, the surfaces shall be 100% inspected.

EN13445-5, Table 6.6.2-3, Map of Weld Types/Weld ID.

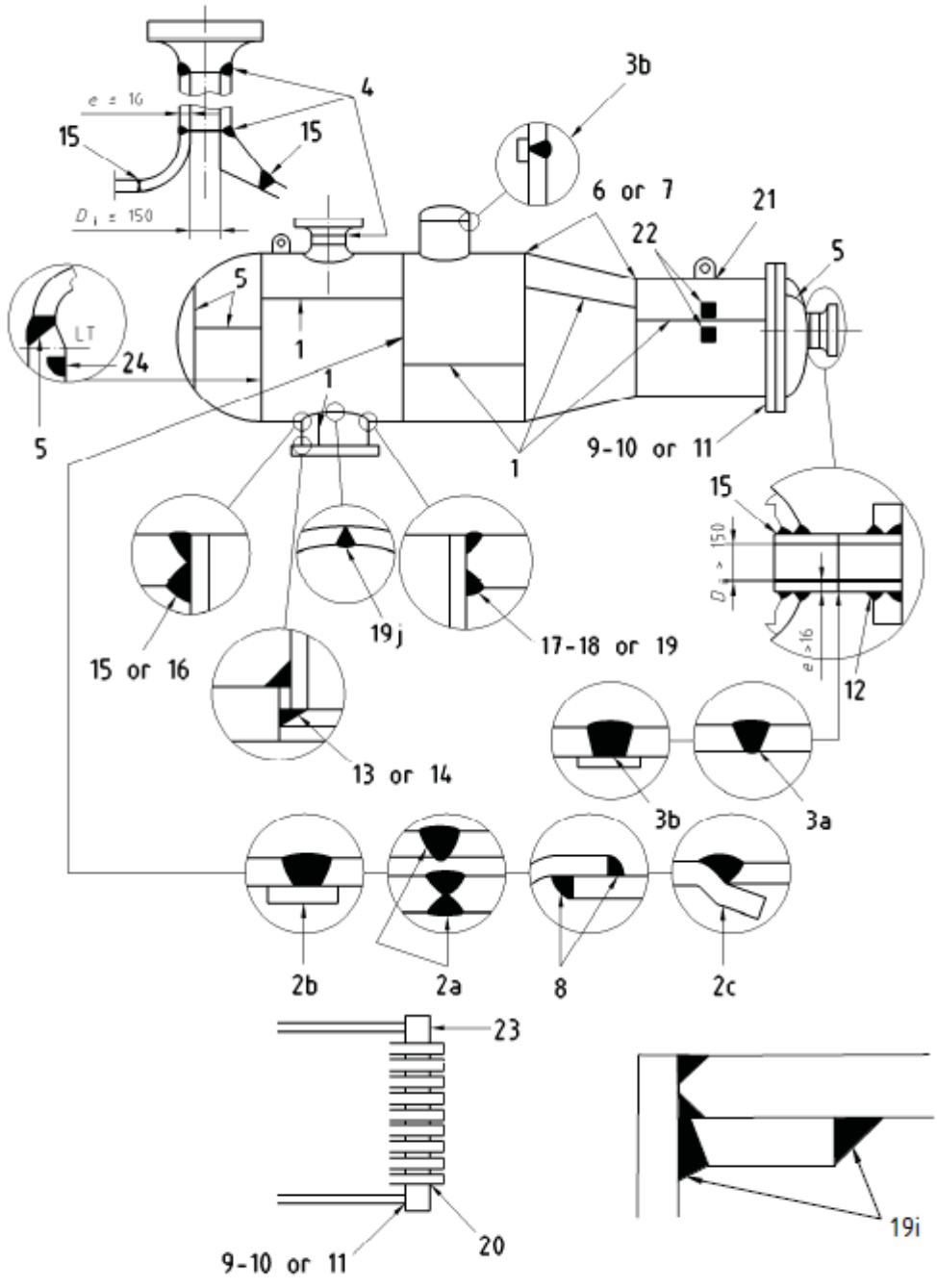
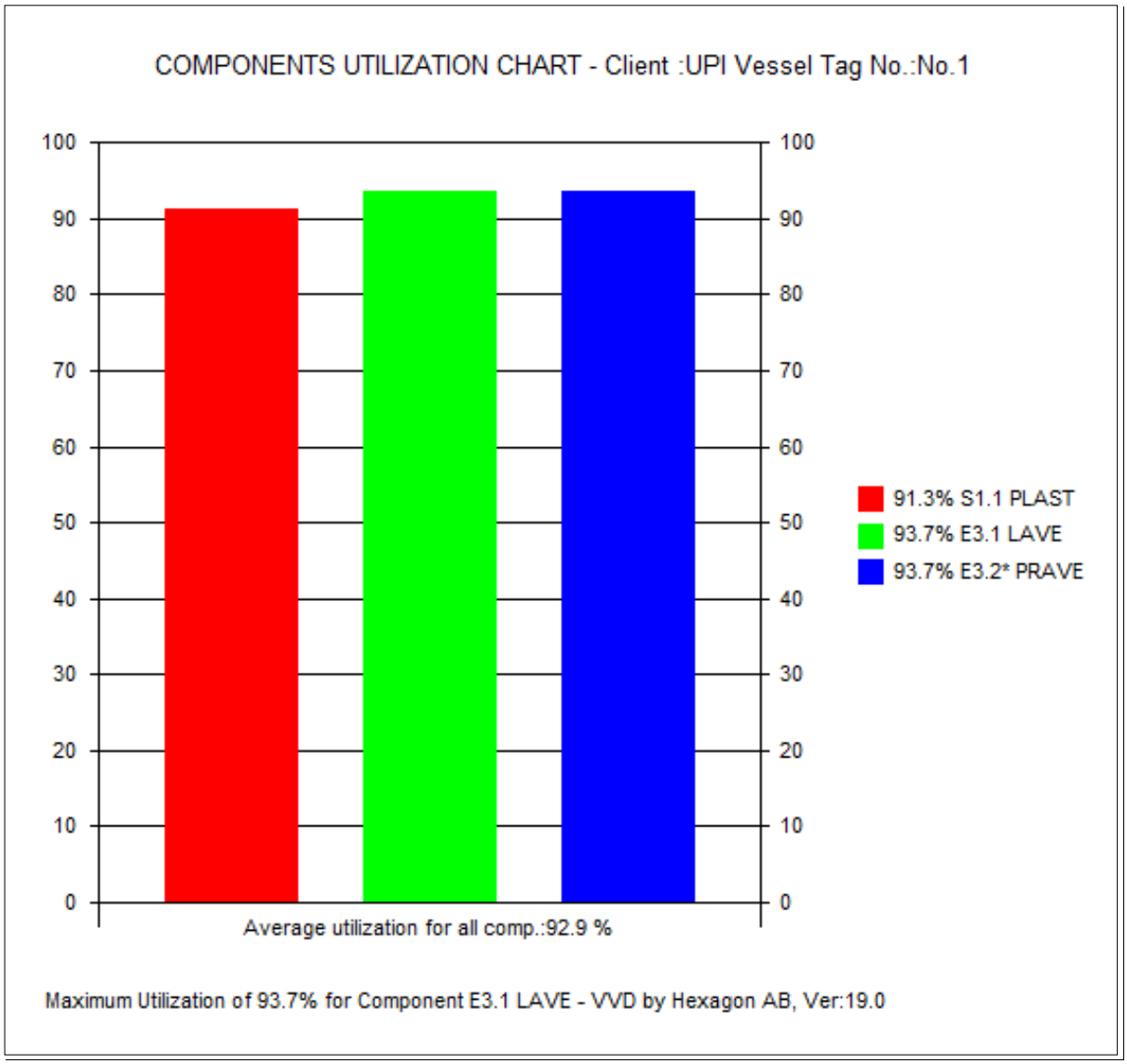


Figure 6.6.2-3 — Type of welds

Utilization Chart

Utilization Chart



Surface Area

ID	No.	Description	Area Outside(m2)	Area Inside(m2)
E3.1	1	Torispherical End, LAVE	5.440	5.405
E3.2*	1	Torispherical End, PRAVE	5.440	5.405
S1.1	1	Cylindrical Shell, PLAST	34.212	34.025
Total	**3**		**45.092**	**44.835**

Welding Information

EN1708-1 Welding Requirements for Pressurized Components

S1.1 Cylindrical Shell PLAST
Comment:

E3.1 Torispherical End LAVE
Comment:

E3.2* Torispherical End PRAVE

Comment:

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 150°C, P=0.6000 MPa, c=1.0 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.................:SG        1.0000
LIQUID HEAD.........................................:LH       2194.00 mm
```

SHELL DATA

```
CYLINDER FABRICATION: Plate Material
WELD JOINT COEFFICIENT: Testing Group  3   (z=0.85)
DIAMETER INPUT: Base Design on Shell Outside Diameter
EN 10028-2:2017, 1.0425 P265GH plate and strip, HT:N THK<=16mm 150'C
Rm=410 Rp=265 Rpt=223 f=148.67 f20=170.83 ftest=252.38 E=202384(N/mm2) ro=7.85
OUTSIDE DIAMETER OF SHELL...........................:De       2200.00 mm
LENGTH OF CYLINDRICAL PART OF SHELL.................:Lcyl     4950.00 mm
NOMINAL WALL THICKNESS (uncorroded).................:en        7.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th          0.00 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)
=2200*0.6215/(2*148.67*0.85+0.6215)=                        5.3967 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =5.4+1+0=                          6.3967 mm

Analysis Thickness
ea = en - c - NegDev =7-1-0=                                 6.0000 mm
```

»7.4.1 Cond.of Applicabilty emin/De=0.0025 <= 0.16« » OK«

Internal Pressure emina=6.4 <= en=7[mm]	91.3%	OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

```
Inside Diameter of Shell
Di = De - 2 * ea =2200-2*6=                                  2188.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2200+2188)/2=                           2194.00 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
MAWPHC = 2 * f * z * ea / Dm =2*148.67*0.85*6/2194=          0.6912 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)
MAWPNC = 2 * f20 * z * (ea + c) / Dm
=2*170.83*0.85*(6+1)/2194=                                  0.9266 MPa
```

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

```
Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*252.38*1*(6+1)/2194=                                     1.6104 MPa
```

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

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.6*170.83/148.67= 0.8618 MPa

Ptmin = 1.43 * Pd =1.43*0.6= 0.8580 MPa

Test Pressure Ptmin=0.8618 <= Ptmax=1.61[MPa]	53.5%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Inside Radius of Shell
ris = Di / 2 (9.5-3) =2188/2= 1094.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr((2 * ris + ea) * ea) (9.5-2) =Sqr((2*1094+6)*6)= 114.73 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*2188,(6*114.73*(148.67-0.5*0.6215)/0.6215-1094*114.73)/(0.5*1094+0
.5*6))= = 70.57 mm

Maximum diameter of Opening Not Requiring Reinforcement Check
dmax2 = 0.15 * Sqr((2 * ris + ea) * ea) (9.5-18)
=0.15*Sqr((2*1094+6)*6)= 17.21 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(70.57,17.21)= 70.57 mm

EN13445-4 Sect. 9.2 Ratio of Deformation

F = en / Dm * 100 (9.2-2) =7/2194*100= 0.3191 %

NOTE: EN13445-4, 5.4.2 Maximum out of roundness for vessels subjected to internal pressure: 1.5% for the ratio of emin/Dm > 0.01

CALCULATION SUMMARY

7.4.2 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

Required Minimum Shell Thickness Excl.Allow. emin :
emin = De * P / (2 * f * z + P) (7.4-2)
=2200*0.6215/(2*148.67*0.85+0.6215)= 5.3967 mm

Required Minimum Shell Thickness Incl.Allow. :
emina = emin + c + NegDev =5.4+1+0= 6.3967 mm

Internal Pressure emina=6.4 <= en=7[mm]	91.3%	OK

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

Ptmax = 2 * ftest * ztest * (ea + c) / Dm
=2*252.38*1*(6+1)/2194= 1.6104 MPa

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

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.6*170.83/148.67= 0.8618 MPa

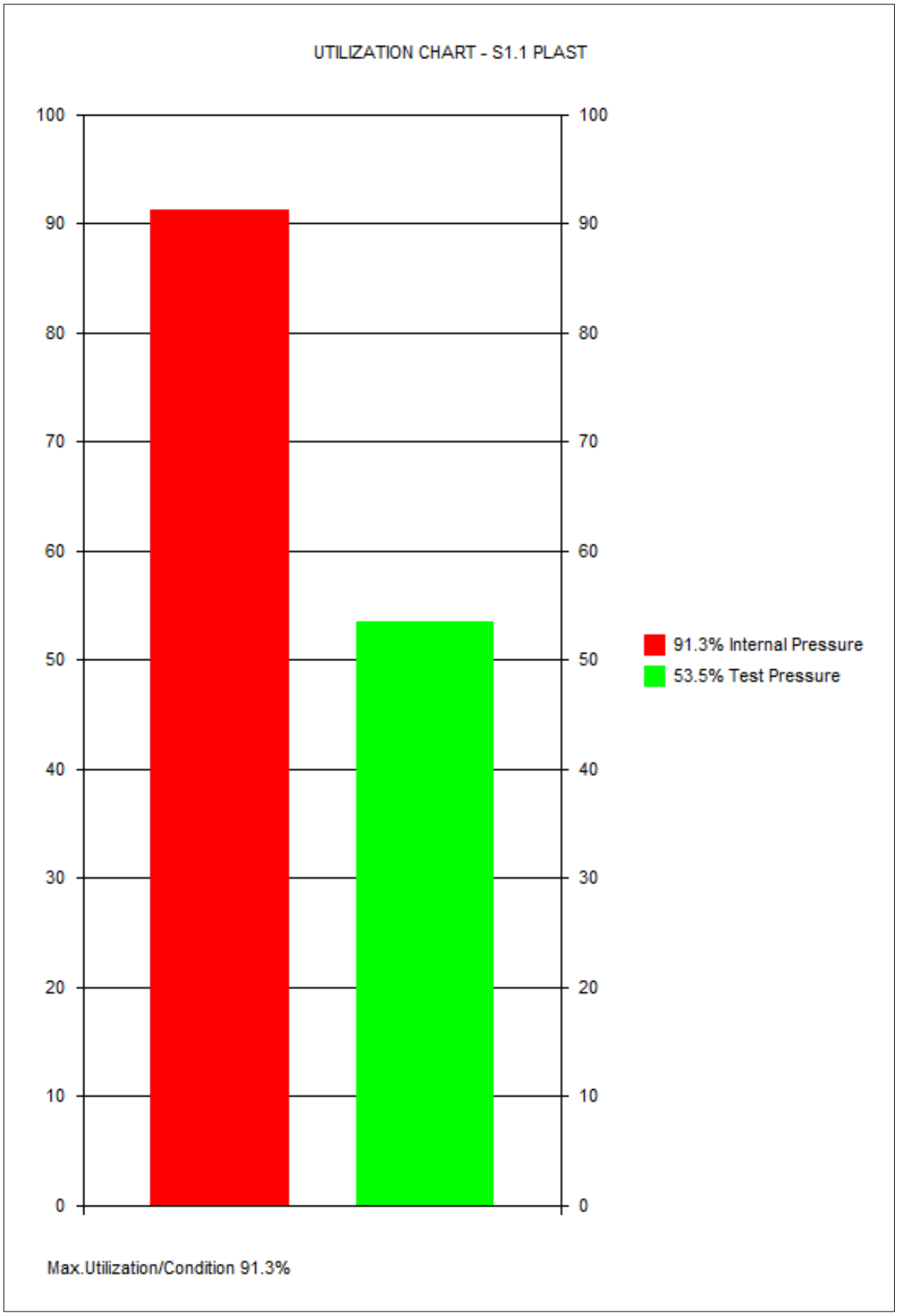
Ptmin = 1.43 * Pd =1.43*0.6= 0.8580 MPa

Test Pressure Ptmin=0.8618 <= Ptmax=1.61[MPa]	53.5%	OK

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(70.57,17.21)= 70.57 mm

Volume:18.61 m3 Weight:1874 kg (SG= 7.85)


UTILIZATION CHART - S1.1 PLAST
100
90
80
70
60
50
40
30
20
10
0
91.3% Internal Pressure
53.5% Test Pressure
Max.Utilization/Condition 91.3%

INPUT DATA

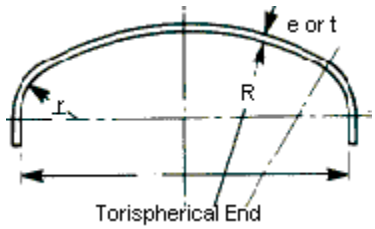
COMPONENT ATTACHMENT/LOCATION

```
Attachment: S1.1    Cylindrical Shell    PLAST
Location: Along z-axis zo=  25
```

GENERAL DESIGN DATA

```
PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 150°C, P=0.6000 MPa, c=1.0 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.................:SG        1.0000
LIQUID HEAD..........................................:LH       2194.00 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       2200.00 mm
LENGTH OF CYLINDRICAL FLANGE OF END.................:Lcyl       25.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE...............:th          0.00 mm
NOMINAL THICKNESS OF HEAD/END (uncorroded)..........:en        7.0000 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 150'C
Rm=410 Rp=265 Rpt=223 f=148.67 f20=170.83 ftest=252.38 E=202384(N/mm2) ro=7.85
Material & Delivery Form: NOT Cold Spun Seamless Austenitic Stainless Steel
```

NOZZLES IN KNUCKLE REGION TO SECTION 7.7

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

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

```
Required Thickness of End to Limit Membrane Stress in Central Part
es = P * R / (2 * f * z - 0.5 * P)                                  (7.5-1)
=0.6215*1760/(2*148.67*1-0.5*0.6215)=                          3.6826 mm

fb = Rpt / 1.5 (7.5-4) =223/1.5=                                 148.67 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*1760+0.2*2188)*((0.6215/(111*148.67)*(2188/338.8)^0.825)^(0.667)
=   5.4932 mm

7.5.3.5 Formulas for Calculation of Factor Beta
Y = MIN( emin / R, 0.04) (7.5-9) =MIN(5.55/1760,0.04)=           0.0032
Z = LOG( 1 / Y) (7.5-10) =LOG(1/0.0032)=                         2.5010
X = r / Di (7.5-11) =338.8/2188.89=                              0.1548
```

```
N = 1.006 - 1 / (6.2 + (90 * Y) ^ 4)                                  (7.5-12)
=1.006-1/(6.2+(90*0.0032)^4)=                              0.8449
Beta01 = N*(-0.1833*Z^3+1.0383*Z^2-1.2943*Z+0.837)                    (7.5-15)
=0.8449*(-0.1833*2.5^3+1.0383*2.5^2-1.2943*2.5+0.837)=     1.0367
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*0.0032-82.5*0.0032^2))=           0.5254
beta = 10 * ((0.2 - X) * Beta01 + (X - 0.1) * Beta02)                 (7.5-16)
=10*((0.2-0.1548)*1.04+(0.1548-0.1)*0.5254)=               0.7566
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
ey = beta * P * (0.75 * R + 0.2 * Di) / f                             (7.5-2)
=0.7566*0.6215*(0.75*1760+0.2*2188.89)/148.67=             5.5596 mm

Required Minimum End Thickness Excl.Allow. emin :
emin = emin =5.56=                                          5.5596 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =5.56+1+0=                            6.5600 mm
```

Internal Pressure emina=6.56 <= en=7[mm]	93.7%	OK

```
Analysis Thickness
ea = en - c - th =7-1-0=                                     6.0000 mm
Inside Diameter of Shell
Di = De - 2 * (en - c) =2200-2*(7-1)=                       2188.00 mm
Mean Diameter of Shell
Dm = (De + Di) / 2 =(2200+2188)/2=                          2194.00 mm
```

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

```
Llim = 0.2 * SQR( Di * emin) =0.2*SQR(2188*5.56)=             22.06 mm
Since Lcyl > Llim, Required Thickness of Straight Cylindrical Flange to 7.4.2
Minimum Thickness of Straight Flange Excl. Allow.
ecyl = P * Di / (2 * f * z - P)                                       (7.4-1)
=0.6215*2188/(2*148.67*1-0.6215)=                          4.5829 mm

Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =4.58+1=                                   5.5800 mm
```

7.5.3.1 Conditions of Applicability - Torispherical Ends

»Geometry Check r=338.8 <= 0.2 * Di=437.6[mm] « » OK«
»Geometry Check r=338.8 >= 0.06 * Di=131.28[mm] « » OK«
»Geometry Check r=338.8 >= 2*e=11.12[mm] « » OK«
»Geometry Check e=5.56 <= 0.08*De=176[mm] « » OK«
»Geometry Check ea=6 >= 0.001*De=2.2[mm] « » OK«
»Geometry Check R=1760 <= De=2200[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*7/(1759+0.5*7)=                                1.3569 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                        (7.5-7)
=170.83*7/(0.7365*(0.75*1759+0.2*2188))=                   0.9242 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                     (7.5-8)
=111*176.67*(7/(0.75*1759+0.2*2188))^1.5*(338.8/2188)^0.825=   1.0585 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*7*170.83*1/(2188+7)=                                    1.0896 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.9242=                                                   0.9242 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

```
Ps = 2 * f * z * ea / (R + 0.5 * ea)                                  (7.5-6)
=2*148.67*1*6/(1760+0.5*6)=                                1.0119 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                        (7.5-7)
=148.67*6/(0.7499*(0.75*1760+0.2*2188))=                   0.6768 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                     (7.5-8)
=111*148.67*(6/(0.75*1760+0.2*2188))^1.5*(338.8/2188)^0.825=   0.7064 MPa
```

```
Pcyl = 2 * ea * f * z / (Di + ea)
=2*6*148.67*1/(2188+6)=                                   0.8131 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.6768=                                                  0.6768 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*7/(1759+0.5*7)=                               2.0047 MPa
Py = f * ea / ( beta * ( 0.75 * R + 0.2 * Di))                    (7.5-7)
=252.38*7/(0.7365*(0.75*1759+0.2*2188))=                  1.3654 MPa
PB = 111*fb*(ea/(0.75*R+0.2*Di))^1.5*(r/Di)^0.825                 (7.5-8)
=111*252.38*(7/(0.75*1759+0.2*2188))^1.5*(338.8/2188)^0.825=   1.5121 MPa
Pcyl = 2 * ea * f * z / (Di + ea)
=2*7*252.38*1/(2188+7)=                                   1.6097 MPa
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.37=                                                    1.3654 MPa
```

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

```
NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.6*170.83/148.67=       0.8618 MPa

Ptmin = 1.43 * Pd =1.43*0.6=                               0.8580 MPa
```

Test Pressure Ptmin=0.8618 <= Ptmax=1.37[MPa]	63.1%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

```
ris = R (9.5-4) =1760=                                  1760.00 mm
Length of Shell Contributing to Reinforcement
Is = Sqr(( 2 * ris + ea) * ea) (9.5-2) =Sqr((2*1760+6)*6)=   145.45 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)
=(6*145.45*(148.67-0.5*0.6215)/0.6215-1760*145.45)/(0.5*1760+0.5*6)
=     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*1760+6)*6)=                                21.82 mm

Maximum Diameter of Unreinforced Opening
dmax = MAX( dmax1, dmax2) =MAX(0,21.82)=                  21.82 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 =5.56=                                        5.5596 mm

Required Minimum End Thickness Incl.Allow. :
emina = emin + c + th =5.56+1+0=                          6.5600 mm
```

Internal Pressure emina=6.56 <= en=7[mm]	93.7%	OK

```
Minimum Thickness of Straight Flange Incl.Corr. :
ecyla = ecyl + c =4.58+1=                                 5.5800 mm
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

```
Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.9242=                                                  0.9242 MPa
```

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=0.6768= 0.6768 MPa

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

Pmax (is the least of Ps, Py, Pb and Pcyl) = Pmax
=1.37= 1.3654 MPa

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

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
Ptmin = 1.25 * Pd * f20 / f =1.25*0.6*170.83/148.67= 0.8618 MPa

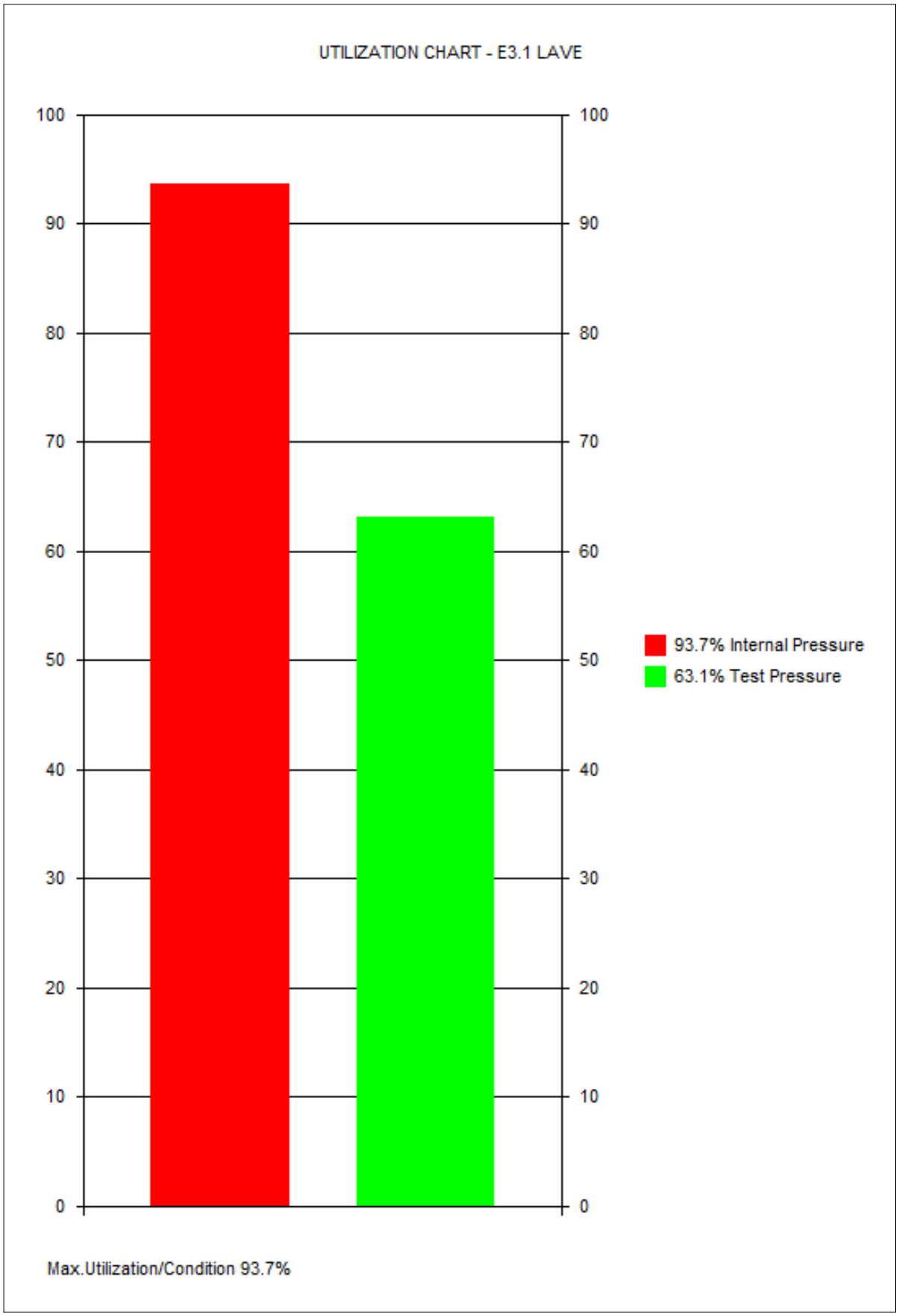
Ptmin = 1.43 * Pd =1.43*0.6= 0.8580 MPa

Test Pressure Ptmin=0.8618 <= Ptmax=1.37[MPa]	63.1%	OK

Maximum diameter of Opening Not Requiring Reinforcement Check , dmax

Maximum Diameter of Unreinforced Opening
dmax = MAX(dmax1, dmax2) =MAX(0,21.82)= 21.82 mm

Volume:1.47 m3 Weight:298 kg (SG= 7.85)


UTILIZATION CHART - E3.1 LAVE
100
90
80
70
60
50
40
30
20
10
0
93.7% Internal Pressure
63.1% Test Pressure
Max.Utilization/Condition 93.7%