

ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

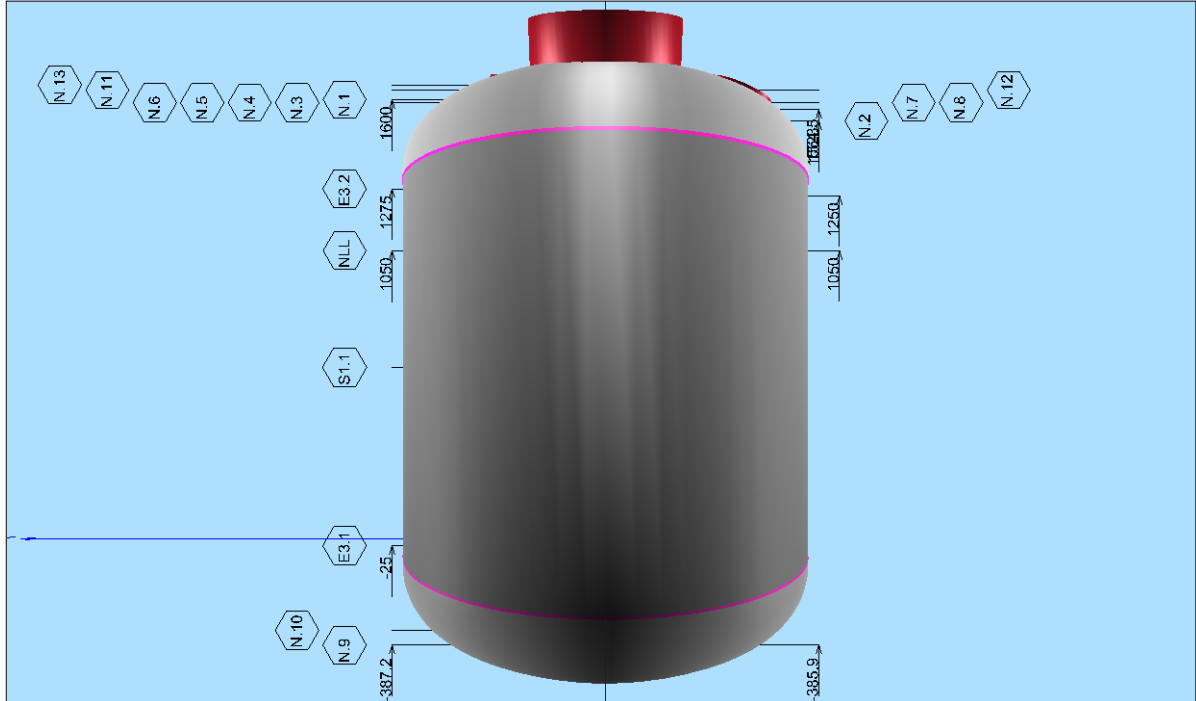
49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS

Rev.:A

(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	0.4
External Design Pressure (MPa)	MPa	0
Hydrotest Pressure (MPa)	MPa	0.63
Maximum Design Temperature (°C)	°C	132
Minimum Design Temperature (°C)	°C	0
Operating Temperature (°C)	°C	
Corrosion Allowance (mm)	mm	0
Content of Vessel		
Specific Density of Oper.Liq		1.1
Normal Liquid Level NLL (mm)	mm	1050

Weight & Volume of Vessel

ID	No.	Wt-UnFinish.	Wt-Finished	Tot. Volume	Test. Liq. Wt	Oper. Liq. Wt
E3.1	1	109.0 kg	106.6 kg	0.400 m3	400.0 kg	440.3 kg
E3.2	1	145.0 kg	130.1 kg	0.401 m3	401.0 kg	0.0 kg
N.1	1	6.0 kg	6.0 kg	0.017 m3	17.0 kg	0.0 kg
N.10	1	2.0 kg	2.0 kg	0.000 m3	0.0 kg	0.2 kg
N.11	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.12	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.13	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.2	1	7.0 kg	7.0 kg	0.001 m3	1.0 kg	0.0 kg
N.3	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.4	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.5	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.6	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg

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ID	No.	Wt-UnFinish.	Wt-Finished	Tot.Volume	Test.Liq.Wt	Oper.Liq.Wt
N.7	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.8	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.0 kg
N.9	1	1.0 kg	1.0 kg	0.000 m3	0.0 kg	0.4 kg
S1.1	1	263.0 kg	263.0 kg	1.924 m3	1924.0 kg	1778.0 kg
Total	16	542.0 kg	524.8 kg	2.743 m3	2743.0 kg	2219.0 kg

Weight Summary/Condition	Weights
Empty Weight of Vessel incl. 5% Contingency	551 kg / 0.6 Tons
Total Test Weight of Vessel (Testing with Water)	3294 kg / 3.3 Tons
Total Operating Weight of Vessel	2770 kg / 2.8 Tons

Max. Allowable Pressure MAWP

ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
E3.1	Torispherical End		0.016 MPa	1.242 MPa	0.955 MPa
E3.2	Torispherical End		0.000 MPa	0.695 MPa	0.558 MPa
N.1	Nozzle,Plate Body		0.000 MPa	1.002 MPa	0.787 MPa
N.10	Reinforcement Ring		0.015 MPa	1.462 MPa	1.170 MPa
N.11	Nozzle,Seamless Pipe		0.000 MPa	2.047 MPa	1.644 MPa
N.12	Nozzle,Seamless Pipe		0.000 MPa	2.047 MPa	1.644 MPa
N.13	Nozzle,Seamless Pipe		0.000 MPa	2.055 MPa	1.649 MPa
N.2	Reinforcement Ring		0.000 MPa	3.060 MPa	2.456 MPa
N.3	Nozzle,Seamless Pipe		0.000 MPa	2.116 MPa	1.698 MPa
N.4	Nozzle,Seamless Pipe		0.000 MPa	2.216 MPa	1.779 MPa
N.5	Nozzle,Seamless Pipe		0.000 MPa	2.116 MPa	1.698 MPa
N.6	Nozzle,Seamless Pipe		0.000 MPa	2.116 MPa	1.698 MPa
N.7	Nozzle,Seamless Pipe		0.000 MPa	2.216 MPa	1.779 MPa
N.8	Nozzle,Seamless Pipe		0.000 MPa	2.116 MPa	1.698 MPa
N.9	Reinforcement Ring		0.016 MPa	1.172 MPa	0.937 MPa
S1.1	Cylindrical Shell	Main Shell	0.011 MPa	1.183 MPa	0.947 MPa
	MAWP			0.695 MPa	0.558 MPa

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

Note : The value for MAWP is at top of vessel, with static liquid head subtracted.

Test Pressure

TEST PRESSURE OF VESSEL - NEW & COLD - VERTICAL

Design Pressure..... : 0.400 MPa

Specified Test Pressure..... : 0.630 MPa

Design Temperature..... : 132.0 C

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
E3.1	Torispherical End-	0.416	1.959	0.623	0.022	0.623	1.937
E3.2	Torispherical End-	0.400	1.043	0.623	0.006	0.623	1.037
GO.1	Nozzle Group: N.1 - N.3 Located in:E3.2 Torispherical End	0.400	1.791	NA	0.00	NA	1.791
GO.1	Nozzle Group: N.9 - N.10 Located in:E3.1 Torispherical End	0.416	1.946	NA	0.0140	NA	1.932
N.1	Nozzle,Plate Body-	0.400	1.504	NA	0.005	NA	1.498
N.10	Reinforcement Ring-	0.415	2.215	NA	0.021	NA	2.194
N.11	Nozzle,Seamless Pipe-	0.400	3.069	NA	0.003	NA	3.067
N.12	Nozzle,Seamless Pipe-	0.400	3.069	NA	0.003	NA	3.067
N.13	Nozzle,Seamless Pipe-	0.400	3.080	NA	0.003	NA	3.077
N.2	Reinforcement Ring-	0.400	4.591	NA	0.002	NA	4.588
N.3	Nozzle,Seamless Pipe-	0.400	3.172	NA	0.003	NA	3.169
N.4	Nozzle,Seamless Pipe-	0.400	3.322	NA	0.003	NA	3.319
N.5	Nozzle,Seamless Pipe-	0.400	3.172	NA	0.003	NA	3.169
N.6	Nozzle,Seamless Pipe-	0.400	3.172	NA	0.003	NA	3.169
N.7	Nozzle,Seamless Pipe-	0.400	3.322	NA	0.003	NA	3.319
N.8	Nozzle,Seamless Pipe-	0.400	3.172	NA	0.003	NA	3.169
N.9	Reinforcement Ring-	0.416	1.781	NA	0.023	NA	1.759
S1.1	Cylindrical Shell-Main Shell	0.411	2.108	0.623	0.019	0.623	2.090

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PtReq = MAX(MIN(PtTop), 1.43*p)= 0.6232 MPa (EN13445-5, 10.2.3.3.1-1 & 2)
HYDRO-TEST
 REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Hydro Test): 0.6232 MPa
 MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Hydro Test): 1.0367 MPa
PNEUMATIC TEST
 REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ...: 0.6389 MPa
 MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...: 1.0430 MPa
 TEST PRESSURE OF: 0.630 MPa AT TOP OF VESSEL IS OK FOR ABOVE COMPONENTS.
 Note : Other components may limit Ptlim than the ones checked above.

TEST PRESSURE OF VESSEL - NEW & COLD - HORIZONTAL

Design Pressure.....: 0.400 MPa
 Specified Test Pressure.....: 0.630 MPa
 Design Temperature.....: 132.0 C

ID	Description	Pdesign	PtMax	PtMin	Wat.Head	PtTop	PtTopMax
E3.1	Torispherical End-	0.416	1.959	0.623	0.008	0.623	1.951
E3.2	Torispherical End-	0.400	1.043	0.623	0.015	0.623	1.028
GO.1	Nozzle Group: N.1 - N.3 Located in:E3.2 Torispherical End	0.400	1.791	NA	0.00	NA	1.791
N.10	Reinforcement Ring-	0.415	2.215	NA	0.006	NA	2.209
N.11	Nozzle,Seamless Pipe-	0.400	3.069	NA	0.003	NA	3.066
N.12	Nozzle,Seamless Pipe-	0.400	3.069	NA	0.008	NA	3.061
N.13	Nozzle,Seamless Pipe-	0.400	3.080	NA	0.010	NA	3.070
N.2	Reinforcement Ring-	0.400	4.591	NA	0.011	NA	4.580
N.3	Nozzle,Seamless Pipe-	0.400	3.172	NA	0.001	NA	3.171
N.4	Nozzle,Seamless Pipe-	0.400	3.322	NA	0.000	NA	3.322
N.5	Nozzle,Seamless Pipe-	0.400	3.172	NA	0.007	NA	3.165
N.6	Nozzle,Seamless Pipe-	0.400	3.172	NA	0.012	NA	3.160
N.7	Nozzle,Seamless Pipe-	0.400	3.322	NA	0.009	NA	3.313
N.8	Nozzle,Seamless Pipe-	0.400	3.172	NA	0.008	NA	3.164
N.9	Reinforcement Ring-	0.416	1.781	NA	0.008	NA	1.773
S.1.1	Cylindrical Shell-Main Shell	0.411	2.108	0.623	0.015	0.623	2.093

PtReq = MAX(MIN(PtTop), 1.43*p)= 0.6232 MPa (EN13445-5, 10.2.3.3.1-1 & 2)
 PhydOper = 0.0157 MPa PhydTest = 0.0149 MPa
 PtReq = PtReq + (PhydOper-PhydTest) (EN13445-5, 10.2.3.3.1-3)

HYDRO-TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Hydro Test): 0.6239 MPa
 MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Hydro Test): 1.0280 MPa

PNEUMATIC TEST

REQUIRED TEST PRESSURE AT TOP OF VESSEL PtReq(Pneumatic Test) ...: 0.6396 MPa
 MAXIMUM TEST PRESSURE AT TOP OF VESSEL PtLim(Pneumatic Test) ...: 1.0430 MPa

TEST PRESSURE OF: 0.630 MPa AT TOP OF VESSEL IS OK FOR ABOVE COMPONENTS.
 Note : Other components may limit Ptlim than the ones checked above.

NOMENCLATURE:

Pdesign- is the design pressure including liquid head at the part under consideration.
 PtMax - is the maximum allowed test pressure determined at the part under consideration.
 PtMin - is the required test pressure determined at the part under consideration.
 Wat.Head - is the water head during hydrotesting at the part under consideration.
 PtBot - is the required test pressure at bottom of the vessel, for the part under consideration.
 PtTop - is the required test pressure at top of the vessel, for the part under consideration.
 PtTopMax - is the maximum test pressure allowed at top of the vessel, for the part under consideration.
 PtReq - is the required minimum test pressure (minimum value of PtTop) at top of vessel for the listed components.
 PtLim - is the maximum allowed test pressure (minimum value for PtTopMax) at top of vessel for the listed components.

EN13445-5 10.2.3.3.8 Pressure of vessels under test shall be gradually increased to a value of approximately 50 % of the specified test pressure, thereafter the pressure shall be increased in stages of approximately 10 % of the specified test pressure until this is reached. The required test pressure shall be maintained for

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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.

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S1.1

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

GENERAL DESIGN DATA

PRESSURE LOADING: Design Component for Internal Pressure Only
PROCESS CARD:
General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000
LIQUID HEAD.....:LH 1050.00 mm

SHELL DATA

CYLINDER FABRICATION: Plate Material
WELD JOINT COEFFICIENT: Testing Group 3 (z=0.85)
DIAMETER INPUT: Base Design on Shell Inside Diameter
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
INSIDE SHELL DIAMETER (corroded).....:Di 1400.00 mm
LENGTH OF CYLINDRICAL PART OF SHELL.....:Lcyl 1250.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 6.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.3000 mm
Calculate minimum shell thickness due to internal pressure at different elevations
with steps of 1000 mm.: NO
Split shell into several shell courses and include welding information: NO

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

7.4.2 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

Required Minimum Shell Thickness Excl.Allow. emin : 2.3727 mm
 $emin = Di * P / (2 * f * z - P) (7.4-1) =$
Required Minimum Shell Thickness Incl.Allow. : 2.6727 mm
 $emina = emin + c + NegDev =$
Analysis Thickness 5.7000 mm
 $ea = en - c - NegDev =$

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

Outside Diameter of Shell
 $De = Di + 2 * (ea + NegDev) =$ 1412.00 mm
Mean Diameter of Shell
 $Dm = (De + Di) / 2 =$ 1406.00 mm
MAWP HOT & CORR. (Corroded condition at design temp.)
 $MAWPHC = 2 * f * z * ea / Dm =$ 0.9585 MPa
MAWP NEW & COLD (Uncorroded condition at ambient temp.)
 $MAWPNC = 2 * f20 * z * (ea + c) / Dm =$ 1.1946 MPa

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

$Ptmax = 2 * ftest * ztest * (ea + c) / Dm =$ 2.1081 MPa

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

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
 $Ptmin = 1.25 * Pd * f20 / f =$ 0.6232 MPa
 $Ptmin = 1.43 * Pd =$ 0.5720 MPa

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EN13445:2014 Issue 3:2016 - 7.4.2 CYLINDRICAL SHELL
S1.1

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Inside Radius of Shell

$$ris = Di / 2 (9.5-3) = 700.00 \text{ mm}$$

Length of Shell Contributing to Reinforcement

$$Is = Sqr((2 * ris + ea) * ea) (9.5-2) = 89.51 \text{ mm}$$

Maximum Diameter of Unreinforced Opening in Shell Checked to Rules in Section 9

$$dmax1 = MIN(0.5 * Di, (ea * Is * (f - 0.5 * P) / (P - ris * Is)) / (0.5 * ris + 0.5 * ea)) (9.5-7, 22, 23) \\ = 324.44 \text{ mm}$$

Maximum diameter of Opening Not Requiring Reinforcement Check

$$dmax2 = 0.15 * Sqr((2 * ris + ea) * ea) (9.5-18) = 13.43 \text{ mm}$$

Maximum Diameter of Unreinforced Opening

$$dmax = MAX(dmax1, dmax2) = 324.44 \text{ mm}$$

EN13445-4 Sect. 9.2 Ratio of Deformation

$$F = en / Dm * 100 (9.2-2) = 0.4267 \%$$

NOTE: EN13445-4, 5.4.2 Maximum out of roundness for vessels subjected to internal pressure: 1.5% for the ratio of $e_{min}/D_m > 0.01$

CALCULATION SUMMARY

7.4.2 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

Required Minimum Shell Thickness Excl.Allow. e_{min} :

$$e_{min} = Di * P / (2 * f * z - P) (7.4-1) = 2.3727 \text{ mm}$$

Required Minimum Shell Thickness Incl.Allow. :

$$e_{minA} = e_{min} + c + NegDev = 2.6727 \text{ mm}$$

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

$$P_{tmax} = 2 * f_{test} * z_{test} * (ea + c) / Dm = 2.1081 \text{ MPa}$$

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE: P_{tmin}

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3

$$P_{tmin} = 1.25 * Pd * f_{20} / f = 0.6232 \text{ MPa}$$

$$P_{tmin} = 1.43 * Pd = 0.5720 \text{ MPa}$$

MAXIMUM DIAMETER OF UNREINFORCED OPENING IN SHELL

Maximum Diameter of Unreinforced Opening

$$dmax = MAX(dmax1, dmax2) = 324.44 \text{ mm}$$

Volume:1.92 m3 Weight:262.7 kg (SG= 7.93)

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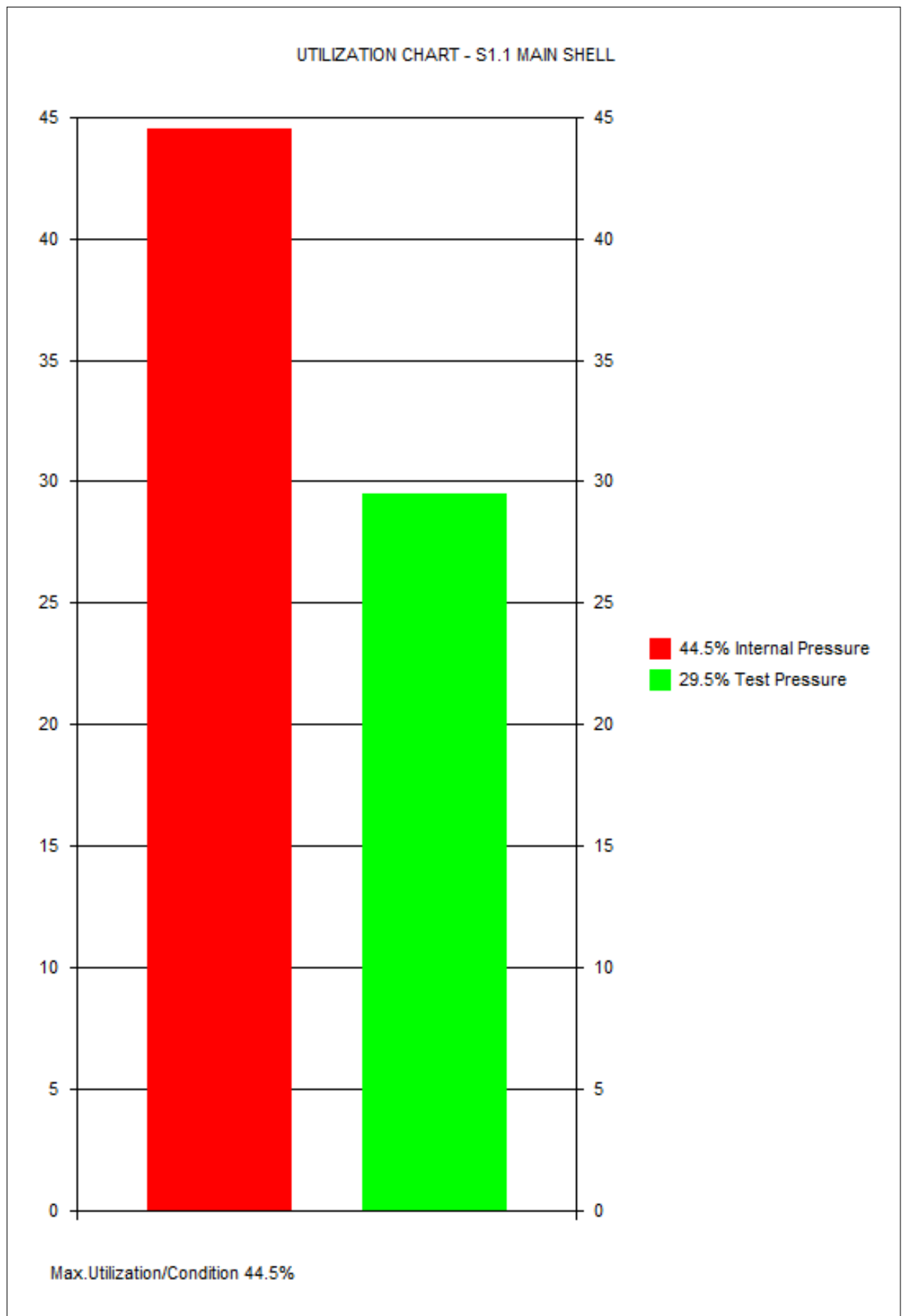
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 E3.1 ConnID:S1.1

INPUT DATA

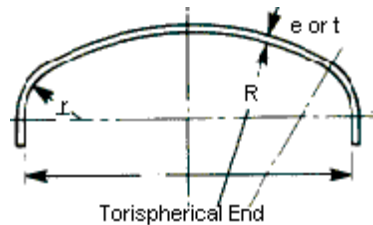
COMPONENT ATTACHMENT/LOCATION

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

GENERAL DESIGN DATA

PRESSURE LOADING: Design Component for Internal Pressure Only
 PROCESS CARD:
 General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa
 SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000
 LIQUID HEAD.....:LH 1438.87 mm

DIMENSIONS OF END



Type of Torispherical End: Dished End KORBBOGEN DIN 28013-28014/SMS 482
 WELD JOINT COEFFICIENT: Testing Group 3 (z=0.85)
 OUTSIDE DIAMETER OF CYLINDRICAL FLANGE OF END.....:De 1412.00 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 6.0000 mm
 Include calculation of forming during fabrication to EN13445-4 Section 9.: NO

MATERIAL DATA FOR END

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
 Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
 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

$$e_s = P * R / (2 * f * z - 0.5 * P) \quad (7.5-1) = \underline{1.9128 \text{ mm}}$$

$$f_b = R_{pt02} / 1.5 \quad (7.5-4) = 104.69 \text{ N/mm}^2$$

 Required Thickness of Knuckle to Avoid Plastic Buckling

$$e_b = (0.75 * R + 0.2 * D_i) * ((P / (111 * f_b)) * (D_i / r)^{0.825})^{(0.667)} \quad (7.5-3)$$

$$= \underline{3.3121 \text{ mm}}$$

7.5.3.5 Formulas for Calculation of Factor Beta

$$Y = \text{MIN}(e_{min} / R, 0.04) \quad (7.5-9) = 0.0023$$

$$Z = \text{LOG}(1 / Y) \quad (7.5-10) = 2.6472$$

$$X = r / D_i \quad (7.5-11) = 0.1546$$

$$N = 1.006 - 1 / (6.2 + (90 * Y)^4) \quad (7.5-12) = 0.8448$$

$$\text{Beta01} = N * (-0.1833 * Z^3 + 1.0383 * Z^2 - 1.2943 * Z + 0.837) \quad (7.5-15) = 1.0867$$

$$\text{Beta02} = \text{MAX}(0.5, 0.95 * (0.56 - 1.94 * Y - 82.5 * Y^2)) \quad (7.5-17)$$

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E3.1 ConnID:S1.1

= 0.5274
 $\beta = 10 * ((0.2 - X) * \beta_{01} + (X - 0.1) * \beta_{02})$ (7.5-16)
= 0.7816
Required Thickness of Knuckle to Avoid Axisymmetric Yielding
 $e_y = \beta * P * (0.75 * R + 0.2 * D_i) / f$ (7.5-2) = 2.5372 mm
Required Minimum End Thickness Excl.Allow. e_{min} :
 $e_{min} = e_{min}$ = 3.3121 mm
Required Minimum End Thickness Incl.Allow. :
 $e_{min_a} = e_{min} + c + t_h$ = 3.3100 mm
Analysis Thickness
 $e_a = e_n - c - t_h$ = 6.0000 mm
Inside Diameter of Shell
 $D_i = D_e - 2 * (e_n - c)$ = 1400.00 mm
Mean Diameter of Shell
 $D_m = (D_e + D_i) / 2 =$ 1406.00 mm

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

$L_{lim} = 0.2 * \sqrt{D_i * e_{min}}$ = 13.62 mm
Since $L_{cyl} > L_{lim}$, Required Thickness of Straight Cylindrical Flange to 7.4.2
Minimum Thickness of Straight Flange Excl. Allow.
 $e_{cyl} = P * D_i / (2 * f * z - P)$ (7.4-1) = 2.3727 mm
Minimum Thickness of Straight Flange Incl.Corr. :
 $e_{cyl_a} = e_{cyl} + c =$ 2.3700 mm

7.5.3.1 Conditions of Applicability - Torispherical Ends

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

$P_s = 2 * f * z * e_a / (R + 0.5 * e_a)$ (7.5-6) = 1.5610 MPa
 $P_y = f * e_a / (\beta * (0.75 * R + 0.2 * D_i))$ (7.5-7) = 1.3060 MPa
 $P_B = 111 * f_b * (e_a / (0.75 * R + 0.2 * D_i))^{1.5} * (r / D_i)^{0.825}$ (7.5-8) = 1.6077 MPa
 $P_{cyl} = 2 * e_a * f * z / (D_i + e_a) =$ 1.2574 MPa
 P_{max} (is the least of P_s, P_y, P_b and P_{cyl}) = $P_{max} =$ 1.2574 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

$P_s = 2 * f * z * e_a / (R + 0.5 * e_a)$ (7.5-6) = 1.2524 MPa
 $P_y = f * e_a / (\beta * (0.75 * R + 0.2 * D_i))$ (7.5-7) = 1.0478 MPa
 $P_B = 111 * f_b * (e_a / (0.75 * R + 0.2 * D_i))^{1.5} * (r / D_i)^{0.825}$ (7.5-8) = 0.9710 MPa
 $P_{cyl} = 2 * e_a * f * z / (D_i + e_a) =$ 1.0089 MPa
 P_{max} (is the least of P_s, P_y, P_b and P_{cyl}) = $P_{max} =$ 0.9710 MPa

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

$P_s = 2 * f * z * e_a / (R + 0.5 * e_a)$ (7.5-6) = 2.7547 MPa
 $P_y = f * e_a / (\beta * (0.75 * R + 0.2 * D_i))$ (7.5-7) = 1.9590 MPa
 $P_B = 111 * f_b * (e_a / (0.75 * R + 0.2 * D_i))^{1.5} * (r / D_i)^{0.825}$ (7.5-8) = 2.2967 MPa
 $P_{cyl} = 2 * e_a * f * z / (D_i + e_a) =$ 2.2191 MPa
 P_{max} (is the least of P_s, P_y, P_b and P_{cyl}) = $P_{max} =$ 1.9590 MPa

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE: P_{tmin}

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3
 $P_{tmin} = 1.25 * P_d * f_{20} / f =$ 0.6232 MPa
 $P_{tmin} = 1.43 * P_d =$ 0.5720 MPa

Maximum diameter of Opening Not Requiring Reinforcement Check , d_{max}

$r_{is} = R$ (9.5-4) = 1129.60 mm
Length of Shell Contributing to Reinforcement
 $I_s = \sqrt{(2 * r_{is} + e_a) * e_a}$ (9.5-2) = 116.58 mm
Maximum Diameter of Unreinforced Opening in Shell Checked to Rules in Section 9
 $d_{max1} = \text{MIN}(0.5 * D_i, (e_a * I_s * (f - 0.5 * P) / (P - r_{is} * I_s)) / (0.5 * r_{is} + 0.5 * e_a))$ (9.5-7, 22, 23)
= 195.76 mm
Maximum diameter of Opening Not Requiring Reinforcement Check

ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

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E3.1 ConnID:S1.1

$$d_{max2} = 0.15 * \text{Sqr}((2 * r_{is} + e_a) * e_a) (9.5-18) = \underline{\underline{17.49 \text{ mm}}}$$

Maximum Diameter of Unreinforced Opening

$$d_{max} = \text{MAX}(d_{max1}, d_{max2}) = \underline{\underline{195.76 \text{ mm}}}$$

CALCULATION SUMMARY

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

7.5.3.2 Required Minimum End Thickness

Required Minimum End Thickness Excl.Allow. e_{min} :

$$e_{min} = e_{min} = \underline{\underline{3.3121 \text{ mm}}}$$

Required Minimum End Thickness Incl.Allow. :

$$e_{min_a} = e_{min} + c + t_h = \underline{\underline{3.3100 \text{ mm}}}$$

Minimum Thickness of Straight Flange Incl.Corr. :

$$e_{cyl_a} = e_{cyl} + c = \underline{\underline{2.3700 \text{ mm}}}$$

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

$$P_{max} (\text{is the least of } P_s, P_y, P_b \text{ and } P_{cyl}) = P_{max} = \underline{\underline{1.2574 \text{ MPa}}}$$

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

$$P_{max} (\text{is the least of } P_s, P_y, P_b \text{ and } P_{cyl}) = P_{max} = \underline{\underline{0.9710 \text{ MPa}}}$$

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

$$P_{max} (\text{is the least of } P_s, P_y, P_b \text{ and } P_{cyl}) = P_{max} = \underline{\underline{1.9590 \text{ MPa}}}$$

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE: P_{tmin}

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3

$$P_{tmin} = 1.25 * P_d * f_{20} / f = \underline{\underline{0.6232 \text{ MPa}}}$$

$$P_{tmin} = 1.43 * P_d = \underline{\underline{0.5720 \text{ MPa}}}$$

Maximum diameter of Opening Not Requiring Reinforcement Check , d_{max}

Maximum Diameter of Unreinforced Opening

$$d_{max} = \text{MAX}(d_{max1}, d_{max2}) = \underline{\underline{195.76 \text{ mm}}}$$

Volume:0.4003 m3 Weight:108.1 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

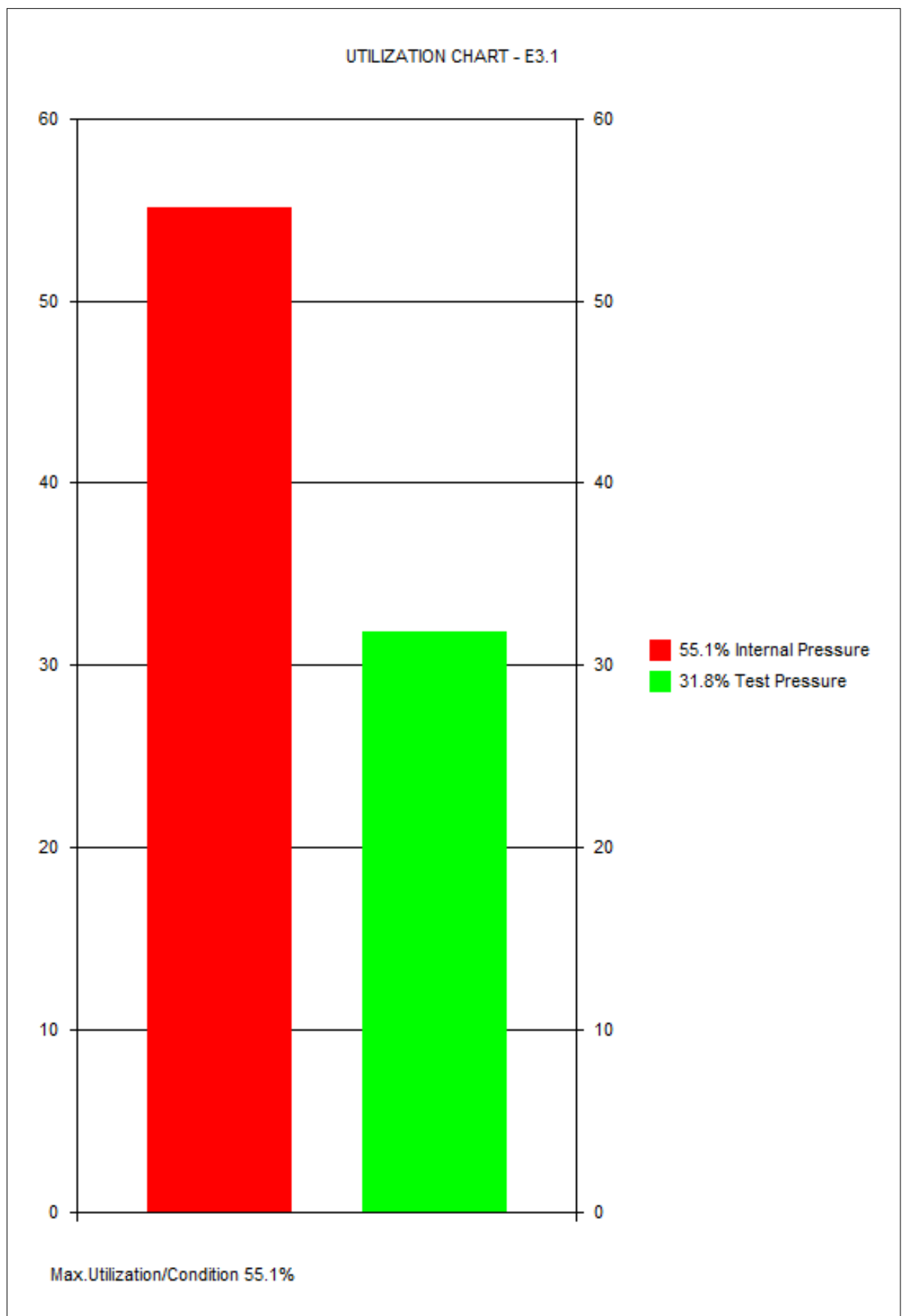
49 Reactor, Volume 2000 L

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Rev.:A

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E3.1 ConnID:S1.1



ORION.GROUP LLC

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E3.2 ConnID:S1.1

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: S1.1 Cylindrical Shell Main Shell
Location: Along z-axis z1= 1250

GENERAL DESIGN DATA

PRESSURE LOADING: Design Component for Internal Pressure Only

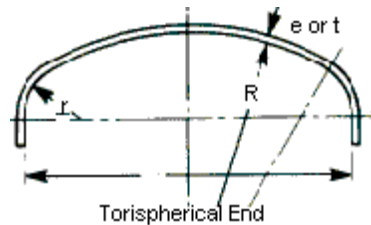
PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

LIQUID HEAD.....:LH 0.00 mm

DIMENSIONS OF END



Type of Torispherical End: Dished End KORBOGEN DIN 28013-28014/SMS 482
WELD JOINT COEFFICIENT: Testing Group 3 (z=0.85)
OUTSIDE DIAMETER OF CYLINDRICAL FLANGE OF END.....:De 1416.00 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 8.0000 mm
Include calculation of forming during fabrication to EN13445-4 Section 9.: NO

MATERIAL DATA FOR END

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
Material & Delivery Form: NOT Cold Spun Seamless Austenitic Stainless Steel

NOZZLES IN KNUCKLE REGION TO SECTION 7.7

Nozzles In Knuckle Region: YES
LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

7.7 Nozzles Which Encroach Into the Knuckle Region

$$\begin{aligned} V &= \text{LOG}(1000 * P / f) \quad (7.7.7) = 0.4588 \\ A &= 0.54 + 0.41 * V - 0.044 * V^3 \quad (7.7.8) = 0.7239 \\ B &= 7.77 - 4.53 * V + 0.744 * V^2 \quad (7.7.9) = 5.8481 \\ \text{BetaK} &= \text{MAX}(A + B * \text{dib} / \text{De}, 1 + 0.5 * B * \text{dib} / \text{De}) \quad (7.7.10) \\ &= 2.6154 \end{aligned}$$

7.5.3 - TORISPHERICAL ENDS UNDER INTERNAL PRESSURE

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7.5.3.2 Required Minimum End Thickness

Required Thickness of End to Limit Membrane Stress in Central Part
 $e_s = P * R / (2 * f * z - 0.5 * P) \text{ (7.5-1)} = \underline{1.9182 \text{ mm}}$
 $f_b = R_{pt02} / 1.5 \text{ (7.5-4)} = 104.69 \text{ N/mm}^2$
 Required Thickness of Knuckle to Avoid Plastic Buckling
 $e_b = (0.75 * R + 0.2 * D_i) * ((P / (111 * f_b)) * (D_i / r)^{0.825})^{(0.667)} \text{ (7.5-3)}$
 $= \underline{3.3140 \text{ mm}}$
 7.5.3.5 Formulas for Calculation of Factor Beta
 $Y = \text{MIN}(e_{min} / R, 0.04) \text{ (7.5-9)} = 0.0053$
 $Z = \text{LOG}(1 / Y) \text{ (7.5-10)} = 2.2758$
 $X = r / D_i \text{ (7.5-11)} = 0.1553$
 $N = 1.006 - 1 / (6.2 + (90 * Y)^4) \text{ (7.5-12)} = 0.8460$
 $\text{Beta01} = N * (-0.1833 * Z^3 + 1.0383 * Z^2 - 1.2943 * Z + 0.837) \text{ (7.5-15)} = 0.9379$
 $\text{Beta02} = \text{MAX}(0.5, 0.95 * (0.56 - 1.94 * Y - 82.5 * Y^2)) \text{ (7.5-17)}$
 $= 0.5200$
 $\text{beta} = 10 * ((0.2 - X) * \text{Beta01} + (X - 0.1) * \text{Beta02}) \text{ (7.5-16)}$
 $= 0.7067$
 Required Thickness of Knuckle to Avoid Axisymmetric Yielding
 $e_y = \text{beta} * \text{BetaK} * P * (0.75 * R + 0.2 * D_i) / f \text{ (7.5-2)} = \underline{6.0097 \text{ mm}}$
 Required Minimum End Thickness Excl.Allow. e_{min} :
 $e_{min} = e_{min} = \underline{\underline{6.0097 \text{ mm}}}$
 Required Minimum End Thickness Incl.Allow. :
 $e_{minA} = e_{min} + c + t_h = \underline{\underline{6.0100 \text{ mm}}}$
 Analysis Thickness
 $e_a = e_n - c - t_h = 8.0000 \text{ mm}$
 Inside Diameter of Shell
 $D_i = D_e - 2 * (e_n - c) = 1400.00 \text{ mm}$
 Mean Diameter of Shell
 $D_m = (D_e + D_i) / 2 = 1408.00 \text{ mm}$

7.5.3.4 - Required Minimum Thickness of Straight Cylindrical Flange

$L_{lim} = 0.2 * \text{SQR}(D_i * e_{min}) = 18.35 \text{ mm}$
 Since $L_{cyl} > L_{lim}$, Required Thickness of Straight Cylindrical Flange to 7.4.2
 Minimum Thickness of Straight Flange Excl. Allow.
 $e_{cyl} = P * D_i / (2 * f * z - P) \text{ (7.4-1)} = \underline{2.3727 \text{ mm}}$
 Minimum Thickness of Straight Flange Incl.Corr. :
 $e_{cylA} = e_{cyl} + c = \underline{\underline{2.3700 \text{ mm}}}$

7.7.2 Conditions of Applicability - Nozzles in Knuckle Region

- » - The nozzle centre-line shall lie between normal to the wall of the end and parallel to the vessel centre-line.
- » - The location of the nozzle shall be such that it does not cross the tangentline between knuckle and cylinder.
- » - Nozzles parallel to the vessel centre line and with outside diameter in line with the outside diameter of the vessel are included in these requirements.
- » - Welded on compensation is not permitted.
- » - When the distance between the edge of the nozzle where it meets the knuckle and the knuckle/cylinder tan line is less than $2.5 * \text{SQR}(e * r) = 90.5 \text{ mm}$ the validit
- » Minimum distance between edge of nozzle and the knuckle/cylinder tangent line:
 Along Surface
 $\text{MinSurfDist} = 2.5 * \text{Sqr}(e_{min} * r) = 90.50 \text{ mm}$
 In Radial Direction
 $\text{MinRadDist} = (1 - \text{Cos}(\text{MinSurfDist} / r)) * r = \underline{18.51 \text{ mm}}$

7.5.3.1 Conditions of Applicability - Torispherical Ends

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

$P_s = 2 * f * z * e_a / (R + 0.5 * e_a) \text{ (7.5-6)} = 2.0736 \text{ MPa}$
 $P_y = f * e_a / (\text{beta} * \text{BetaK1} * (0.75 * R + 0.2 * D_i)) \text{ (7.5-7)}$
 $= 0.6953 \text{ MPa}$
 $P_B = 111 * f_b * (e_a / (0.75 * R + 0.2 * D_i))^{1.5} * (r / D_i)^{0.825} \text{ (7.5-8)} = 2.4730 \text{ MPa}$
 $P_{cyl} = 2 * e_a * f * z / (D_i + e_a) = 1.6742 \text{ MPa}$

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P_{max} (is the least of P_s , P_y , P_b and P_{cyl}) = P_{max} = 0.6953 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

$P_s = 2 * f * z * ea / (R + 0.5 * ea)$ (7.5-6) = 1.6638 MPa
 $P_y = f * ea / (\beta * \beta_{K1} * (0.75 * R + 0.2 * Di))$ (7.5-7) = 0.5579 MPa
 $P_b = 111 * f_b * (ea / (0.75 * R + 0.2 * Di))^{1.5} * (r/Di)^{0.825}$ (7.5-8) = 1.4937 MPa
 $P_{cyl} = 2 * ea * f * z / (Di + ea)$ = 1.3433 MPa
 P_{max} (is the least of P_s , P_y , P_b and P_{cyl}) = P_{max} = 0.5579 MPa

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

$P_s = 2 * f * z * ea / (R + 0.5 * ea)$ (7.5-6) = 3.6594 MPa
 $P_y = f * ea / (\beta * \beta_{K1} * (0.75 * R + 0.2 * Di))$ (7.5-7) = 1.0430 MPa
 $P_b = 111 * f_b * (ea / (0.75 * R + 0.2 * Di))^{1.5} * (r/Di)^{0.825}$ (7.5-8) = 3.5329 MPa
 $P_{cyl} = 2 * ea * f * z / (Di + ea)$ = 2.9545 MPa
 P_{max} (is the least of P_s , P_y , P_b and P_{cyl}) = P_{max} = 1.0430 MPa

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE: P_{tmin}

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3

$P_{tmin} = 1.25 * P_d * f_{20} / f$ = 0.6232 MPa

$P_{tmin} = 1.43 * P_d$ = 0.5720 MPa

Maximum diameter of Opening Not Requiring Reinforcement Check , d_{max}

$r_{is} = R$ (9.5-4) = 1132.80 mm
Length of Shell Contributing to Reinforcement
 $I_s = \sqrt{(2 * r_{is} + ea) * ea}$ (9.5-2) = 134.87 mm
Maximum Diameter of Unreinforced Opening in Shell Checked to Rules in Section 9
 $d_{max1} = \text{MIN}(0.5 * Di, (ea * I_s * (f - 0.5 * P) / (P - r_{is} * I_s)) / (0.5 * r_{is} + 0.5 * ea))$ (9.5-7, 22, 23) = 388.85 mm
Maximum diameter of Opening Not Requiring Reinforcement Check
 $d_{max2} = 0.15 * \sqrt{(2 * r_{is} + ea) * ea}$ (9.5-18) = 20.23 mm
Maximum Diameter of Unreinforced Opening
 $d_{max} = \text{MAX}(d_{max1}, d_{max2})$ = 388.85 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. e_{min} :
 $e_{min} = e_{min}$ = 6.0097 mm

Required Minimum End Thickness Incl.Allow. :
 $e_{min_a} = e_{min} + c + th$ = 6.0100 mm

Minimum Thickness of Straight Flange Incl.Corr. :
 $e_{cyl_a} = e_{cyl} + c$ = 2.3700 mm

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

P_{max} (is the least of P_s , P_y , P_b and P_{cyl}) = P_{max} = 0.6953 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

P_{max} (is the least of P_s , P_y , P_b and P_{cyl}) = P_{max} = 0.5579 MPa

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E3.2 ConnID:S1.1

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

P_{max} (is the least of P_s , P_y , P_b and P_{cyl}) = P_{max} = 1.0430 MPa

EN13445-5;10.2.3.3 REQUIRED MIN.HYDROSTATIC TEST PRESSURE: P_{tmin}

NEW AT AMBIENT TEMP. FOR TEST GROUPS 1, 2 and 3

$P_{tmin} = 1.25 * P_d * f_{20} / f =$ 0.6232 MPa

$P_{tmin} = 1.43 * P_d =$ 0.5720 MPa

Maximum diameter of Opening Not Requiring Reinforcement Check , d_{max}

Maximum Diameter of Unreinforced Opening

$d_{max} = \text{MAX}(d_{max1}, d_{max2}) =$ 388.85 mm

Volume:0.4010 m3 Weight:144.7 kg (SG= 7.93)

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Client : BTL2103

Vessel No.:1403

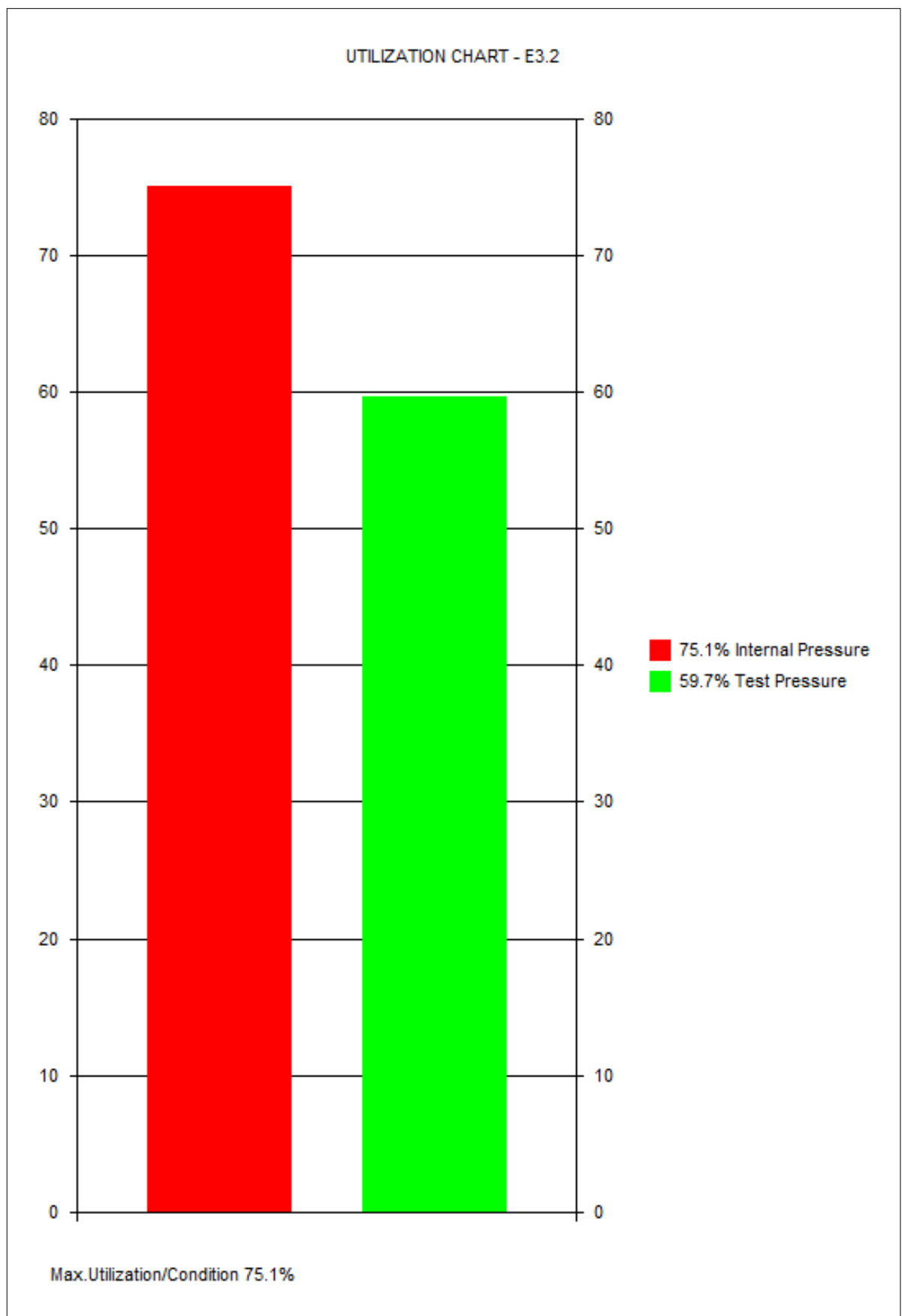
49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS

Rev.:A

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E3.2 ConnID:S1.1



ORION.GROUP LLC

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Vessel No.:1403

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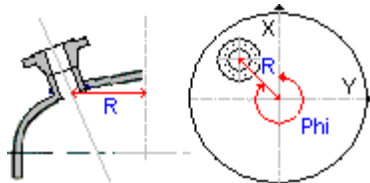
N.1 ConnID:E3.2

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



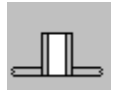
Radial off center

Orientation & Location of Nozzle: Radial to End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 90.00 Degr.

Distance between Center of End and Center of Nozzle.:R 400.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Plate Body

WELD JOINT COEFFICIENT: Testing Group 3 (z=0.85)

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fb=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

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N.1 ConnID:E3.2



Attachment: Set In Flush Nozzle
Shape of Nozzle/Opening: Circular
Nozzle Diameter: Base Design on Nozzle OD
Application:
9.4.6.3 NOT a critical fatigue area, and calc.temp.is outside creep range.
OUTSIDE NOZZLE DIAMETER.....:deb 458.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 4.0000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.3000 mm
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 100.00 mm

WELDING DATA

Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld
Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam
ANGLE BETWN.BRANCH AXIS AND A LINE NORMAL TO MAIN BODY:Phi 0.00 Degr.

DATA FOR REINFORCEMENT PAD



Type of Pad: No Pad

LIMITS OF REINFORCEMENT

Reduction of Limits of Reinforcement: No Reduction Required

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

Shell Analysis Thickness eas
 $eas = en - c - th = 8.0000 \text{ mm}$
Nozzle Analysis Thickness eab
 $eab = enb - cn - NegDev = 3.7000 \text{ mm}$
Reduction of Nozzle Material Strength Due To Nozzle Longitudinal Weld
 $fb = fb * z = 118.21 \text{ N/mm}^2$
 $ris = R (9.5-4) = 1132.80 \text{ mm}$
 $dib = deb - 2 * eab = 450.60 \text{ mm}$
Min.Nozzle Thk.Based on Internal Pressure ebp
 $ebp = P * deb / (2 * fb * z + P) = 0.7700 \text{ mm}$
Allowable Stresses
 $fob = \text{Min}(fs, fb) (9.5-8) = 118.21 \text{ N/mm}^2$

This nozzle is located in the knuckle region outside the limit of $De/10$ (ref.fig.9.5-4).
NOTE: Since this opening/nozzle is located in the knuckle region outside the limit of $De/10$ (ref.fig.9.5-4), it is covered by the calculation of the end E3.2 according to requirements in section 7.7.

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

ORION.GROUP LLC

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Area of Shell Afs

Limit of Reinforcement Along Shell

$$Iso = \text{Sqr}((2 * ris + eas) * eas) = 134.87 \text{ mm}$$

Set In Nozzle

$$Afs = eas * Iso (9.5-79) = 1078.93 \text{ mm}^2$$

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)

$$Ibo = \text{MIN}(\text{Sqr}((deb - eb) * eb), ho) (9.5-76) = 41.00 \text{ mm}$$

Set In Nozzle

$$Afb = eb * (Ibo + Ibi + eas) (9.5-78) = 181.30 \text{ mm}^2$$

Calculation of Pressure Loaded Areas

In the Nozzle Apb

$$Apb = 0.5 * dib * (Ibo + eas) (9.5-84) = 11039.45 \text{ mm}^2$$

Spherical Shell/End on any Section Aps

$$Aps = 0.5 * ris^2 * (Is + a) / (0.5 * eas + ris) (9.5-105) = 2,0626E05 \text{ mm}^2$$

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$$pAReq = P * (Aps + Apb + 0.5 * Apphi) (9.5-7) = 86.92 \text{ kN}$$

Pressure Area Available pA(aval.)

$$pAAval = (Afs + Afb) * (fs - 0.5 * P) + Afp * (fop - 0.5 * P) + Afb * (fob - 0.5 * P) (9.5-7) = 171.23 \text{ kN}$$

Maximum Allowable Pressure Pmax

$$Pmax = (Afs + Afb) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afb + Afp)) (9.5-10) = 0.7869 \text{ MPa}$$

Max.Allowable Test Pressure Ptmx

$$Ptmx = 1.5035 \text{ MPa}$$

Weight of Nozzle: 5.9kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell

$$Iso = \text{Sqr}((2 * ris + eas) * eas) = 134.87 \text{ mm}$$

Limit of Reinforcement Along Nozzle (outside shell)

$$Ibo = \text{MIN}(\text{Sqr}((deb - eb) * eb), ho) (9.5-76) = 41.00 \text{ mm}$$

Pressure Area Required pA(req.)

$$pAReq = P * (Aps + Apb + 0.5 * Apphi) (9.5-7) = 86.92 \text{ kN}$$

Pressure Area Available pA(aval.)

$$pAAval = (Afs + Afb) * (fs - 0.5 * P) + Afp * (fop - 0.5 * P) + Afb * (fob - 0.5 * P) (9.5-7) = 171.23 \text{ kN}$$

Maximum Allowable Pressure Pmax

$$Pmax = (Afs + Afb) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afb + Afp)) (9.5-10) = 0.7869 \text{ MPa}$$

ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.1 ConnID:E3.2

Volume:0.0172 m3 Weight:5.9 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

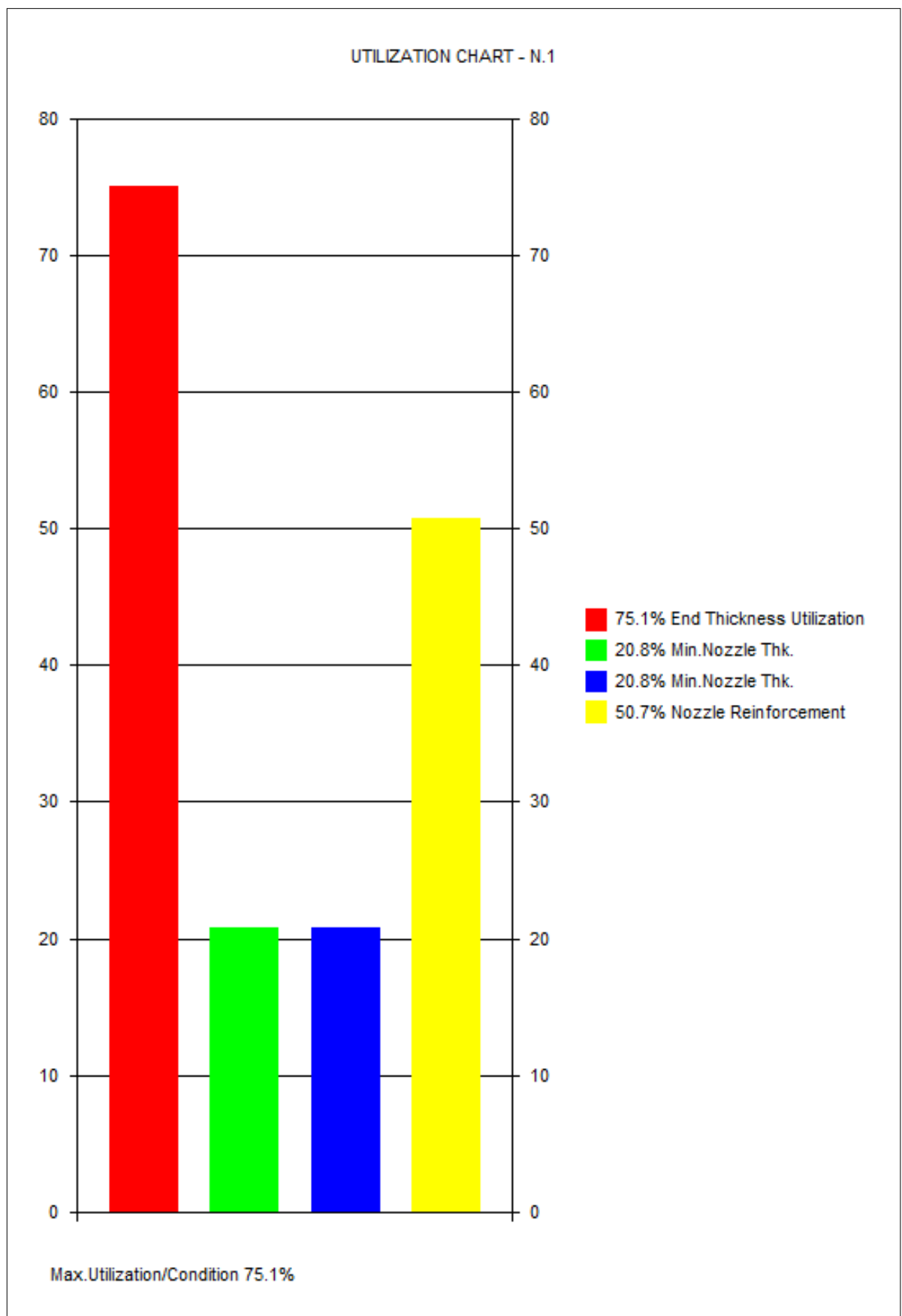
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.1 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.2 ConnID:E3.2

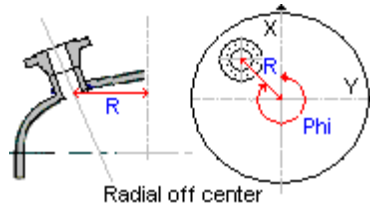
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO

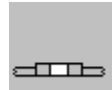


Orientation & Location of Nozzle: Radial to End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 150.00 Degr.

Distance between Center of End and Center of Nozzle.:R 500.00 mm

GENERAL DESIGN DATA



Type of Opening: Opening With Reinforcement Ring

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

RING DATA

Location of closure opening: Outside the shell

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fr=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

WIDTH OF RING (uncorroded).....:Ir 47.50 mm

THICKNESS/HEIGHT OF RING.....:enr 30.00 mm

INSIDE DIAMETER OF RING (corroded).....:dib 125.00 mm

Size of Flange and Nozzle:

Comment (Optional):

ORION.GROUP LLC

Client : BTL2103

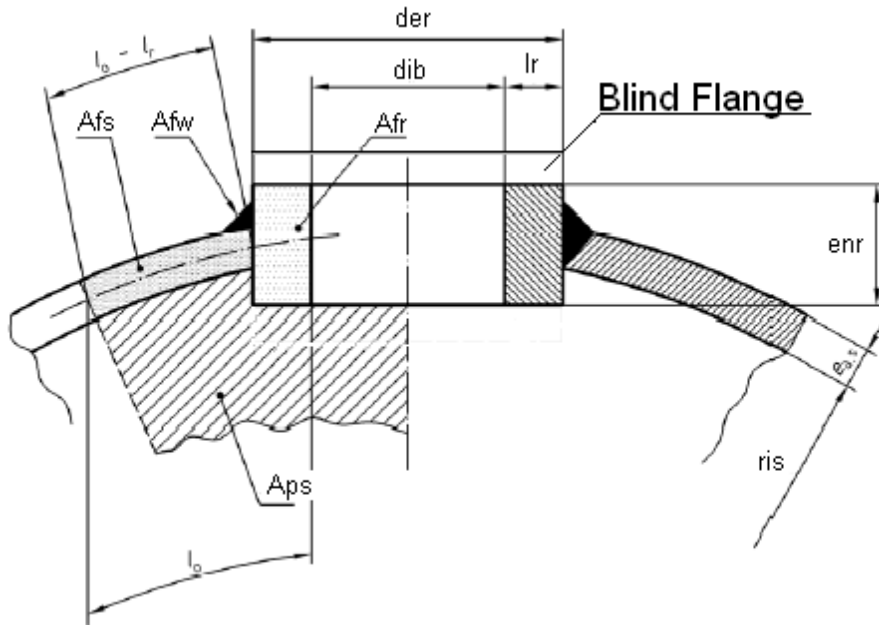
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.2 ConnID:E3.2



WELDING DATA

Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld

WELDING REQUIREMENTS TO EN 1708-1:2010

Comment(Optional):

Type of welded connection: Not Applicable

CALCULATION DATA

PRELIMINARY CALCULATIONS

Shell Analysis Thickness eas	
$eas = en - c - th =$	8.0000 mm
Ring Analysis Thickness ear	
$ear = enr - c =$	30.00 mm
$ris = R (9.5-4) =$	1132.80 mm
Allowable Stresses	
$for/fob = \text{Min}(fs, fb) (9.5-8) =$	139.07 N/mm ²

This nozzle is located in the knuckle region outside the limit of $De/10$ (ref.fig.9.5-4).

NOTE: Since this opening/nozzle is located in the knuckle region outside the limit of $De/10$ (ref.fig.9.5-4), it is covered by the calculation of the end E3.2 according to requirements in section 7.7.

9.5.2.4.3 Shells with openings without nozzle, reinforced by reinforcement rings.

Calculation of Stress Loaded Areas Effective as Reinforcement

Reinforcement Ring

Effective Thickness of Reinforcement Ring for Reinforcement Calculations	
$er = \text{MIN}(ear, \text{MAX}(3 * eas, 3 * Ir)) (9.5-45) =$	30.00 mm
Limit of Reinforcement Along Shell and Ring I_o	
$I_o = \text{Sqr}((2 * ris + eam) * eam) (9.5-46) =$	178.04 mm
Average Thickness Along Length I_o	
$eam = eas + (er - eas) * Ir / I_o (9.5-48) =$	13.87 mm
Area of Ring Afr/Afb	
$Afr/Afb = er * Ir (9.5-55) =$	1425.00 mm ²
Limit of Reinforcement Along Shell	
$I_{so} = \text{Sqr}((2 * ris + eas) * eas) =$	134.87 mm
$I_s = \text{MIN}(I_{so}, I_o - Ir) (9.5-50) =$	130.54 mm

ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

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N.2 ConnID:E3.2

Area of Shell

$$Afs = eas * Is (9.5-54) = \underline{\underline{1044.34 \text{ mm}^2}}$$

Calculation of Pressure Loaded Areas

$$Apr/Apb = 0.5 * dib * er = \underline{\underline{1875.00 \text{ mm}^2}}$$

Spherical Shell/End on any Section Aps

$$Aps = 0.5 * ris^2 * (Is+a) / (0.5 * eas + ris) + a * (eas+ep) (9.5-72) = \underline{\underline{1,3674E05 \text{ mm}^2}}$$

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$$pAReq = P * (Aps + Apr + 0.5 * Apphi) (9.5-7) = \underline{\underline{55.45 \text{ kN}}}$$

Pressure Area Available pA(aval.)

$$pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P) (9.5-16) = \underline{\underline{342.92 \text{ kN}}}$$

Maximum Allowable Pressure Pmax

$$Pmax = (Afs + Afw + Afr) * fs / ((Aps + Apr + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afr + Afp)) (9.5-17) = \underline{\underline{2.4555 \text{ MPa}}}$$

Max.Allowable Test Pressure Ptmax

$$Ptmax = = \underline{\underline{4.5908 \text{ MPa}}}$$

Weight of Nozzle: 6.1kg

CALCULATION SUMMARY

9.5.2.4.3 Shells with openings without nozzle, reinforced by reinforcement rings.

Pressure Area Required pA(req.)

$$pAReq = P * (Aps + Apr + 0.5 * Apphi) (9.5-7) = \underline{\underline{55.45 \text{ kN}}}$$

Pressure Area Available pA(aval.)

$$pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P) (9.5-16) = \underline{\underline{342.92 \text{ kN}}}$$

Maximum Allowable Pressure Pmax

$$Pmax = (Afs + Afw + Afr) * fs / ((Aps + Apr + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afr + Afp)) (9.5-17) = \underline{\underline{2.4555 \text{ MPa}}}$$

Volume:0.0005000 m3 Weight:6.1 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

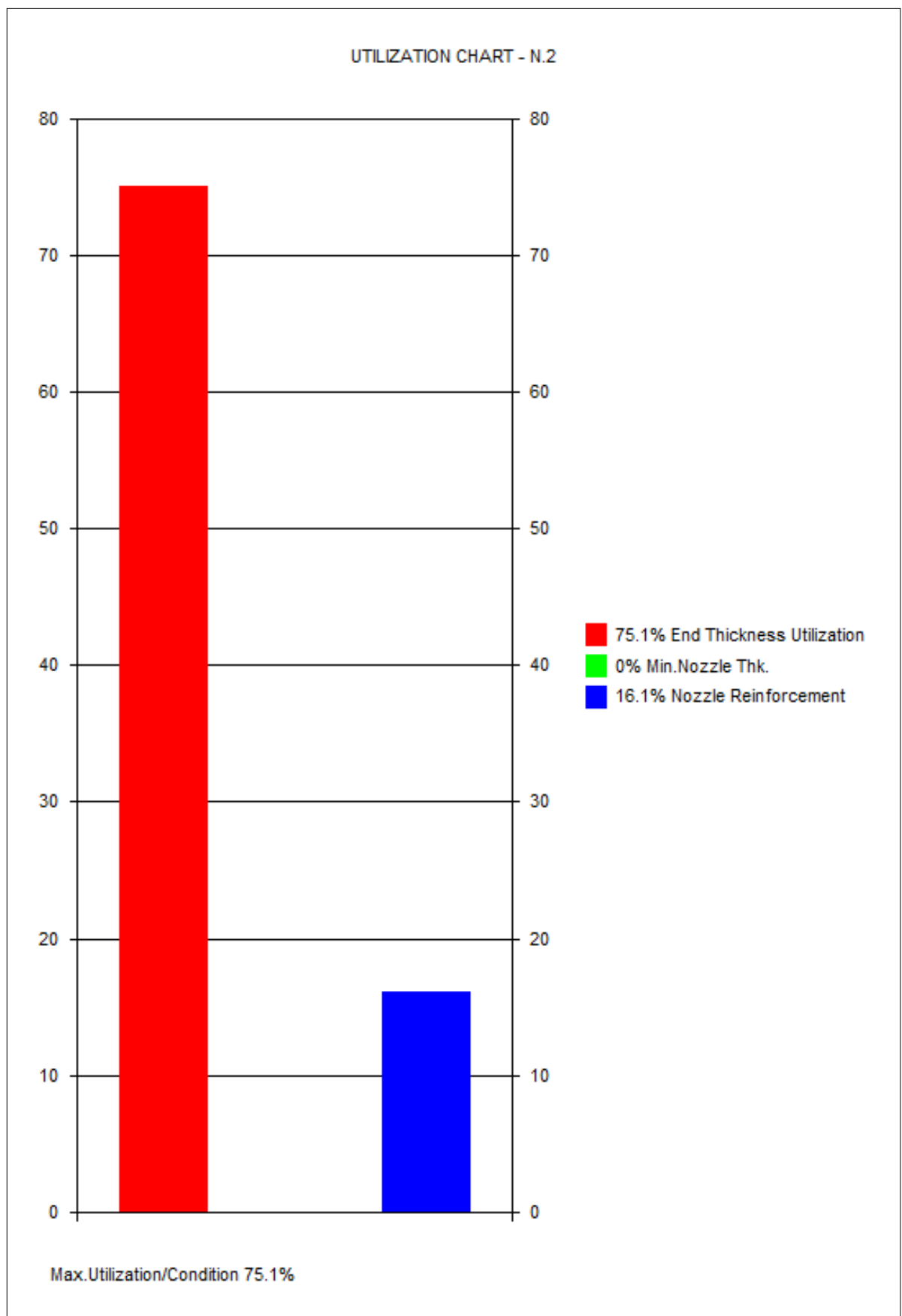
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.2 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.3 ConnID:E3.2

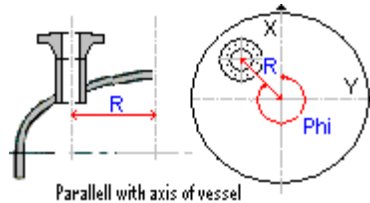
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



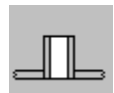
Orientation & Location of Nozzle:

Axis of Nozzle is Parallel with Axis of End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 20.00 Degr.

Distance between Center of End and Center of Nozzle.:R 400.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Seamless Pipe

EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

Rm=490 Rp=225 Rpt=187.2 fb=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.3 ConnID:E3.2



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 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 30.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 50.00 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 20.68 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 = 8.0000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev = 1.0500 mm
ris = R (9.5-4) = 1132.80 mm
dib = deb - 2 * eab = 38.90 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P) = 0.0700 mm
Allowable Stresses
fob = Min(fs, fb) (9.5-8) = 124.80 N/mm2

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas) = 134.87 mm
Set In Nozzle
Afs = eas * Iso (9.5-79) = 1078.93 mm2

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.3 ConnID:E3.2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 6.4767 mm
Set In Nozzle
 $Afb = \text{eb} * (Ibo + Ibi + \text{eas})$ (9.5-78) = 15.20 mm²

Calculation of Pressure Loaded Areas

In the Nozzle Apb
 $Apb = 0.5 * \text{dib} * (Ibo + \text{eas})$ (9.5-84) = 281.57 mm²
Additional Area due to Obliquity of Nozzle Ap(phi)
 $Apphi = 0.5 * \text{dib}^2 * \text{Tan}(\text{phi})$ (9.5-112) = 285.56 mm²
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * \text{ris}^2 * (\text{Is} + \text{a}) / (0.5 * \text{eas} + \text{ris})$ (9.5-115) = 88487.33 mm²

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 35.56 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)
= 151.72 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs+Afw)*fs+Afb*fob / ((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp))$ (9.5-10)
= 1.6985 MPa

Max.Allowable Test Pressure Ptmx

$Ptmx =$ = 3.1722 MPa

Weight of Nozzle: .1094kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * \text{ris} + \text{eas}) * \text{eas})$ = 134.87 mm
Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 6.4767 mm

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 35.56 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)
= 151.72 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs+Afw)*fs+Afb*fob / ((Aps+Apb+0.5*Apphi)+0.5*(Afs+Afw+Afb+Afp))$ (9.5-10)
= 1.6985 MPa

Volume:0.0001000 m³ Weight:0.1 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

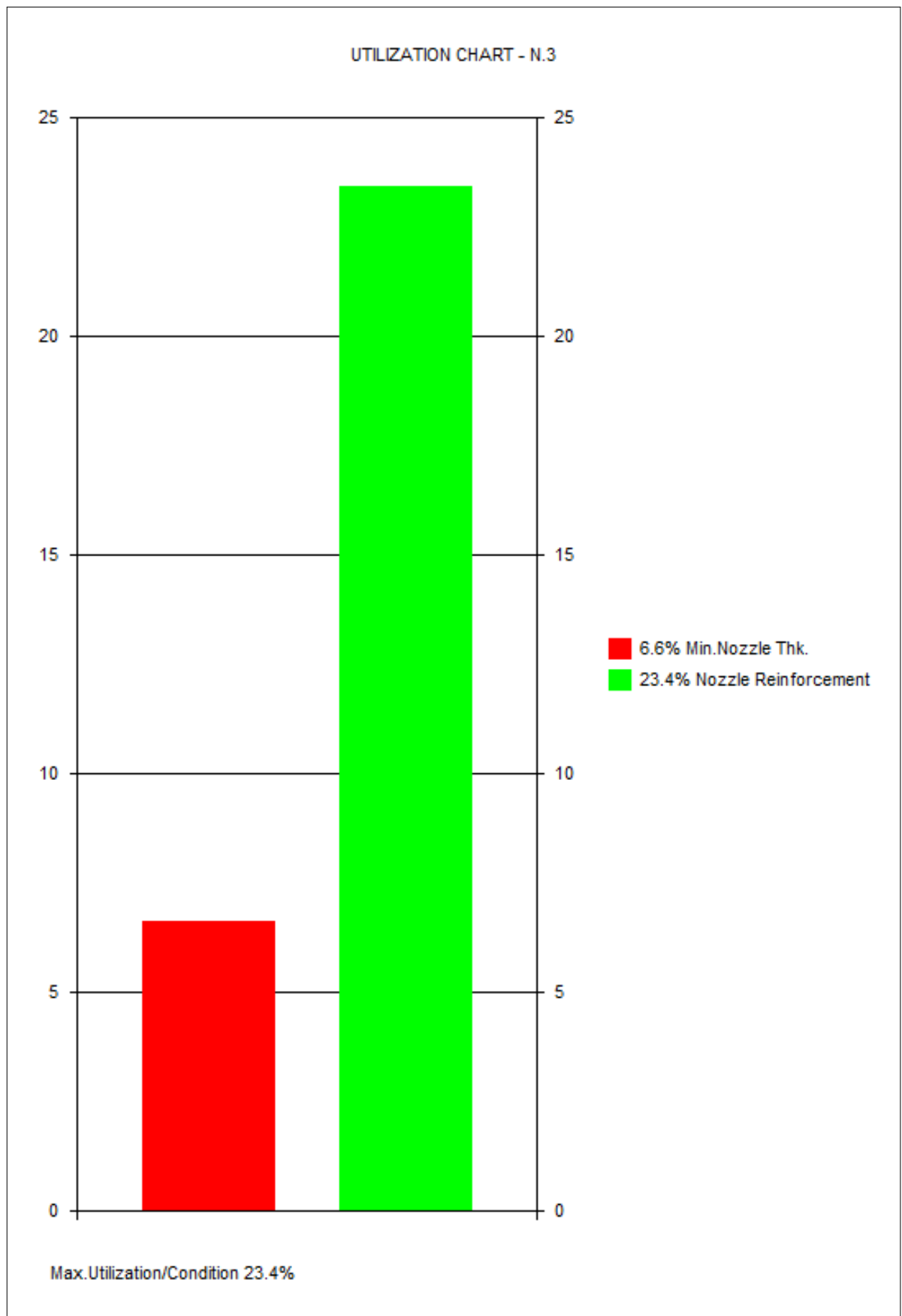
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.3 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.4 ConnID:E3.2

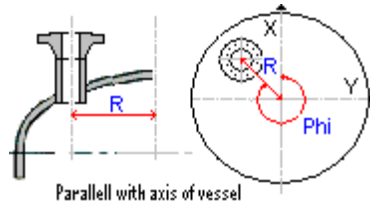
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



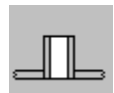
Orientation & Location of Nozzle:

Axis of Nozzle is Parallel with Axis of End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 0.00 Degr.

Distance between Center of End and Center of Nozzle.:R 400.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Seamless Pipe

EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

Rm=490 Rp=225 Rpt=187.2 fb=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.4 ConnID:E3.2



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 28.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 30.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 50.00 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 20.68 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 = 8.0000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev = 1.0500 mm
ris = R (9.5-4) = 1132.80 mm
dib = deb - 2 * eab = 25.90 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P) = 0.0400 mm
Allowable Stresses
fob = Min(fs, fb) (9.5-8) = 124.80 N/mm2

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas) = 134.87 mm
Set In Nozzle
Afs = eas * Iso (9.5-79) = 1078.93 mm2

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
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N.4 ConnID:E3.2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 5.3195 mm
Set In Nozzle
 $Afb = \text{eb} * (Ibo + Ibi + \text{eas})$ (9.5-78) = 13.99 mm²

Calculation of Pressure Loaded Areas

In the Nozzle Apb
 $Apb = 0.5 * \text{dib} * (Ibo + \text{eas})$ (9.5-84) = 172.49 mm²
Additional Area due to Obliquity of Nozzle Ap(phi)
 $Apphi = 0.5 * \text{dib}^2 * \text{Tan}(\text{phi})$ (9.5-112) = 126.59 mm²
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * \text{ris}^2 * (\text{Is} + \text{a}) / (0.5 * \text{eas} + \text{ris})$ (9.5-115) = 84565.34 mm²

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 33.92 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)
= 151.57 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.7785 MPa

Max.Allowable Test Pressure Ptmx

$Ptmx =$ = 3.3219 MPa

Weight of Nozzle: .0685kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * \text{ris} + \text{eas}) * \text{eas})$ = 134.87 mm
Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 5.3195 mm

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 33.92 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)
= 151.57 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.7785 MPa

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

ORION.GROUP LLC

Client : BTL2103

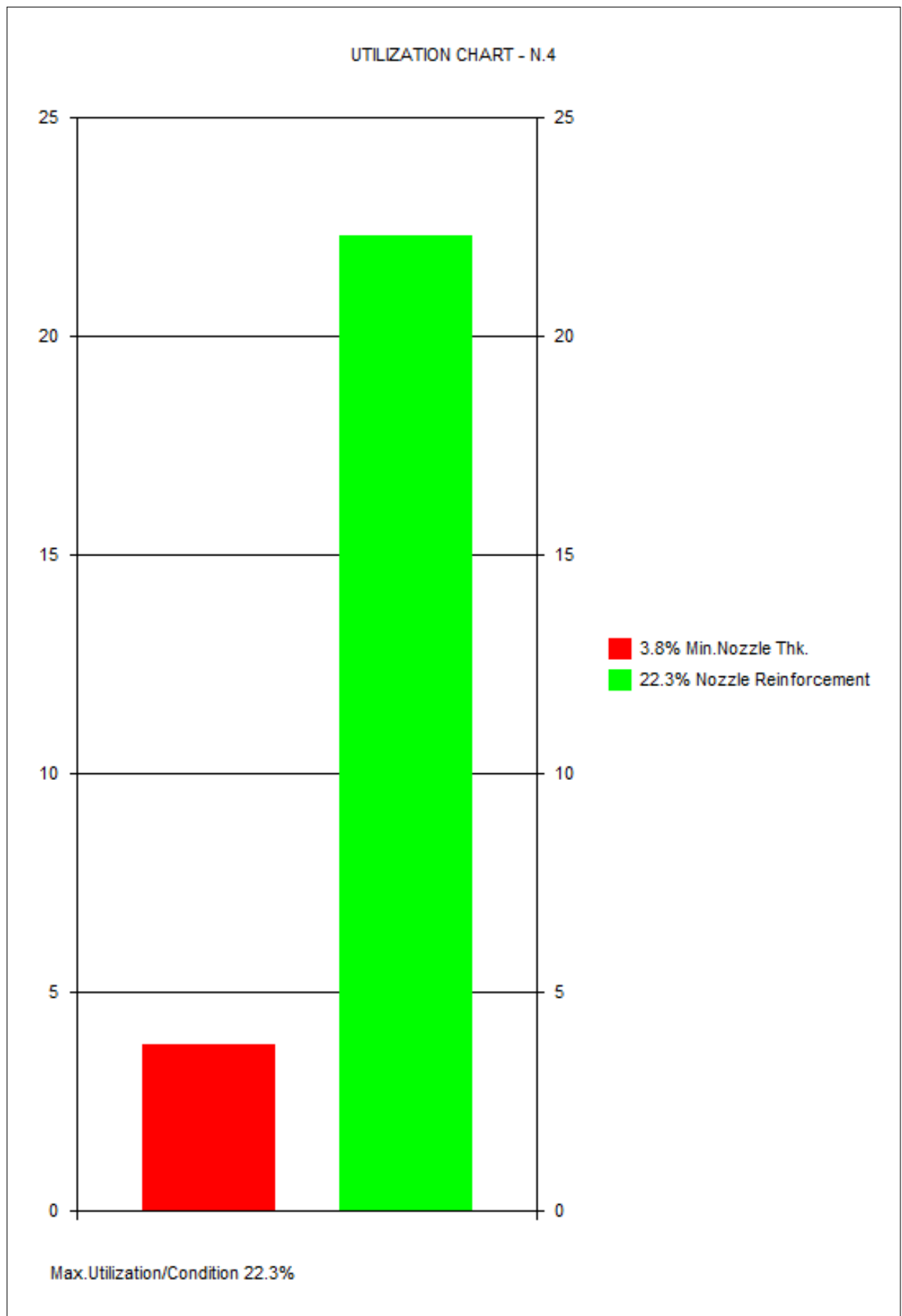
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.4 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.5 ConnID:E3.2

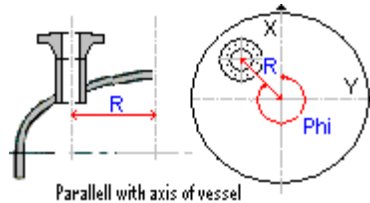
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



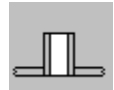
Orientation & Location of Nozzle:

Axis of Nozzle is Parallel with Axis of End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 305.00 Degr.

Distance between Center of End and Center of Nozzle.:R 400.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Seamless Pipe

EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

Rm=490 Rp=225 Rpt=187.2 fb=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.5 ConnID:E3.2



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 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 30.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 50.00 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 20.68 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 = 8.0000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev = 1.0500 mm
ris = R (9.5-4) = 1132.80 mm
dib = deb - 2 * eab = 38.90 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P) = 0.0700 mm
Allowable Stresses
fob = Min(fs, fb) (9.5-8) = 124.80 N/mm2

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas) = 134.87 mm
Set In Nozzle
Afs = eas * Iso (9.5-79) = 1078.93 mm2

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
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N.5 ConnID:E3.2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 6.4767 mm
Set In Nozzle
 $Afb = \text{eb} * (Ibo + Ibi + \text{eas})$ (9.5-78) = 15.20 mm²

Calculation of Pressure Loaded Areas

In the Nozzle Apb
 $Apb = 0.5 * \text{dib} * (Ibo + \text{eas})$ (9.5-84) = 281.57 mm²
Additional Area due to Obliquity of Nozzle Ap(phi)
 $Apphi = 0.5 * \text{dib}^2 * \text{Tan}(\text{phi})$ (9.5-112) = 285.56 mm²
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * \text{ris}^2 * (\text{Is} + \text{a}) / (0.5 * \text{eas} + \text{ris})$ (9.5-115) = 88487.33 mm²

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 35.56 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)
= 151.72 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6985 MPa

Max.Allowable Test Pressure Ptmx

$Ptmx = =$ 3.1722 MPa

Weight of Nozzle: .1094kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * \text{ris} + \text{eas}) * \text{eas}) =$ 134.87 mm
Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 6.4767 mm

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 35.56 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)
= 151.72 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6985 MPa

Volume:0.0001000 m³ Weight:0.1 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

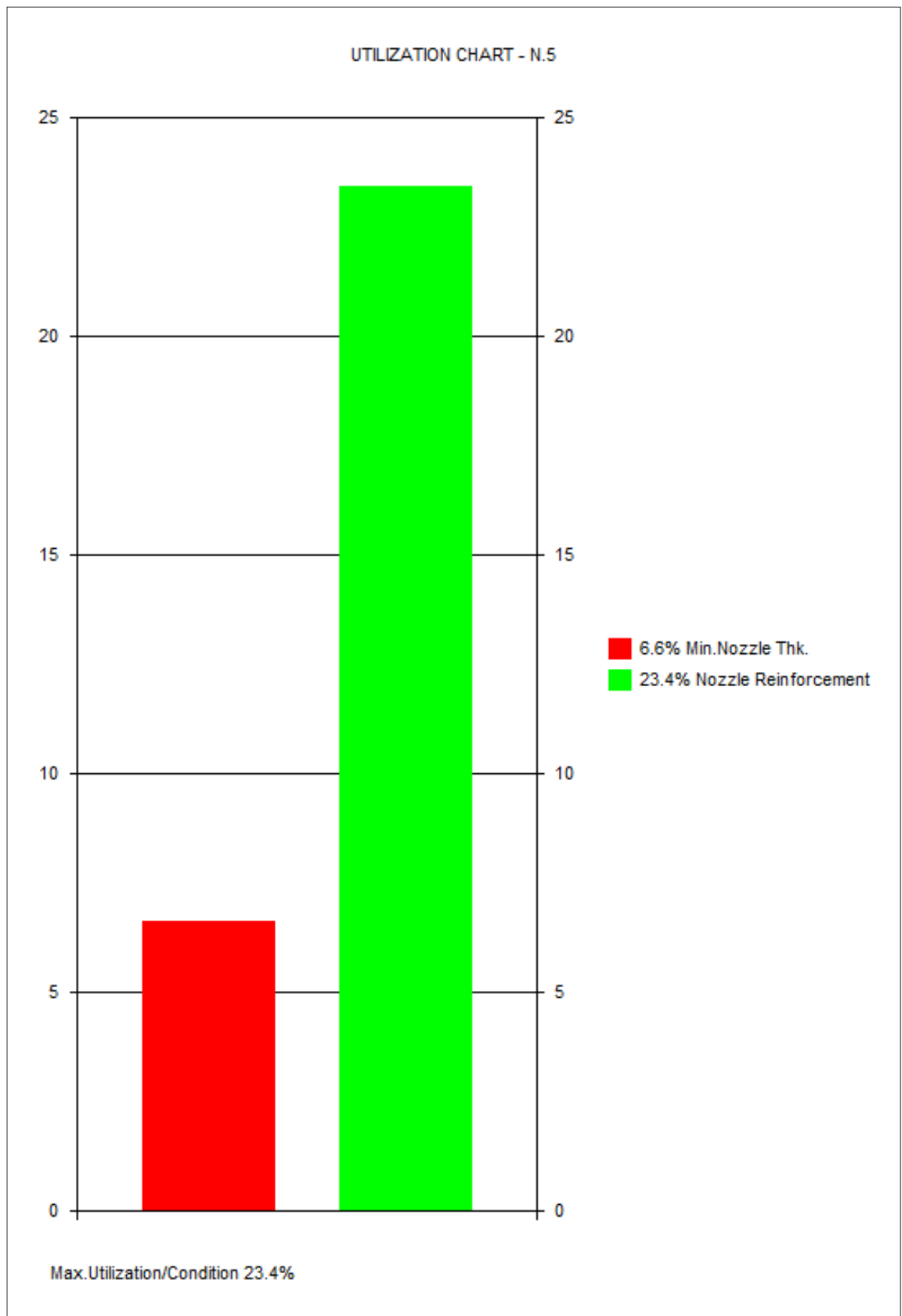
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.5 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.6 ConnID:E3.2

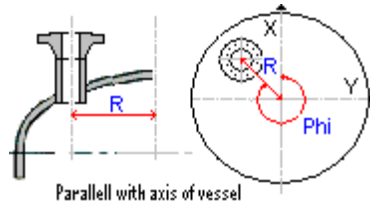
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



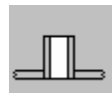
Orientation & Location of Nozzle:

Axis of Nozzle is Parallel with Axis of End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 270.00 Degr.

Distance between Center of End and Center of Nozzle.:R 400.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Seamless Pipe

EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

Rm=490 Rp=225 Rpt=187.2 fb=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.6 ConnID:E3.2



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 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 30.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 50.00 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 20.68 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 = 8.0000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev = 1.0500 mm
ris = R (9.5-4) = 1132.80 mm
dib = deb - 2 * eab = 38.90 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P) = 0.0700 mm
Allowable Stresses
fob = Min(fs, fb) (9.5-8) = 124.80 N/mm2

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas) = 134.87 mm
Set In Nozzle
Afs = eas * Iso (9.5-79) = 1078.93 mm2

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.6 ConnID:E3.2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 6.4767 mm
Set In Nozzle
 $Afb = \text{eb} * (Ibo + Ibi + \text{eas})$ (9.5-78) = 15.20 mm²

Calculation of Pressure Loaded Areas

In the Nozzle Apb
 $Apb = 0.5 * \text{dib} * (Ibo + \text{eas})$ (9.5-84) = 281.57 mm²
Additional Area due to Obliquity of Nozzle Ap(phi)
 $Apphi = 0.5 * \text{dib}^2 * \text{Tan}(\text{phi})$ (9.5-112) = 285.56 mm²
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * \text{ris}^2 * (\text{Is} + \text{a}) / (0.5 * \text{eas} + \text{ris})$ (9.5-115) = 88487.33 mm²

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 35.56 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)
= 151.72 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6985 MPa

Max.Allowable Test Pressure Ptmx

$Ptmx =$ = 3.1722 MPa

Weight of Nozzle: .1094kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * \text{ris} + \text{eas}) * \text{eas})$ = 134.87 mm
Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 6.4767 mm

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 35.56 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)
= 151.72 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6985 MPa

Volume:0.0001000 m³ Weight:0.1 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

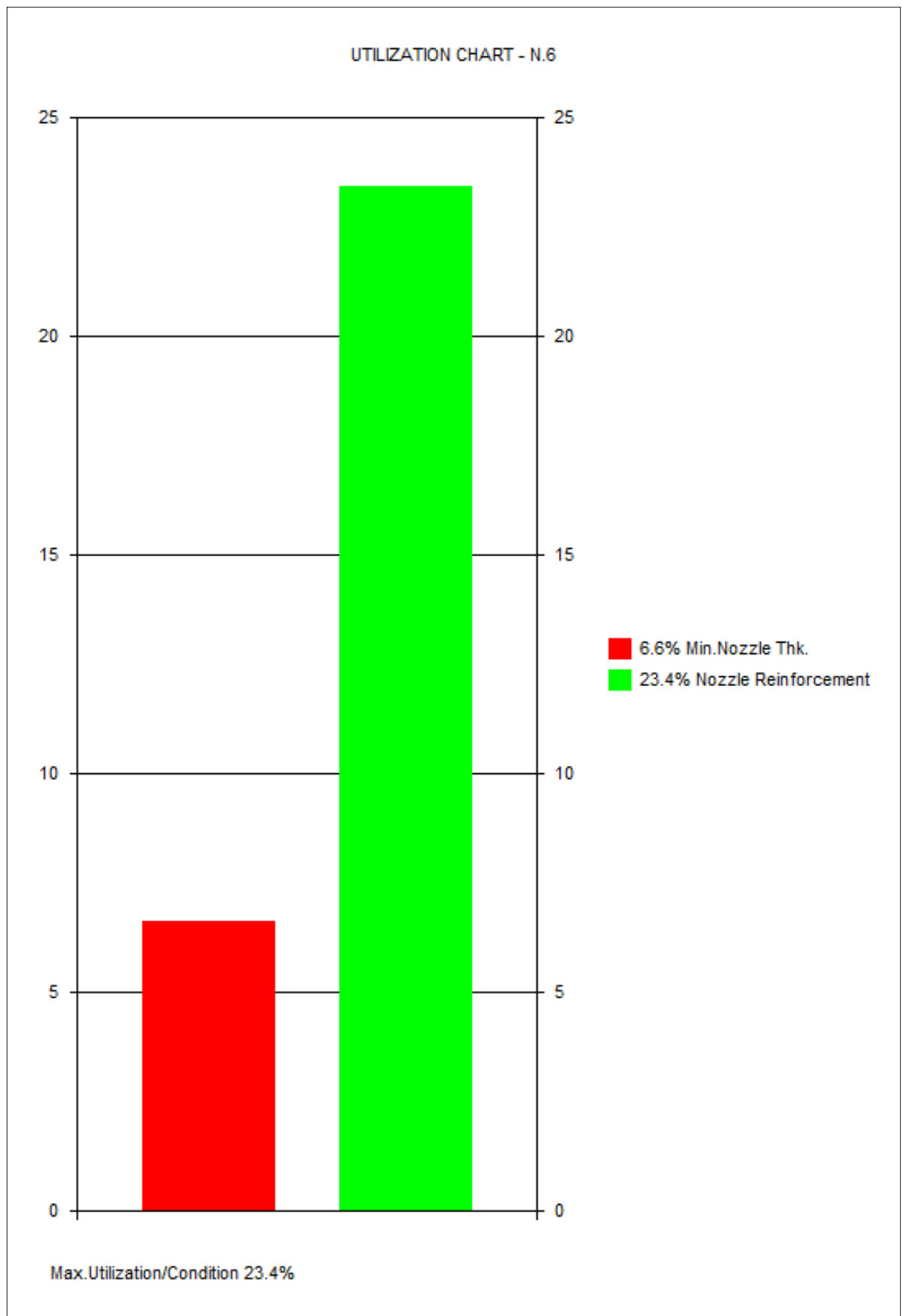
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.6 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.7 ConnID:E3.2

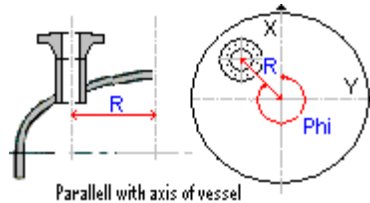
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



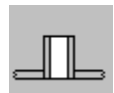
Orientation & Location of Nozzle:

Axis of Nozzle is Parallel with Axis of End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 205.00 Degr.

Distance between Center of End and Center of Nozzle.:R 400.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Seamless Pipe

EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

Rm=490 Rp=225 Rpt=187.2 fb=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.7 ConnID:E3.2



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 28.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 30.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 50.00 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 20.68 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 = 8.0000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev = 1.0500 mm
ris = R (9.5-4) = 1132.80 mm
dib = deb - 2 * eab = 25.90 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P) = 0.0400 mm
Allowable Stresses
fob = Min(fs, fb) (9.5-8) = 124.80 N/mm2

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas) = 134.87 mm
Set In Nozzle
Afs = eas * Iso (9.5-79) = 1078.93 mm2

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.7 ConnID:E3.2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 5.3195 mm
Set In Nozzle
 $Afb = \text{eb} * (Ibo + Ibi + \text{eas})$ (9.5-78) = 13.99 mm²

Calculation of Pressure Loaded Areas

In the Nozzle Apb
 $Apb = 0.5 * \text{dib} * (Ibo + \text{eas})$ (9.5-84) = 172.49 mm²
Additional Area due to Obliquity of Nozzle Ap(phi)
 $Apphi = 0.5 * \text{dib}^2 * \text{Tan}(\text{phi})$ (9.5-112) = 126.59 mm²
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * \text{ris}^2 * (\text{Is} + \text{a}) / (0.5 * \text{eas} + \text{ris})$ (9.5-115) = 84565.34 mm²

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 33.92 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)
= 151.57 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.7785 MPa

Max.Allowable Test Pressure Ptmx

$Ptmx =$ = 3.3219 MPa

Weight of Nozzle: .0685kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * \text{ris} + \text{eas}) * \text{eas})$ = 134.87 mm
Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 5.3195 mm

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 33.92 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)
= 151.57 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.7785 MPa

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

ORION.GROUP LLC

Client : BTL2103

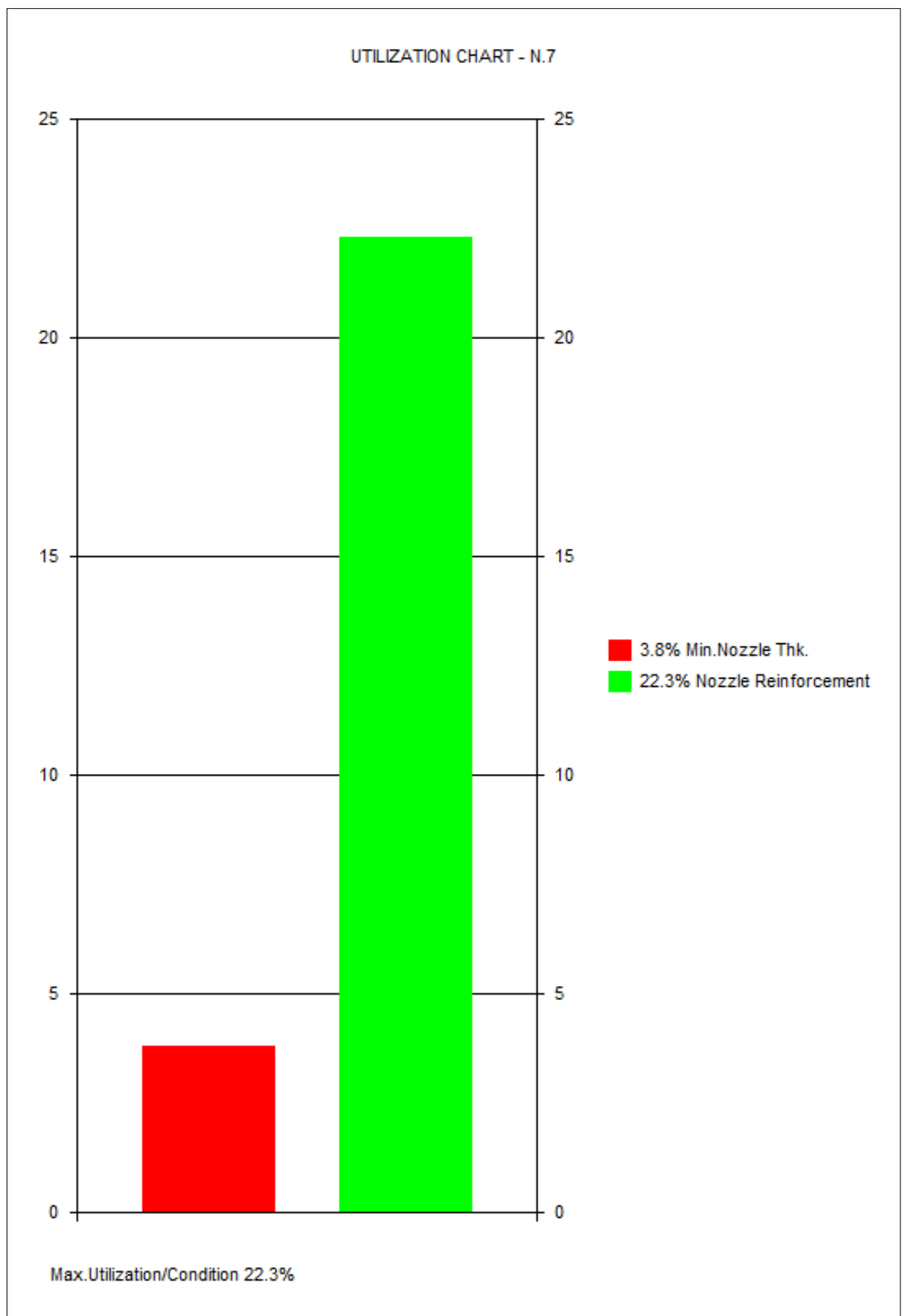
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.7 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.8 ConnID:E3.2

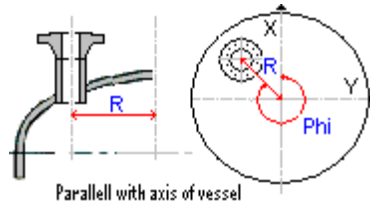
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



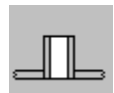
Orientation & Location of Nozzle:

Axis of Nozzle is Parallel with Axis of End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 187.00 Degr.

Distance between Center of End and Center of Nozzle.:R 400.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Seamless Pipe

EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

Rm=490 Rp=225 Rpt=187.2 fb=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

ORION.GROUP LLC

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N.8 ConnID:E3.2



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 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 30.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 50.00 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 20.68 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 = 8.0000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev = 1.0500 mm
ris = R (9.5-4) = 1132.80 mm
dib = deb - 2 * eab = 38.90 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P) = 0.0700 mm
Allowable Stresses
fob = Min(fs, fb) (9.5-8) = 124.80 N/mm2

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas) = 134.87 mm
Set In Nozzle
Afs = eas * Iso (9.5-79) = 1078.93 mm2

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N.8 ConnID:E3.2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 6.4767 mm
Set In Nozzle
 $Afb = \text{eb} * (Ibo + Ibi + \text{eas})$ (9.5-78) = 15.20 mm²

Calculation of Pressure Loaded Areas

In the Nozzle Apb
 $Apb = 0.5 * \text{dib} * (Ibo + \text{eas})$ (9.5-84) = 281.57 mm²
Additional Area due to Obliquity of Nozzle Ap(phi)
 $Apphi = 0.5 * \text{dib}^2 * \text{Tan}(\text{phi})$ (9.5-112) = 285.56 mm²
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * \text{ris}^2 * (\text{Is} + \text{a}) / (0.5 * \text{eas} + \text{ris})$ (9.5-115) = 88487.33 mm²

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 35.56 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)
= 151.72 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6985 MPa

Max.Allowable Test Pressure Ptmx

$Ptmx =$ = 3.1722 MPa

Weight of Nozzle: .1094kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * \text{ris} + \text{eas}) * \text{eas})$ = 134.87 mm
Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 6.4767 mm

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 35.56 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)
= 151.72 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6985 MPa

Volume:0.0001000 m³ Weight:0.1 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

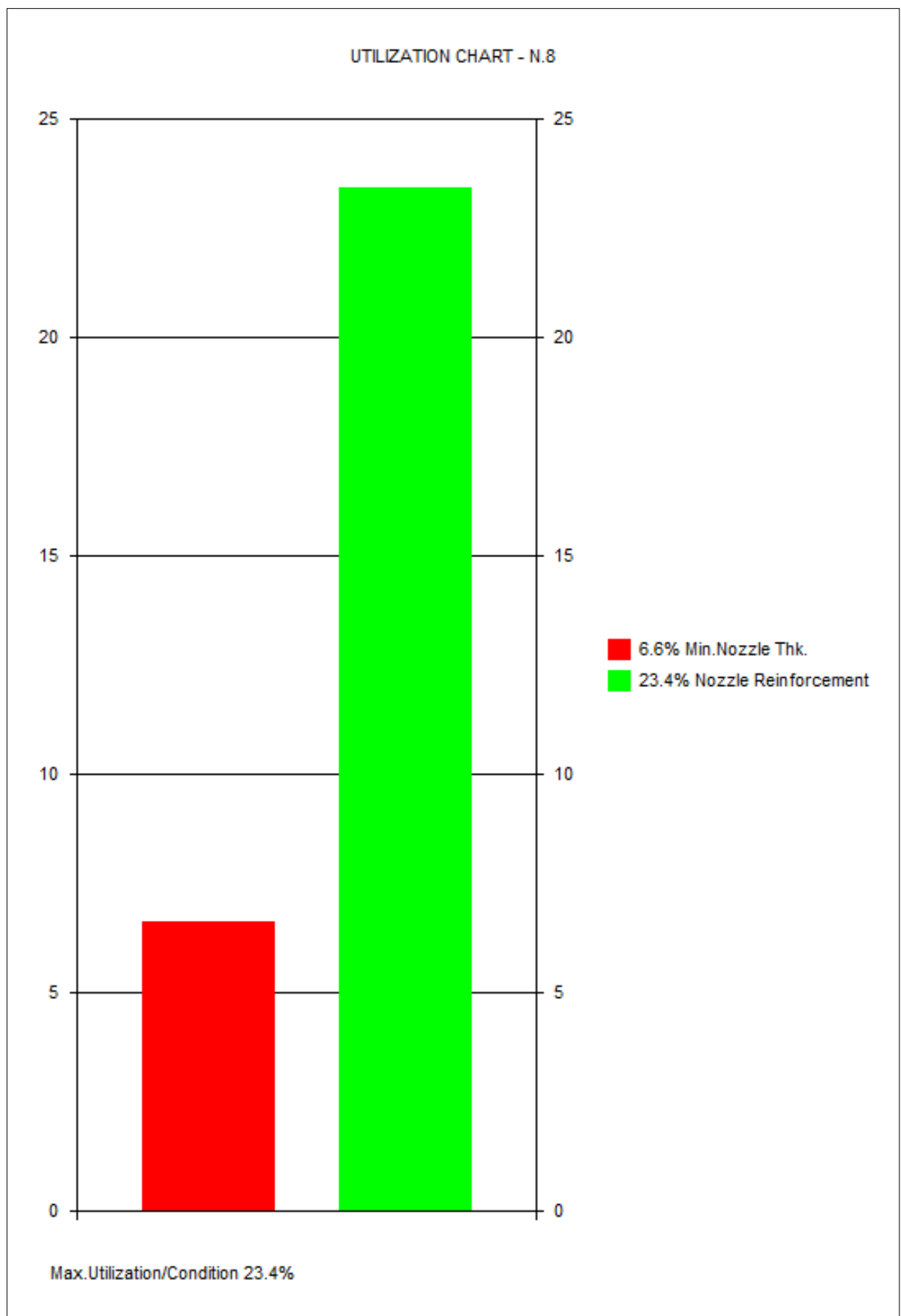
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.8 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
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Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.9 ConnID:E3.1

WELDING DATA

Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

Shell Analysis Thickness eas
 $eas = en - c - th = 6.0000 \text{ mm}$
Ring Analysis Thickness ear
 $ear = enr - c = 15.00 \text{ mm}$
 $ris = R (9.5-4) = 1129.60 \text{ mm}$
Allowable Stresses
 $for/fob = \text{Min}(fs, fb) (9.5-8) = 139.07 \text{ N/mm}^2$

9.5.2.4.3 Shells with openings without nozzle, reinforced by reinforcement rings.

Calculation of Stress Loaded Areas Effective as Reinforcement

Reinforcement Ring

Effective Thickness of Reinforcement Ring for Reinforcement Calculations
 $er = \text{MIN}(ear, \text{MAX}(3 * eas, 3 * Ir)) (9.5-45) = 15.00 \text{ mm}$
Limit of Reinforcement Along Shell and Ring Io
 $Io = \text{Sqr}((2 * ris + eam) * eam) (9.5-46) = 120.71 \text{ mm}$
Average Thickness Along Length Io
 $eam = eas + (er - eas) * Ir / Io (9.5-48) = 6.3728 \text{ mm}$
Area of Ring Afr/Afb
 $Afr/Afb = er * Ir (9.5-55) = 75.00 \text{ mm}^2$
Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * ris + eas) * eas) = 116.58 \text{ mm}$
 $Is = \text{MIN}(Iso, Io - Ir) (9.5-50) = 115.71 \text{ mm}$
Area of Shell
 $Afs = eas * Is (9.5-54) = 694.25 \text{ mm}^2$

Calculation of Pressure Loaded Areas

$Apr/Apb = 0.5 * dib * er = 1125.00 \text{ mm}^2$
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * ris^2 * (Is+a) / (0.5 * eas + ris) + a * (eas+ep) (9.5-72) = 1,1076E05 \text{ mm}^2$

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apr + 0.5 * Apphi) (9.5-7) = 44.75 \text{ kN}$

Pressure Area Available pA(aval.)

$pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P) (9.5-16) = 106.83 \text{ kN}$

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw + Afr) * fs / ((Aps + Apr + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afr + Afp)) (9.5-17)$
 $= 0.9529 \text{ MPa}$

Max.Allowable Test Pressure Ptxmax

$Ptxmax = 1.7815 \text{ MPa}$

Weight of Nozzle: .2896kg

ORION.GROUP LLC

Client : BTL2103

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N.9 ConnID:E3.1

CALCULATION SUMMARY

9.5.2.4.3 Shells with openings without nozzle, reinforced by reinforcement rings.

Pressure Area Required pA(req.)

$$pA_{Req} = P * (A_{ps} + A_{pr} + 0.5 * A_{pphi}) \quad (9.5-7) = \underline{\underline{44.75 \text{ kN}}}$$

Pressure Area Available pA(aval.)

$$pAA_{val} = (A_{fs} + A_{fw} + A_{fp} + A_{fr}) * (f_s - 0.5 * P) \quad (9.5-16) = \underline{\underline{106.83 \text{ kN}}}$$

Maximum Allowable Pressure Pmax

$$P_{max} = (A_{fs} + A_{fw} + A_{fr}) * f_s / ((A_{ps} + A_{pr} + 0.5 * A_{pphi}) + 0.5 * (A_{fs} + A_{fw} + A_{fr} + A_{fp})) \quad (9.5-17)$$
$$= \underline{\underline{0.9529 \text{ MPa}}}$$

Volume:0.0004000 m3 Weight:0.3 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

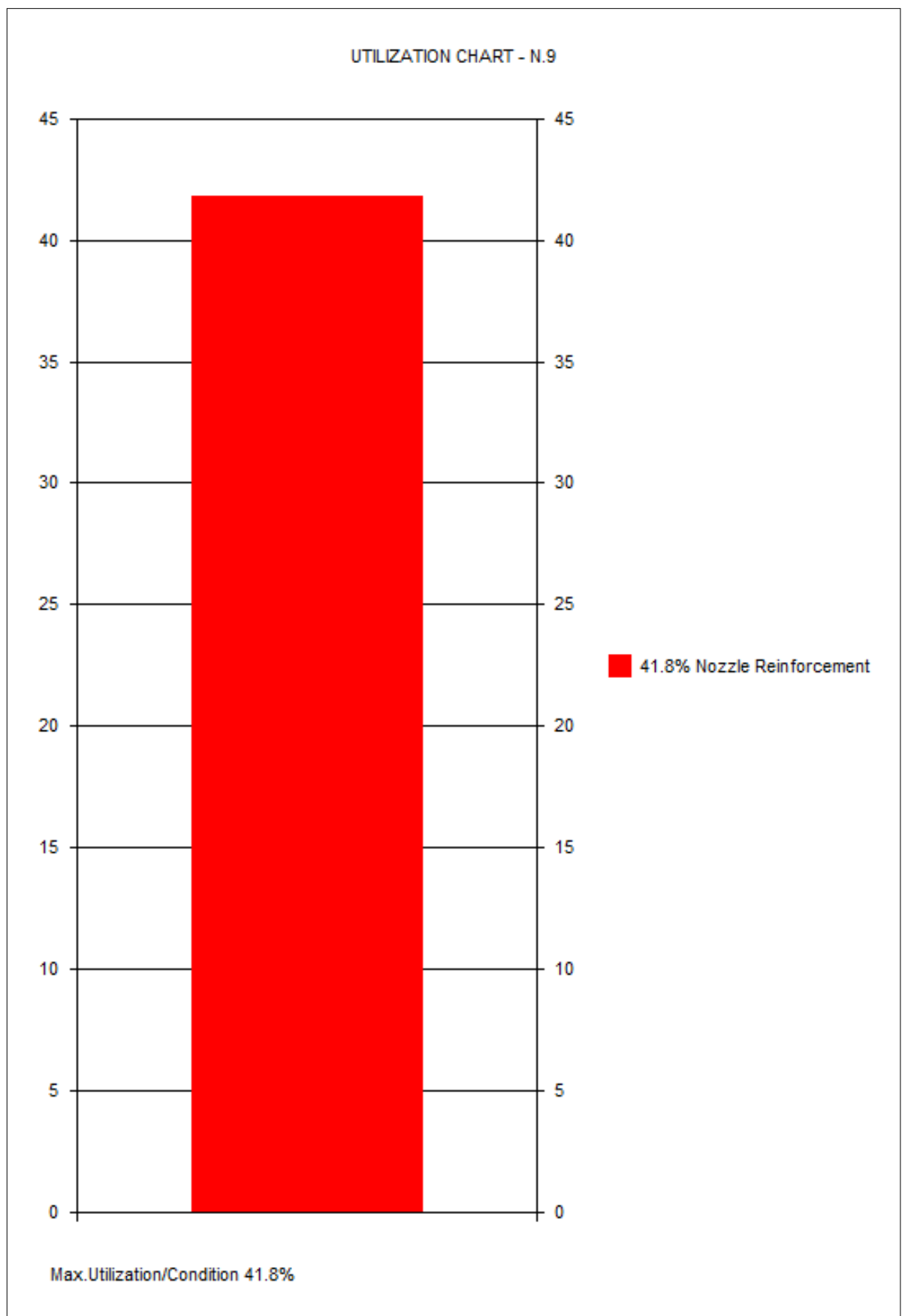
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

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N.9 ConnID:E3.1



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

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N.10 ConnID:E3.1

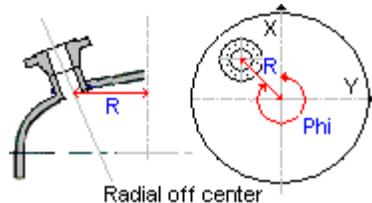
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.1 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



Radial off center

Orientation & Location of Nozzle: Radial to End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 315.00 Degr.

Distance between Center of End and Center of Nozzle.:R 350.00 mm

GENERAL DESIGN DATA



Type of Opening: Opening With Reinforcement Ring

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

LIQUID HEAD.....:LH 1380.43 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 1412.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 6.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1129.60 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

RING DATA

Location of closure opening: Outside the shell

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fr=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

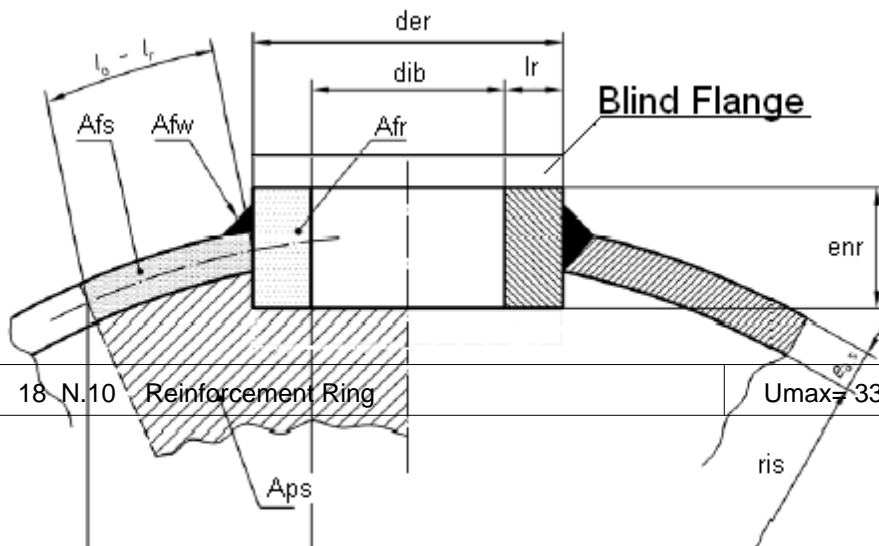
WIDTH OF RING (uncorroded).....:Ir 36.00 mm

THICKNESS/HEIGHT OF RING.....:enr 10.00 mm

INSIDE DIAMETER OF RING (corroded).....:dib 118.00 mm

Size of Flange and Nozzle: 1 1/4"

Comment (Optional):



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N.10 ConnID:E3.1

WELDING DATA

Nozzle/Pad to Shell Welding Area: Exclude Area of Nozzle to Shell Weld

WELDING REQUIREMENTS TO EN 1708-1:2010

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

CALCULATION DATA

PRELIMINARY CALCULATIONS

Shell Analysis Thickness eas
 $eas = en - c - th = 6.0000 \text{ mm}$
Ring Analysis Thickness ear
 $ear = enr - c = 10.00 \text{ mm}$
 $ris = R (9.5-4) = 1129.60 \text{ mm}$
Allowable Stresses
 $for/fob = \text{Min}(fs, fb) (9.5-8) = 139.07 \text{ N/mm}^2$

9.5.2.4.3 Shells with openings without nozzle, reinforced by reinforcement rings.

Calculation of Stress Loaded Areas Effective as Reinforcement

Reinforcement Ring

Effective Thickness of Reinforcement Ring for Reinforcement Calculations
 $er = \text{MIN}(ear, \text{MAX}(3 * eas, 3 * Ir)) (9.5-45) = 10.00 \text{ mm}$
Limit of Reinforcement Along Shell and Ring Io
 $Io = \text{Sqr}((2 * ris + eam) * eam) (9.5-46) = 127.69 \text{ mm}$
Average Thickness Along Length Io
 $eam = eas + (er - eas) * Ir / Io (9.5-48) = 7.1277 \text{ mm}$
Area of Ring Afr/Afb
 $Afr/Afb = er * Ir (9.5-55) = 360.00 \text{ mm}^2$
Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * ris + eas) * eas) = 116.58 \text{ mm}$
 $Is = \text{MIN}(Iso, Io - Ir) (9.5-50) = 91.69 \text{ mm}$
Area of Shell
 $Afs = eas * Is (9.5-54) = 550.14 \text{ mm}^2$

Calculation of Pressure Loaded Areas

$Apr/Apb = 0.5 * dib * er = 590.00 \text{ mm}^2$
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * ris^2 * (Is+a) / (0.5 * eas + ris) + a * (eas+ep) (9.5-72) = 1,058E05 \text{ mm}^2$

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apr + 0.5 * Apphi) (9.5-7) = 42.55 \text{ kN}$

Pressure Area Available pA(aval.)

$pAAval = (Afs + Afw + Afp + Afr) * (fs - 0.5 * P) (9.5-16) = 126.39 \text{ kN}$

Maximum Allowable Pressure Pmax

$Pmax = (Afs+Afw+Afr)*fs / ((Aps+Apr+0.5*Apphi)+0.5*(Afs+Afw+Afr+Afp)) (9.5-17)$
 $= 1.1847 \text{ MPa}$

Max.Allowable Test Pressure Ptxax

$Ptxax = 2.2148 \text{ MPa}$

Weight of Nozzle: 1.4kg

ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

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Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.10 ConnID:E3.1

CALCULATION SUMMARY

9.5.2.4.3 Shells with openings without nozzle, reinforced by reinforcement rings.

Pressure Area Required pA(req.)

$$pA_{Req} = P * (A_{ps} + A_{pr} + 0.5 * A_{pphi}) \quad (9.5-7) = \underline{\underline{42.55 \text{ kN}}}$$

Pressure Area Available pA(aval.)

$$pA_{Aval} = (A_{fs} + A_{fw} + A_{fp} + A_{fr}) * (f_s - 0.5 * P) \quad (9.5-16) = \underline{\underline{126.39 \text{ kN}}}$$

Maximum Allowable Pressure Pmax

$$P_{max} = (A_{fs} + A_{fw} + A_{fr}) * f_s / ((A_{ps} + A_{pr} + 0.5 * A_{pphi}) + 0.5 * (A_{fs} + A_{fw} + A_{fr} + A_{fp})) \quad (9.5-17)$$
$$= \underline{\underline{1.1847 \text{ MPa}}}$$

Volume:0.0002000 m3 Weight:1.4 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

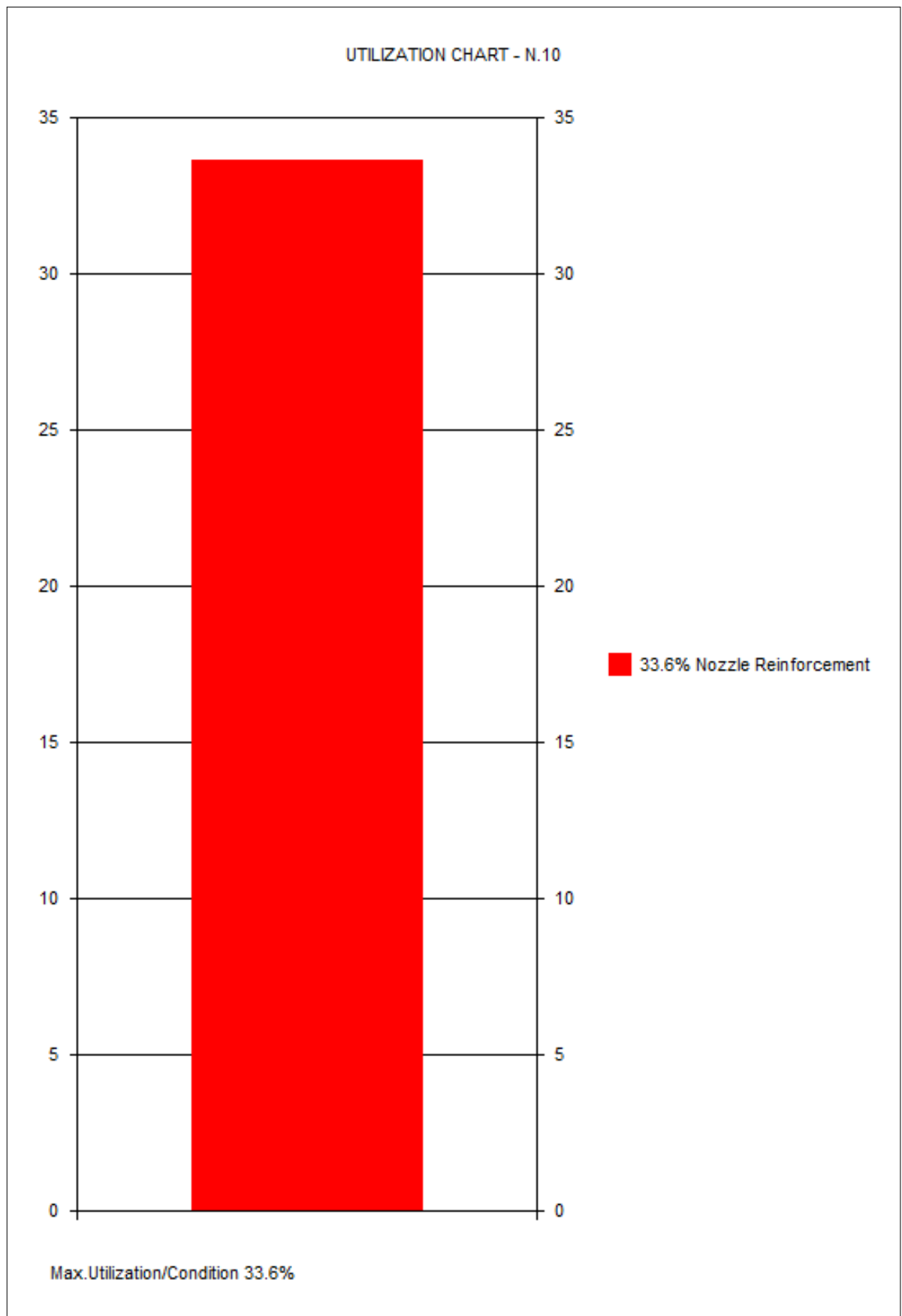
Vessel No.:1403

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Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

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N.10 ConnID:E3.1



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

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Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

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N.11 ConnID:E3.2

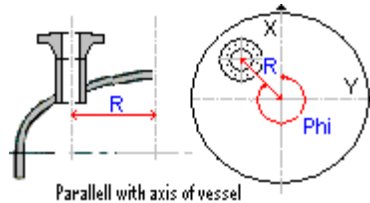
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



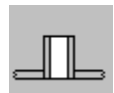
Orientation & Location of Nozzle:

Axis of Nozzle is Parallel with Axis of End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 0.00 Degr.

Distance between Center of End and Center of Nozzle.:R 245.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%

Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Seamless Pipe

EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

Rm=490 Rp=225 Rpt=187.2 fb=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.11 ConnID:E3.2



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 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 30.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 50.00 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 12.49 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 = 8.0000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev = 1.0500 mm
ris = R (9.5-4) = 1132.80 mm
dib = deb - 2 * eab = 50.90 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P) = 0.0800 mm
Allowable Stresses
fob = Min(fs, fb) (9.5-8) = 124.80 N/mm2

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas) = 134.87 mm
Set In Nozzle
Afs = eas * Iso (9.5-79) = 1078.93 mm2

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.11 ConnID:E3.2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 7.3856 mm
Set In Nozzle
 $Afb = \text{eb} * (Ibo + Ibi + \text{eas})$ (9.5-78) = 16.15 mm²

Calculation of Pressure Loaded Areas

In the Nozzle Apb
 $Apb = 0.5 * \text{dib} * (Ibo + \text{eas})$ (9.5-84) = 391.56 mm²
Additional Area due to Obliquity of Nozzle Ap(phi)
 $Apphi = 0.5 * \text{dib}^2 * \text{Tan}(\text{phi})$ (9.5-112) = 286.96 mm²
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * \text{ris}^2 * (\text{Is} + \text{a}) / (0.5 * \text{eas} + \text{ris})$ (9.5-115) = 91440.28 mm²

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 36.79 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)
= 151.84 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6435 MPa

Max.Allowable Test Pressure Ptmx

$Ptmx = =$ 3.0693 MPa

Weight of Nozzle: .1347kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * \text{ris} + \text{eas}) * \text{eas}) =$ 134.87 mm
Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 7.3856 mm

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 36.79 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)
= 151.84 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6435 MPa

Volume:0.0001000 m³ Weight:0.1 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

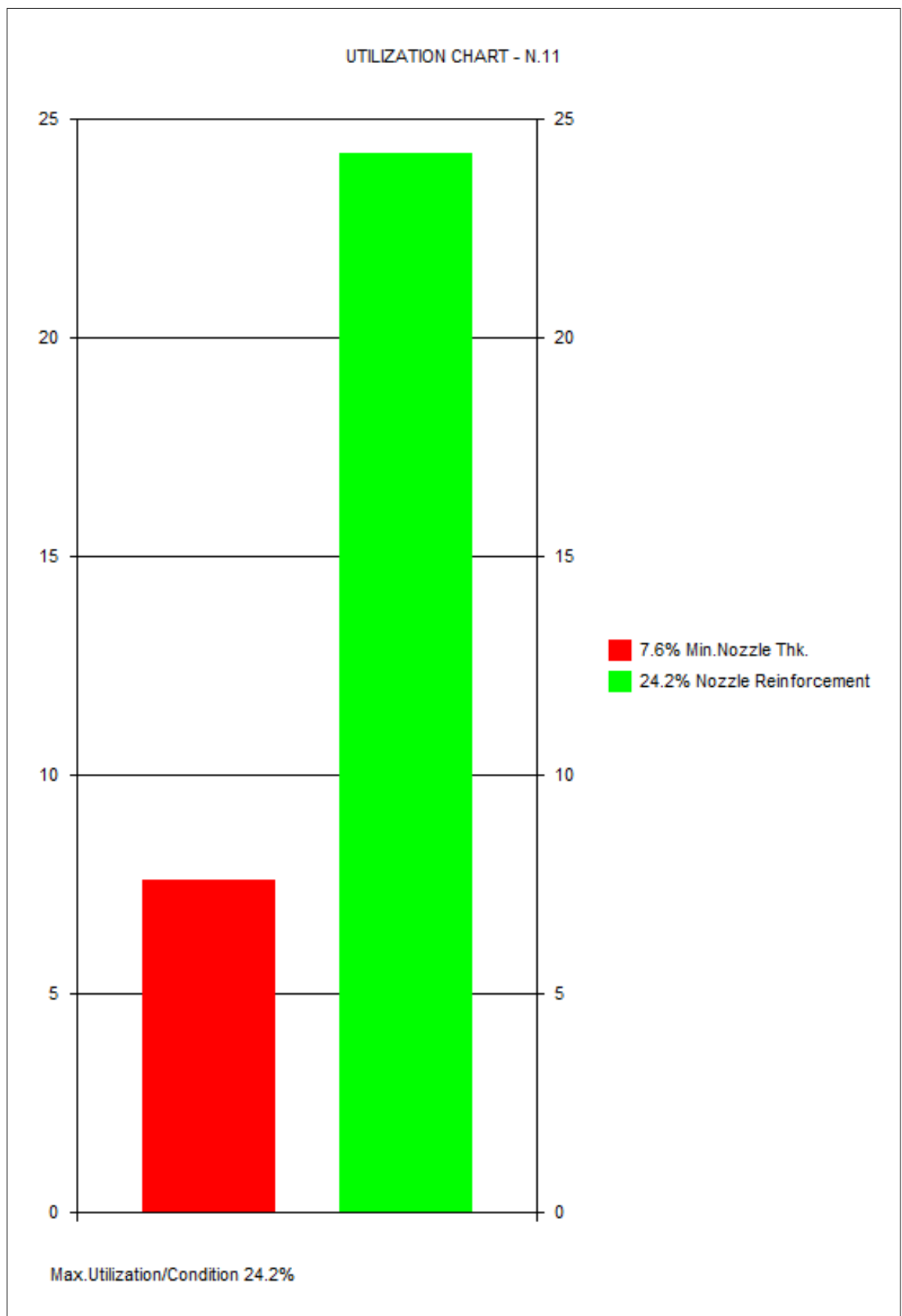
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.11 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.12 ConnID:E3.2

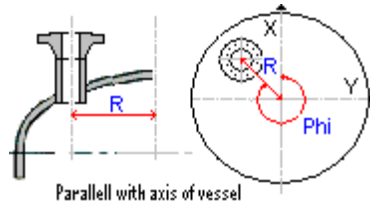
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



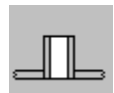
Orientation & Location of Nozzle:

Axis of Nozzle is Parallel with Axis of End (Off Center)

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

Distance between Center of End and Center of Nozzle.:R 245.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Seamless Pipe

EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

Rm=490 Rp=225 Rpt=187.2 fb=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.12 ConnID:E3.2



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 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 30.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 50.00 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 12.49 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 = 8.0000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev = 1.0500 mm
ris = R (9.5-4) = 1132.80 mm
dib = deb - 2 * eab = 50.90 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P) = 0.0800 mm
Allowable Stresses
fob = Min(fs, fb) (9.5-8) = 124.80 N/mm2

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas) = 134.87 mm
Set In Nozzle
Afs = eas * Iso (9.5-79) = 1078.93 mm2

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.12 ConnID:E3.2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 7.3856 mm
Set In Nozzle
 $Afb = \text{eb} * (Ibo + Ibi + \text{eas})$ (9.5-78) = 16.15 mm²

Calculation of Pressure Loaded Areas

In the Nozzle Apb
 $Apb = 0.5 * \text{dib} * (Ibo + \text{eas})$ (9.5-84) = 391.56 mm²
Additional Area due to Obliquity of Nozzle Ap(phi)
 $Apphi = 0.5 * \text{dib}^2 * \text{Tan}(\text{phi})$ (9.5-112) = 286.96 mm²
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * \text{ris}^2 * (\text{Is} + \text{a}) / (0.5 * \text{eas} + \text{ris})$ (9.5-115) = 91440.28 mm²

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 36.79 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)
= 151.84 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6435 MPa

Max.Allowable Test Pressure Ptmx

$Ptmx =$ = 3.0693 MPa

Weight of Nozzle: .1347kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * \text{ris} + \text{eas}) * \text{eas})$ = 134.87 mm
Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 7.3856 mm

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 36.79 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)
= 151.84 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6435 MPa

Volume:0.0001000 m³ Weight:0.1 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

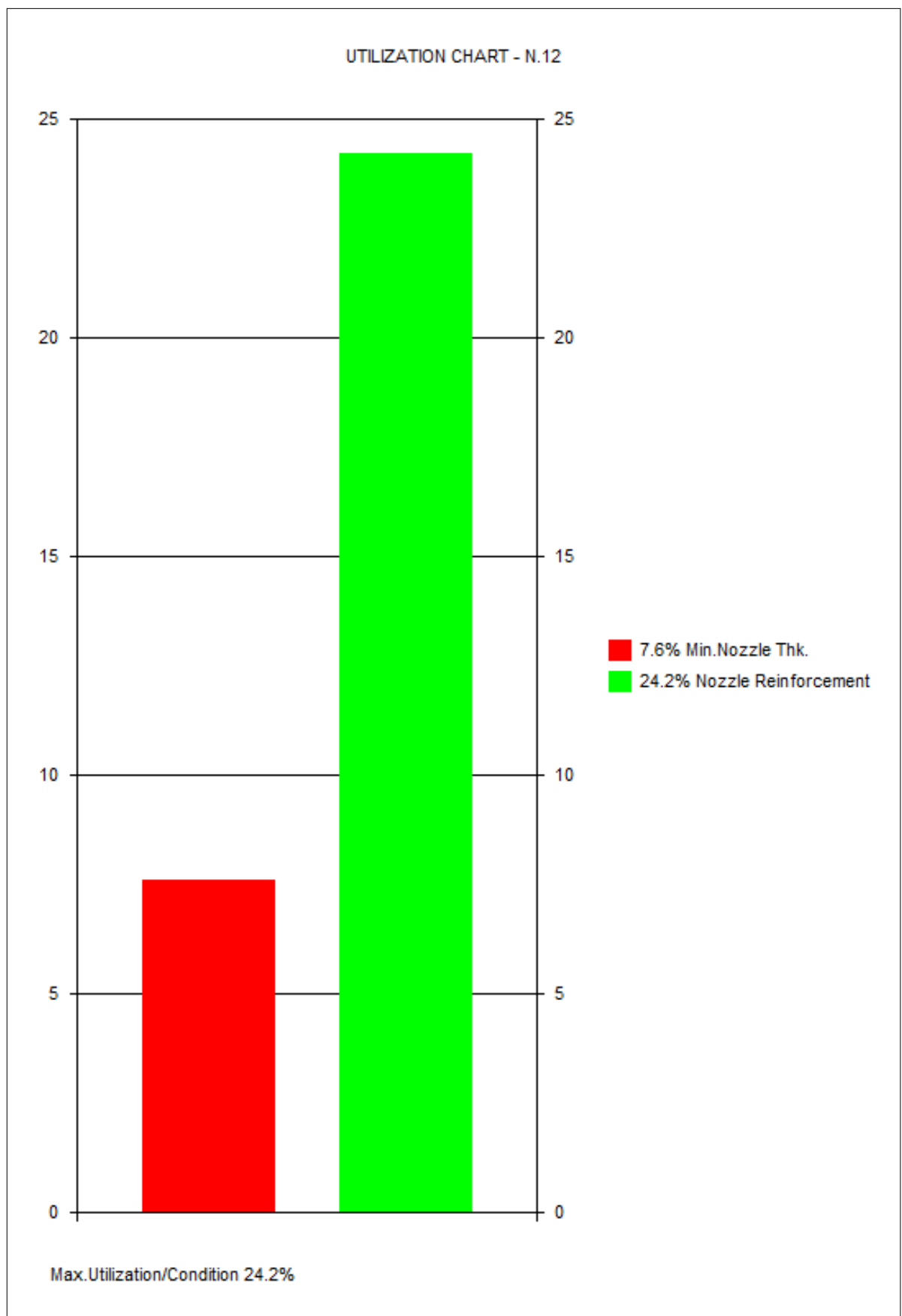
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.12 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.13 ConnID:E3.2

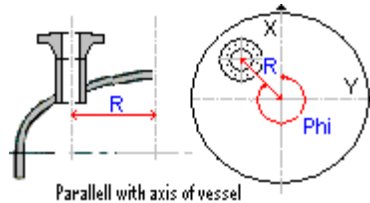
INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E3.2 Torispherical End

S1.1

Connect this nozzle to the nozzle neck of another nozzle: NO



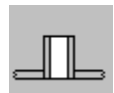
Orientation & Location of Nozzle:

Axis of Nozzle is Parallell with Axis of End (Off Center)

Angle of Rotation of nozzle axis projected in the x-y plane:Phi 270.00 Degr.

Distance between Center of End and Center of Nozzle.:R 135.00 mm

GENERAL DESIGN DATA



Type of Opening: Nozzle Without Standard ASME or DIN/EN Flange Attachment

PRESSURE LOADING: Design Component for Internal Pressure Only

PROCESS CARD:

General Design Data : Temp= 132°C, P=0.4000 MPa, c=0.0 mm, Pext=0.0000 MPa

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.1000

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 1416.00 mm

NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.00 mm

INSIDE SPHERICAL RADIUS (corroded).....:R 1132.80 mm

LARGEST INSIDE DIAMETER OF NOZZLE IN KNUCKLE REGION.:d 458.00 mm

EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%

Rm=520 Rp=260 Rpt=187.48 fs=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

NOZZLE MATERIAL DATA



Delivery Form: Seamless Pipe

EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

Rm=490 Rp=225 Rpt=187.2 fb=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93

NOZZLE DIMENSIONAL DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.13 ConnID:E3.2



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 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
Size of Flange and Nozzle:
Comment (Optional):
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 30.00 %
NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 50.00 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 6.8444 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 = 8.0000 mm
Nozzle Analysis Thickness eab
eab = enb - cn - NegDev = 1.0500 mm
ris = R (9.5-4) = 1132.80 mm
dib = deb - 2 * eab = 50.90 mm
Min.Nozzle Thk.Based on Internal Pressure ebp
ebp = P * deb / (2 * fb * z + P) = 0.0800 mm
Allowable Stresses
fob = Min(fs, fb) (9.5-8) = 124.80 N/mm2

GEOMETRIC LIMITATIONS

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

Calculation of Stress Loaded Areas Effective as Reinforcement

Area of Shell Afs

Limit of Reinforcement Along Shell
Iso = Sqr((2 * ris + eas) * eas) = 134.87 mm
Set In Nozzle
Afs = eas * Iso (9.5-79) = 1078.93 mm2

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
N.13 ConnID:E3.2

Area of Nozzle Afb

Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 7.3856 mm
Set In Nozzle
 $Afb = \text{eb} * (Ibo + Ibi + \text{eas})$ (9.5-78) = 16.15 mm²

Calculation of Pressure Loaded Areas

In the Nozzle Apb
 $Apb = 0.5 * \text{dib} * (Ibo + \text{eas})$ (9.5-84) = 391.56 mm²
Additional Area due to Obliquity of Nozzle Ap(phi)
 $Apphi = 0.5 * \text{dib}^2 * \text{Tan}(\text{phi})$ (9.5-112) = 155.49 mm²
Spherical Shell/End on any Section Aps
 $Aps = 0.5 * \text{ris}^2 * (\text{Is} + \text{a}) / (0.5 * \text{eas} + \text{ris})$ (9.5-115) = 91184.83 mm²

9.5.2 Reinforcement Rules

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 36.66 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)
= 151.84 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6492 MPa

Max.Allowable Test Pressure Ptmx

$Ptmx =$ = 3.0800 MPa

Weight of Nozzle: .124kg

CALCULATION SUMMARY

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

Limit of Reinforcement Along Shell
 $Iso = \text{Sqr}((2 * \text{ris} + \text{eas}) * \text{eas})$ = 134.87 mm
Limit of Reinforcement Along Nozzle (outside shell)
 $Ibo = \text{MIN}(\text{Sqr}((\text{deb} - \text{eb}) * \text{eb}), \text{ho})$ (9.5-76) = 7.3856 mm

Pressure Area Required pA(req.)

$pAReq = P * (Aps + Apb + 0.5 * Apphi)$ (9.5-7) = 36.66 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)
= 151.84 kN

Maximum Allowable Pressure Pmax

$Pmax = (Afs + Afw) * fs + Afb * fob / ((Aps + Apb + 0.5 * Apphi) + 0.5 * (Afs + Afw + Afb + Afp))$ (9.5-10)
= 1.6492 MPa

Volume:0.0001000 m³ Weight:0.1 kg (SG= 7.93)

ORION.GROUP LLC

Client : BTL2103

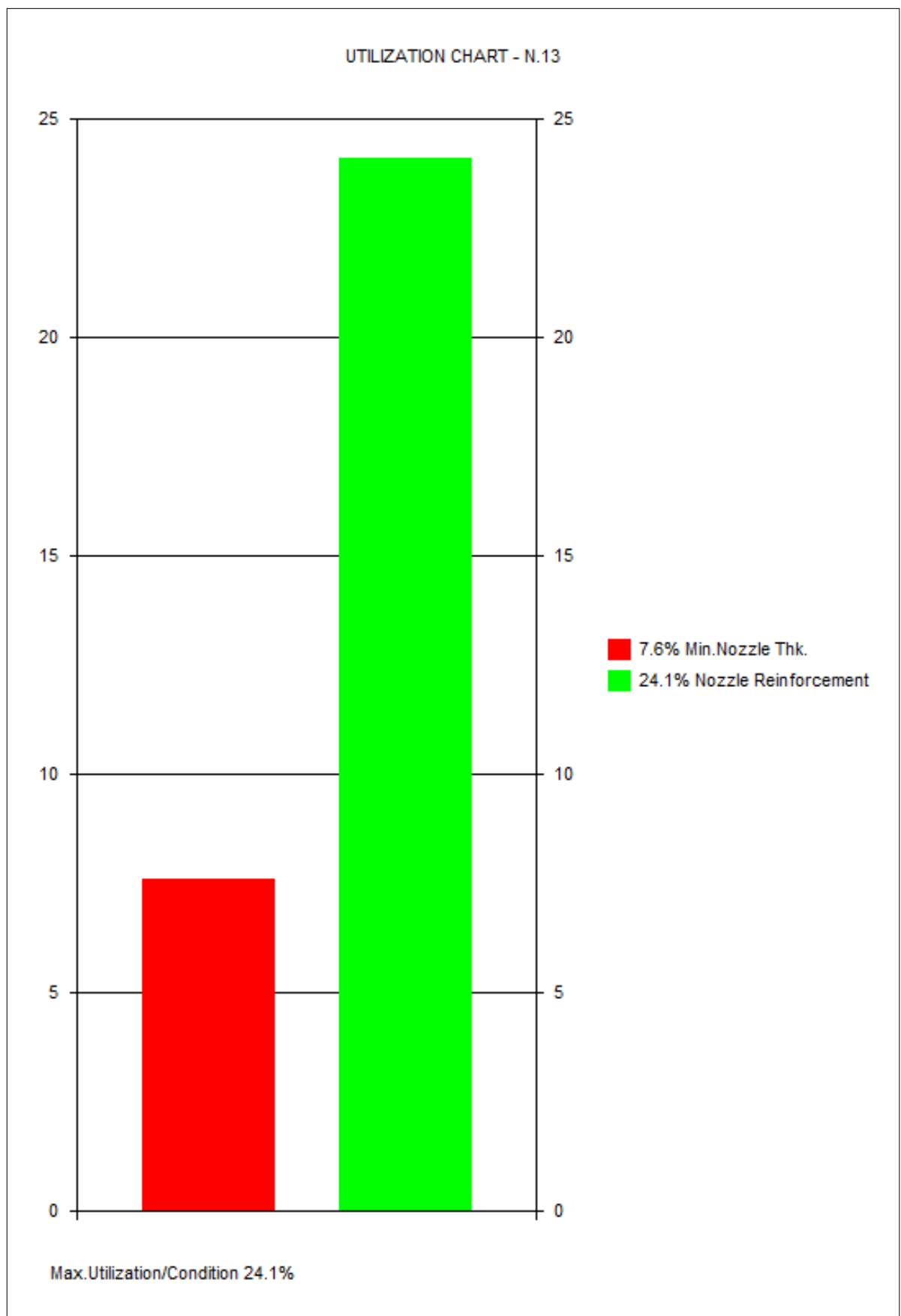
Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS

N.13 ConnID:E3.2



ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.5 ISOLATED OPENINGS IN SHELLS
GO.1 ConnID:E3.2

EN13445 - 9.6 MULTIPLE OPENINGS
GO.1 29 Mar. 2023 17:28

SUMMARY OF CALCULATION RESULTS :
No. of Nozzles Considered : 13
No. of Permutations: 56
No. of Nozzle Pairs Classified as Groups: 18
No. of Nozzle Groups Requiring Additional Reinforcement : 0

Nozzles on Component :E3.2 Torispherical End
NOMENCLATURE :
Distance(mm); Lb = Center Dist.between the pair of Nozzles
Distance(mm); s = Dist.between OD of Nozzles = Lb-a1-a2 ; Iso = Isol+Iso2
Pres.Area(N); pAreq.= Pressure Area Required, pAaval = Pressure Area Available
Status (---); N/A = Not a Group, OK = Sufficient Reinf., ADD = Add reinf.

No.	Nozz1	Nozz2	---s---	--Iso--	---Lb--	Grp.	-pAreq.--	-pAaval--	-U-	-STS-
1	N.1	N.2	123	270	463	Yes	109805	355643	30%	OK
2	N.1	N.3	211	270	462	Yes	108895	257647	42%	OK
3	N.1	N.4	327	270	572	No	---N/A---	---N/A---	N/A	N/A
4	N.1	N.5	527	270	778	No	---N/A---	---N/A---	N/A	N/A
5	N.1	N.6	566	270	818	No	---N/A---	---N/A---	N/A	N/A
6	N.1	N.7	440	270	685	No	---N/A---	---N/A---	N/A	N/A
7	N.1	N.8	355	270	606	No	---N/A---	---N/A---	N/A	N/A
8	N.1	N.11	218	270	475	Yes	111813	265241	42%	OK
9	N.1	N.12	218	270	475	Yes	111813	265241	42%	OK
10	N.1	N.13	287	270	544	No	---N/A---	---N/A---	N/A	N/A
11	N.2	N.3	706	270	837	No	---N/A---	---N/A---	N/A	N/A
12	N.2	N.4	769	270	894	No	---N/A---	---N/A---	N/A	N/A
13	N.2	N.5	773	270	904	No	---N/A---	---N/A---	N/A	N/A
14	N.2	N.6	668	270	799	No	---N/A---	---N/A---	N/A	N/A
15	N.2	N.7	305	270	430	No	---N/A---	---N/A---	N/A	N/A
16	N.2	N.8	174	270	305	Yes	69755	393342	17%	OK
17	N.2	N.11	604	270	741	No	---N/A---	---N/A---	N/A	N/A
18	N.2	N.12	190	270	326	Yes	74648	410658	18%	OK
19	N.2	N.13	459	270	596	No	---N/A---	---N/A---	N/A	N/A
20	N.3	N.4	105	270	139	Yes	31647	119741	26%	OK
21	N.3	N.5	450	270	491	No	---N/A---	---N/A---	N/A	N/A
22	N.3	N.6	624	270	665	No	---N/A---	---N/A---	N/A	N/A
23	N.3	N.7	782	270	817	No	---N/A---	---N/A---	N/A	N/A
24	N.3	N.8	771	270	812	No	---N/A---	---N/A---	N/A	N/A
25	N.3	N.11	148	270	195	Yes	44423	168403	26%	OK
26	N.3	N.12	599	270	646	No	---N/A---	---N/A---	N/A	N/A
27	N.3	N.13	425	270	472	No	---N/A---	---N/A---	N/A	N/A
28	N.4	N.5	337	270	371	No	---N/A---	---N/A---	N/A	N/A
29	N.4	N.6	537	270	572	No	---N/A---	---N/A---	N/A	N/A
30	N.4	N.7	769	270	797	No	---N/A---	---N/A---	N/A	N/A
31	N.4	N.8	781	270	816	No	---N/A---	---N/A---	N/A	N/A
32	N.4	N.11	121	270	162	Yes	36841	138534	26%	OK
33	N.4	N.12	615	270	656	No	---N/A---	---N/A---	N/A	N/A
34	N.4	N.13	389	270	430	No	---N/A---	---N/A---	N/A	N/A
35	N.5	N.6	200	270	241	Yes	54751	225989	24%	OK
36	N.5	N.7	586	270	621	No	---N/A---	---N/A---	N/A	N/A
37	N.5	N.8	656	270	697	No	---N/A---	---N/A---	N/A	N/A
38	N.5	N.11	285	270	332	No	---N/A---	---N/A---	N/A	N/A
39	N.5	N.12	538	270	585	No	---N/A---	---N/A---	N/A	N/A
40	N.5	N.13	260	270	307	Yes	69764	293230	23%	OK
41	N.6	N.7	398	270	432	No	---N/A---	---N/A---	N/A	N/A
42	N.6	N.8	494	270	535	No	---N/A---	---N/A---	N/A	N/A
43	N.6	N.11	428	270	475	No	---N/A---	---N/A---	N/A	N/A
44	N.6	N.12	428	270	475	No	---N/A---	---N/A---	N/A	N/A
45	N.6	N.13	226	270	273	Yes	62088	255458	24%	OK

EN13445 - 9.6 MULTIPLE OPENINGS
GO.1 29 Mar. 2023 17:28

Nozzles on Component :E3.2 Torispherical End

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
 49 Reactor, Volume 2000 L
 Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
 EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
 GO.1

NOMENCLATURE :
 Distance(mm); Lb = Center Dist.between the pair of Nozzles
 Distance(mm); s = Dist.between OD of Nozzles = Lb-a1-a2 ; Iso = Iso1+Iso2
 Pres.Area(N); pAreq.= Pressure Area Required, pAaval = Pressure Area Available
 Status (---); N/A = Not a Group, OK = Sufficient Reinf., ADD = Add reinf.

No.	Nozz1	Nozz2	---s---	--Iso--	---Lb--	Grp.-pAreq.--	-pAaval--	-U-	-STS-
46	N.7	N.8	91	270	125	Yes	28532	104410	27% OK
47	N.7	N.11	600	270	641	No	---N/A---	---N/A---	N/A N/A
48	N.7	N.12	171	270	211	Yes	48003	193460	24% OK
49	N.7	N.13	331	270	371	No	---N/A---	---N/A---	N/A N/A
50	N.8	N.11	608	270	655	No	---N/A---	---N/A---	N/A N/A
51	N.8	N.12	119	270	166	Yes	37924	136418	27% OK
52	N.8	N.13	367	270	414	No	---N/A---	---N/A---	N/A N/A
53	N.11	N.12	441	270	494	No	---N/A---	---N/A---	N/A N/A
54	N.11	N.13	228	270	281	Yes	63857	257397	24% OK
55	N.12	N.13	228	270	281	Yes	63857	257397	24% OK

Max.test pressure P_{tmax}= 1.791 for Nozzle Group: N.1 - N.3 Located in:E3.2 T

EN13445 - 9.6 MULTIPLE OPENINGS
 GO.1 29 Mar. 2023 17:28

Nozzles on Component :E3.1 Torispherical End
 NOMENCLATURE :
 Distance(mm); Lb = Center Dist.between the pair of Nozzles
 Distance(mm); s = Dist.between OD of Nozzles = Lb-a1-a2 ; Iso = Iso1+Iso2
 Pres.Area(N); pAreq.= Pressure Area Required, pAaval = Pressure Area Available
 Status (---); N/A = Not a Group, OK = Sufficient Reinf., ADD = Add reinf.

No.	Nozz1	Nozz2	---s---	--Iso--	---Lb--	Grp.-pAreq.--	-pAaval--	-U-	-STS-
56	N.9	N.10	181	233	356	Yes	83993	210911	39% OK

Max.test pressure P_{tmax}= 1.946 for Nozzle Group: N.9 - N.10 Located in:E3.1

INPUT DATA

Extent of Nozzle Interaction Check

Select Extent of Nozzle Interaction Check:
 Check All Components. ==> No. of Nozzles/Permutations : 13/ 56

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
 DESIGN PRESSURE.....:P 0.4000 MPa
 INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
 OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
 NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
 EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
 Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.1

NOZZLE SIZE ...:
 OUTSIDE NOZZLE DIAMETER.....:deb 458.00 mm
 NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 4.0000 mm
 NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.3000 mm
 MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded).:epb 0.7700 mm
 EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
 Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
 OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
GO.1

DATA FOR NOZZLE: N.2

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 220.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 47.50 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.3000 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.1 - N.2 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 463.49 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 122.74 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 2,616E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 981.92 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 109.80 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)$
= 21.39 kN
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)$
= 197.89 kN
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 355.64 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.1

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 458.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.3000 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.7700 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.3

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
GO.1

Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.1 - N.3 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 462.03 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 210.95 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 2,6077E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1687.61 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 108.89 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)$
= 21.39 kN
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)$
= 1.8940 kN
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 257.65 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.1

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 458.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.3000 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.7700 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.11

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
GO.1

CALCULATION DATA

Nozzle Group: N.1 - N.11 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 474.76 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 217.68 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 2,6796E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1741.44 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 111.81 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)$
= 21.39 kN
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)$
= 2.0129 kN
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 265.24 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.1

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 458.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 4.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.3000 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.7700 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.12

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
GO.1

Nozzle Group: N.1 - N.12 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 474.76 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 217.68 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 2,6796E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1741.44 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 111.81 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P) = 21.39 \text{ kN}$
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P) = 2.0129 \text{ kN}$
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 265.24 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.2

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 220.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 47.50 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 14.25 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.8

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.2 - N.8 Located in:E3.2 Torispherical End

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
GO.1

Preliminary Calculations

Center Distance Between Nozzles Lb = = 304.90 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 174.23 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 1,7209E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1393.81 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 69.75 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)$
= 197.89 kN
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)$
= 1.8940 kN
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 393.34 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.2

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 220.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 47.50 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 14.25 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.12

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.2 - N.12 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 326.38 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 189.71 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 1,8421E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1517.64 \text{ mm}^2$

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
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Pressure Area Required pA(req.)

$$pA_{Req} = P * (ApLs + Apb1 + 0.5 * Apphi1 + Apb2 + 0.5 * Apphi2) \quad (9.6-4) = \underline{\underline{74.65 \text{ kN}}}$$

Pressure Area Available pA(aval.)

$$\begin{aligned} pANozz1 &= Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P) \\ &= 197.89 \text{ kN} \\ pANozz2 &= Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P) \\ &= 2.0129 \text{ kN} \\ pAAval &= (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 \quad (9.6-4) = \underline{\underline{410.66 \text{ kN}}} \end{aligned}$$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.3

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):.epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.4

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 28.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):.epb 0.0400 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.3 - N.4 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 139.01 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 104.51 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) \quad (9.6-5) = \underline{\underline{78458.23 \text{ mm}^2}}$
 $AfLs = (Lb - a1 - a2) * eas \quad (9.6-7) = \underline{\underline{836.07 \text{ mm}^2}}$

Pressure Area Required pA(req.)

$$pA_{Req} = P * (ApLs + Apb1 + 0.5 * Apphi1 + Apb2 + 0.5 * Apphi2) \quad (9.6-4) = \underline{\underline{31.65 \text{ kN}}}$$

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
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Pressure Area Available pA(aval.)

$$\begin{aligned} pANozz1 &= Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P) \\ &= 1.8940 \text{ kN} \\ pANozz2 &= Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P) \\ &= 1.7426 \text{ kN} \\ pAAval &= (AfLs+Afw1+Afw2)*(fs-0.5*P)+pANozz1+pANozz2 \quad (9.6-4) = \underline{\underline{119.74 \text{ kN}}} \end{aligned}$$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.3

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.11

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.3 - N.11 Located in:E3.2 Torispherical End

Preliminary Calculations

$$\begin{aligned} \text{Center Distance Between Nozzles } Lb &= 195.07 \text{ mm} \\ \text{Distance Between OD of Nozzles} \\ s &= Lb - a1 - a2 = 148.07 \text{ mm} \\ ApLs &= 0.5 * ris ^ 2 * Lb / (ris + 0.5 * eas) \quad (9.6-5) = \underline{1,101E05 \text{ mm}^2} \\ AfLs &= (Lb - a1 - a2) * eas \quad (9.6-7) = \underline{1184.53 \text{ mm}^2} \end{aligned}$$

Pressure Area Required pA(req.)

$$pAReq = P * (ApLs+Apb1+0.5*Apph1+Apb2+0.5*Apph2) \quad (9.6-4) = \underline{\underline{44.42 \text{ kN}}}$$

Pressure Area Available pA(aval.)

$$\begin{aligned} pANozz1 &= Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P) \\ &= 1.8940 \text{ kN} \\ pANozz2 &= Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P) \\ &= 2.0129 \text{ kN} \\ pAAval &= (AfLs+Afw1+Afw2)*(fs-0.5*P)+pANozz1+pANozz2 \quad (9.6-4) = \underline{\underline{168.40 \text{ kN}}} \end{aligned}$$

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
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GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.4

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 28.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):.epb 0.0400 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.11

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):.epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.4 - N.11 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 161.82 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 121.32 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) \text{ (9.6-5) } =$ 91332.35 mm²
 $AfLs = (Lb - a1 - a2) * eas \text{ (9.6-7) } =$ 970.54 mm²

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) \text{ (9.6-4) } =$ 36.84 kN

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)$
= 1.7426 kN
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)$
= 2.0129 kN
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 \text{ (9.6-4) } =$ 138.53 kN

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
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SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.5

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.6

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.5 - N.6 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 241.01 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 200.01 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) =$ 1,3603E05 mm2
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) =$ 1600.06 mm2

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) =$ 54.75 kN

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)$
= 1.8940 kN
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)$
= 1.8940 kN
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) =$ 225.99 kN

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
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DATA FOR NOZZLE: N.5

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.13

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.5 - N.13 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 307.43 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 260.43 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 1,7352E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 2083.41 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 69.76 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)$
= 1.8940 kN
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)$
= 2.0129 kN
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 293.23 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate, THK<=75mm 132'C, A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.6

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
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Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.13

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.6 - N.13 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 273.43 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 226.43 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 1,5433E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1811.41 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAREq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 62.09 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)$
= 1.8940 kN
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)$
= 2.0129 kN
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 255.46 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.7

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 28.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0400 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
GO.1

DATA FOR NOZZLE: N.8

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):.epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.7 - N.8 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 125.21 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 90.71 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 70669.41 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 725.67 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apphi1 + Apb2 + 0.5 * Apphi2) (9.6-4) = 28.53 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)$
= 1.7426 kN
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)$
= 1.8940 kN
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 104.41 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate, THK<=75mm 132'C, A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.7

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 28.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):.epb 0.0400 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.12

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):.epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
GO.1

Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.7 - N.12 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 211.26 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 170.76 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 1,1924E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1366.06 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 48.00 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P) = 1.7426 \text{ kN}$
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P) = 2.0129 \text{ kN}$
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 193.46 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.8

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 41.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0700 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.12

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
GO.1

CALCULATION DATA

Nozzle Group: N.8 - N.12 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 166.28 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 119.28 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 93849.61 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 954.21 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 37.92 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P) = 1.8940 \text{ kN}$
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P) = 2.0129 \text{ kN}$
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 136.42 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.11

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.13

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
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GO.1

Nozzle Group: N.11 - N.13 Located in:E3.2 Torispherical End

Preliminary Calculations

Center Distance Between Nozzles Lb = = 281.07 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 228.07 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 1,5864E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1824.52 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 63.86 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P) = 2.0129 \text{ kN}$
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P) = 2.0129 \text{ kN}$
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 257.40 \text{ kN}$

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4000 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.2 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1416.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 8.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.12

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.13

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 53.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 1.5000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.4500 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.0800 mm
EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT THK<=60mm 132'C
Rm=490 Rp=225 Rpt=187.2 f=124.8 f20=150 ftest=214.29 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.12 - N.13 Located in:E3.2 Torispherical End

ORION.GROUP LLC

Client : BTL2103 Vessel No.:1403
49 Reactor, Volume 2000 L
Visual Vessel Design by Hexagon PPM,Ver:20.0 Operator :RS Rev.:A
EN13445:2014 Issue 3:2016 - 9.6 Multiple Openings
GO.1

Preliminary Calculations

Center Distance Between Nozzles Lb = = 281.07 mm
Distance Between OD of Nozzles
s = Lb - a1 - a2 = 228.07 mm
 $ApLs = 0.5 * ris^2 * Lb / (ris + 0.5 * eas) (9.6-5) = 1,5864E05 \text{ mm}^2$
 $AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1824.52 \text{ mm}^2$

Pressure Area Required pA(req.)

$pAReq = P * (ApLs + Apb1 + 0.5 * Apph1 + Apb2 + 0.5 * Apph2) (9.6-4) = 63.86 \text{ kN}$

Pressure Area Available pA(aval.)

$pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P) = 2.0129 \text{ kN}$
 $pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P) = 2.0129 \text{ kN}$
 $pAAval = (AfLs + Afw1 + Afw2) * (fs - 0.5 * P) + pANozz1 + pANozz2 (9.6-4) = 257.40 \text{ kN}$

Max.test pressure P_{tmax}= 1.791 for Nozzle Group: N.1 - N.3 Located in:E3.2 Torispherical End
= 1.7910 MPa

GENERAL DESIGN DATA

CALCULATION TEMPERATURE.....:Temp 132.00 °C
DESIGN PRESSURE.....:P 0.4155 MPa
INTERNAL CORROSION ALLOWANCE.....:c 0.00 mm

SHELL DATA

Nozzles on Component :E3.1 Torispherical End
OUTSIDE DIAMETER OF SHELL.....:De 1412.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:en 6.0000 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93

DATA FOR NOZZLE: N.9

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 160.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 5.0000 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 1.5000 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

DATA FOR NOZZLE: N.10

NOZZLE SIZE ...:
OUTSIDE NOZZLE DIAMETER.....:deb 190.00 mm
NOMINAL NOZZLE THICKNESS (uncorroded).....:enb 36.00 mm
NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 10.80 mm
MIN.NOZZLE THICKN.DUE TO PRESSURE LOADING(corroded):epb 0.00 mm
EN 10028-7:2016, 1.4404 X2CrNiMo17-12-2 P=Hot Rolled Plate , THK<=75mm 132'C,A>=35%
Rm=520 Rp=260 Rpt=187.48 f=139.07 f20=173.33 ftest=260 E=190466(N/mm2) ro=7.93
OUTWARD NOZZLE WELD, THROAT DIMENSION.....:mo 0.00 mm

CALCULATION DATA

Nozzle Group: N.9 - N.10 Located in:E3.1 Torispherical End

ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS Rev.:A

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Preliminary Calculations

Center Distance Between Nozzles Lb = = 355.82 mm

Distance Between OD of Nozzles

s = Lb - a1 - a2 = 180.64 mm

ApLs = 0.5 * ris ^ 2 * Lb / (ris + 0.5 * eas) (9.6-5) = 2,0043E05 mm2

AfLs = (Lb - a1 - a2) * eas (9.6-7) = 1083.85 mm2

Pressure Area Required pA(req.)

pAReq = P*(ApLs+Apb1+0.5*Apph1+Apb2+0.5*Apph2) (9.6-4) = 83.99 kN

Pressure Area Available pA(aval.)

pANozz1 = Afp1 * (fop1 - 0.5 * P) + Afb1 * (fob1 - 0.5 * P)
= 10.41 kN

pANozz2 = Afp2 * (fop2 - 0.5 * P) + Afb2 * (fob2 - 0.5 * P)
= 49.99 kN

pAAval = (AfLs+Afw1+Afw2)*(fs-0.5*P)+pANozz1+pANozz2 (9.6-4) = 210.91 kN

Max.test pressure P_{tmax}= 1.946 for Nozzle Group: N.9 - N.10 Located in:E3.1 Torispherical End

= 1.9460 MPa

CALCULATION SUMMARY

Nozzle Group: N.1 - N.2 Located in:E3.2 Torispherical End

Nozzle Group: N.1 - N.3 Located in:E3.2 Torispherical End

Nozzle Group: N.1 - N.11 Located in:E3.2 Torispherical End

Nozzle Group: N.1 - N.12 Located in:E3.2 Torispherical End

Nozzle Group: N.2 - N.8 Located in:E3.2 Torispherical End

Nozzle Group: N.2 - N.12 Located in:E3.2 Torispherical End

Nozzle Group: N.3 - N.4 Located in:E3.2 Torispherical End

Nozzle Group: N.3 - N.11 Located in:E3.2 Torispherical End

Nozzle Group: N.4 - N.11 Located in:E3.2 Torispherical End

Nozzle Group: N.5 - N.6 Located in:E3.2 Torispherical End

Nozzle Group: N.5 - N.13 Located in:E3.2 Torispherical End

Nozzle Group: N.6 - N.13 Located in:E3.2 Torispherical End

Nozzle Group: N.7 - N.8 Located in:E3.2 Torispherical End

Nozzle Group: N.7 - N.12 Located in:E3.2 Torispherical End

Nozzle Group: N.8 - N.12 Located in:E3.2 Torispherical End

ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS

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Nozzle Group: N.11 - N.13 Located in:E3.2 Torispherical End

Nozzle Group: N.12 - N.13 Located in:E3.2 Torispherical End

Nozzle Group: N.9 - N.10 Located in:E3.1 Torispherical End

ORION.GROUP LLC

Client : BTL2103

Vessel No.:1403

49 Reactor, Volume 2000 L

Visual Vessel Design by Hexagon PPM, Ver:20.0 Operator :RS

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GO.1

