







OWNER:  شرکت سست و سویی توهم ایرانیان (سایه و شیشه)	BUSHEHR PETROCHEMICAL COMPANY MEG PLANT						EPC CONTRACTOR:  Chagalesh-Enerchimi-Steam Joint Venture BUPC-MEG PLANT PROJECT		
	AFTER COOLER MECHANICAL STRENGHT CALCULATION FOR EMERGENCY INSTRUMENT AIR COMPRESSOR								
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With reference to clause M8 of TCL PV ELITE native file shall be submitted.



AFTER COOLER MECHANICAL STRENGHT CALCULATION FOR EMERGENCY INSTRUMENT AIR COMPRESSOR

 شرکت سست و سویی توهم ایرانیان توسعه نیروگاهی	 Chagalesh-Enerchimi-Steam Joint Venture BUPC-MEG PLANT PROJECT	BUSHEHR PETROCHEMICAL COMPANY MEG PLANT
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Approval or review hereunder shall not be construed to relieve Vendor / Subcontractor of his responsibilities and liability under the contract.		

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

Design Data & Process Information

Description	Units	Design Data	Design Data
Process Card		Shell Side	Tube Side
Design Code & Specifications		ASME VIII Div.1 2019	ASME VIII Div.1 2019
Internal Design Pressure (MPa)	MPa	2.5	1
External Design Pressure (MPa)	MPa	0.1	0.1
Hydrotest Pressure (MPa)	MPa	3.75	1.5
Maximum Design Temperature (°C)	°C	210	95
Minimum Design Temperature (°C)	°C	-10	-10
Operating Temperature (°C)	°C		
Corrosion Allowance (mm)	mm	1	1
Content of Vessel			
Specific Density of Oper.Liq		1	1
Normal Liquid Level NLL (mm)	mm	200	200

Weight & Volume of Vessel

PROCESS CARD NO.: 1 SHELL SIDE

ID	No.	Wt-UnFinish.	Wt-Finished	Tot.Volume	Test.Liq.Wt	Oper.Liq.Wt
S1.1	1	13.0 kg	12.8 kg	0.016 m3	16.0 kg	14.9 kg
TB.1	1	0.0 kg	0.0 kg	-0.001 m3	-1.3 kg	-1.9 kg
Total	2	13.0 kg	12.8 kg	0.015 m3	14.7 kg	13.1 kg

PROCESS CARD NO.: 2 TUBE SIDE

ID	No.	Wt-UnFinish.	Wt-Finished	Tot.Volume	Test.Liq.Wt	Oper.Liq.Wt
E4.1	1	7.0 kg	6.5 kg	0.000 m3	0.0 kg	0.0 kg
E4.2*	1	7.0 kg	7.0 kg	0.000 m3	0.0 kg	0.0 kg
F.1	1	6.0 kg	6.0 kg	0.001 m3	1.0 kg	0.5 kg
F.2*	1	6.0 kg	6.0 kg	0.001 m3	1.0 kg	0.8 kg
F.3	1	6.0 kg	6.0 kg	0.001 m3	1.0 kg	0.8 kg
F.4*	1	6.0 kg	6.0 kg	0.001 m3	1.0 kg	0.8 kg
N.1	1	4.0 kg	4.0 kg	0.000 m3	0.0 kg	0.2 kg
N.2*	1	4.0 kg	4.0 kg	0.000 m3	0.0 kg	0.2 kg
N.3	1	0.0 kg	0.0 kg	0.000 m3	0.0 kg	0.0 kg
N.4*	1	0.0 kg	0.0 kg	0.000 m3	0.0 kg	0.0 kg
S1.2	1	2.0 kg	2.0 kg	0.001 m3	1.0 kg	0.8 kg
S1.3*	1	2.0 kg	2.0 kg	0.001 m3	1.0 kg	0.8 kg
T.1	1	3.0 kg	3.0 kg	0.000 m3	0.0 kg	0.0 kg
T.2	1	3.0 kg	3.0 kg	0.000 m3	0.0 kg	0.0 kg
TB.1	1	4.0 kg	4.0 kg	0.001 m3	1.0 kg	1.4 kg
Total	15	60.0 kg	59.5 kg	0.007 m3	7.0 kg	6.4 kg

SUMMATION OF DATA FOR ALL COMPONENTS :

Total : 17 73 kg 72 kg 0.022 m3 22 kg 19 kg

Weight Summary/Condition	Shell Side	Tube Side	Total
Empty Weight of Vessel incl. 5% Contingency	13 kg / 0.0 Tons	62 kg / 0.1 Tons	75 kg
Total Test Weight of Vessel (Testing with Water)	28 kg / 0.0 Tons	69 kg / 0.1 Tons	97 kg
Total Operating Weight of Vessel	27 kg / 0.0 Tons	69 kg / 0.1 Tons	96 kg

Center of Gravity

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PROCESS CARD NO.: 1 SHELL SIDE

ID	X-Empty	Y-Empty	Z-Empty	X-Test	Y-Test	Z-Test	X-Oper	Y-Oper	Z-Oper
S1.1	0	0	490	0	0	525	0	0	525

SHELL SIDE CENTER OF GRAVITY AT CONDITIONS BELOW	X	Y	Z
Empty Vessel	0	0	490
Test Condition of Vessel (Testing with Water)	0	0	509
Operating Condition of Vessel	0	0	509

PROCESS CARD NO.: 2 TUBE SIDE

ID	X-Empty	Y-Empty	Z-Empty	X-Test	Y-Test	Z-Test	X-Oper	Y-Oper	Z-Oper
E4.1	0	0	-138	0	0	-134	0	0	-134
E4.2*	0	0	1184	0	0	1184	0	0	1184
F.1	0	0	-72	0	0	-72	0	0	-72
F.2*	0	0	1113	0	0	1113	0	0	1113
F.3	0	0	-27	0	0	-27	0	0	-27
F.4*	0	0	1077	0	0	1077	0	0	1077
N.1	150	0	80	115	0	80	115	0	80
N.2*	-150	0	980	-115	0	980	-115	0	980
N.3	41	0	-153	41	0	-160	41	0	-160
N.4*	-40	0	-152	-40	0	-159	-40	0	-159
S1.2	0	0	-105	0	0	-105	0	0	-105
S1.3*	0	0	1155	0	0	1155	0	0	1155
T.1	0	0	-68	0	0	-68	0	0	-68
T.2	0	0	510	0	0	510	0	0	510
TB.1	0	0	221	0	0	221	0	0	221

TUBE SIDE CENTER OF GRAVITY AT CONDITIONS BELOW	X	Y	Z
Empty Vessel	0	0	479
Test Condition of Vessel (Testing with Water)	0	0	479
Operating Condition of Vessel	0	0	479

CENTER OF GRAVITY AT CONDITIONS BELOW	X	Y	Z
Empty Vessel	0	0	481
Test Condition of Vessel (Testing with Water)	0	0	488
Operating Condition of Vessel	0	0	488

Max. Allowable Pressure MAWP

PROCESS CARD NO.: 1 SHELL SIDE

ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
S1.1	Cylindrical Shell	Main Shell	0.003 MPa	5.021 MPa	3.314 MPa
T.1	Tubesheet	Tubesheet	0.000 MPa	12.115 MPa	10.684 MPa
T.2	Tubesheet	Tubesheet floating	0.000 MPa	17.231 MPa	15.183 MPa
TB.1	Tube Bundle	Tube bundle	0.000 MPa	2.764 MPa	2.709 MPa
	MAWP			2.764 MPa	2.709 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.

PROCESS CARD NO.: 2 TUBE SIDE

ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
E4.1	Welded Flat End	Head left	0.003 MPa	9.836 MPa	9.120 MPa
E4.2*	Welded Flat End	Head right	0.003 MPa	9.836 MPa	9.120 MPa
F.1	RT - Flange	Flanging Head left	0.003 MPa	3.310 MPa	3.310 MPa
F.2*	RT - Flange	Flanging Head right	0.003 MPa	3.310 MPa	3.310 MPa
F.3	RT - Flange	Flanging Shell left	0.003 MPa	3.310 MPa	3.310 MPa
F.4*	RT - Flange	Flanging Shell right	0.003 MPa	3.310 MPa	3.310 MPa
N.3	Open.Without Nozzle	N4	0.002 MPa	5.244 MPa	4.756 MPa
N.4*	Open.Without Nozzle	N3	0.002 MPa	5.244 MPa	4.756 MPa
S1.2	Cylindrical Shell	Channel Head left	0.003 MPa	11.102 MPa	10.112 MPa
S1.3*	Cylindrical Shell	Channel Head right	0.003 MPa	11.102 MPa	10.112 MPa
T.1	Tubesheet	Tubesheet	0.000 MPa	12.104 MPa	10.680 MPa
T.2	Tubesheet	Tubesheet floating	0.000 MPa	17.216 MPa	15.184 MPa

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ID	Comp. Type	Description	Liq.Head	MAWP New & Cold	MAWP Hot & Corr.
TB.1	Tube Bundle	Tube bundle	0.000 MPa	8.432 MPa	8.432 MPa
	MAWP			3.310 MPa	3.310 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.

Bill of Materials

ID	No	Description	Component Dimensions	Material Standard
E4.1	1	Welded Flat End-Head left	Do= 215, t= 27, Lcyl= 1, es= .85, r= 20	ID 3, SA-182(M) Gr.F316L, S31603 Forgings, PNo=8
E4.2*	1	Welded Flat End-Head right	Do= 215, t= 27, Lcyl= 1, es= .85, r= 20	ID 3, SA-182(M) Gr.F316L, S31603 Forgings, PNo=8
F.1	1	RT - Flange-Flanging Head left	OD= 215, ID= 133.3, thk= 36, h= 0, g1= 15.8	ID 3, SA-182(M) Gr.F316L, S31603 Forgings, PNo=8
F.1	4	Bolts	M12x1.75 ;, Area= 76.25	ID 4, SA-193(M) Gr.B7, G41400 Bolting
F.2*	1	RT - Flange-Flanging Head right	OD= 215, ID= 134.5, thk= 36, h= 18, g1= 17.5	ID 3, SA-182(M) Gr.F316L, S31603 Forgings, PNo=8
F.2*	4	Bolts	M12x1.75 ;, Area= 76.25	ID 4, SA-193(M) Gr.B7, G41400 Bolting
F.3	1	RT - Flange-Flanging Shell left	OD= 215, ID= 134.5, thk= 36, h= 18, g1= 17.5	ID 3, SA-182(M) Gr.F316L, S31603 Forgings, PNo=8
F.3	4	Bolts	M12x1.75 ;, Area= 76.25	ID 4, SA-193(M) Gr.B7, G41400 Bolting
F.4*	1	RT - Flange-Flanging Shell right	OD= 215, ID= 134.5, thk= 36, h= 18, g1= 17.5	ID 3, SA-182(M) Gr.F316L, S31603 Forgings, PNo=8
F.4*	4	Bolts	M12x1.75 ;, Area= 76.25	ID 4, SA-193(M) Gr.B7, G41400 Bolting
N.1	1	Flange:ASME B16.5:Class 300 lbs	WN Welding Neck, 1a RF Raised Face	2.3 16Cr-12Ni-2Mo :A 182 Gr. F316L - A 240 Gr. 316L
N.1	1	Nozzle,Plate Body-N1	2" do=60.3,t=3.91,L=110.5,ho=100	ID 9, SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8
N.2*	1	Flange:ASME B16.5:Class 300 lbs	WN Welding Neck, 1a RF Raised Face	2.3 16Cr-12Ni-2Mo :A 182 Gr. F316L - A 240 Gr. 316L
N.2*	1	Nozzle,Plate Body-N1	2" do=60.3,t=3.91,L=110.5,ho=100	ID 9, SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8
N.3	1	Open.Without Nozzle-N4	di=40	ID 5, SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8
N.4*	1	Open.Without Nozzle-N3	di=40	ID 5, SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8
S1.1	1	Cylindrical Shell-Main Shell	Do= 141.3, t= 3.4, L= 1050	ID 5, SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8
S1.2	1	Cylindrical Shell-Channel Head left	Do= 215, t= 13.35, L= 30	ID 3, SA-182(M) Gr.F316L, S31603 Forgings, PNo=8
S1.3*	1	Cylindrical Shell-Channel Head right	Do= 215, t= 13.35, L= 30	ID 3, SA-182(M) Gr.F316L, S31603 Forgings, PNo=8
T.1	1	Tubesheet-Tubesheet	OD= 132.2, thk= 28, N= 72 tubes	ID 11, SB-148(M), M01, C95820 Castings
T.2	1	Tubesheet-Tubesheet floating	OD= 132.2, thk= 28, N= 72 tubes	ID 11, SB-148(M), M01, C95820 Castings
TB.1	1	Tube Bundle-Tube bundle	N= 72, dt= 7.5, tt= .5, L= 606	ID 7, SB-111(M), O61, C70600 Smls. cond. tube

Nozzle List

ID	Service	SIZE	STANDARD/CLASS	ID	Standout	X	Y	Z	Rot.	Orient.
N.1	N1	2"	ASME B16.5 300 lbs WN -RF Raised Face SCH 40S	55.5	100	69	0	80	0	Radial
N.2*	N1	2"	ASME B16.5 300 lbs WN -RF Raised Face SCH 40S	55.5	100	-69	0	980	180	Radial
N.3	N4	2"		0	100	40.5	0	-153.5	0	Radial
N.4*	N3	2"		0	100	-40.5	0	-152.5	180	Radial

Maximum Component Utilization - Umax

ID	Comp.Type	Umax(%)	Limited by
E4.1	Welded Flat End	35.6%	Flat Head Thickness
E4.2*	Welded Flat End	35.6%	Flat Head Thickness

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ID	Comp.Type	Umax(%)	Limited by
F.1	RT - Flange	30.2%	Bolting Area Check
F.2*	RT - Flange	30.2%	Bolting Area Check
F.3	RT - Flange	30.2%	Bolting Area Check
F.4*	RT - Flange	30.2%	Bolting Area Check
N.1	Nozzle,Plate Body	73.3%	UG-45 Min.Nozzle Neck Thk.
N.2*	Nozzle,Plate Body	73.3%	UG-45 Min.Nozzle Neck Thk.
N.3	Open.Without Nozzle	19.0%	UG-37 Nozzle Reinforcement
N.4*	Open.Without Nozzle	19.0%	UG-37 Nozzle Reinforcement
S1.1	Cylindrical Shell	85.8%	Internal Pressure
S1.2	Cylindrical Shell	28.2%	Internal Pressure
S1.3*	Cylindrical Shell	28.2%	Internal Pressure
T.1	Tubesheet	26.4%	Tubesheet Bending Stress
T.2	Tubesheet	18.5%	Tubesheet Bending Stress
TB.1	Tube Bundle	95.9%	External Pressure

Component with highest utilization Umax = 95.9% TB.1 Tube bundle

Average utilization of all components Umean= 41.2%

Material Data/Mechanical Properties

ID	Material Name	Temp	ST	SY	SYd	S_d	Sr	fcest	E-mod	Note
1	SA-213(M) Gr.TP316L, S31603 Smls. tube, PNo=8 , SG=7.85	120	485	170	138.6	115	115	153	185000	G5
2	SA-479(M) Gr.304L, S30403 Bar, PNo=8 , SG=7.85	100	485	170	146	115	115	153	187909	G5, G21, G22, T4
3	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8 , SG=7.85	120	450	170	138.6	115	115	153	185000	G5
4	SA-193(M) Gr.B7, G41400 Bolting , Max.T= 100mm, SG=7.85	95	795	655	609.6	159	159	589.5	0	T5
5	SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 , SG=7.85	120	515	205	169.6	138	138	184.5	186212	G5, G12, T8, W12, W13, W14
6	SA-240(M) Gr.316Ti, S31635 Plate, PNo=8 , SG=7.85	100	515	205	180	138	138	184.5	187909	G5, G12, T8
7	SB-111(M), O61, C70600 Smls. cond. tube , SG=7.85	95	275	100	97.9	68.9	68.9	90	122285	G5, T5
8	SA-479(M) Gr.304L, S30403 Bar, PNo=8 , SG=7.85	120	485	170	139.6	115	115	153	186212	G5, G21, G22, T4
9	SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8 , SG=7.85	100	485	170	145	115	115	153	187000	G5, G21, W12, W14
10	SB-111(M), O61, C68700 Smls. cond. tube , SG=7.85	210	345	125	0	20.8	82.7	112.5	124000	T3
11	SB-148(M), M01, C95820 Castings , SG=7.85	204	650	270	259.8	167.5	179	243	141976	G15

Notation:

Thickness in mm, stress in N/mm², temperature in deg.C

TG : Test Group 1 to 4

Max.T: Maximum thickness for this stress set, 0 or 999 = No limit specified

S/C : CS = Carbon Steel, SS = Stainless Steel

SG : SG = Specific Gravity (Water = 1.0)

ST : MIN.TENSILE STRENGTH at room temp.

SY : MIN. YIELD STRENGTH at room temp.

SYd : MIN. YIELD STRENGTH at calc.temp.

S_d : DESIGN STRESS at calc.temp.

Sr : DESIGN STRESS at room temp.

Note : G5 = Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the shorttime tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceeded 662/3% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress

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values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction. For Section III applications, Table Y-2 lists multiplying factors that, when applied to the yield strength values shown in Table Y-1, will give allowable stress values that will result in lower levels of permanent strain.

Note : G21 = For Section I, use is limited to PEB-5.3. See PG-5.5 for cautionary note.

Note : G22 = For Section I applications, use of external pressure charts for material in the form of barstock is permitted for stiffening rings only.

Note : T4 = Allowable stresses for temperatures of 480°C and above are values obtained from time-dependent properties.

Note : T5 = Allowable stresses for temperatures of 450°C and above are values obtained from time-dependent properties.

Note : G12 = At temperatures above 550°C, these stress values apply only when the carbon is 0.04% or higher on heat analysis.

Note : T8 = Allowable stresses for temperatures of 595°C and above are values obtained from time-dependent properties.

Note : W12 = These S values do not include a longitudinal weld efficiency factor. For Section III applications, for materials welded without filler metal, ultrasonic examination, radiographic examination, or eddy current examination, in accordance with NC-2550, shall provide a longitudinal weld efficiency factor of 1.00. Materials welded with filler metal meeting the requirements of NC-2560 shall receive a longitudinal weld efficiency factor of 1.00. Other longitudinal weld efficiency factors shall be in accordance with the following: (a) for single butt weld, with filler metal, 0.80; (b) for single or double butt weld, without filler metal, 0.85; (c) for double butt weld, with filler metal, 0.90; (d) for single or double butt weld, with radiography, 1.00.

Note : W13 = For Section I applications, electric resistance and autogenous welded tubing may be used with these stresses, provided the following additional restrictions and requirements are met: (a) The tubing shall be used for boiler, waterwall, superheater, and economizer tubes that are enclosed within the setting. (b) The maximum outside diameter shall be 89 mm. (c) The weld seam of each tube shall be subjected to an angle beam ultrasonic inspection per SA-450. (d) A complete volumetric inspection of the entire length of each tube shall be performed in accordance with SA-450. (e) Material test reports shall be supplied.

Note : W14 = These S values do not include a weld factor. For Section VIII, Division 1, and Section XII applications using welds made without filler metal, the tabulated tensile stress values shall be multiplied by 0.85. For welds made with filler metal, consult UW-12 for Section VIII, Division 1, or TW-130.4 for Section XII, as applicable.

Note : T3 = Allowable stresses for temperatures of 175°C and above are values obtained from time-dependent properties.

Note : G15 = To these stress values a quality factor as specified in ND-3115 of Section III; UG-24 of Section VIII, Division 1; or TM-190 of Section XII shall be applied for castings. This is not intended to apply to valves and fittings made to recognized standards.

Comp.Location in Global Coord.System

ID	Comp. Type	X	Y	Z	Teta	Phi	ConnID
E4.1	Welded Flat End	0	0	-120	0.0	0.0	S1.2
E4.2*	Welded Flat End	0	0	1170	0.0	0.0	S1.3*
F.1	RT - Flange	0	0	-54	0.0	0.0	F.3
F.2*	RT - Flange	0	0	1086	0.0	0.0	F.4*
F.3	RT - Flange	0	0	0	0.0	0.0	S1.1
F.4*	RT - Flange	0	0	1050	0.0	0.0	S1.1
N.1	Nozzle,Plate Body	69	0	80	90.0	0.0	S1.1
N.2*	Nozzle,Plate Body	-69	0	980	90.0	180.0	S1.1
N.3	Open.Without Nozzle	41	0	-153	0.0	0.0	E4.1
N.4*	Open.Without Nozzle	-40	0	-152	0.0	180.0	E4.1
S1.1	Cylindrical Shell	0	0	0	0.0	0.0	
S1.2	Cylindrical Shell	0	0	-90	0.0	0.0	F.1

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ID	Comp. Type	X	Y	Z	Teta	Phi	ConnID
S1.3*	Cylindrical Shell	0	0	1140	0.0	0.0	F.2*
T.1	Tubesheet	0	0	-54	0.0	0.0	F.3
T.2	Tubesheet	0	0	496	0.0	0.0	TB.1
TB.1	Tube Bundle	0	0	0	0.0	0.0	T.1

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

The basis for the coordinate system used by the software is a right handed coordinate system with the z-axis as the center axis of rotational geometry for the components, and Teta as the Polar Angle and Phi as the Azimuthal Angle

MDMT Minimum Design Metal Temperature

Table :

ID-Description	Material Name	tn(mm)	tg(mm)	Ratio	E(*)	Curve
E4.1 Head left - End	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	27.0	6.8	0.10	1.00	
E4.2* Head right - End	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	27.0	6.8	0.10	1.00	
F.1 Flangering Head left - Bolts	SA-193(M) Gr.B7, G41400 Bolting	11.0	11.0	0.30	1.00	
F.1 Flangering Head left - Flange	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	36.0	9.0	0.30	1.00	
F.2* Flangering Head right - Bolts	SA-193(M) Gr.B7, G41400 Bolting	11.0	11.0	0.30	1.00	
F.2* Flangering Head right - Flange	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	36.0	9.0	0.30	1.00	
F.2* Flangering Head right - Hub	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	3.2	3.2	0.19	1.00	
F.3 Flangering Shell left - Bolts	SA-193(M) Gr.B7, G41400 Bolting	11.0	11.0	0.30	1.00	
F.3 Flangering Shell left - Flange	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	36.0	9.0	0.30	1.00	
F.3 Flangering Shell left - Hub	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	3.2	3.2	0.19	1.00	
F.4* Flangering Shell right - Bolts	SA-193(M) Gr.B7, G41400 Bolting	11.0	11.0	0.30	1.00	
F.4* Flangering Shell right - Flange	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	36.0	9.0	0.30	1.00	
F.4* Flangering Shell right - Hub	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	3.2	3.2	0.19	1.00	
N.1 N1 - Flange	2.3 16Cr-12Ni-2Mo :A 182 Gr. F316L - A 240 Gr. 316L	0.0	0.0	0.28	1.00	NA
N.1 N1 - Nozzle	SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8	3.9	3.9	0.12	0.85	
N.2* N1 - Flange	2.3 16Cr-12Ni-2Mo :A 182 Gr. F316L - A 240 Gr. 316L	0.0	0.0	0.28	1.00	NA
N.2* N1 - Nozzle	SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8	3.9	3.9	0.12	0.85	
N.3 N4 - Nozzle	SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8	3.9	3.9	0.19	1.00	
N.4* N3 - Nozzle	SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8	3.9	3.9	0.19	1.00	
S1.1 Main Shell - Shell	SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8	3.4	3.4	0.75	0.85	
S1.2 Channel Head left - Shell	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	13.4	13.4	0.10	0.85	
S1.3* Channel Head right - Shell	SA-182(M) Gr.F316L, S31603 Forgings, PNo=8	13.4	13.4	0.10	0.85	
T.1 Tubesheet - T-Sheet	SB-148(M), M01, C95820 Castings	28.0	7.0	0.26	1.00	
T.2 Tubesheet floating - T-Sheet	SB-148(M), M01, C95820 Castings	28.0	7.0	0.19	1.00	
TB.1 Tube bundle - Tube	SB-111(M), O61, C70600 Smls. cond. tube	0.5	0.5	0.96	1.00	

Table Continued

ID-Description	T1(C)	T2(C)	MDMT(C)	Comments
E4.1 Head left - End			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
E4.2* Head right - End			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
F.1 Flangering Head left - Bolts	-48.0	-80.0	-105	

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ID-Description	T1(C)	T2(C)	MDMT(C)	Comments
F.1 Flanging Head left - Flange			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
F.2* Flanging Head right - Bolts	-48.0	-80.0	-105	
F.2* Flanging Head right - Flange			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
F.2* Flanging Head right - Hub			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
F.3 Flanging Shell left - Bolts	-48.0	-80.0	-105	
F.3 Flanging Shell left - Flange			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
F.3 Flanging Shell left - Hub			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
F.4* Flanging Shell right - Bolts	-48.0	-80.0	-105	
F.4* Flanging Shell right - Flange			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
F.4* Flanging Shell right - Hub			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
N.1 N1 - Flange	-196	-80.0	-276	ASME B16.5 Flange
N.1 N1 - Nozzle			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
N.2* N1 - Flange	-196	-80.0	-276	ASME B16.5 Flange
N.2* N1 - Nozzle			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
N.3 N4 - Nozzle			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
N.4* N3 - Nozzle			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
S1.1 Main Shell - Shell			-196	For thermally treated materials, ref. is made to UHA-51(c)
S1.2 Channel Head left - Shell			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
S1.3* Channel Head right - Shell			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
T.1 Tubesheet - T-Sheet			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
T.2 Tubesheet floating - T-Sheet			-	NOTE: UHA-51(g) Material is exempted from impact testing due to low stress. Ratio of design stress to allowable tensile stress is less than 0.35.
TB.1 Tube bundle - Tube			-196	NOTE: If the carbon content is above 0.1% impact testing of base material and HAZ is required if MDMT required is lower than -48C.

MDMT CALCULATIONS PER UCS-66, UG-20(f), UHA-51 and Appendix JJ

MDMT Required : -10.0 C

MDMT Lowest Allowable: -105 C

NOMENCLATURE:

tn - Nominal thickness of component under consideration(including corr. allow.).

tg - Governing thickness of component under consideration.

Ratio- $\frac{tr \cdot E(*)}{(tn-c)}$, utilization of component for given process conditions.

tr - Required minimum thickness of component at calculation temperature of MDMT.

E(*) - Joint efficiency factor, not lower than 0.8.

Curve- Applicable curve A, B, C or D in Figure UCS-66.

T1 - Unadjusted MDMT/Lowest allowable temperature for given part, value taken from Figure UCS-66 based on curve A, B, C or D.

T2 - Reduction in MDMT without impact testing per Figure UCS-66.1.

NOTES:

UCS-68(c) If postweld heat treatment is performed when it is not otherwise a requirement, a 17C reduction in impact test exemption temp. may be given to the

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min. permissible temp. for P.no.1 materials.

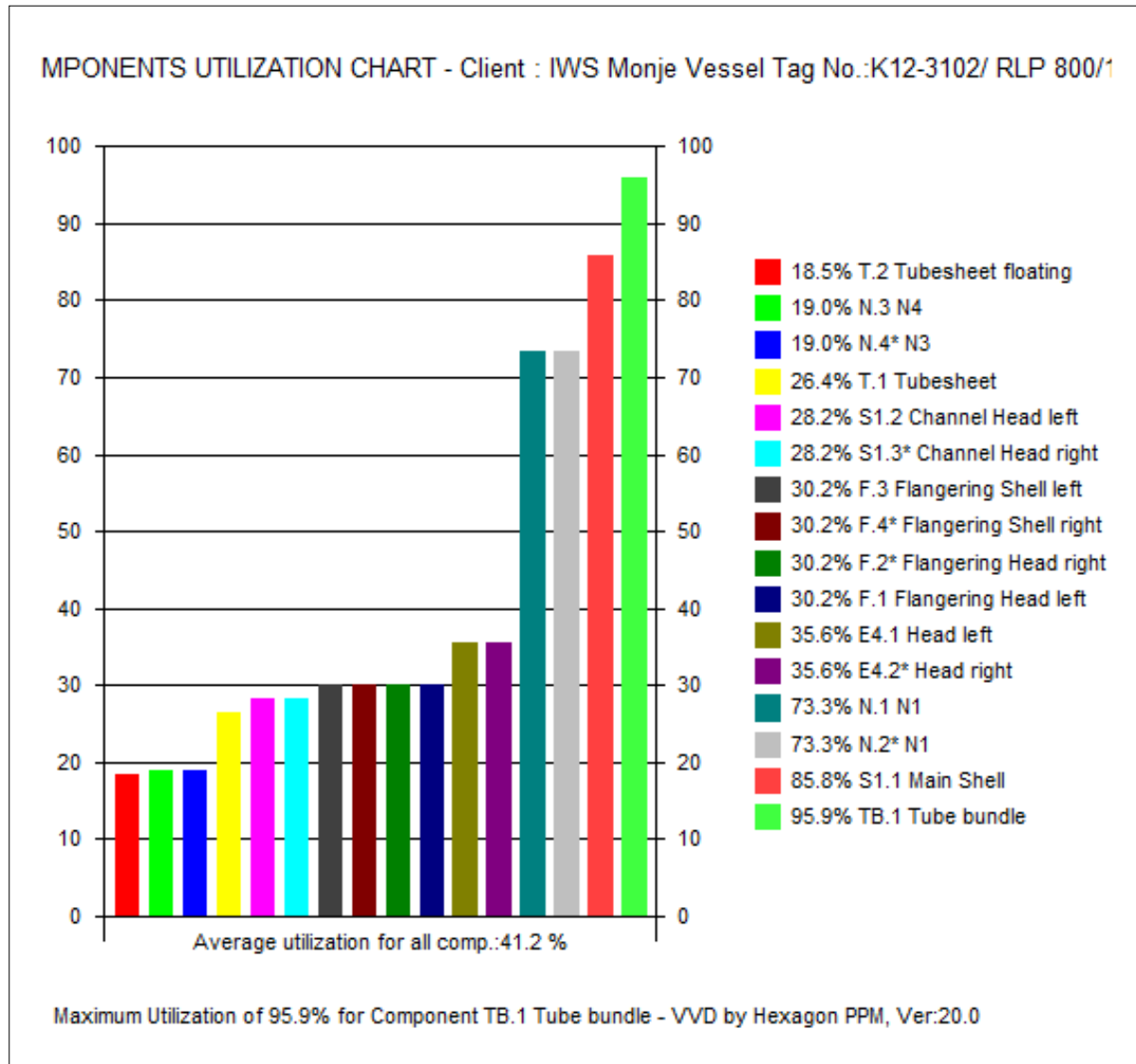
The maximum general primary stress in the pads are conservatively assumed to be the same as that in the corroded shell.

Note: For austenitic stainless steels, reference is made to UHA-51(c) for thermally treated materials.

NOTE: LOWEST MDMT = -105 C (Warmest Value)

Utilization Chart

Utilization Chart



Tube Layout

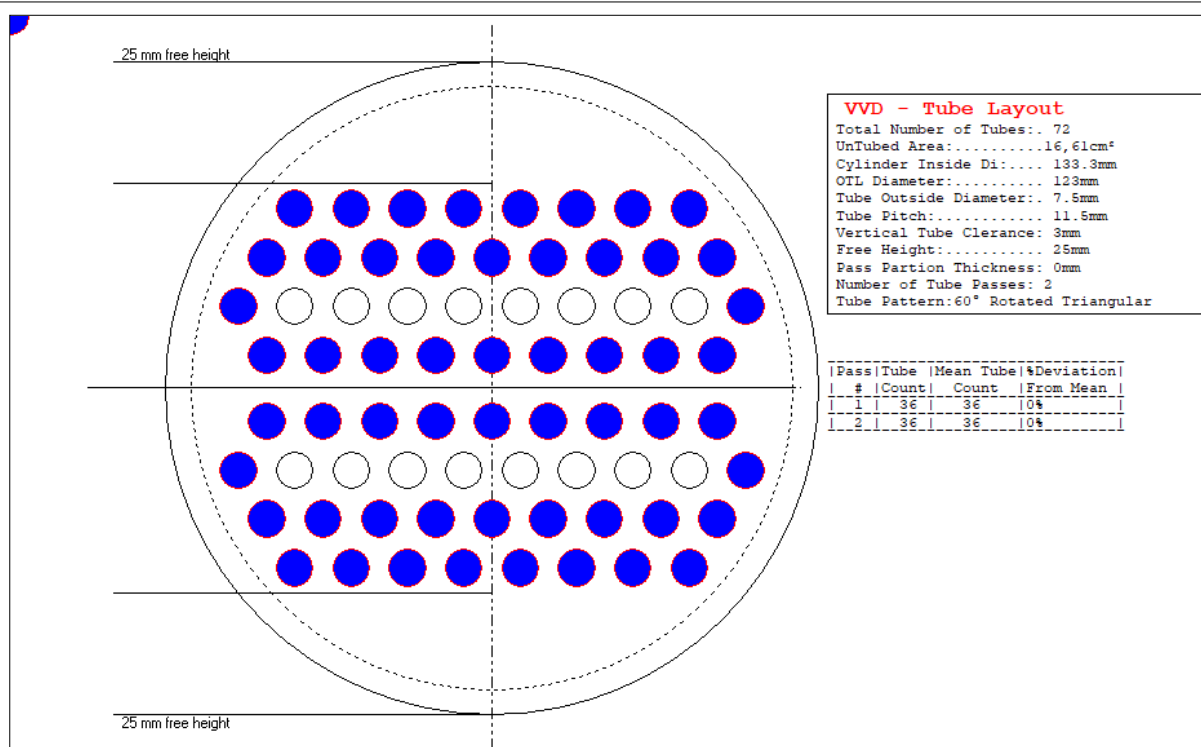
Tube Layout

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Surface Area

PROCESS CARD NO.: 1 SHELL SIDE

ID	No.	Description	Area Outside(m2)	Area Inside(m2)
S1.1	1	Cylindrical Shell, Main Shell	0.466	0.453
Total	1		0.466	0.453

PROCESS CARD NO.: 2 TUBE SIDE

ID	No.	Description	Area Outside(m2)	Area Inside(m2)
E4.1	1	Welded Flat End, Head left	0.036	0.036
E4.2*	1	Welded Flat End, Head right	0.036	0.036
F.1	1	RT - Flange, Flangering Head left	0.024	0.015
F.2*	1	RT - Flange, Flangering Head right	0.053	0.023
F.3	1	RT - Flange, Flangering Shell left	0.053	0.023
F.4*	1	RT - Flange, Flangering Shell right	0.053	0.023
N.1	1	Nozzle,Plate Body, N1	0.019	0.016
N.2*	1	Nozzle,Plate Body, N1	0.019	0.016
N.3	1	Open.Without Nozzle, N4	0.000	0.000
N.4*	1	Open.Without Nozzle, N3	0.000	0.000
S1.2	1	Cylindrical Shell, Channel Head left	0.020	0.018
S1.3*	1	Cylindrical Shell, Channel Head right	0.020	0.018
T.1	1	Tubesheet, Tubesheet	0.000	0.000
T.2	1	Tubesheet, Tubesheet floating	0.000	0.000
TB.1	1	Tube Bundle, Tube bundle	1.028	0.891
Total	15		1.361	1.115

SUMMATION OF DATA FOR ALL COMPONENTS :
 Total :Ao= 0.466 m2, Ai= 0.453 m2

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ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

S1.1 Main Shell 17 Feb. 2022 13:07 PC# 1

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

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

$$P_{tmax} = S_{Ytest} * E_{test} * (t_a + c) / (R + 0.6 * (t_a + c))$$
$$= 184.5 * 1 * (1.975 + 1) / (68.675 + 0.6 * (1.975 + 1)) =$$

7.7901 MPa

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

$$P_{tmin} = 1.1 * P_d * S_r / S = 1.1 * 2.5 * 138 / 138 =$$

2.7500 MPa

Test Pressure P_{tmin}=2.75 <= P_{tmax}=7.79[MPa]

35.3%

OK

SECT. UG28 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

Preliminary Calculations

$$Ratio1 = D_o / t = 141.3 / 1.975 =$$

71.54

$$Ratio2 = L / D_o = 0 / 141.3 =$$

0.00

Value of A from Fig.G (Part D), A = 0.097478

Value of B from External Pressure Chart HA-2(based on Temp=210) B = 97.29

$$P_{max} = (4 / 3) * B / (D_o / t)$$

$$= (4 / 3) * 97.29 / (141.3 / 1.975) =$$

1.8131 MPa

External Pressure P_{max}=1.81 >= P_{ext}=0.1[MPa]

5.5%

OK

Required Minimum Thickness Due to External Pressure Incl.Allow.:1.6 mm

CALCULATION SUMMARY

UG-27 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

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

$$t_{min} = P * R_o / (S * E + 0.4 * P)$$

(APP.1-1 (1))

$$= 2.5026 * 70.65 / (138 * 0.85 + 0.4 * 2.5026) =$$

1.4946 mm

Required Minimum Shell Thickness Incl.Allow. :

$$t_{mina} = t_{min} + c + NegDev = 1.49 + 1 + 0.425 =$$

2.9196 mm

Internal Pressure t_{mina}=2.92 <= t_n=3.4[mm]

85.8%

OK

MAWP HOT & CORR. (Corroded condition at design temp.)

$$MAWPHC = S * E * t_a / (R + 0.6 * t_a)$$

$$= 138 * 0.85 * 1.975 / (68.675 + 0.6 * 1.975) =$$

3.3162 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)

$$MAWPNC = S_r * E * (t_a + c) / (R - c + 0.6 * (t_a + c))$$

$$= 138 * 0.85 * (1.975 + 1) / (68.675 - 1 + 0.6 * (1.975 + 1)) =$$

5.0240 MPa

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

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

$$P_{tmax} = S_{Ytest} * E_{test} * (t_a + c) / (R + 0.6 * (t_a + c))$$

$$= 184.5 * 1 * (1.975 + 1) / (68.675 + 0.6 * (1.975 + 1)) =$$

7.7901 MPa

Test Pressure P_{tmin}=2.75 <= P_{tmax}=7.79[MPa]

35.3%

OK

SECT. UG28 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

$$P_{max} = (4 / 3) * B / (D_o / t)$$

$$= (4 / 3) * 97.29 / (141.3 / 1.975) =$$

1.8131 MPa

External Pressure P_{max}=1.81 >= P_{ext}=0.1[MPa]

5.5%

OK

Required Minimum Thickness Due to External Pressure Incl.Allow.:1.6 mm

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

S1.1 Main Shell 17 Feb. 2022 13:07 PC# 1

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 210 FOR: 5 SA-312(M)
Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 , the material must be re-selected from the material database.

WARNING: A non zero value needs to be specified for the unsupported length.

Volume:0.0156 m3 Weight:12.1 kg (SG= 7.85)

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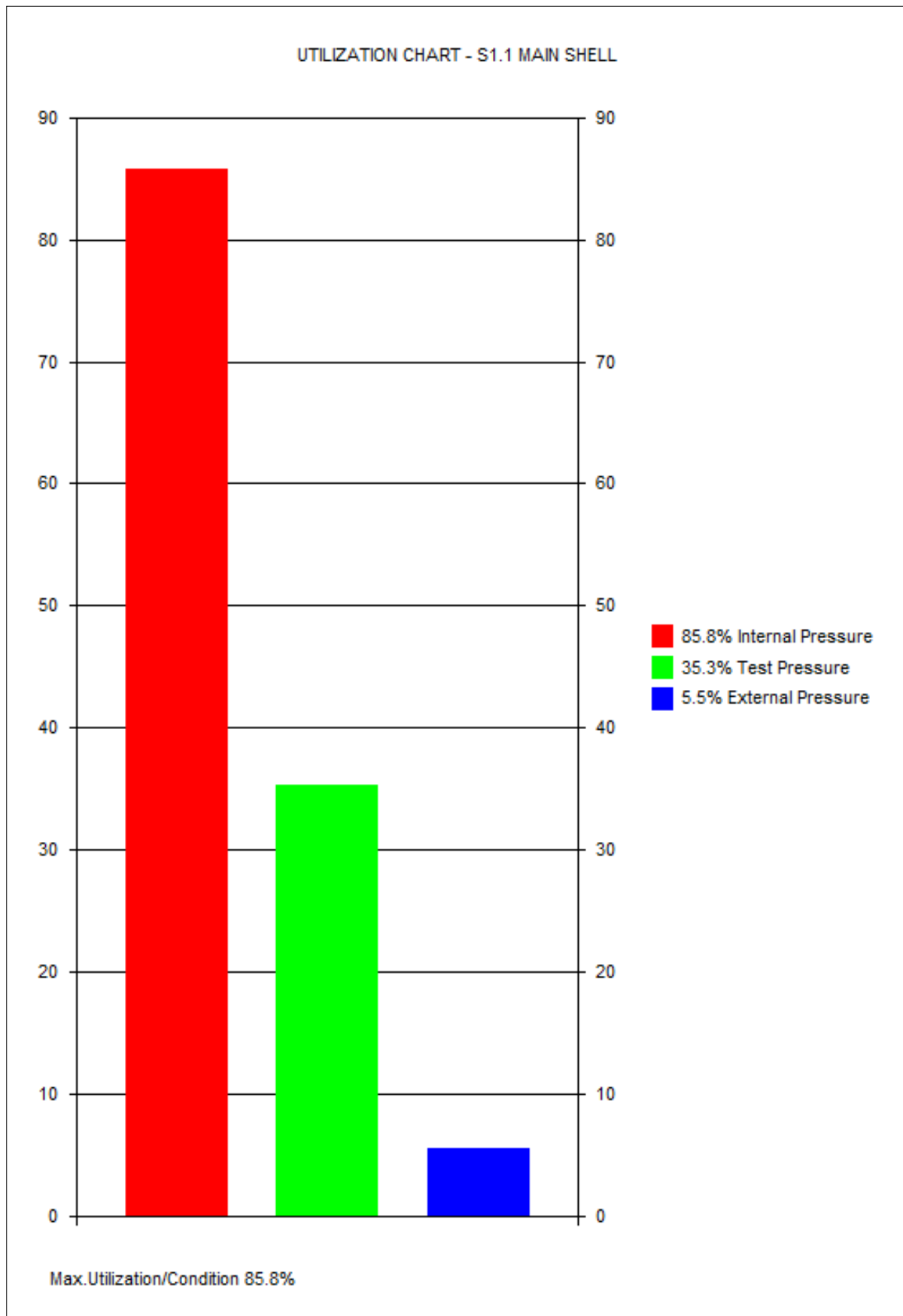
Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

S1.1 Main Shell

17 Feb. 2022 13:07 PC# 1



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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

S1.2 Channel Head left 17 Feb. 2022 13:08 ConnID:F.1 PC# 2

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: F.1 RT - Flange Flangering Head left F.3
Location: Along z-axis z1= -90

GENERAL DESIGN DATA

PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD: Tube Side : Temp= 95°C, P=1.0000 MPa, c=1.0 mm, Pext=0.1000 MPa
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.0000
LIQUID HEAD.....:LH 267.65 mm

SHELL DATA

CYLINDER FABRICATION: Seamless Pipe
NEGATIVE TOLERANCE: Negative tolerance specified in % of nominal thickness
SA-182(M) Gr.F316L, S31603 Forgings, PNo=8 120'C
ST=450 SY=170 SYd=138.6 S=115 Sr=115 Stest=153 (N/mm2)
WELD JOINT EFFICIENCY FACTOR: Spot RT UW-11(b) Type 1 (E=0.85)
Minimum thickness check to UG-16 does NOT apply.: NO
OUTSIDE DIAMETER OF SHELL.....:Do 215.00 mm
LENGTH OF CYLINDRICAL PART OF SHELL.....:Lcyl 30.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:tn 13.35 mm
NEGATIVE DEVIATION/TOLERANCE.....: 12.50 %
Split shell into several shell courses and include welding information: NO

EXTERNAL PRESSURE

UNSUPPORTED LENGTH OF SHELL (Fig.UG-28.1).....:L 0.00 mm

CALCULATION DATA

UG-27 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

Outside Radius of Shell
 $R_o = D_o / 2 = 215/2 = 107.50$ mm
»Thin Cylinder Check $P=1.0026 \leq 0.385 * S * E=37.63$ [MPa] «» OK«
Required Minimum Shell Thickness Excl.Allow. tmin : (APP.1-1 (1))
 $t_{min} = P * R_o / (S * E + 0.4 * P) = 1.0026 * 107.5 / (115 * 0.85 + 0.4 * 1.0026) = 1.0981$ mm
»Thin Cylinder Check $t_{min}=1.1 < 0.5 * R=53.75$ [mm] « » OK«
Required Minimum Shell Thickness Incl.Allow. :
 $t_{min a} = t_{min} + c + NegDev = 1.1 + 1 + 1.67 = 3.7668$ mm
Analysis Thickness
 $t_a = t_n - c - NegDev = 13.35 - 1 - 1.67 = 10.68$ mm

Internal Pressure $t_{min a}=3.77 \leq t_n=13.35$ [mm]	28.2%	OK
--	-------	----

»Shell - Min.thickness to UG-16 $Thk=10.68 \geq UG-16(b) (1.5mm)=1.5$ [mm] «» OK«

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

Inside Diameter of Shell
 $D_i = D_o - 2 * t_a = 215 - 2 * 10.68 = 193.64$ mm
Inside Radius of Shell
 $R = D_i / 2 = 193.64/2 = 96.82$ mm
MAWP HOT & CORR. (Corroded condition at design temp.)
 $MAWPHC = S * E * t_a / (R + 0.6 * t_a) = 115 * 0.85 * 10.68 / (96.82 + 0.6 * 10.68) = 10.11$ MPa
MAWP NEW & COLD (Uncorroded condition at ambient temp.)
 $MAWPNC = S_r * E * (t_a + c) / (R - c + 0.6 * (t_a + c)) = 115 * 0.85 * (10.68 + 1) / (96.82 - 1 + 0.6 * (10.68 + 1)) = 11.10$ MPa

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Vessel Tag No.:K12-3102/ RLP 800/140

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ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

S1.2 Channel Head left 17 Feb. 2022 13:08 ConnID:F.1 PC# 2

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

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

$$P_{tmax} = S_{Ytest} * E_{test} * (t_a + c) / (R + 0.6 * (t_a + c))$$
$$= 153 * 1 * (10.68 + 1) / (96.82 + 0.6 * (10.68 + 1)) =$$

17.21 MPa

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

$$P_{tmin} = 1.1 * P_d * S_r / S = 1.1 * 1 * 115 / 115 =$$

1.1000 MPa**Test Pressure P_{tmin}=1.1 <= P_{tmax}=17.21[MPa]****6.3%****OK**

SECT. UG28 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

Preliminary Calculations

Ratio1 = Do / t = 215/10.68 =

20.13

Ratio2 = L / Do = 0/215 =

0.00

Value of A from Fig.G (Part D), A = 0.09793

Value of B from External Pressure Chart HA-4(based on Temp=95) B = 97.92

$$P_{max} = (4 / 3) * B / (Do / t)$$

$$= (4/3) * 97.92 / (215/10.68) =$$

6.4864 MPa**External Pressure P_{max}=6.49 >= P_{ext}=0.1[MPa]****1.5%****OK**

Required Minimum Thickness Due to External Pressure Incl.Allow.:3 mm

CALCULATION SUMMARY

UG-27 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

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

$$t_{min} = P * R_o / (S * E + 0.4 * P)$$

(APP.1-1 (1))

$$= 1.0026 * 107.5 / (115 * 0.85 + 0.4 * 1.0026) =$$

1.0981 mm

Required Minimum Shell Thickness Incl.Allow. :

$$t_{mina} = t_{min} + c + NegDev = 1.1 + 1 + 1.67 =$$

3.7668 mm**Internal Pressure t_{mina}=3.77 <= t_n=13.35[mm]****28.2%****OK**

MAWP HOT & CORR. (Corroded condition at design temp.)

$$MAWPHC = S * E * t_a / (R + 0.6 * t_a)$$

$$= 115 * 0.85 * 10.68 / (96.82 + 0.6 * 10.68) =$$

10.11 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)

$$MAWPNC = S_r * E * (t_a + c) / (R - c + 0.6 * (t_a + c))$$

$$= 115 * 0.85 * (10.68 + 1) / (96.82 - 1 + 0.6 * (10.68 + 1)) =$$

11.10 MPa

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

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

$$P_{tmax} = S_{Ytest} * E_{test} * (t_a + c) / (R + 0.6 * (t_a + c))$$

$$= 153 * 1 * (10.68 + 1) / (96.82 + 0.6 * (10.68 + 1)) =$$

17.21 MPa**Test Pressure P_{tmin}=1.1 <= P_{tmax}=17.21[MPa]****6.3%****OK**

SECT. UG28 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

$$P_{max} = (4 / 3) * B / (Do / t)$$

$$= (4/3) * 97.92 / (215/10.68) =$$

6.4864 MPa**External Pressure P_{max}=6.49 >= P_{ext}=0.1[MPa]****1.5%****OK**

Required Minimum Thickness Due to External Pressure Incl.Allow.:3 mm

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Vessel Tag No.:K12-3102/ RLP 800/140

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ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

S1.2 Channel Head left 17 Feb. 2022 13:08 ConnID:F.1 PC# 2

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 3 SA-182(M)
Gr.F316L, S31603 Forgings, PNo=8 , the material must be re-selected from the material
database.

WARNING: A non zero value needs to be specified for the unsupported length.

Volume:0.0008835 m3 Weight:2 kg (SG= 7.85)

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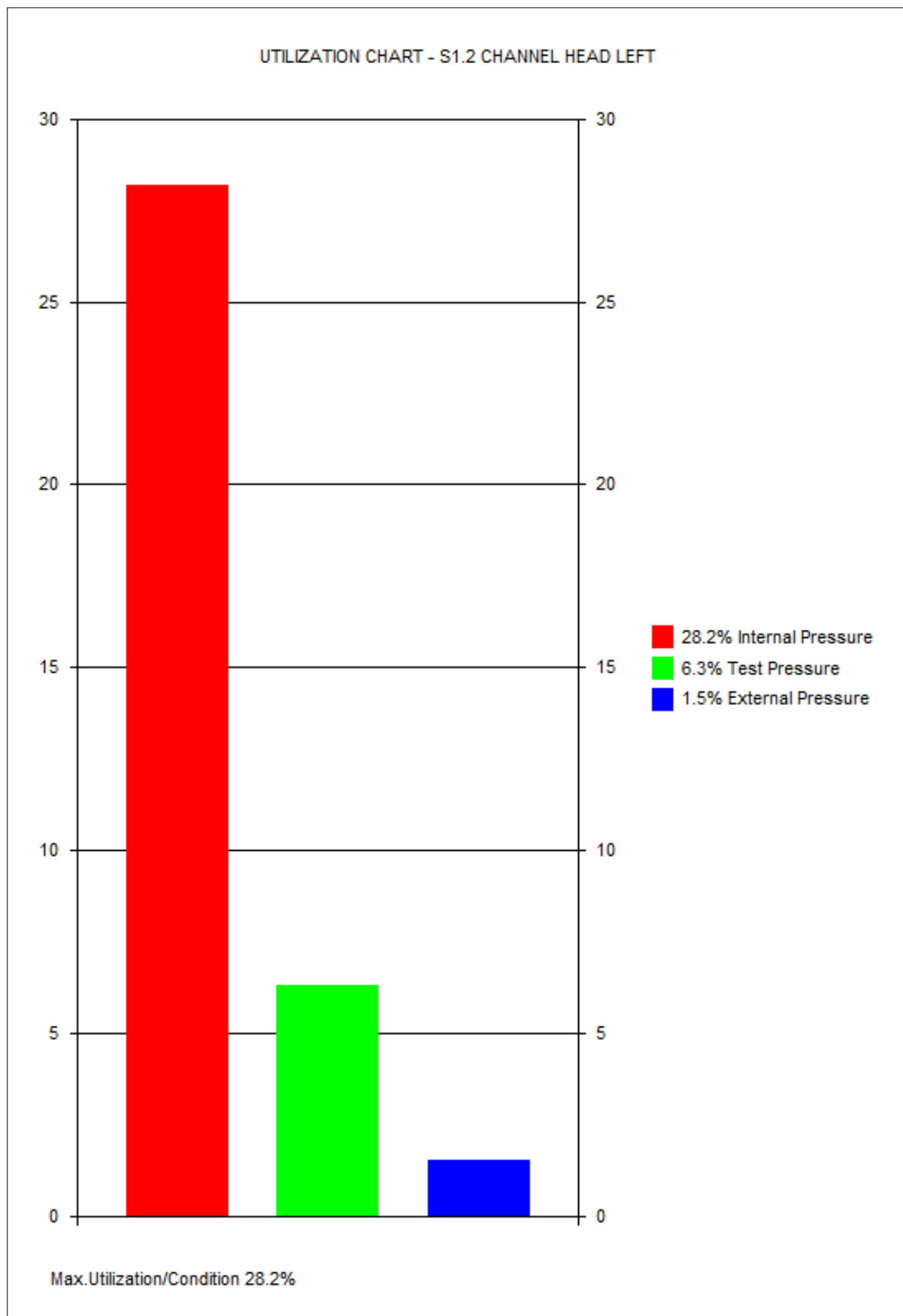
Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

S1.2 Channel Head left 17 Feb. 2022 13:08 ConnID:F.1 PC# 2



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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-34 UNSTAYED FLAT HEADS AND COVERS

E4.1 Head left 17 Feb. 2022 13:08 ConnID:S1.2 PC# 2

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

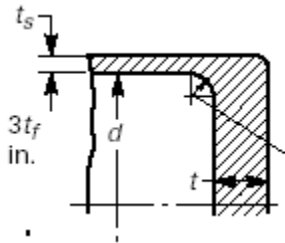
Attachment: S1.2 Cylindrical Shell Channel Head left F.1
 Location: Along z-axis z1= -120

GENERAL DESIGN DATA

PROCESS CARD: Tube Side : Temp= 95°C, P=1.0000 MPa, c=1.0 mm
 SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.0000
 LIQUID HEAD.....:LH 295.15 mm

DATA FOR FLAT END

Include Straight Bar Stiffeners to Reduce Cover Deflection.: NO
 Shape of Cover: Circular
 WELD JOINT EFFICIENCY FACTOR: Spot RT UW-11(b) Type 1 (E=0.85)



TYPE OF FLAT WELDED END:

b_2) C=0.33m Integral head with rmin=10mm when ts<=38mm and rmin=0.25ts
 INSIDE HUB/CORNER RADIUS.....:r 20.00 mm
 LENGTH OF CYLINDRICAL PART OF END.....:Lc 1.0000 mm
 NOMINAL THICKNESS OF HEAD/END (uncorroded).....:tn 27.00 mm
 SA-182(M) Gr.F316L, S31603 Forgings, PNo=8 120'C
 ST=450 SY=170 SYd=138.6 S=115 Sr=115 Stest=153 (N/mm2)

DATA FOR CYLINDRICAL SHELL SECTION

CYLINDER DIAMETER: Base Design on Cylinder Outside Diameter
 OUTSIDE DIAMETER OF SHELL.....:Do 215.00 mm
 NOMINAL WALL THICKNESS (uncorroded).....:tsn 13.35 mm
 WELD JOINT EFFICIENCY FACTOR: Spot RT UW-11(b) Type 1 (E=0.85)
 SA-182(M) Gr.F316L, S31603 Forgings, PNo=8 120'C
 ST=450 SY=170 SYd=138.6 Ss=115 Ssr=115 Sstest=153 (N/mm2)

CALCULATION DATA

Analysis thickness of cylindrical shell
 $ts = tsn - c = 13.35 - 1 = 12.35 \text{ mm}$

Inside diameter of cylindrical shell
 $Di = Do - 2 * ts = 215 - 2 * 12.35 = 190.30 \text{ mm}$

$m = tr / tsn = 1.1 / 13.35 = 0.0823$

$C = \text{MAX}(C * m \ 0.2) = \text{MAX}(0.33 * 0.0823, 0.2) = 0.2000$

UG-34(c) MIN.THICKNESS OF FLAT HEAD t

Minimum thickness excluding corrosion tmin
 $tmin = d * \text{Sqr}(C * P / (S * E)) = 190.3 * \text{Sqr}(0.2 * 1.0029 / (115 * 0.85)) = 8.6203 \text{ mm}$

Minimum thickness including corrosion t
 $t = tmin + c = 8.62 + 1 = 9.6203 \text{ mm}$

Flat Head Thickness $th=27 \geq t=9.62[\text{mm}]$	35.6%	OK
--	-------	----

Minimum hub/corner radius rmin:
 $rmin (\text{Min}(19 \text{ and } 10 \text{ or } 0.25 * tsn) = rmin = 10 = 10.00 \text{ mm}$

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-34 UNSTAYED FLAT HEADS AND COVERS

E4.1 Head left 17 Feb. 2022 13:08 ConnID:S1.2 PC# 2

»Corner Radius Check $r=20 \geq r_{min}=10[\text{mm}]$ « » OK«

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

$$P_{max} = S * E * (t / (d)) ^ 2 / (C)$$
$$=115*0.85*(27/(190.3))^2/(0.2)=$$

9.8387 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

$$P_{max} = S * E * (t / (d)) ^ 2 / (C)$$
$$=115*0.85*(26/(190.3))^2/(0.2)=$$

9.1234 MPa

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

$$P_{max} = S * E * (t / (d)) ^ 2 / (C)$$
$$=153*0.85*(27/(190.3))^2/(0.2)=$$

13.09 MPa

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

$$P_{tmin} = 1.1 * P_d * S_r / S =1.1*1*115/115=$$

1.1000 MPa

Test Pressure $P_{tmin}=1.1 \leq P_{tmax}=13.09[\text{MPa}]$

8.4%

OK

CALCULATION SUMMARY

UG-34(c) MIN.THICKNESS OF FLAT HEAD t

Minimum thickness including corrosion t
 $t = t_{min} + c =8.62+1=$

9.6203 mm

Flat Head Thickness $t_h=27 \geq t=9.62[\text{mm}]$

35.6%

OK

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

$$P_{max} = S * E * (t / (d)) ^ 2 / (C)$$
$$=115*0.85*(27/(190.3))^2/(0.2)=$$

9.8387 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

$$P_{max} = S * E * (t / (d)) ^ 2 / (C)$$
$$=115*0.85*(26/(190.3))^2/(0.2)=$$

9.1234 MPa

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

$$P_{max} = S * E * (t / (d)) ^ 2 / (C)$$
$$=153*0.85*(27/(190.3))^2/(0.2)=$$

13.09 MPa

Test Pressure $P_{tmin}=1.1 \leq P_{tmax}=13.09[\text{MPa}]$

8.4%

OK

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 3 SA-182(M)

Gr.F316L, S31603 Forgings, PNo=8 , the material must be re-selected from the material database.

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

SEAB GmbH -

Client : IWS Monje

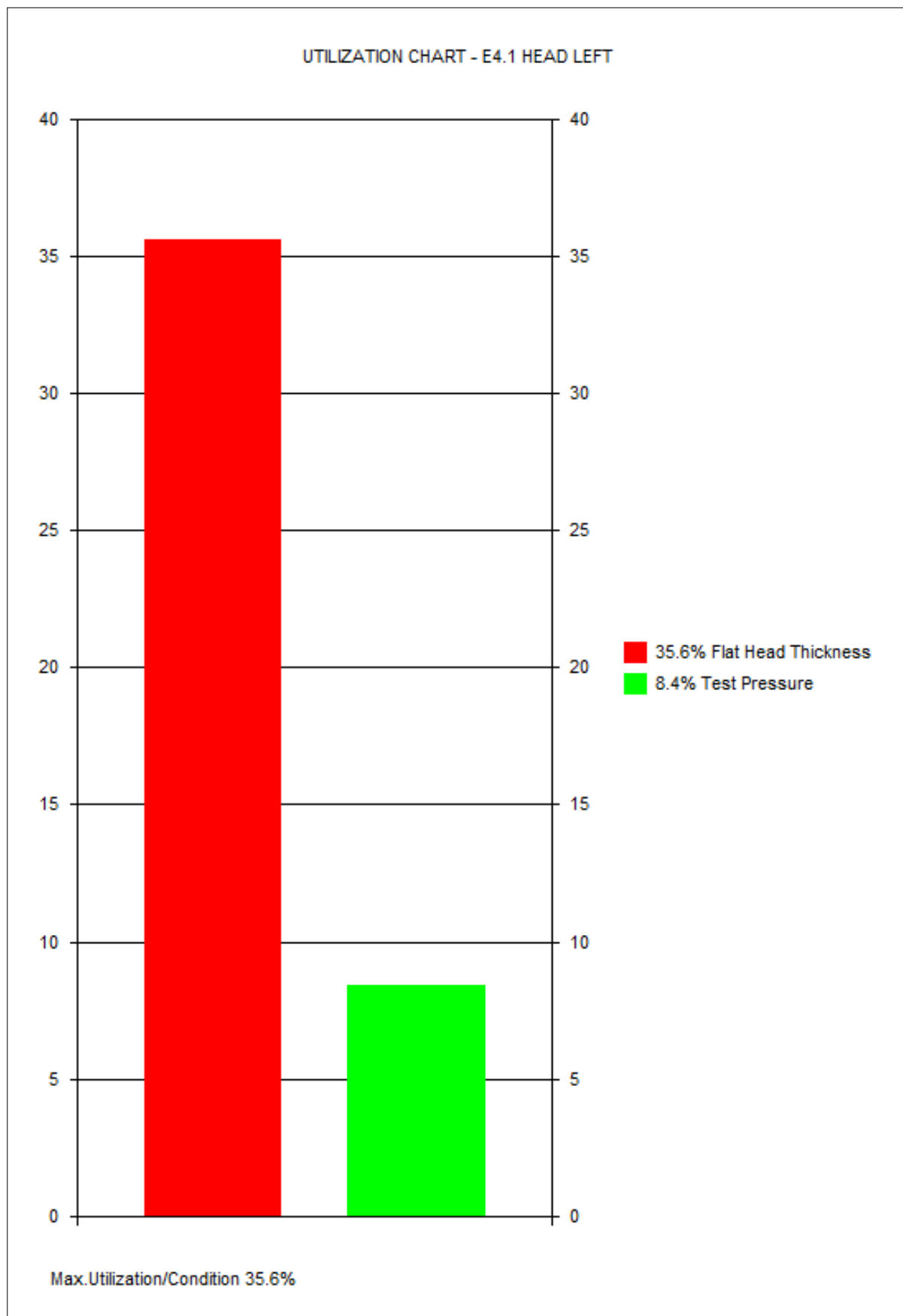
Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-34 UNSTAYED FLAT HEADS AND COVERS

E4.1 Head left

17 Feb. 2022 13:08 ConnID:S1.2 PC# 2



SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-37 REINFORCEMENT REQUIRED FOR OPENINGS IN SHELLS

N.1 N1

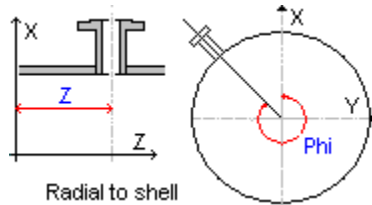
17 Feb. 2022 13:08 ConnID:S1.1 PC# 2

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: S1.1 Cylindrical Shell Main Shell

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



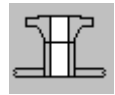
Radial to shell

Orientation & Location of Nozzle: Radial to Shell

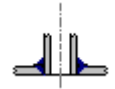
z-location of nozzle along axis of attachment.....:z 80.00 mm

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

GENERAL DESIGN DATA



Type of Opening: Standard ASME or DIN/EN Flange Attachment



Nozzle Type: Set In Flush Nozzle

Nozzle Weld Intersect: Nozzle Does NOT Intersect with a Welded Shell Seam

PRESSURE LOADING: Design Component for Internal and External Pressure

PROCESS CARD: Tube Side : Temp= 95°C, P=1.0000 MPa, c=1.0 mm, Pext=0.1000 MPa

Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.0000

LIQUID HEAD.....:LH 131.05 mm

Include Nozzle Load Calculation: NO

SHELL DATA (S1.1)

Shell Type: Cylindrical Shell

OUTSIDE DIAMETER OF SHELL.....:Do 141.30 mm

NOMINAL WALL THICKNESS (uncorroded).....:tn 3.4000 mm

WELD JOINT EFFICIENCY FACTOR.....:E1 1.0000

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....:th 0.4250 mm

REQUIRED THICKNESS FOR EXTERNAL PRESSURE(excl.allow.):text 0.1898 mm

SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 120'C

ST=515 SY=205 SYd=169.6 Sv=138 Sr=138 Stest=184.5 (N/mm2)

NOZZLE DATA

SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8 100'C

ST=485 SY=170 SYd=145 Sn=115 Sr=115 Stest=153 (N/mm2)

Nozzle without pipe connections(access/inspection openings): NO

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-37 REINFORCEMENT REQUIRED FOR OPENINGS IN SHELLS

N.1 N1

17 Feb. 2022 13:08 ConnID:S1.1 PC# 2



Delivery Form: Plate Body

Nozzle Diameter: Base Design on Nozzle OD

WELD JOINT EFFICIENCY FACTOR: Spot RT UW-11(b) Type 1 (E=0.85)

OUTSIDE NOZZLE DIAMETER.....:deb 60.32 mm

NOMINAL NOZZLE THICKNESS (uncorroded).....:tnb 3.9100 mm

Size of Flange and Nozzle: 2"

Comment (Optional): SCH 40S

NEGATIVE TOLERANCE/THINNING ALLOWANCE.....: 0.5000 mm

NOZZLE STANDOUT MEASURED FROM VESSEL OD.....:ho 100.00 mm

FLANGE DATA

A: Flange Standard: ASME B16.5/B16.47 Flanges

E: Pressure Class: ASME B16.5:Class 300 lbs

C: Flange Type: WN Welding Neck

D: Facing Sketch/ANSI facing (Table 3.8.3(2)): 1a RF Raised Face

Flange Material Category: 2.3 16Cr-12Ni-2Mo :A 182 Gr. F316L - A 240 Gr. 316L

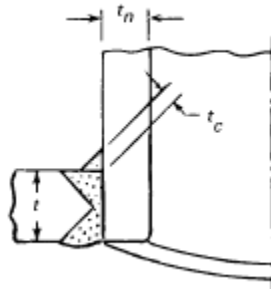
ASME 300lb-Flange Rating(at 95C)= 3.532 MPa, Max.Test Pressure = 6.3 MPa

DATA FOR REINFORCEMENT PAD

Type of Pad: No Pad

WELDING DATA

Nozzle to Shell Welding Area: Include Area of Nozzle to Shell Weld as Min.Required



Weld Connection:

Full Penetration Weld(from both sides) + Outward Fillet Weld (to=tc)

LIMITS OF REINFORCEMENT

Reduction of Limits of Reinforcement: No Reduction Required

CALCULATION DATA

GEOMETRIC LIMITATIONS

Material Strength Reduction Factor fr1-4

Strength Reduction Factor for Nozzle Inserted Through Vessel Wall fr1

fr1 = MIN(Sn / Sv, 1) =MIN(115/138,1)= 0.8333

Strength Reduction Factor for Nozzle fr2

fr2 = MIN(Sn / Sv, 1) =MIN(115/138,1)= 0.8333

PRELIMINARY CALCULATIONS

Shell Analysis Thickness t

t = tn - c - th =3.4-1-0.425= 1.9750 mm

Nozzle Analysis Thickness tn

tn = tnb - cn - NegDev =3.91-1-0.5= 2.4100 mm

Inside Radius of Shell R

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Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-37 REINFORCEMENT REQUIRED FOR OPENINGS IN SHELLS

N.1 N1 17 Feb. 2022 13:08 ConnID:S1.1 PC# 2

$$R = Do / 2 - t = 141.3/2 - 1.975 = 68.68 \text{ mm}$$

Required Thickness of a Seamless Shell t_r

$$t_r = P * R / (S_v * E_1 - 0.6 * P)$$

$$= 1.0013 * 68.675 / (138 * 1 - 0.6 * 1.0013) = 0.5005 \text{ mm}$$

$$d = deb - 2 * t_n = 60.32 - 2 * 2.41 = 55.50 \text{ mm}$$

Inside Radius of Nozzle R_n

$$R_n = (deb - 2 * t_n) / 2 = (60.32 - 2 * 2.41) / 2 = 27.75 \text{ mm}$$

Minimum nozzle thickness due to pressure

$$t_{rn} = P * R_n / (S_n * E - 0.6 * P)$$

$$= 1.0013 * 27.75 / (115 * 0.85 - 0.6 * 1.0013) = 0.2860 \text{ mm}$$

UG-40 LIMITS OF REINFORCEMENT

Parallel to Vessel Wall (half diameter limit)

$$L_v = \text{MAX}(d, d / 2 + t + t_n)$$

$$= \text{MAX}(55.5, 55.5 / 2 + 1.975 + 2.41) = 55.50 \text{ mm}$$

Normal to Vessel Wall Outside

$$L_{no} = \text{MIN}(2.5 * t, 2.5 * t_n + t_e)$$

$$= \text{MIN}(2.5 * 1.975, 2.5 * 2.41 + 0) = 4.9375 \text{ mm}$$

Effective Material Diameter Limit

$$d_{eff} = 2 * L_v = 2 * 55.5 = 111.00 \text{ mm}$$

UG-37 Calculation of Stress Loaded Areas Effective as Reinforcement

Area Available in Shell A1

$$A_1 = (d_{eff} - d) * (E_1 * t - F * t_r) - 2 * t_n * (E_1 * t - F * t_r) * (1 - fr_1)$$

$$= (111 - 55.5) * (1 * 1.975 - 1 * 0.5005) - 2 * 2.41 * (1 * 1.975 - 1 * 0.5005) * (1 - 0.8333)$$

$$= 80.65 \text{ mm}^2$$

Area Available in Nozzle Projecting Outward A2

$$A_2 = 2 * (t_n - t_{rn}) * fr_2 * \text{MIN}(L_{no}, h_o)$$

$$= 2 * (2.41 - 0.286) * 0.8333 * \text{MIN}(4.94, 100) = 17.48 \text{ mm}^2$$

Area Available in Welds A4

Area Available in Nozzle Outward Weld A41

$$A_{41} = \text{Leg}_{41}^2 * fr_2 = 3.4^2 * 0.8333 = 9.6333 \text{ mm}^2$$

$$A_4 = A_{41} + A_{42} + A_{43} = 9.63 + 0 + 0 = 9.6333 \text{ mm}^2$$

Total Area Available Aavail

$$A_{avail} = A_1 + A_2 + A_3 + A_4 + A_5 = 80.65 + 17.48 + 0 + 9.63 + 0 =$$

$$107.76 \text{ mm}^2$$

UG-37(c) Total Area Required

Total Area Required A_{req}

$$A_{req} = d * t_r * F + 2 * t_n * t_r * F * (1 - fr_1)$$

$$= 55.5 * 0.5005 * 1 + 2 * 2.41 * 0.5005 * 1 * (1 - 0.8333) = 28.18 \text{ mm}^2$$

UG-37 Nozzle Reinforcement Aavail=107.76 >=
Areq=28.18[mm2]

26.1%

OK

NOTE : UG-36(c)(3a) THIS NOZZLE IS EXEMPT FROM AREA CALCULATIONS WHEN CONSIDERED ISOLATED AND WITHOUT RAPID PRESSURE FLUCTUATIONS.

UG-41.1 WELD STRENGTH AND WELD LOADS (Sketch a or b)

NOTE: UW-15(b) Strength calculations for attachment welds are NOT required for this detail.

MAXIMUM ALLOWABLE PRESSURES

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-37 REINFORCEMENT REQUIRED FOR OPENINGS IN SHELLS

N.1 N1

17 Feb. 2022 13:08 ConnID:S1.1 PC# 2

FLANGE RATING

ASME 300lb-Flange Rating(at 95C)= 3.532 MPa, Max.Test Pressure = 6.3 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

$P_{max}(t, t_n, S_v, S_n)(2, 2.4, 138, 115) = ==$ 2.3656 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

$P_{max}(t, t_n, S_v, S_n)(3, 3.4, 138, 115) = ==$ 3.5922 MPa

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

$P_{max}(t, t_n, S_v, S_n)(3, 3.4, 184.5, 153) = ==$ 4.7937 MPa

UG-37(d) Nozzle Reinforcement - External Pressure

Available Reinforcement Area

$A_{avail} = A1 + A2 + A3 + A4 + A5 = 97.64 + 17.89 + 0 + 9.63 + 0 =$ 125.17 mm²

UG-37(d) Nozzle Reinforcement Ext.Press. $A_{avail}=125.17 >=$
 $A_{req}=5.34[\text{mm}^2]$

4.2%

OK

UW-16(d) DIMENSIONS OF FILLET WELDS:

Throat dimension of fillet welds on nozzle:

- at outward nozzle weld at nozzle OD, $t_{min} = \text{lesser of } 19.0, t_n \text{ or } t/(te) = 3.4 \text{ mm}$
 $t_{o(min)} = \text{MIN}(6, 0.7 * t_{min}) = 2.38 \text{ mm}$

Minimum length of legs:

- at outward nozzle weld at nozzle OD, $\text{Leg}_{41}(\text{min}) = 3.4 \text{ mm}$

»UW-16(d) Outward Nozzle Fillet Weld, Leg Size $\text{Leg}_{41}=3.4 >= \text{Leg}_{41}(\text{min})=3.4[\text{mm}]$ «» OK«

UG-45 NOZZLE NECK THICKNESS

UG-45 Minimum Nozzle Neck Thickness Required for Internal and External Pressure

$t_a = \text{MAX}(t_{rn}, t_{extn}) + c_n = \text{MAX}(0.286, 0.2355) + 1 =$ 1.2860 mm

$t_{b1} = \text{MAX}(t_r, t_{min16}) + c_n = \text{MAX}(0.5005, 1.5) + 1 =$ 2.5000 mm

$t_{b2} = \text{MAX}(t_{rPext}, t_{min16}) + c_n = \text{MAX}(0.0372, 1.5) + 1 =$ 2.5000 mm

$t_{b3}(\text{Value from Table UG-45} + c_n) = ==$ 4.4200 mm

$t_b = \text{MIN}(t_{b3}, \text{MAX}(t_{b1}, t_{b2}))$

$= \text{MIN}(4.42, \text{MAX}(2.5, 2.5)) =$ 2.5000 mm

Minimum Thickness of Nozzle Neck to UG-45

$t_{UG45} = \text{MAX}(t_a, t_b) = \text{MAX}(1.29, 2.5) =$ 2.5000 mm

UG-45 Min.Nozzle Neck Thk. $t_{UG45}=2.5 <= t_{nb-}$
 $\text{tolerance}=3.41[\text{mm}]$

73.3%

OK

Weight of Nozzle:0.2594kg Flange: 4kg

CALCULATION SUMMARY

$A_{avail} = A1 + A2 + A3 + A4 + A5 = 80.65 + 17.48 + 0 + 9.63 + 0 =$ 107.76 mm²

Total Area Required A_{req}

$A_{req} = d * t_r * F + 2 * t_n * t_r * F * (1 - fr1)$

$= 55.5 * 0.5005 * 1 + 2 * 2.41 * 0.5005 * 1 * (1 - 0.8333) =$ 28.18 mm²

UG-37 Nozzle Reinforcement $A_{avail}=107.76 >=$
 $A_{req}=28.18[\text{mm}^2]$

26.1%

OK

MAXIMUM ALLOWABLE PRESSURES

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

$P_{max}(t, t_n, S_v, S_n)(2, 2.4, 138, 115) = ==$ 2.3656 MPa

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-37 REINFORCEMENT REQUIRED FOR OPENINGS IN SHELLS

N.1 N1

17 Feb. 2022 13:08 ConnID:S1.1 PC# 2

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

$P_{max}(t, t_n, S_v, S_n)(3, 3.4, 138, 115) = ==$

3.5922 MPa

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

$P_{max}(t, t_n, S_v, S_n)(3, 3.4, 184.5, 153) = ==$

4.7937 MPa

UG-37(d) Nozzle Reinforcement - External Pressure

Available Reinforcement Area

$A_{avail} = A1 + A2 + A3 + A4 + A5 = 97.64 + 17.89 + 0 + 9.63 + 0 =$

125.17 mm²

UG-37(d) Nozzle Reinforcement Ext.Press. $A_{avail}=125.17 \geq A_{req}=5.34[\text{mm}^2]$	4.2%	OK
UG-45 Min.Nozzle Neck Thk. $t_{UG45}=2.5 \leq t_{nb-tolerance}=3.41[\text{mm}]$	73.3%	OK

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 5 SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 , the material must be re-selected from the material database.

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 9 SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8 , the material must be re-selected from the material database.

WARNING : U-1(c)(2) APPLICABILITY, ID OF VESSEL IS LESS THAN 152 mm.

Volume:0.0002000 m³ Weight:4 kg (SG= 7.85)

SEAB GmbH -

Client : IWS Monje

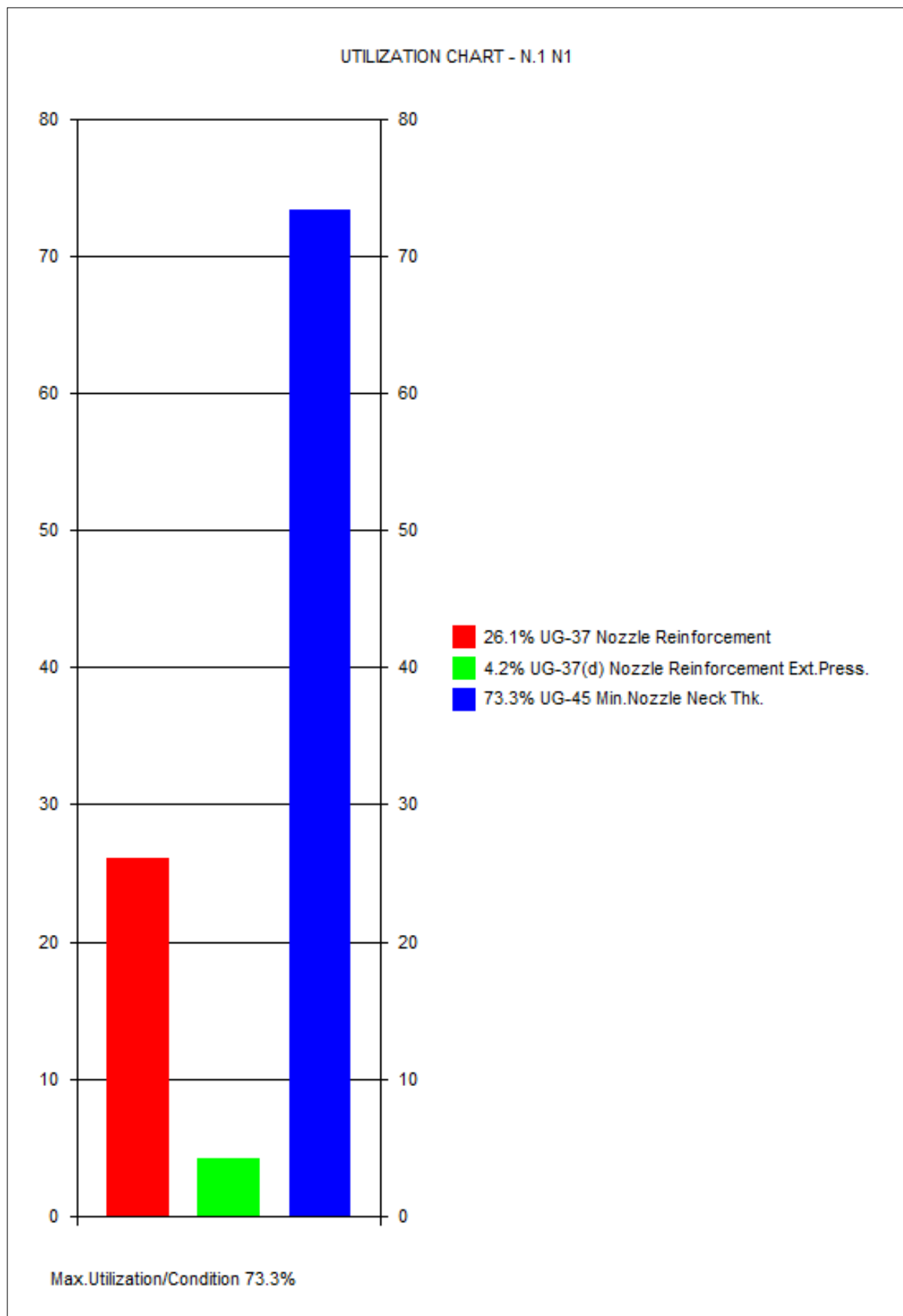
Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-37 REINFORCEMENT REQUIRED FOR OPENINGS IN SHELLS

N.1 N1

17 Feb. 2022 13:08 ConnID:S1.1 PC# 2



SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-39 REINF.REQUIRED FOR OPENINGS IN FLAT HEADS

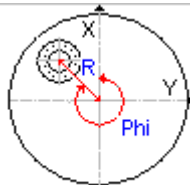
N.3 N4

17 Feb. 2022 13:08 ConnID:E4.1 PC# 2

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: E4.1 Welded Flat End Head left S1.2
Connect this nozzle to the nozzle neck of another nozzle: NO



Off Center

Orientation & Location of Nozzle: Radial to End (Off Center)
Angle of Rotation of nozzle axis projected in the x-y plane:Phi 0.00 Degr.
Distance between Center of End and Center of Nozzle.:R 40.50 mm

GENERAL DESIGN DATA



Type of Opening: Opening Without Nozzle/Ring
PRESSURE LOADING: Design Component for Internal and External Pressure
PROCESS CARD: Tube Side : Temp= 95°C, P=1.0000 MPa, c=1.0 mm, Pext=0.1000 MPa
Apply a different corrosion allowance to nozzle neck than the shell thickness.: NO
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.0000
LIQUID HEAD.....:LH 159.50 mm

SHELL DATA (E4.1)

Shell Type: Welded Flat End
OUTSIDE DIAMETER OF SHELL.....:Do 215.00 mm
NOMINAL WALL THICKNESS (uncorroded).....:tn 27.00 mm
WELD JOINT EFFICIENCY FACTOR.....:E1 1.0000
REQUIRED THICKNESS FOR EXTERNAL PRESSURE(excl.allow.):text 0.1898 mm
REQUIRED THICKNESS OF UNPIERCED COVER(corroded).....:t 8.6203 mm
SA-182(M) Gr.F316L, S31603 Forgings, PNo=8 120'C
ST=450 SY=170 SYd=138.6 Sv=115 Sr=115 Stest=153 (N/mm2)

OPENING DATA

DIAMETER OF OPENING IN SHELL(corroded).....:dib 40.00 mm

LIMITS OF REINFORCEMENT

Reduction of Limits of Reinforcement: No Reduction Required

CALCULATION DATA

GEOMETRIC LIMITATIONS

PRELIMINARY CALCULATIONS

Shell Analysis Thickness t
 $t = t_n - c - t_h = 27 - 1 - 0 = 26.00$ mm
Inside Radius of Shell R
 $R = D_o / 2 - t = 215 / 2 - 26 = 81.50$ mm
 $d_{eb} = d + 2 * t_n = 40 + 2 * 0 = 40.00$ mm
 $d_{eb} = d + 2 * t_n = 40 + 2 * 0 = 40.00$ mm
Inside Radius of Nozzle Rn
 $R_n = d / 2 = 40 / 2 = 20.00$ mm
Minimum nozzle thickness due to pressure

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-39 REINF.REQUIRED FOR OPENINGS IN FLAT HEADS

N.3 N4 17 Feb. 2022 13:08 ConnID:E4.1 PC# 2

$$\text{trn} = P * Rn / (Sn * E - 0.6 * P) \\ = 1.0016 * 20 / (115 * 1 - 0.6 * 1.0016) = 0.1751 \text{ mm}$$

UG-40 LIMITS OF REINFORCEMENT

Parallel to Vessel Wall (half diameter limit)
 $Lv = \text{MAX}(d, d / 2 + t + tn) = \text{MAX}(40, 40 / 2 + 26 + 0) = 46.00 \text{ mm}$

Normal to Vessel Wall Outside
 $Lno = \text{MIN}(2.5 * t, 2.5 * tn + te) \\ = \text{MIN}(2.5 * 26, 2.5 * 0 + 0) = 0.00 \text{ mm}$

Effective Material Diameter Limit
 $deff = 2 * Lv = 2 * 46 = 92.00 \text{ mm}$

UG-37 Calculation of Stress Loaded Areas Effective as Reinforcement

Area Available in Shell A1

$$A1 = (deff - d) * (E1 * t - F * tr) - 2 * tn * (E1 * t - F * tr) * (1 - fr1) \\ = (92 - 40) * (1 * 26 - 1 * 8.62) - 2 * 0 * (1 * 26 - 1 * 8.62) * (1 - 1) = 903.74 \text{ mm}^2$$

Area Available in Nozzle Projecting Outward A2

$$A2 = 2 * (tn - trn) * fr2 * \text{MIN}(Lno, ho) \\ = 2 * (0 - 0.1751) * 1 * \text{MIN}(0, 0) = 0.00 \text{ mm}^2$$

Area Available in Welds A4

$$A4 = A41 + A42 + A43 = 0 + 0 + 0 = 0.00 \text{ mm}^2$$

Total Area Available Aavail

$$Aavail = A1 + A2 + A3 + A4 + A5 = 903.74 + 0 + 0 + 0 + 0 = 903.74 \text{ mm}^2$$

UG-39(b)(1) Total Area Required

Total Area Required Areq
 $Areq = 0.5 * d * tr + tn * tr * (1 - fr1) \\ = 0.5 * 40 * 8.62 + 0 * 8.62 * (1 - 1) = 172.41 \text{ mm}^2$

UG-39(d)(1) Alternative to (b)(1), Minimum Head/Cover Thickness trmin

$$Cnew = \text{MIN}(2 * C, 0.75) = \text{MIN}(2 * 0.2, 0.75) = 0.4000$$

$$\text{trmin} = tr * \text{SQR}(Cnew / C) = 8.62 * \text{SQR}(0.4 / 0.2) = 12.19 \text{ mm}$$

UG-37 Nozzle Reinforcement Aavail=903.74 >= Areq=172.41[mm2]

19.0%

OK

MAXIMUM ALLOWABLE PRESSURES

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

$$Pmax(t, tn, Sv, Sn)(26, 0, 115, 115) = 4.7576 \text{ MPa}$$

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

$$Pmax(t, tn, Sv, Sn)(27, 0, 115, 115) = 5.2459 \text{ MPa}$$

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

$$Pmax(t, tn, Sv, Sn)(27, 0, 153, 153) = 6.9611 \text{ MPa}$$

UG-37(d) Nozzle Reinforcement - External Pressure

Available Reinforcement Area
 $Aavail = A1 + A2 + A3 + A4 + A5 = 1342.13 + 0 + 0 + 0 + 0 = 1342.13 \text{ mm}^2$

UG-37(d) Nozzle Reinforcement Ext.Press. Aavail=1342.13 >= Areq=1.9[mm2]

0.1%

OK

Weight of Nozzle:0.00kg

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ASME VIII Div.1:2019 - UG-39 REINF.REQUIRED FOR OPENINGS IN FLAT HEADS

N.3 N4

17 Feb. 2022 13:08 ConnID:E4.1 PC# 2

CALCULATION SUMMARY

Aavail = A1 + A2 + A3 + A4 + A5 =903.74+0+0+0+0=

903.74 mm2

Total Area Required Areq

Areq = 0.5 * d * tr + tn * tr * (1 - fr1)

=0.5*40*8.62+0*8.62*(1-1)=

172.41 mm2

UG-37 Nozzle Reinforcement Aavail=903.74 >=
Areq=172.41[mm2]

19.0%

OK

MAXIMUM ALLOWABLE PRESSURES

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :HOT & CORR

Pmax (t,tn,Sv,Sn)(26,0,115,115) = ==

4.7576 MPa

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :NEW & COLD

Pmax (t,tn,Sv,Sn)(27,0,115,115) = ==

5.2459 MPa

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

Pmax (t,tn,Sv,Sn)(27,0,153,153) = ==

6.9611 MPa

UG-37(d) Nozzle Reinforcement - External Pressure

Available Reinforcement Area

Aavail = A1 + A2 + A3 + A4 + A5 =1342.13+0+0+0+0=

1342.13 mm2

UG-37(d) Nozzle Reinforcement Ext.Press. Aavail=1342.13 >=
Areq=1.9[mm2]

0.1%

OK

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 3 SA-182(M)

Gr.F316L, S31603 Forgings, PNo=8

, the material must be re-selected from the material

database.

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

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Client : IWS Monje

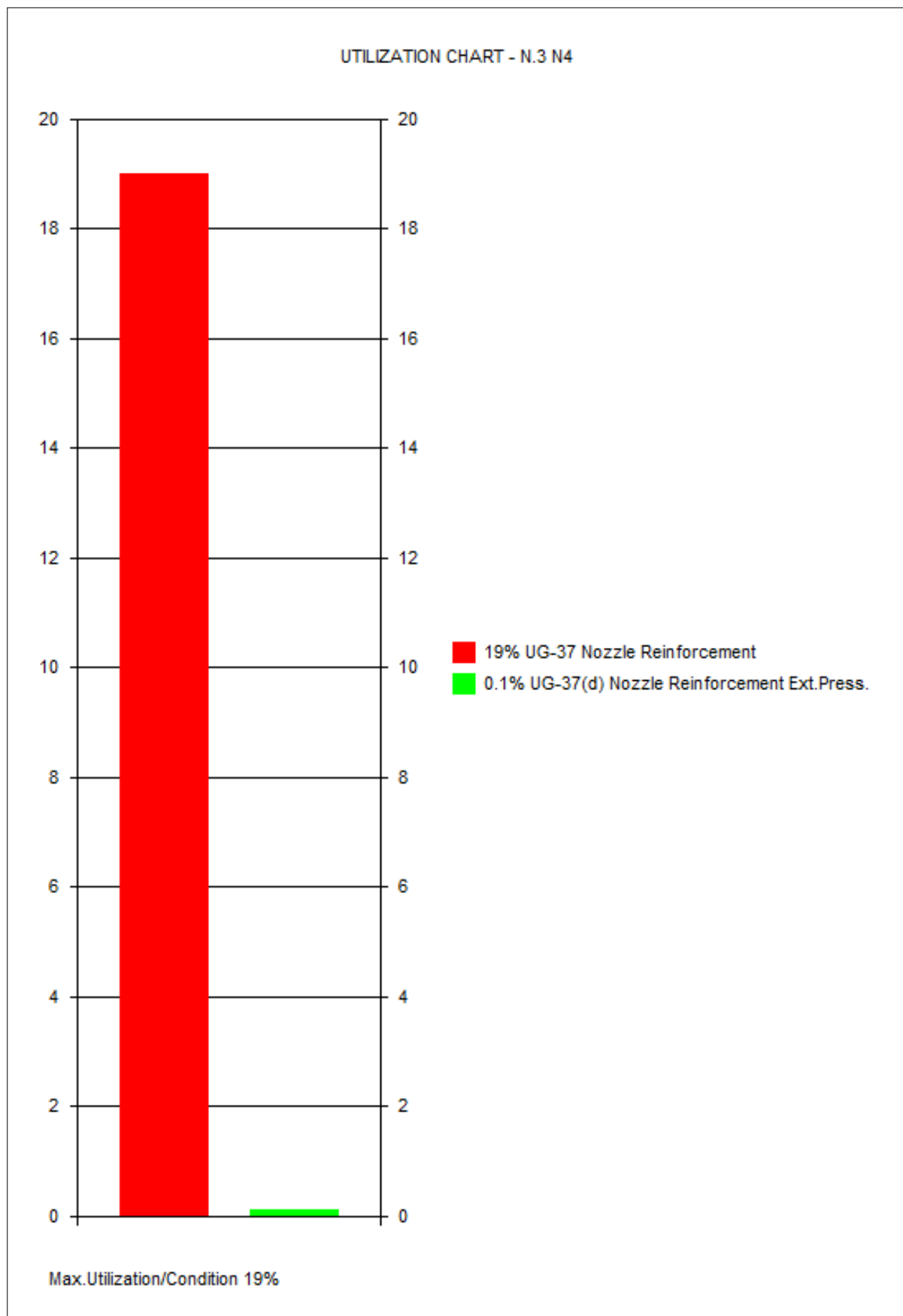
Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-39 REINF.REQUIRED FOR OPENINGS IN FLAT HEADS

N.3 N4

17 Feb. 2022 13:08 ConnID:E4.1 PC# 2



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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.1 Flangering Head left 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

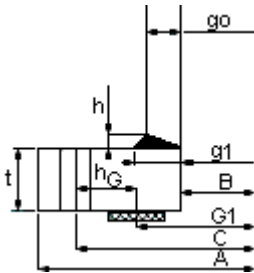
Attachment: F.3 RT - Flange Flangering Shell left S1.1
Location: Along z-axis z1= -54
Include a standard ANSI, DIN or EN flange without performing detailed calculations.: NO

GENERAL DESIGN DATA

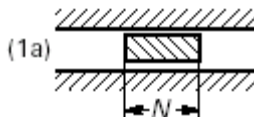
PROCESS CARD: Tube Side : Temp= 95°C, P=1.0000 MPa, c=1.0 mm
SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.0000
LIQUID HEAD.....:LH 307.50 mm
B: Pressure loading: Flange under internal pressure
LETHAL SERVICE - APPLY BOLT SPACING CORR.FACTOR TO 2-6 AND RIGIDITY INDEX TO 2-14.: NO
EXTERNAL LOADS ON FLANGE (PD5500 ENQ 5500/123): NO
SPECIFY BOLT LOADS FROM 2nd./MATING FLANGE: NO

TYPE OF FLANGE AND GASKET FACING

A: Flange Standard: User Specified Flanges



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



D: Flange Facing (Sketch/Description): 1a Flat Face

SHELL/NOZZLE DATA

SHELL/NOZZLE SIZE & COMMENT: S1.1
SA-182(M) Gr.F316L, S31603 Forgings, PNo=8 120'C
ST=450 SY=170 SYd=138.6 fs=115 fs20=115 Stest=153 (N/mm2)
OUTSIDE DIAMETER OF SHELL/NOZZLE:Do 215.00 mm
WALL THICKNESS OF NOZZLE/SHELL(uncorroded).....:s1 40.85 mm

FLANGE DATA

FLANGE HUB: Flange Without Hub
REVERSE FLANGE: No (The bolts are located on the outside)
DESIGN METHOD: B) LOOSE FLANGE METHOD(If requirements are met)
FLANGE BORE: Smooth
OUTSIDE DIAMETER OF FLANGE.....:A 215.00 mm
THICKNESS OF FLANGE(uncorroded).....:e 36.00 mm
CORROSION ALLOWANCE FOR FLANGE FACE.....:cf 0.00 mm
SA-182(M) Gr.F316L, S31603 Forgings, PNo=8 120'C
ST=450 SY=170 SYd=138.6 SFO=115 SFA=115 Stest=153 (N/mm2)
INCLUDE APPENDIX 2-14, FLANGE RIGIDITY CALCULATION: YES
MODULUS OF ELASTICITY at design temp.....:E 2,0E05 N/mm2
MODULUS OF ELASTICITY at ambient temp.....:E20 2,0E05 N/mm2

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.1 Flangering Head left 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

BOLTING DATA

REDUCE SAFETY AGAINST ABUSE BY CAREFULLY CONTROLLING THE BOLTING-UP TORQUE: NO
BOLTING TORQUE CALCULATION: NO

NOMINAL BOLTING SIZE & COMMENT: M12x1.75 ;

EFFECTIVE BOLT AREA per bolt.....:Ae	76.25 mm ²
RECOMMENDED MINIMUM BOLT CENTER TO EDGE CLEARANCE...:Bce	16.00 mm
RECOMMENDED MINIMUM BOLT CENTER/RADIAL CLEARANCE...:Bcr	20.00 mm
DIAMETER OF BOLT HOLES IN FLANGE.....:d	12.00 mm
NUMBER OF BOLTS.....:n	4.0000
BOLT-CIRCLE DIAMETER.....:C	180.00 mm
SA-193(M) Gr.B7, G41400 Bolting THK<=100mm 95'C	
ST=795 SY=655 SYd=609.57 Sb=159 Sa=159 Stest=589.5 (N/mm ²)	

GASKET DATA

Table 2-5.1 Gasket factors m & y Facing:

Mineral Fiber 1.6 mm thick m=2.75 Y=25.5 2 1a,1b,1c,1d,4,5

CONTACT WIDTH OF GASKET.....:N 1.0000 mm

OUTSIDE DIAMETER OF GASKET.....:Go 132.20 mm

TEMA RGP-RCB-11.7 Include Additional Loads from Pass Partition Plate Gasket: NO

CALCULATION DATA

GASKET DETAILS

$b = \text{MIN VALUE}(2.52 * \text{Sqr}(bo), bo) = = 0.5000 \text{ mm}$

FLANGE LOADS

$HD = 0.785 * B^2 * p = 0.785 * 135.3^2 * 1.003 = 14.41 \text{ kN}$

$H = 0.785 * G^2 * p = 0.785 * 131.2^2 * 1.003 = 13.55 \text{ kN}$

$H_p = (2 * \text{PI} * b * G * m) * p$

$= (2 * 3.14 * 0.5 * 131.2 * 2.75) * 1.003 = 1.1369 \text{ kN}$

$HT = H - HD = 13553.09 - 14413.39 = -0.8603 \text{ kN}$

MOMENT ARMS

$hG = (C - G) / 2 = (180 - 131.2) / 2 = 24.40 \text{ mm}$

$hD = (C - B - g1) / 2 = (180 - 135.3 - 39.85) / 2 = 2.4250 \text{ mm}$

$hT = (2 * C - B - G) / 4 = (2 * 180 - 135.3 - 131.2) / 4 = 23.38 \text{ mm}$

BOLT LOADS

Operating condition

$Wop = H + H_p = 13553.09 + 1136.89 = 14.69 \text{ kN}$

Bolting up condition

$Wamb = \text{PI} * b * G * y = 3.14 * 0.5 * 131.2 * 25.5 = 5.2553 \text{ kN}$

BOLTING AREA

$A_{m1} = Wop / Sb = 14689.97 / 159 = 92.39 \text{ mm}^2$

$A_{m2} = Wamb / Sa = 5255.26 / 159 = 33.05 \text{ mm}^2$

Required Bolting Area Am

$A_m = \text{MAX}(A_{m1}, A_{m2}) = \text{MAX}(92.39, 33.05) = 92.39 \text{ mm}^2$

Available Bolting Area Ab

$Ab (\text{num.bolts} * \text{root area}) = n * Ae = 4 * 76.25 = 305.00 \text{ mm}^2$

Bolting Area Check $Ab=305 \geq Am=92.39[\text{mm}^2]$

30.2%

OK

Bolt Spacing

$B_s = C * \text{PI} / n = 180 * 3.14 / 4 = 141.37 \text{ mm}$

2-5 Recommended Maximum Bolt Spacing

$B_{max} = 2 * db + 6 * e / (m + 0.5)$
 $= 2 * 12 + 6 * 36 / (2.75 + 0.5) = 90.46 \text{ mm}$

$W = 0.5 * (Ab + Am) * Sa = 0.5 * (305 + 92.39) * 159 = 31.59 \text{ kN}$

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ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.1 Flangering Head left 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

FLANGE MOMENTS

$$\begin{aligned} Mop &= HD * hD + HT * hT + HG * hG \\ &= 14413.39 * 2.42 + 860.3 * 23.375 + 1136.89 * 24.4 = 42.58 \text{ Nm} \\ Mamb &= W * hG = 31592.49 * 24.4 = 770.86 \text{ Nm} \\ Mo &= Mop = 42.58 = 42.58 \text{ Nm} \\ Ma &= Mamb = 770.86 = 770.86 \text{ Nm} \end{aligned}$$

SHAPE CONSTANTS

$$\begin{aligned} K &= A / B = 215 / 135.3 = 1.5891 \\ ho &= \text{SQR}(B * go) = 73.428 \quad h/ho = 0.000 \quad K=A/B = 1.589 \quad g1/go = 1.000 \\ \text{VALUES FOR T,U,Y AND Z FROM FIGURE 2-7.1} \\ T &= 1.672 \quad Z = 2.311 \quad Y = 4.367 \quad U = 4.799 \\ F &= 0.909 \quad V = 0.550 \quad f = 1.000 \\ d &= U / V * ho * go^2 = 4.799 / 0.5501 * 73.43 * 39.85^2 = 1,0172E06 \text{ mm}^3 \\ e &= F / ho = 0.9089 / 73.43 = 0.0124 \text{ mm}^{-1} \\ L &= (t * e + 1) / T + t^3 / d \\ &= (36 * 0.0124 + 1) / 1.672 + 36^3 / 1.0172E06 = 0.9105 \end{aligned}$$

OPERATING CONDITION

$$M = Mo = 42.58 = 42.58 \text{ Nm}$$

Flange Stresses with Flange Thickness e= 36 mm

Longitudinal Hub Stress

$$SH = f * M / (L * g1^2 * B) = 1 * 42.58 / (0.9105 * 39.85^2 * 135.3) = 0.2177 \text{ N/mm}^2$$

Radial Flange Stress

$$SR = (1.333 * t * e + 1) * M / (L * t^2 * B) = (1.333 * 36 * 0.0124 + 1) * 42.58 / (0.9105 * 36^2 * 135.3) = 0.4252 \text{ N/mm}^2$$

Tangential Flange Stress

$$ST = Y * M / (t^2 * B) - (Z * SR) = 4.367 * 42.58 / (36^2 * 135.3) - (2.311 * 0.4252) = 0.0780 \text{ N/mm}^2$$

Stress Limits

Hub Stress SH=0.2177 <= 1.5 * MIN(Sf;SfH)=172.5[N/mm2]	0.1%	OK
Radial Stress SR=0.4252 <= Sf=115[N/mm2]	0.3%	OK
Tangential Stress ST=0.078 <= Sf=115[N/mm2]	0.0%	OK
Radial+Hub Stress 0.5*(SH+SR)=0.3214 <= Sf=115[N/mm2]	0.2%	OK
Tangential+Hub Stress 0.5*(SH+ST)=0.1478 <= Sf=115[N/mm2]	0.1%	OK

APPENDIX 2-14, FLANGE RIGIDITY

Rigidity Index

$$J = 52.14 * V * M / (L * E * go^2 * 0.3 * ho) = 52.14 * 0.5501 * 42582.89 / (0.9105 * 200000 * 39.85^2 * 0.3 * 73.43) = 1,9174E-04$$

BOLTING UP CONDITION

$$M = Ma = 770.86 = 770.86 \text{ Nm}$$

Flange Stresses with Flange Thickness e= 36 mm

Longitudinal Hub Stress

$$SH = f * M / (L * g1^2 * B) = 1 * 770.86 / (0.9105 * 39.85^2 * 135.3) = 3.9405 \text{ N/mm}^2$$

Radial Flange Stress

$$SR = (1.333 * t * e + 1) * M / (L * t^2 * B) = (1.333 * 36 * 0.0124 + 1) * 770.86 / (0.9105 * 36^2 * 135.3) = 7.6966 \text{ N/mm}^2$$

Tangential Flange Stress

$$ST = Y * M / (t^2 * B) - (Z * SR) = 4.367 * 770.86 / (36^2 * 135.3) - (2.311 * 7.7) = 1.4112 \text{ N/mm}^2$$

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.1 Flangering Head left 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

Stress Limits

Hub Stress $SH=3.94 \leq 1.5 * \text{MIN}(Sf;SfH)=172.5[N/mm^2]$	2.2%	OK
Radial Stress $SR=7.7 \leq Sf=115[N/mm^2]$	6.6%	OK
Tangential Stress $ST=1.41 \leq Sf=115[N/mm^2]$	1.2%	OK
Radial+Hub Stress $0.5*(SH+SR)=5.82 \leq Sf=115[N/mm^2]$	5.0%	OK
Tangential+Hub Stress $0.5*(SH+ST)=2.68 \leq Sf=115[N/mm^2]$	2.3%	OK

APPENDIX 2-14, FLANGE RIGIDITY

Rigidity Index

$$J = 52.14 * V * M / (L * E * g_o ^ 2 * 0.3 * h_o)$$

$$= 52.14 * 0.5501 * 7.7086E05 / (0.9105 * 200000 * 39.85^2 * 0.3 * 73.43) = \underline{\underline{0.0035}}$$

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

$$P_{tmin} = 1.1 * P_d * S_r / S = 1.1 * 1 * 115 / 115 =$$

$$\underline{\underline{1.1000 \text{ MPa}}}$$

Test Pressure $P_{tmin}=1.1 \leq P_{tmax}=11.371[MPa]$	9.6%	OK
--	------	----

PRESSURE AND TORQUE SUMMARY

Table PRESSURE AND TORQUE SUMMARY FOR F.1 :

Description	Temp(C)	P(MPa)	Limited By	Min.Req.Total Bolt Force(kN)
Design Pressure(corroded)	95	1.00	Bolting Area Check	14.69
Max.Allow.Pressure(corroded)	95	3.31	Bolting Area Check	48.53
Max.Allow.Pressure(corroded)	Ambient	3.31	Bolting Area Check	48.53
Max.Allow.Test Pressure(corroded)	Ambient	11.37	Bolting Area Check	166.54
Required Test Pressure	Ambient	1.10	Bolting Area Check	16.15

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

CALCULATION SUMMARY

BOLTING AREA

Bolting Area Check $A_b=305 \geq A_m=92.39[mm^2]$	30.2%	OK
---	-------	----

OPERATING CONDITION

Flange Stresses with Flange Thickness $e=36 \text{ mm}$

Longitudinal Hub Stress

$$SH = f * M / (L * g_1 ^ 2 * B)$$

$$= 1 * 42.58 / (0.9105 * 39.85^2 * 135.3) =$$

$$\underline{\underline{0.2177 \text{ N/mm}^2}}$$

Radial Flange Stress

$$SR = (1.333 * t * e + 1) * M / (L * t ^ 2 * B)$$

$$= (1.333 * 36 * 0.0124 + 1) * 42.58 / (0.9105 * 36^2 * 135.3) =$$

$$\underline{\underline{0.4252 \text{ N/mm}^2}}$$

Tangential Flange Stress

$$ST = Y * M / (t ^ 2 * B) - (Z * SR)$$

$$= 4.367 * 42.58 / (36^2 * 135.3) - (2.311 * 0.4252) =$$

$$\underline{\underline{0.0780 \text{ N/mm}^2}}$$

Stress Limits

Hub Stress $SH=0.2177 \leq 1.5 * \text{MIN}(Sf;SfH)=172.5[N/mm^2]$	0.1%	OK
Radial Stress $SR=0.4252 \leq Sf=115[N/mm^2]$	0.3%	OK
Tangential Stress $ST=0.078 \leq Sf=115[N/mm^2]$	0.0%	OK
Radial+Hub Stress $0.5*(SH+SR)=0.3214 \leq Sf=115[N/mm^2]$	0.2%	OK
Tangential+Hub Stress $0.5*(SH+ST)=0.1478 \leq Sf=115[N/mm^2]$	0.1%	OK

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.1 Flangering Head left 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

APPENDIX 2-14, FLANGE RIGIDITY

Rigidity Index

$$J = 52.14 * V * M / (L * E * g_o ^ 2 * 0.3 * h_o)$$

$$= 52.14 * 0.5501 * 42582.89 / (0.9105 * 200000 * 39.85^2 * 0.3 * 73.43) = 1,9174E-04$$

BOLTING UP CONDITION

Flange Stresses with Flange Thickness e= 36 mm

Longitudinal Hub Stress

$$SH = f * M / (L * g_l ^ 2 * B)$$

$$= 1 * 770.86 / (0.9105 * 39.85^2 * 135.3) =$$

3.9405 N/mm2

Radial Flange Stress

$$SR = (1.333 * t * e + 1) * M / (L * t ^ 2 * B)$$

$$= (1.333 * 36 * 0.0124 + 1) * 770.86 / (0.9105 * 36^2 * 135.3) =$$

7.6966 N/mm2

Tangential Flange Stress

$$ST = Y * M / (t ^ 2 * B) - (Z * SR)$$

$$= 4.367 * 770.86 / (36^2 * 135.3) - (2.311 * 7.7) =$$

1.4112 N/mm2

Stress Limits

Hub Stress SH=3.94 <= 1.5 * MIN(Sf;SfH)=172.5[N/mm2]	2.2%	OK
Radial Stress SR=7.7 <= Sf=115[N/mm2]	6.6%	OK
Tangential Stress ST=1.41 <= Sf=115[N/mm2]	1.2%	OK
Radial+Hub Stress 0.5*(SH+SR)=5.82 <= Sf=115[N/mm2]	5.0%	OK
Tangential+Hub Stress 0.5*(SH+ST)=2.68 <= Sf=115[N/mm2]	2.3%	OK

APPENDIX 2-14, FLANGE RIGIDITY

Rigidity Index

$$J = 52.14 * V * M / (L * E * g_o ^ 2 * 0.3 * h_o)$$

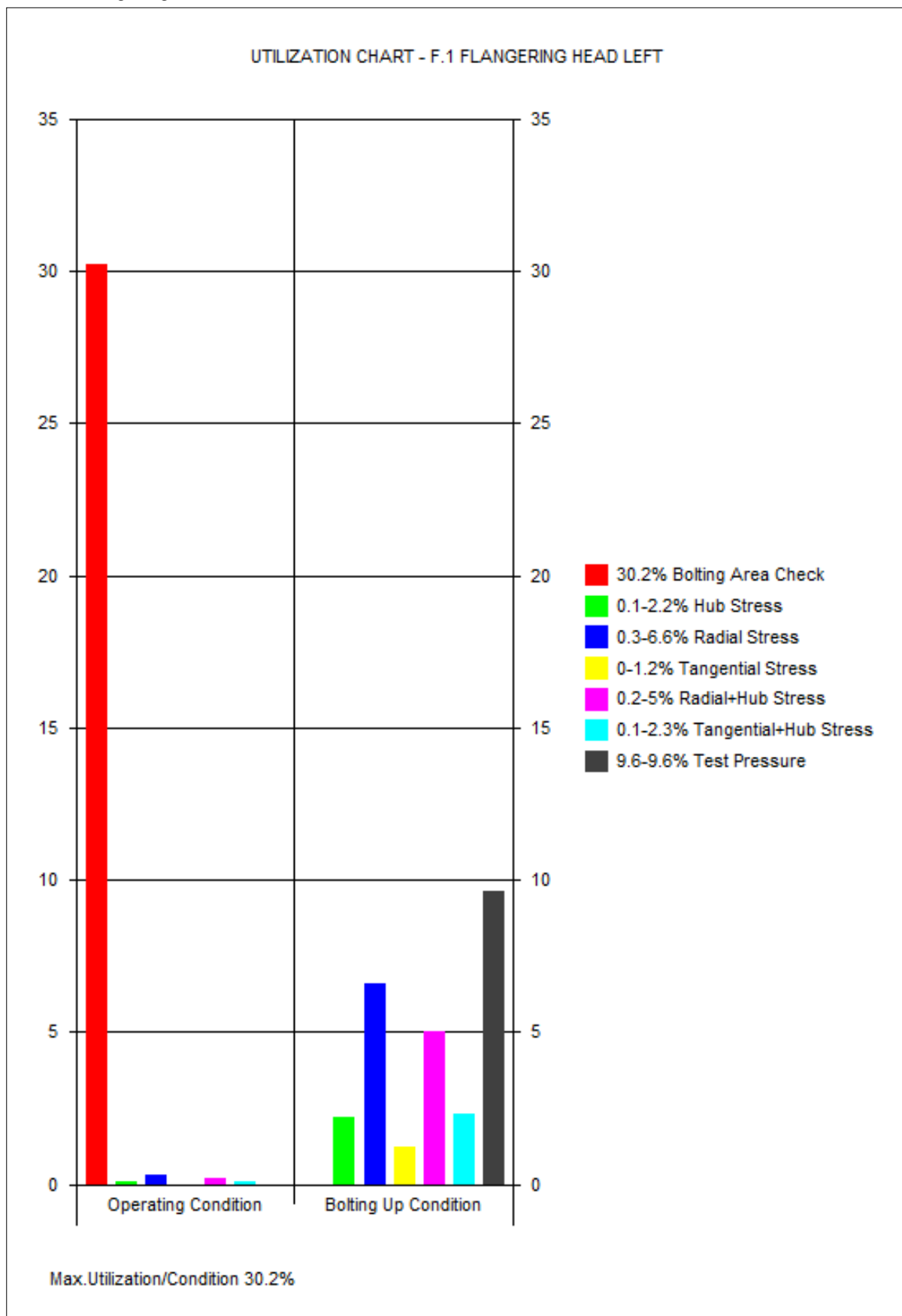
$$= 52.14 * 0.5501 * 7.7086E05 / (0.9105 * 200000 * 39.85^2 * 0.3 * 73.43) = 0.0035$$

Test Pressure P _{tmin} =1.1 <= P _{tmax} =11.371[MPa]	9.6%	OK
--	------	----

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 3 SA-182(M) Gr.F316L, S31603 Forgings, PNo=8, the material must be re-selected from the material database.

Warning: Invalid gasket location/dimension.

Volume:0.0005176 m3 Weight:6 kg (SG= 7.85)



SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.3 Flanging Shell left 17 Feb. 2022 13:08 ConnID:S1.1 PC# 2

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: S1.1 Cylindrical Shell Main Shell

Location: Along z-axis zo= 0

Include a standard ANSI, DIN or EN flange without performing detailed calculations.: NO

GENERAL DESIGN DATA

PROCESS CARD: Tube Side : Temp= 95°C, P=1.0000 MPa, c=1.0 mm

SPECIFIC DENSITY OF OPERATING LIQUID.....:SG 1.0000

LIQUID HEAD.....:LH 270.65 mm

B: Pressure loading: Flange under internal pressure

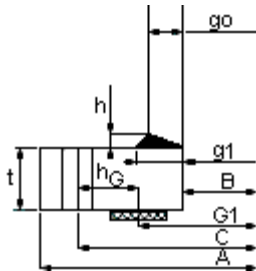
LETHAL SERVICE - APPLY BOLT SPACING CORR.FACTOR TO 2-6 AND RIGIDITY INDEX TO 2-14.: NO

EXTERNAL LOADS ON FLANGE (PD5500 ENQ 5500/123): NO

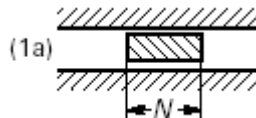
SPECIFY BOLT LOADS FROM 2nd./MATING FLANGE: NO

TYPE OF FLANGE AND GASKET FACING

A: Flange Standard: User Specified Flanges



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



D: Flange Facing (Sketch/Description): 1a Flat Face

SHELL/NOZZLE DATA

SHELL/NOZZLE SIZE & COMMENT: S1.1

SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 120'C

ST=515 SY=205 SYd=169.6 fs=138 fs20=138 Stest=184.5 (N/mm²)

OUTSIDE DIAMETER OF SHELL/NOZZLE:Do 141.30 mm

WALL THICKNESS OF NOZZLE/SHELL(uncorroded).....:s1 3.4000 mm

FLANGE DATA

FLANGE HUB: Flange With Hub

REVERSE FLANGE: No (The bolts are located on the outside)

DESIGN METHOD: A) INTEGRAL FLANGE METHOD

FLANGE BORE: Smooth

OUTSIDE DIAMETER OF FLANGE.....:A 215.00 mm

THICKNESS OF FLANGE(uncorroded).....:e 36.00 mm

CORROSION ALLOWANCE FOR FLANGE FACE.....:cf 0.00 mm

SA-182(M) Gr.F316L, S31603 Forgings, PNo=8 120'C

ST=450 SY=170 SYd=138.6 SFO=115 SFA=115 Stest=153 (N/mm²)

INCLUDE APPENDIX 2-14, FLANGE RIGIDITY CALCULATION: YES

MODULUS OF ELASTICITY at design temp.....:E 2,0E05 N/mm²

MODULUS OF ELASTICITY at ambient temp.....:E20 2,0E05 N/mm²

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.3 Flangering Shell left 17 Feb. 2022 13:08 ConnID:S1.1 PC# 2

DATA FOR FLANGE HUB

LENGTH OF HUB.....:h 18.00 mm
THICKNESS OF HUB AT BACK OF FLANGE corroded.....:g1 17.50 mm
THICKNESS OF HUB AT SMALL END corroded.....:go 3.2000 mm
SA-182(M) Gr.F316L, S31603 Forgings, PNo=8 120'C
ST=450 SY=170 SYd=138.6 SHO=115 SHA=115 Stest=153 (N/mm2)

BOLTING DATA

REDUCE SAFETY AGAINST ABUSE BY CAREFULLY CONTROLLING THE BOLTING-UP TORQUE: NO
BOLTING TORQUE CALCULATION: NO
NOMINAL BOLTING SIZE & COMMENT: M12x1.75 ;
EFFECTIVE BOLT AREA per bolt.....:Ae 76.25 mm2
RECOMMENDED MINIMUM BOLT CENTER TO EDGE CLEARANCE...:Bce 16.00 mm
RECOMMENDED MINIMUM BOLT CENTER/RADIAL CLEARANCE....:Bcr 20.00 mm
DIAMETER OF BOLT HOLES IN FLANGE.....:d 12.00 mm
NUMBER OF BOLTS.....:n 4.0000
BOLT-CIRCLE DIAMETER.....:C 180.00 mm
SA-193(M) Gr.B7, G41400 Bolting THK<=100mm 95'C
ST=795 SY=655 SYd=609.57 Sb=159 Sa=159 Stest=589.5 (N/mm2)

GASKET DATA

Table 2-5.1 Gasket factors m & y Facing:
Mineral Fiber 1.6 mm thick m=2.75 Y=25.5 2 1a,1b,1c,1d,4,5
CONTACT WIDTH OF GASKET.....:N 1.0000 mm
OUTSIDE DIAMETER OF GASKET.....:Go 132.20 mm
TEMA RGP-RCB-11.7 Include Additional Loads from Pass Partition Plate Gasket: NO

CALCULATION DATA

GASKET DETAILS

$b = \text{MIN VALUE}(2.52 * \text{Sqr}(bo), bo) = == 0.5000 \text{ mm}$

FLANGE LOADS

$HD = 0.785 * B^2 * p = 0.785 * 136.5^2 * 1.0027 = 14.67 \text{ kN}$
 $H = 0.785 * G^2 * p = 0.785 * 131.2^2 * 1.0027 = 13.55 \text{ kN}$
 $H_p = (2 * \text{PI} * b * G * m) * p = 1.1365 \text{ kN}$
 $HT = H - HD = 13549.03 - 14665.81 = -1.12 \text{ kN}$

MOMENT ARMS

$hG = (C - G) / 2 = (180 - 131.2) / 2 = 24.40 \text{ mm}$
 $hD = (C - B - g1) / 2 = (180 - 136.5 - 17.5) / 2 = 13.00 \text{ mm}$
 $hT = (2 * C - B - G) / 4 = (2 * 180 - 136.5 - 131.2) / 4 = 23.08 \text{ mm}$

BOLT LOADS

Operating condition
 $Wop = H + H_p = 13549.03 + 1136.55 = 14.69 \text{ kN}$
Bolting up condition
 $Wamb = \text{PI} * b * G * y = 3.14 * 0.5 * 131.2 * 25.5 = 5.2553 \text{ kN}$

BOLTING AREA

$A_{m1} = Wop / Sb = 14685.58 / 159 = 92.36 \text{ mm}^2$
 $A_{m2} = Wamb / Sa = 5255.26 / 159 = 33.05 \text{ mm}^2$
Required Bolting Area A_m
 $A_m = \text{MAX}(A_{m1}, A_{m2}) = \text{MAX}(92.36, 33.05) = 92.36 \text{ mm}^2$
Available Bolting Area A_b
 $A_b (\text{num.bolts} * \text{root area}) = n * Ae = 4 * 76.25 = 305.00 \text{ mm}^2$

Bolting Area Check $A_b=305 \geq A_m=92.36[\text{mm}^2]$

30.2%

OK

Bolt Spacing

$B_s = C * \text{PI} / n = 180 * 3.14 / 4 = 141.37 \text{ mm}$

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.3 Flangering Shell left 17 Feb. 2022 13:08 ConnID:S1.1 PC# 2

2-5 Recommended Maximum Bolt Spacing

$$B_{max} = 2 * db + 6 * e / (m + 0.5)$$

$$= 2 * 12 + 6 * 36 / (2.75 + 0.5) =$$

90.46 mm

$$W = 0.5 * (A_b + A_m) * S_a = 0.5 * (305 + 92.36) * 159 =$$

31.59 kN

FLANGE MOMENTS

$$M_{op} = HD * h_D + HT * h_T + HG * h_G$$

$$= 14665.81 * 13 + -1120 * 23.075 + 1136.55 * 24.4 =$$

192.62 Nm

$$M_{amb} = W * h_G = 31590.29 * 24.4 =$$

770.80 Nm

$$M_o = M_{op} = 192.62 =$$

192.62 Nm

$$M_a = M_{amb} = 770.8 =$$

770.80 Nm

SHAPE CONSTANTS

$$K = A / B = 215 / 136.5 =$$

1.5751

$$h_o = \sqrt{B * g_o} = 20.900 \quad h / h_o = 0.861 \quad K = A / B = 1.575 \quad g_1 / g_o = 5.469$$

VALUES FOR T,U,Y AND Z FROM FIGURE 2-7.1

$$T = 1.678 \quad Z = 2.351 \quad Y = 4.448 \quad U = 4.888$$

$$F = 0.685 \quad V = 0.047 \quad f = 4.676$$

$$d = U / V * h_o * g_o^2 = 4.888 / 0.0467 * 20.9^3 * 2 =$$

22384.03 mm³

$$e = F / h_o = 0.6845 / 20.9 =$$

0.0328 mm-1

$$L = (t * e + 1) / T + t^3 / d$$

$$= (36 * 0.0328 + 1) / 1.678 + 36^3 / 22384.03 =$$

3.3830

OPERATING CONDITION

$$M = M_o = 192.62 =$$

192.62 Nm

Flange Stresses with Flange Thickness e= 36 mm

Longitudinal Hub Stress

$$SH = f * M / (L * g_1^2 * B)$$

$$= 4.68 * 192.62 / (3.38 * 17.5^2 * 136.5) =$$

6.3694 N/mm²

Radial Flange Stress

$$SR = (1.333 * t * e + 1) * M / (L * t^2 * B)$$

$$= (1.333 * 36 * 0.0328 + 1) * 192.62 / (3.38 * 36^2 * 136.5) =$$

0.8277 N/mm²

Tangential Flange Stress

$$ST = Y * M / (t^2 * B) - (Z * SR)$$

$$= 4.448 * 192.62 / (36^2 * 136.5) - (2.351 * 0.8277) =$$

2.8971 N/mm²

Stress Limits

Hub Stress SH=6.37 <= 1.5 * MIN(Sf;SfH)=172.5[N/mm ²]	3.6%	OK
Radial Stress SR=0.8277 <= Sf=115[N/mm ²]	0.7%	OK
Tangential Stress ST=2.9 <= Sf=115[N/mm ²]	2.5%	OK
Radial+Hub Stress 0.5*(SH+SR)=3.6 <= Sf=115[N/mm ²]	3.1%	OK
Tangential+Hub Stress 0.5*(SH+ST)=4.63 <= Sf=115[N/mm ²]	4.0%	OK

APPENDIX 2-14, FLANGE RIGIDITY

Rigidity Index

$$J = 52.14 * V * M / (L * E * g_o^2 * 0.3 * h_o)$$

$$= 52.14 * 0.0467 * 1.9262E05 / (3.38 * 200000 * 3.2^2 * 0.3 * 20.9) =$$

0.0108

BOLTING UP CONDITION

$$M = M_a = 770.8 =$$

770.80 Nm

Flange Stresses with Flange Thickness e= 36 mm

Longitudinal Hub Stress

$$SH = f * M / (L * g_1^2 * B)$$

$$= 4.68 * 770.8 / (3.38 * 17.5^2 * 136.5) =$$

25.49 N/mm²

Radial Flange Stress

$$SR = (1.333 * t * e + 1) * M / (L * t^2 * B)$$

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.3 Flangering Shell left 17 Feb. 2022 13:08 ConnID:S1.1 PC# 2

$$=(1.333*36*0.0328+1)*770.8/(3.38*36^2*136.5)= \underline{3.3124 \text{ N/mm}^2}$$

Tangential Flange Stress

$$ST = Y * M / (t^2 * B) - (Z * SR)$$

$$=4.448*770.8/(36^2*136.5)-(2.351*3.31)= \underline{11.59 \text{ N/mm}^2}$$

Stress Limits

Hub Stress SH=25.49 <= 1.5 * MIN(Sf;SfH)=172.5[N/mm2]	14.7%	OK
Radial Stress SR=3.31 <= Sf=115[N/mm2]	2.8%	OK
Tangential Stress ST=11.59 <= Sf=115[N/mm2]	10.0%	OK
Radial+Hub Stress 0.5*(SH+SR)=14.4 <= Sf=115[N/mm2]	12.5%	OK
Tangential+Hub Stress 0.5*(SH+ST)=18.54 <= Sf=115[N/mm2]	16.1%	OK

APPENDIX 2-14, FLANGE RIGIDITY

Rigidity Index

$$J = 52.14 * V * M / (L * E * g_0^2 * 0.3 * h_0)$$

$$=52.14*0.0467*7.708E05/(3.38*200000*3.2^2*0.3*20.9)= \underline{\underline{0.0432}}$$

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

$$P_{tmin} = 1.1 * P_d * S_r / S = 1.1*1*115/115=$$

$$\underline{\underline{1.1000 \text{ MPa}}}$$

Test Pressure P _{tmin} =1.1 <= P _{tmax} =11.371[MPa]	9.6%	OK
--	------	----

PRESSURE AND TORQUE SUMMARY

Table PRESSURE AND TORQUE SUMMARY FOR F.3 :

Description	Temp(C)	P(MPa)	Limited By	Min.Req.Total Bolt Force(kN)
Design Pressure(corroded)	95	1.00	Bolting Area Check	14.69
Max.Allow.Pressure(corroded)	95	3.31	Bolting Area Check	48.52
Max.Allow.Pressure(corroded)	Ambient	3.31	Bolting Area Check	48.52
Max.Allow.Test Pressure(corroded)	Ambient	11.37	Bolting Area Check	166.54
Required Test Pressure	Ambient	1.10	Bolting Area Check	16.15

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

CALCULATION SUMMARY

BOLTING AREA

Bolting Area Check A _b =305 >= A _m =92.36[mm ²]	30.2%	OK
---	-------	----

OPERATING CONDITION

Flange Stresses with Flange Thickness e= 36 mm

Longitudinal Hub Stress

$$SH = f * M / (L * g_1^2 * B)$$

$$=4.68*192.62/(3.38*17.5^2*136.5)= \underline{6.3694 \text{ N/mm}^2}$$

Radial Flange Stress

$$SR = (1.333 * t * e + 1) * M / (L * t^2 * B)$$

$$=(1.333*36*0.0328+1)*192.62/(3.38*36^2*136.5)= \underline{0.8277 \text{ N/mm}^2}$$

Tangential Flange Stress

$$ST = Y * M / (t^2 * B) - (Z * SR)$$

$$=4.448*192.62/(36^2*136.5)-(2.351*0.8277)= \underline{2.8971 \text{ N/mm}^2}$$

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - APPENDIX 2 RULES FOR BOLTED FLANGE CONNECTIONS

F.3 Flangering Shell left 17 Feb. 2022 13:08 ConnID:S1.1 PC# 2

Stress Limits

Hub Stress $SH=6.37 \leq 1.5 * \text{MIN}(Sf;SfH)=172.5[N/mm^2]$	3.6%	OK
Radial Stress $SR=0.8277 \leq Sf=115[N/mm^2]$	0.7%	OK
Tangential Stress $ST=2.9 \leq Sf=115[N/mm^2]$	2.5%	OK
Radial+Hub Stress $0.5*(SH+SR)=3.6 \leq Sf=115[N/mm^2]$	3.1%	OK
Tangential+Hub Stress $0.5*(SH+ST)=4.63 \leq Sf=115[N/mm^2]$	4.0%	OK

APPENDIX 2-14, FLANGE RIGIDITY

Rigidity Index

$$J = 52.14 * V * M / (L * E * g_0^2 * 0.3 * h_0)$$

$$= 52.14 * 0.0467 * 1.9262E05 / (3.38 * 200000 * 3.2^2 * 0.3 * 20.9) = 0.0108$$

BOLTING UP CONDITION

Flange Stresses with Flange Thickness $e=36$ mm

Longitudinal Hub Stress

$$SH = f * M / (L * g_1^2 * B)$$

$$= 4.68 * 770.8 / (3.38 * 17.5^2 * 136.5) = 25.49 \text{ N/mm}^2$$

Radial Flange Stress

$$SR = (1.333 * t * e + 1) * M / (L * t^2 * B)$$

$$= (1.333 * 36 * 0.0328 + 1) * 770.8 / (3.38 * 36^2 * 136.5) = 3.3124 \text{ N/mm}^2$$

Tangential Flange Stress

$$ST = Y * M / (t^2 * B) - (Z * SR)$$

$$= 4.448 * 770.8 / (36^2 * 136.5) - (2.351 * 3.31) = 11.59 \text{ N/mm}^2$$

Stress Limits

Hub Stress $SH=25.49 \leq 1.5 * \text{MIN}(Sf;SfH)=172.5[N/mm^2]$	14.7%	OK
Radial Stress $SR=3.31 \leq Sf=115[N/mm^2]$	2.8%	OK
Tangential Stress $ST=11.59 \leq Sf=115[N/mm^2]$	10.0%	OK
Radial+Hub Stress $0.5*(SH+SR)=14.4 \leq Sf=115[N/mm^2]$	12.5%	OK
Tangential+Hub Stress $0.5*(SH+ST)=18.54 \leq Sf=115[N/mm^2]$	16.1%	OK

APPENDIX 2-14, FLANGE RIGIDITY

Rigidity Index

$$J = 52.14 * V * M / (L * E * g_0^2 * 0.3 * h_0)$$

$$= 52.14 * 0.0467 * 7.708E05 / (3.38 * 200000 * 3.2^2 * 0.3 * 20.9) = 0.0432$$

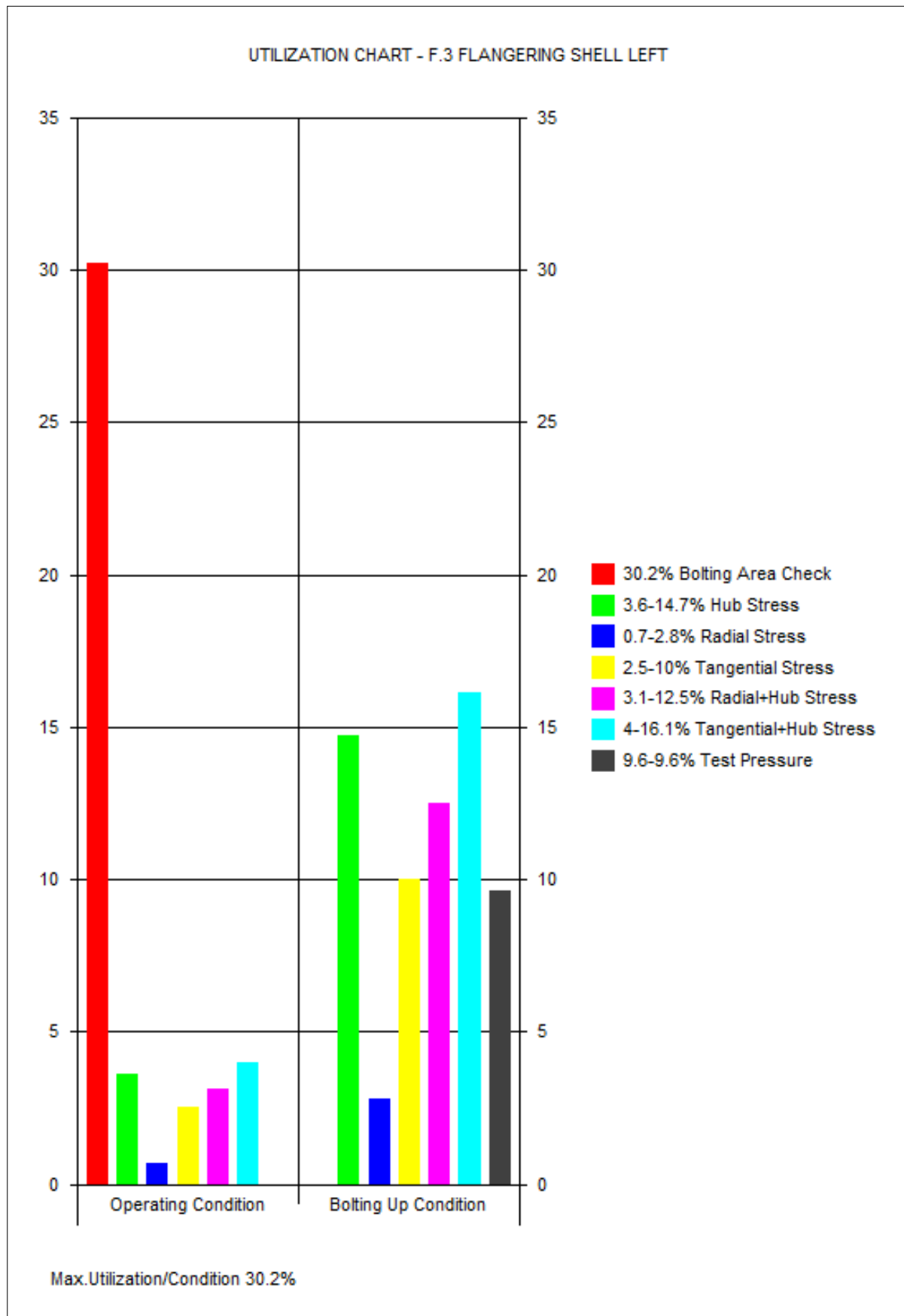
Test Pressure $P_{tmin}=1.1 \leq P_{tmax}=11.371[MPa]$	9.6%	OK
--	------	----

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 5 SA-312(M)
Gr.TP316, S31600 Smls. & wld. pipe, PNo=8, the material must be re-selected from the material database.

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 3 SA-182(M)
Gr.F316L, S31603 Forgings, PNo=8, the material must be re-selected from the material database.

Warning: Invalid gasket location/dimension.

Volume:0.0007902 m3 Weight:6 kg (SG= 7.85)



SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.1 Tubesheet 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

INPUT DATA

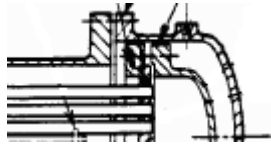
COMPONENT ATTACHMENT/LOCATION

Attachment: F.3 RT - Flange
Location: Along z-axis z1= -54

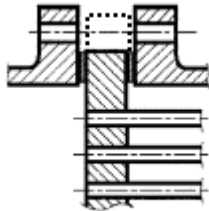
Flangering Shell left

S1.1

GENERAL DESIGN DATA



Type of Heat Exchanger: UHX-14 Floating Tubesheet Heat Exchangers
Type of Tubesheet: Stationary Tubesheet
Type of Floating Tubesheet Exchanger: With Immersed Floating Head



Configuration Type: d1 Tubesheet gasketed with shell and channel
UHX-14.6 Calc.Procedure for Effect of Radial Differential Thermal Exp. Adj.to
Tubesheet: NO

LOAD CASES (LC)

Table LOAD CASES:

Description	ID	=LC1=	=LC2=	=LC3=
Shell-Side Pressure (MPa)	Ps	0	2.82	2.82
Tube-Side Pressure (MPa)	Pt	1	0	1
Shell-Side Corr.Allow. (mm)	cs	1	1	1
Tube-Side Corr.Allow. (mm)	ct	1	1	1
Thermal Stress Factor	MdT	0	0	0
Mean Shell Temperature (°C)	Tsm	NA	NA	NA
Mean Tube Temperature (°C)	Ttm	NA	NA	NA

=LC1=: =LC1=

=LC2=: =LC2=

=LC3=: =LC3=

ALLOWABLE STRESS FOR EACH LOAD CASE

Material Design Temperatures:

Select material design temperatures from the process card.

Ttubesheet= 210, Tshell= 210, Ttube= 210, Tchannel= 95(all values in °C)

Table LOAD CASES:

Description	ID	=LC1=	=LC2=	=LC3=
Allowable Stress M Factor	Mf	1.0	1.0	1.0

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.1 Tubesheet 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

DATA FOR TUBESHEET

SB-148(M), M01, C95820 Castings 204'C

ST=650 SY=270 Sy=259.84 S=167.52 Sr=179 Stest=243 (N/mm2)

OUTSIDE DIAMETER OF TUBESHEET(Ref. UHX-10(b)).....:A	132.20 mm
NOMINAL THICKNESS OF TUBESHEET (uncorroded).....:hn	28.00 mm
ELASTIC MODULUS OF TUBESHEET at tubesheet design temp.:E	1,894E05 N/mm2
POISSON'S RATIO FOR TUBESHEET MATERIAL.....:v	0.3000

DATA FOR TUBES AND TUBES LAYOUT

Tube Layout: Triangular Pattern

SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8 100'C

ST=485 SY=170 Syt=145 St=115 Sr=115 Stest=153 (N/mm2)

ELASTIC MODULUS OF TUBES at tube design temp.....:Et	1,8621E05 N/mm2
NOMINAL OUTSIDE DIAMETER OF TUBES.....:dt	7.5000 mm
TUBE SIZE & COMMENT: S1.2	
NOMINAL THICKNESS OF TUBES.....:tt	0.5000 mm
TUBE PITCH (Spacing between centers).....:p	11.50 mm
DIAMETER OF TUBEHOLE IN TUBESHEET.....:dh	8.0000 mm
DIAMETER OF OUTER TUBE LIMIT CIRCLE.....:Do	123.00 mm
NUMBER OF TUBEHOLES IN TUBESHEET.....:Nt	72.00 piec
TOTAL AREA OF UNTUBED LANES(UL1*Ll1+UL2*Ll2+...).....:AL	1600.00 mm2
TUBE EXPANSION DEPTH RATIO (0<=ro<=1.0).....:ro	1.0000
TUBE-SIDE PASS PARTITION GROOVE DEPTH(Fig.UHX-11.1):hg	1.0000 mm
THERMAL EXPANSION COEF.OF TUBES at mean metal temp.:atm	1,614E-05 mm/mmC
TUBE BUCKLING LENGTH lt=l*k (Ref. UHX-13.5.9(b)(1)):lt	1.0000 mm
TUBE LENGTH BETWEEN INNER FACES OF TUBESHEETS.....:L	800.00 mm
POISSON'S RATIO FOR TUBE MATERIAL.....:vt	0.3000
PERIMETER OF THE TUBE LAYOUT MEASURED CENTER ON OUTER MOST TUBES:Cp	0.00 mm
TOTAL AREA ENCLOSED BY Cp.....:Ap	0.00 mm2

DATA FOR TUBE TO TUBESHEET JOINT

Tube to Tubesheet Weld: Full Strength Weld to UW-20.4

Qualification of Tube-to-Tubesheet Joint: The Joint IS Qualified by Tests

FIG. UW-20.1 Weld Types: Sketch a) Fillet Weld

TUBE TO TUBESHEET FILLET WELD LEG.....:af	1.0000 mm
---	-----------

SHELL DATA

SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 120'C

ST=515 SY=205 Sys=169.6 Ss=138 Sr=138 Stest=184.5 (N/mm2)

INSIDE DIAMETER OF SHELL(corroded).....:Ds	133.30 mm
THICKNESS OF SHELL (uncorroded).....:ts	3.2000 mm
ELASTIC MODULUS OF SHELL MATERIAL at shell design temp:Es	1,8621E05 N/mm2
POISSON'S RATIO FOR SHELL MATERIAL.....:vs	0.3000

CHANNEL DATA

SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 120'C

ST=515 SY=205 Syc=169.6 Sc=138 Sr=138 Stest=184.5 (N/mm2)

INSIDE DIAMETER OF CHANNEL(corroded).....:Dc	133.30 mm
THICKNESS OF CHANNEL (uncorroded).....:tc	3.2000 mm
ELASTIC MODULUS OF CHANNEL at channel design temp...:Ec	1,8833E05 N/mm2
POISSON'S RATIO FOR CHANNEL MATERIAL.....:vc	0.3000

FLANGE DATA

DIAMETER OF SHELL GASKET LOAD REACTION.....:Gs	152.00 mm
SHELL FLANGE DESIGN BOLT LOAD FOR ASSEMBLY COND.....:Ws	53.00 kN
SHELL FLANGE DESIGN BOLT LOAD FOR OPERATING COND....:Wmls	53.00 kN
DIAMETER OF CHANNEL GASKET LOAD REACTION.....:Gc	152.00 mm
CHANNEL FLANGE DESIGN BOLT LOAD FOR ASSEMBLY COND...:Wc	53.00 kN
CHANNEL FLANGE DESIGN BOLT LOAD FOR OPERATING COND...:Wmlc	53.00 kN
BOLT-CIRCLE DIAMETER.....:C	152.00 mm

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.1 Tubesheet 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

CALCULATION DATA

LOAD CASE:=LC1==LC1=

PRELIMINARY CALCULATIONS

UW-20 TUBE-TO-TUBESHEET WELDS

Allowable Stress in Weld

$$S_w = \text{MIN}(S , S_t) = \text{MIN}(167.52, 115) = 115.00 \text{ N/mm}^2$$

Weld Strength Factor

$$f_w = S_t / S_w = 115/115 = 1.0000$$

Axial Tube Strength

$$F_t = \text{PI} * t_t * (d_t - t_t) * S_t = 3.14 * 0.5 * (7.5 - 0.5) * 115 = 1264.49 \text{ N}$$

Minimum Required Length of the Weld Leg

$$a_r = \text{Sqr}((0.75 * d_t)^2 + 2.73 * t_t * (d_t - t_t) * f_w * f_d) - 0.75 * d_t$$
$$= \text{Sqr}((0.75 * 7.5)^2 + 2.73 * 0.5 * (7.5 - 0.5) * 1 * 1) - 0.75 * 7.5 = 0.7934 \text{ mm}$$

Minimum Required Size of Fillet Weld Leg

$$a_{fmin} = \text{MAX}(a_r , t_t) = \text{MAX}(0.7934, 0.5) = 0.7934 \text{ mm}$$

Fillet Weld Strength

$$F_f = \text{MIN}(0.55 * \text{PI} * a_f * (d_t + 0.67 * a_f) * S_w , F_t)$$
$$= \text{MIN}(0.55 * 3.14 * 1 * (7.5 + 0.67 * 1) * 115, 1264.49) = 1264.49 \text{ N}$$

TABLE UHX-8.1 TUBESHEET EFFECTIVE BOLT LOAD $W^*=W_m1c=$ 53.00kN

Tubesheet Analysis Thickness h

$$h = h_n - c_t - c_s = 28 - 1 - 1 = 26.00 \text{ mm}$$

UHX-11.5.1 Determination of Effective Dimensions and Ligament Efficiency

Basic efficiency for shear

$$m_y = (p - d_t) / p = (11.5 - 7.5) / 11.5 = 0.3478$$

Effective Tube Hole Diameter (dstar)

$$d_{star} = \text{MAX}(d_t - 2 * t_t * (E_t / E) * (S_t / S) * r_o, d_t - 2 * t_t)$$
$$= \text{MAX}(7.5 - 2 * 0.5 * (186212 / 189400) * (115 / 167.52) * 1, 7.5 - 2 * 0.5) = 6.8251 \text{ mm}$$

Effective Pitch(pstar)

$$p_{star} = p / \text{Sqr}(1 - 4 * \text{MIN}(A_L, 4 * D_o * p) / (\text{PI} * D_o^2))$$
$$= 11.5 / \text{Sqr}(1 - 4 * \text{MIN}(1600, 4 * 123 * 11.5) / (3.14 * 123^2)) = 12.36 \text{ mm}$$

$$M_{ystar} = (p_{star} - d_{star}) / p_{star} = (12.36 - 6.83) / 12.36 = 0.4479$$

UHX-11.5.2 Determination of Effective Elastic Properties Estar and vstar

EstarOverE(Estar/E) from figure UHX-11.3a) = 0.4763(h/p=2.26)

$$E_{star} = \text{EstarOverE} * E = 0.4763 * 189400 = 90213.95 \text{ N/mm}^2$$

vstar from figure UHX-11.3b) = 0.3032(h/p=2.26)

UHX-14.5.1 Step 1

Radial Channel Dimension ac

$$a_c = G_c / 2 = 152 / 2 = 76.00 \text{ mm}$$

Radial Shell Dimension as

$$a_s = G_s / 2 = 152 / 2 = 76.00 \text{ mm}$$

Parameters

$$a_o = D_o / 2 = 123 / 2 = 61.50 \text{ mm}$$

Diameter Ratio ros for Shell

$$r_{os} = a_s / a_o = 76 / 61.5 = 1.2358$$

Diameter Ratio roc for Channel

$$r_{oc} = a_c / a_o = 76 / 61.5 = 1.2358$$

Tubesheet Drilling Coefficients

$$x_s = 1 - N_t * (d_t / (2 * a_o))^2$$
$$= 1 - 72 * (7.5 / (2 * 61.5))^2 = 0.7323$$

$$x_t = 1 - N_t * ((d_t - 2 * t_t) / (2 * a_o))^2$$
$$= 1 - 72 * ((7.5 - 2 * 0.5) / (2 * 61.5))^2 = 0.7989$$

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.1 Tubesheet 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

UHX-14.5.2 Step 2, Shell and Tube Axial Stiffness

UHX-14.5.3 Step 3, Tube Bundle to Tubesheet Rigidity Ratio

$$Xa = (24*(1-vstar^2)*Nt*Et*tt*(dt-tt)*ao^2/(Estar*L*h^3))^0.25$$

$$= (24*(1-0.3032^2)*72*186212*0.5*(7.5-0.5)*61.5^2/(90213.95*800*26^3))^0.25$$

$$= 1.3214$$

Zd (from figure UHX-13.2) = 0.7123
 Zv (from figure UHX-13.2) = 0.1859
 Zw (from figure UHX-13.2) = 0.1859
 Zm (from figure UHX-13.2) = 0.7493

UHX-14.5.4 Step 4, Ratio K and Parameters F, Phi, Q and U

Diameter Ratio K
 $K = A / Do = 132.2/123 = 1.0748$

$F = (1 - vstar) / Estar * (LamdaS + LamdaC + E * Log(K))$
 $= (1-0.3032)/90213.95*(0+0+189400*Log(1.07)) = 0.1055$

$phi = (1 + vstar) * F = (1+0.3032)*0.1055 = 0.1375$

$Q1 = (ros - 1 - phi * Zv) / (1 + phi * Zm)$
 $= (1.24-1-0.1375*0.1859)/(1+0.1375*0.7493) = 0.1906$

UHX-14.5.5 Step 5

$Omegas = ros * ks * Betas * Deltas * (1 + h * Betas)$
 $= 1.24*0*0*0*(1+26*0) = 0.00 \text{ mm}^2$

$Omegasstar = ao^2 * (ros^2 - 1) * (ros - 1) / 4 - Omegas$
 $= 61.5^2*(1.24^2-1)*(1.24-1)/4-0 = 117.52 \text{ mm}^2$

$Omegac = roc * kc * Betac * Deltac * (1 + h * Betac)$
 $= 1.24*0*0*0*(1+26*0) = 0.00 \text{ mm}^2$

$Omegacstar = ao^2*((roc^2+1)*(roc-1)/4-(ros-1)/2)-Omegas$
 $= 61.5^2*((1.24^2+1)*(1.24-1)/4-(1.24-1)/2)-0 = 117.52 \text{ mm}^2$

$yb = (Gc - Gs) / Do = (152-152)/123 = 0.00 \text{ mm}$

$Psstar = 0 = 0.00 \text{ MPa}$

$Pcstar = 0 = 0.00 \text{ MPa}$

UHX-14.5.6 Step 6

Effective Pressure Pe
 $Pe = Ps - Pt = 0-1 = -1 \text{ MPa}$

UHX-14.5.7 Step 7

$Q2 = (Omegasstar*Ps-Omegacstar*Pt+yb/(2*PI)*Wstar)/(1+phi*Zm)$
 $= (117.52*0-117.52*1+0/(2*3.14)*53000)/(1+0.1375*0.7493) = -106.54 \text{ N}$

$Q3 = Q1 + 2 * Q2 / (Pe * ao^2)$
 $= 0.1906+2*-106.54/(-1*61.5^2) = 0.2469$

$Fm = MAX(Fm(x))$ (from Table UHX-13.1) = 0.3141

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$Sigma = 1.5 * Fm / Mystar * (2 * ao / (h - hg))^2 * Pe$
 $= 1.5*0.3141/0.4479*(2*61.5/(26-0))^2*-1 = -23.54 \text{ N/mm}^2$

Tubesheet Bending Stress Sigma=23.54 <= 1.5 * S=251.28[N/mm2]

9.3%

OK

UHX-14.5.8 Step 8, Shear Stress in Tubesheet (Tau)

UHX-14.5.8(a) Tau is not required to be calculated since ABS(Pe) < 1.6 * s_0 * my * H_1 / ao ; 1.000 < 39.414 (MPa)

Tubesheet Shear Stress Tau=0 <= MIN(0.8*S, 0.533*Sy)=134.02[N/mm2]

0.0%

OK

UHX-14.5.9 Step 9, Tube Design

$Ftmin = MIN(Ft(x))$ (from Table UHX-13.2) = 0.8300
 $Ftmax = MAX(Ft(x))$ (from Table UHX-13.2) = 1.1559

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Vessel Tag No.:K12-3102/ RLP 800/140

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ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.1 Tubesheet 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

Axial Tube Stress (Pe < 0)

$$\begin{aligned} \text{Sig}t1 &= (P_s * x_s - P_t * x_t - P_e * F_{tmin}) / (x_t - x_s) \\ &= (0 * 0.7323 - 1 * 0.7989 - -1 * 0.83) / (0.7989 - 0.7323) = 0.4658 \text{ N/mm}^2 \\ \text{Sig}t2 &= (P_s * x_s - P_t * x_t - P_e * F_{tmax}) / (x_t - x_s) \\ &= (0 * 0.7323 - 1 * 0.7989 - -1 * 1.16) / (0.7989 - 0.7323) = 5.3583 \text{ N/mm}^2 \\ \text{Sig}t_{\text{Max}} &= \text{MAX}(\text{Sig}t1, \text{Sig}t2) = \text{MAX}(0.4658, 5.36) = 5.3583 \text{ N/mm}^2 \end{aligned}$$

Tube Axial Stress Sig_{tMax}=5.36 <= St=115[N/mm²]	4.6%	OK
---	-------------	-----------

Largest Tube-to-Tubesheet Joint Load, W_t

$$\begin{aligned} W_t &= \text{PI} * (d_t - t_t) * t_t * \text{Sig}t_{\text{Max}} \\ &= 3.14 * (7.5 - 0.5) * 0.5 * 5.36 = 58.92 \text{ N} \end{aligned}$$

Tube Weld Max.Axial Load W_t=58.92 <= L_{max}=1264.49[N] (UW-20)	4.6%	OK
--	-------------	-----------

UHX-14.5.10 Step 10, Stresses in Shell

Axial Membrane Stress Sig_{sm}

$$\begin{aligned} \text{Sig}sm &= (a_o^2 * (P_e + (r_o s^2 - 1) * (P_s - P_t)) + a_s^2 * P_t) / (G_s * t_s) \\ &= (61.5^2 * (-1 + (1.24^2 - 1) * (0 - 1)) + 76^2 * 1) / (152 * 2.2) = -3.793E-07 \text{ N/mm}^2 \\ \text{Temp}1 &= \text{Betas} * \text{Deltas} * P_s = 0 * 0 * 0 = 0.00 \\ \text{Temp}2 &= 6 * (1 - \nu_{\text{star}}^2) / \text{Estar} * (a_o^3 / h^3) * (1 + h * \text{Betas} / 2) \\ &= 6 * (1 - 0.3032^2) / 90213.95 * (61.5^3 / 26^3) * (1 + 26 * 0 / 2) = 7.9927E-04 \\ \text{Temp}3 &= P_e * (Z_v + Z_m * Q_1) + 2 / a_o^2 * Z_m * Q_2 \\ &= -1 * (0.1859 + 0.7493 * 0.1906) + 2 / 61.5^2 * 0.7493 * -106.54 = -0.3709 \\ \text{Axial Bending Stress Sig}sb & \\ \text{Sig}sb &= 6 * k_s / t_s^2 * (\text{Temp}1 + \text{Temp}2 * \text{Temp}3) \\ &= 6 * 0 / 2.2^2 * (0 + 7.9927E-04 * -0.3709) = 0.00 \text{ N/mm}^2 \\ \text{Total Axial Stress Sig} & \\ \text{Sig} &= \text{ABS}(\text{Sig}sm) + \text{ABS}(\text{Sig}sb) \\ &= \text{ABS}(-3.793E-07) + \text{ABS}(0) = 3.793E-07 \text{ N/mm}^2 \end{aligned}$$

Total Axial Shell Stress Sig_s=3.793E-07 <= 1.5 * S_s=207[N/mm²]	0.0%	OK
---	-------------	-----------

Tubesheet Bending Stress (Option 3) Sigma_{O3}=0 <= 1.5 * S=251.28[N/mm²]	0.0%	OK
--	-------------	-----------

LOAD CASE:=LC2==LC2=

PRELIMINARY CALCULATIONS

UW-20 TUBE-TO-TUBESHEET WELDS

Allowable Stress in Weld

$$\begin{aligned} S_w &= \text{MIN}(S, St) = \text{MIN}(167.52, 115) = 115.00 \text{ N/mm}^2 \\ \text{Weld Strength Factor} & \\ f_w &= St / S_w = 115 / 115 = 1.0000 \\ \text{Axial Tube Strength} & \\ F_t &= \text{PI} * t_t * (d_t - t_t) * St = 3.14 * 0.5 * (7.5 - 0.5) * 115 = 1264.49 \text{ N} \\ \text{Minimum Required Length of the Weld Leg} & \\ a_r &= \text{Sqr}((0.75 * d_t)^2 + 2.73 * t_t * (d_t - t_t) * f_w * f_d) - 0.75 * d_t \\ &= \text{Sqr}((0.75 * 7.5)^2 + 2.73 * 0.5 * (7.5 - 0.5) * 1 * 1) - 0.75 * 7.5 = 0.7934 \text{ mm} \\ \text{Minimum Required Size of Fillet Weld Leg} & \\ a_{fmin} &= \text{MAX}(a_r, t_t) = \text{MAX}(0.7934, 0.5) = 0.7934 \text{ mm} \\ \text{Fillet Weld Strength} & \\ F_f &= \text{MIN}(0.55 * \text{PI} * a_f * (d_t + 0.67 * a_f) * S_w, F_t) \\ &= \text{MIN}(0.55 * 3.14 * 1 * (7.5 + 0.67 * 1) * 115, 1264.49) = 1264.49 \text{ N} \end{aligned}$$

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Client : IWS Monje

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.1 Tubesheet 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

TABLE UHX-8.1 TUBESHEET EFFECTIVE BOLT LOAD $W^*=Wm1s=$ 53.00kN

Tubesheet Analysis Thickness h

$$h = h_n - c_t - c_s = 28 - 1 - 1 = 26.00 \text{ mm}$$

UHX-11.5.1 Determination of Effective Dimensions and Ligament Efficiency

Basic efficiency for shear

$$m_y = (p - dt) / p = (11.5 - 7.5) / 11.5 = 0.3478$$

Effective Tube Hole Diameter (dstar)

$$d_{star} = \text{MAX}(dt - 2 \cdot tt \cdot (E_t / E) \cdot (St / S) \cdot r_o, dt - 2 \cdot tt) \\ = \text{MAX}(7.5 - 2 \cdot 0.5 \cdot (186212 / 189400) \cdot (115 / 167.52) \cdot 1, 7.5 - 2 \cdot 0.5) = 6.8251 \text{ mm}$$

Effective Pitch(pstar)

$$p_{star} = p / \text{Sqr}(1 - 4 \cdot \text{MIN}(AL, 4 \cdot Do \cdot p) / (\pi \cdot Do^2)) \\ = 11.5 / \text{Sqr}(1 - 4 \cdot \text{MIN}(1600, 4 \cdot 123 \cdot 11.5) / (3.14 \cdot 123^2)) = 12.36 \text{ mm}$$

$$M_{y_{star}} = (p_{star} - d_{star}) / p_{star} = (12.36 - 6.83) / 12.36 = 0.4479$$

UHX-11.5.2 Determination of Effective Elastic Properties Estar and vstar

EstarOverE(Estar/E) from figure UHX-11.3a) = 0.4763(h/p=2.26)

$$E_{star} = \text{EstarOverE} \cdot E = 0.4763 \cdot 189400 = 90213.95 \text{ N/mm}^2$$

vstar from figure UHX-11.3b) = 0.3032(h/p=2.26)

UHX-14.5.1 Step 1

Radial Channel Dimension ac

$$a_c = G_c / 2 = 152 / 2 = 76.00 \text{ mm}$$

Radial Shell Dimension as

$$a_s = G_s / 2 = 152 / 2 = 76.00 \text{ mm}$$

Parameters

$$a_o = Do / 2 = 123 / 2 = 61.50 \text{ mm}$$

Diameter Ratio ros for Shell

$$r_{os} = a_s / a_o = 76 / 61.5 = 1.2358$$

Diameter Ratio roc for Channel

$$r_{oc} = a_c / a_o = 76 / 61.5 = 1.2358$$

Tubesheet Drilling Coefficients

$$x_s = 1 - N_t \cdot (dt / (2 \cdot a_o))^2 \\ = 1 - 72 \cdot (7.5 / (2 \cdot 61.5))^2 = 0.7323$$

$$x_t = 1 - N_t \cdot ((dt - 2 \cdot tt) / (2 \cdot a_o))^2 \\ = 1 - 72 \cdot ((7.5 - 2 \cdot 0.5) / (2 \cdot 61.5))^2 = 0.7989$$

UHX-14.5.2 Step 2, Shell and Tube Axial Stiffness

UHX-14.5.3 Step 3, Tube Bundle to Tubesheet Rigidity Ratio

$$X_a = (24 \cdot (1 - v_{star})^2 \cdot N_t \cdot E_t \cdot tt \cdot (dt - tt) \cdot a_o^2 / (E_{star} \cdot L \cdot h^3))^0.25 \\ = (24 \cdot (1 - 0.3032)^2 \cdot 72 \cdot 186212 \cdot 0.5 \cdot (7.5 - 0.5) \cdot 61.5^2 / (90213.95 \cdot 800 \cdot 26^3))^0.25 \\ = 1.3214$$

$$Z_d \text{ (from figure UHX-13.2)} = 0.7123$$

$$Z_v \text{ (from figure UHX-13.2)} = 0.1859$$

$$Z_w \text{ (from figure UHX-13.2)} = 0.1859$$

$$Z_m \text{ (from figure UHX-13.2)} = 0.7493$$

UHX-14.5.4 Step 4, Ratio K and Parameters F, Phi, Q and U

Diameter Ratio K

$$K = A / Do = 132.2 / 123 = 1.0748$$

$$F = (1 - v_{star}) / E_{star} \cdot (\text{Lamda}_S + \text{Lamda}_C + E \cdot \text{Log}(K)) \\ = (1 - 0.3032) / 90213.95 \cdot (0 + 0 + 189400 \cdot \text{Log}(1.07)) = 0.1055$$

$$\phi = (1 + v_{star}) \cdot F = (1 + 0.3032) \cdot 0.1055 = 0.1375$$

$$Q_1 = (r_{os} - 1 - \phi \cdot Z_v) / (1 + \phi \cdot Z_m) \\ = (1.24 - 1 - 0.1375 \cdot 0.1859) / (1 + 0.1375 \cdot 0.7493) = 0.1906$$

UHX-14.5.5 Step 5

$$\Omega_{gas} = r_{os} \cdot k_s \cdot \text{Betas} \cdot \text{Deltas} \cdot (1 + h \cdot \text{Betas}) \\ = 1.24 \cdot 0 \cdot 0 \cdot (1 + 26 \cdot 0) = 0.00 \text{ mm}^2$$

$$\Omega_{gas_{star}} = a_o^2 \cdot (r_{os}^2 - 1) \cdot (r_{os} - 1) / 4 - \Omega_{gas} \\ = 61.5^2 \cdot (1.24^2 - 1) \cdot (1.24 - 1) / 4 - 0 = 117.52 \text{ mm}^2$$

$$\Omega_{gac} = r_{oc} \cdot k_c \cdot \text{Betac} \cdot \text{Deltac} \cdot (1 + h \cdot \text{Betac}) \\ = 1.24 \cdot 0 \cdot 0 \cdot (1 + 26 \cdot 0) = 0.00 \text{ mm}^2$$

SEAB GmbH -

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ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.1 Tubesheet 17 Feb. 2022 13:08 ConnID:F.3 PC# 2

$\Omega_{gacstar} = a_o^2 * ((r_{oc}^2 + 1) * (r_{oc} - 1) / 4 - (r_{os} - 1) / 2) - \Omega_{gac}$
 $= 61.5^2 * ((1.24^2 + 1) * (1.24 - 1) / 4 - (1.24 - 1) / 2) - 0 = 117.52 \text{ mm}^2$
 $y_b = (G_c - G_s) / D_o = (152 - 152) / 123 = 0.00 \text{ mm}$
 $P_{sstar} = 0 = 0 = 0.00 \text{ MPa}$
 $P_{cstar} = 0 = 0 = 0.00 \text{ MPa}$

UHX-14.5.6 Step 6

Effective Pressure P_e

$P_e = P_s - P_t = 2.82 - 0 = 2.8200 \text{ MPa}$

UHX-14.5.7 Step 7

$Q_2 = (\Omega_{gasstar} * P_s - \Omega_{gacstar} * P_t + y_b / (2 * \pi) * W_{star}) / (1 + \phi * Z_m)$
 $= (117.52 * 2.82 - 117.52 * 0 + 0 / (2 * 3.14) * 53000) / (1 + 0.1375 * 0.7493) = 300.44 \text{ N}$
 $Q_3 = Q_1 + 2 * Q_2 / (P_e * a_o^2)$
 $= 0.1906 + 2 * 300.44 / (2.82 * 61.5^2) = 0.2469$
 $F_m = \text{MAX}(F_m(x)) \text{ (from Table UHX-13.1)} = 0.3141$

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$\sigma = 1.5 * F_m / M_{ystar} * (2 * a_o / (h - h_g))^2 * P_e$
 $= 1.5 * 0.3141 / 0.4479 * (2 * 61.5 / (26 - 0))^2 * 2.82 = 66.38 \text{ N/mm}^2$

Tubesheet Bending Stress $\sigma = 66.38 \leq 1.5 * S = 251.28 \text{ [N/mm}^2]$

26.4%

OK

UHX-14.5.8 Step 8, Shear Stress in Tubesheet (Tau)

UHX-14.5.8(a) Tau is not required to be calculated since $ABS(P_e) < 1.6 * s_0 * m_y * H_1 / a_o$; $2.820 < 39.414 \text{ (MPa)}$

Tubesheet Shear Stress $\tau = 0 \leq \text{MIN}(0.8 * S, 0.533 * S_y) = 134.02 \text{ [N/mm}^2]$

0.0%

OK

UHX-14.5.9 Step 9, Tube Design

$F_{tmin} = \text{MIN}(F_t(x)) \text{ (from Table UHX-13.2)} = 0.8300$
 $F_{tmax} = \text{MAX}(F_t(x)) \text{ (from Table UHX-13.2)} = 1.1559$

Axial Tube Stress ($P_e < 0$)

$\sigma_{t1} = (P_s * x_s - P_t * x_t - P_e * F_{tmin}) / (x_t - x_s)$
 $= (2.82 * 0.7323 - 0 * 0.7989 - 2.82 * 0.83) / (0.7989 - 0.7323) = -4.13 \text{ N/mm}^2$
 $\sigma_{t2} = (P_s * x_s - P_t * x_t - P_e * F_{tmax}) / (x_t - x_s)$
 $= (2.82 * 0.7323 - 0 * 0.7989 - 2.82 * 1.16) / (0.7989 - 0.7323) = -17.93 \text{ N/mm}^2$
 $\sigma_{tMax} = \text{MAX}(\sigma_{t1}, \sigma_{t2}) = \text{MAX}(-4.13, -17.93) = 17.93 \text{ N/mm}^2$

Tube Axial Stress $\sigma_{tMax} = 17.93 \leq S_t = 115 \text{ [N/mm}^2]$

15.5%

OK

Largest Tube-to-Tubesheet Joint Load, W_t

$W_t = \pi * (d_t - t_t) * t_t * \sigma_{tMax}$
 $= 3.14 * (7.5 - 0.5) * 0.5 * 17.93 = 197.15 \text{ N}$

Tube Weld Max. Axial Load $W_t = 197.15 \leq L_{max} = 1264.49 \text{ [N]}$ (UW-20)

15.5%

OK

UHX-14.5.9(b) Tube Buckling Check

$r_t = \sqrt{d_t^2 + (d_t - 2 * t_t)^2} / 4$
 $= \sqrt{7.5^2 + (7.5 - 2 * 0.5)^2} / 4 = 2.4812 \text{ mm}$
 $F_t = l_t / r_t = 1 / 2.48 = 0.4030$
 $C_t = \sqrt{2 * \pi^2 * E_t / S_y}$
 $= \sqrt{2 * 3.14^2 * 186212 / 145} = 159.22$
 $F_s = \text{MIN}(2.0, \text{MAX}(3.25 - 0.25 * (Z_d + Q_3 * Z_w) * X_a^4, 1.25))$
 $= \text{MIN}(2.0, \text{MAX}(3.25 - 0.25 * (0.7123 + 0.2469 * 0.1859) * 1.32^4, 1.25)) = 2.0000$

UHX-14.5.9(b)(3)(b) Maximum Permissible Buckling Stress S_{tb}

$S_{tb} = \text{MIN}(S_y / F_s * (1 - F_t / (2 * C_t)), S_t)$
 $= \text{MIN}(145 / 2 * (1 - 0.403 / (2 * 159.22)), 115) = 72.41 \text{ N/mm}^2$

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

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Tube Buckling Stress $\text{Sig}_{t\text{Min}}=17.93 \leq \text{Stb}=72.41[\text{N/mm}^2]$	24.7%	OK
--	-------	----

UHX-14.5.10 Step 10, Stresses in Shell

Axial Membrane Stress Sig_{sm}

$$\text{Sig}_{\text{sm}} = (\text{ao}^2 * (\text{Pe} + (\text{ros}^2 - 1) * (\text{Ps} - \text{Pt})) + \text{as}^2 * \text{Pt}) / (\text{Gs} * \text{ts})$$
$$= (61.5^2 * (2.82 + (1.24^2 - 1) * (2.82 - 0)) + 76^2 * 0) / (152 * 2.2) = 48.71 \text{ N/mm}^2$$

$$\text{Temp1} = \text{Betas} * \text{Deltas} * \text{Ps} = 0 * 0 * 2.82 = 0.00$$

$$\text{Temp2} = 6 * (1 - \text{vstar}^2) / \text{Estar} * (\text{ao}^3 / \text{h}^3) * (1 + \text{h} * \text{Betas} / 2)$$
$$= 6 * (1 - 0.3032^2) / 90213.95 * (61.5^3 / 26^3) * (1 + 26 * 0 / 2) = 7.9927\text{E}-04$$

$$\text{Temp3} = \text{Pe} * (\text{Zv} + \text{Zm} * \text{Q1}) + 2 / \text{ao}^2 * \text{Zm} * \text{Q2}$$
$$= 2.82 * (0.1859 + 0.7493 * 0.1906) + 2 / 61.5^2 * 0.7493 * 300.44 = 1.0458$$

Axial Bending Stress Sig_{sb}

$$\text{Sig}_{\text{sb}} = 6 * \text{ks} / \text{ts}^2 * (\text{Temp1} + \text{Temp2} * \text{Temp3})$$
$$= 6 * 0 / 2.2^2 * (0 + 7.9927\text{E}-04 * 1.05) = 0.00 \text{ N/mm}^2$$

Total Axial Stress Sig_{s}

$$\text{Sig}_{\text{s}} = \text{ABS}(\text{Sig}_{\text{sm}}) + \text{ABS}(\text{Sig}_{\text{sb}}) = \text{ABS}(48.71) + \text{ABS}(0) = 48.71 \text{ N/mm}^2$$

Total Axial Shell Stress $\text{Sig}_{\text{s}}=48.71 \leq 1.5 * \text{Ss}=207[\text{N/mm}^2]$	23.5%	OK
--	-------	----

Tubesheet Bending Stress(Option 3) $\text{Sigma}_{\text{O3}}=0 \leq 1.5 * \text{S}=251.28[\text{N/mm}^2]$	0.0%	OK
---	------	----

LOAD CASE:=LC3==LC3=

PRELIMINARY CALCULATIONS

UW-20 TUBE-TO-TUBESHEET WELDS

Allowable Stress in Weld

$$\text{Sw} = \text{MIN}(\text{S}, \text{St}) = \text{MIN}(167.52, 115) = 115.00 \text{ N/mm}^2$$

Weld Strength Factor

$$\text{fw} = \text{St} / \text{Sw} = 115 / 115 = 1.0000$$

Axial Tube Strength

$$\text{Ft} = \text{PI} * \text{tt} * (\text{dt} - \text{tt}) * \text{St} = 3.14 * 0.5 * (7.5 - 0.5) * 115 = 1264.49 \text{ N}$$

Minimum Required Length of the Weld Leg

$$\text{ar} = \text{Sqr}((0.75 * \text{dt})^2 + 2.73 * \text{tt} * (\text{dt} - \text{tt}) * \text{fw} * \text{fd}) - 0.75 * \text{dt}$$
$$= \text{Sqr}((0.75 * 7.5)^2 + 2.73 * 0.5 * (7.5 - 0.5) * 1 * 1) - 0.75 * 7.5 = 0.7934 \text{ mm}$$

Minimum Required Size of Fillet Weld Leg

$$\text{afmin} = \text{MAX}(\text{ar}, \text{tt}) = \text{MAX}(0.7934, 0.5) = 0.7934 \text{ mm}$$

Fillet Weld Strength

$$\text{Ff} = \text{MIN}(0.55 * \text{PI} * \text{af} * (\text{dt} + 0.67 * \text{af}) * \text{Sw}, \text{Ft})$$
$$= \text{MIN}(0.55 * 3.14 * 1 * (7.5 + 0.67 * 1) * 115, 1264.49) = 1264.49 \text{ N}$$

TABLE UHX-8.1 TUBESHEET EFFECTIVE BOLT LOAD $\text{W}^*=\text{Wm1max}= 53.00\text{kN}$

Tubesheet Analysis Thickness h

$$\text{h} = \text{hn} - \text{ct} - \text{cs} = 28 - 1 - 1 = 26.00 \text{ mm}$$

UHX-11.5.1 Determination of Effective Dimensions and Ligament Efficiency

Basic efficiency for shear

$$\text{my} = (\text{p} - \text{dt}) / \text{p} = (11.5 - 7.5) / 11.5 = 0.3478$$

Effective Tube Hole Diameter (dstar)

$$\text{dstar} = \text{MAX}(\text{dt} - 2 * \text{tt} * (\text{Et} / \text{E}) * (\text{St} / \text{S}) * \text{ro}, \text{dt} - 2 * \text{tt})$$
$$= \text{MAX}(7.5 - 2 * 0.5 * (186212 / 189400) * (115 / 167.52) * 1, 7.5 - 2 * 0.5) = 6.8251 \text{ mm}$$

Effective Pitch(pstar)

$$\text{pstar} = \text{p} / \text{Sqr}(1 - 4 * \text{MIN}(\text{AL}, 4 * \text{Do} * \text{p}) / (\text{PI} * \text{Do}^2))$$
$$= 11.5 / \text{Sqr}(1 - 4 * \text{MIN}(1600, 4 * 123 * 11.5) / (3.14 * 123^2)) = 12.36 \text{ mm}$$

$$\text{Mystar} = (\text{pstar} - \text{dstar}) / \text{pstar} = (12.36 - 6.83) / 12.36 = 0.4479$$

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Vessel Tag No.:K12-3102/ RLP 800/140

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UHX-11.5.2 Determination of Effective Elastic Properties Estar and vstar

EstarOverE(Estar/E) from figure UHX-11.3a) = 0.4763(h/p=2.26)
Estar = EstarOverE * E = 0.4763*189400 = 90213.95 N/mm2
vstar from figure UHX-11.3b) = 0.3032(h/p=2.26)

UHX-14.5.1 Step 1

Radial Channel Dimension ac
ac = Gc / 2 = 152/2 = 76.00 mm
Radial Shell Dimension as
as = Gs / 2 = 152/2 = 76.00 mm
Parameters
ao = Do / 2 = 123/2 = 61.50 mm
Diameter Ratio ros for Shell
ros = as / ao = 76/61.5 = 1.2358
Diameter Ratio roc for Channel
roc = ac / ao = 76/61.5 = 1.2358
Tubesheet Drilling Coefficients
xs = 1 - Nt * (dt / (2 * ao)) ^ 2
= 1 - 72 * (7.5 / (2 * 61.5)) ^ 2 = 0.7323
xt = 1 - Nt * ((dt - 2 * tt) / (2 * ao)) ^ 2
= 1 - 72 * ((7.5 - 2 * 0.5) / (2 * 61.5)) ^ 2 = 0.7989

UHX-14.5.2 Step 2, Shell and Tube Axial Stiffness

UHX-14.5.3 Step 3, Tube Bundle to Tubesheet Rigidity Ratio

Xa = (24 * (1 - vstar^2) * Nt * Et * tt * (dt - tt) * ao^2 / (Estar * L * h^3)) ^ 0.25
= (24 * (1 - 0.3032^2) * 72 * 186212 * 0.5 * (7.5 - 0.5) * 61.5^2 / (90213.95 * 800 * 26^3)) ^ 0.25
= 1.3214
Zd (from figure UHX-13.2) = 0.7123
Zv (from figure UHX-13.2) = 0.1859
Zw (from figure UHX-13.2) = 0.1859
Zm (from figure UHX-13.2) = 0.7493

UHX-14.5.4 Step 4, Ratio K and Parameters F, Phi, Q and U

Diameter Ratio K
K = A / Do = 132.2/123 = 1.0748
F = (1 - vstar) / Estar * (LamdaS + LamdaC + E * Log(K))
= (1 - 0.3032) / 90213.95 * (0 + 0 + 189400 * Log(1.07)) = 0.1055
phi = (1 + vstar) * F = (1 + 0.3032) * 0.1055 = 0.1375
Q1 = (ros - 1 - phi * Zv) / (1 + phi * Zm)
= (1.24 - 1 - 0.1375 * 0.1859) / (1 + 0.1375 * 0.7493) = 0.1906

UHX-14.5.5 Step 5

Omegas = ros * ks * Betas * Deltas * (1 + h * Betas)
= 1.24 * 0 * 0 * 0 * (1 + 26 * 0) = 0.00 mm2
Omeasstar = ao^2 * (ros^2 - 1) * (ros - 1) / 4 - Omegas
= 61.5^2 * (1.24^2 - 1) * (1.24 - 1) / 4 - 0 = 117.52 mm2
Omegac = roc * kc * Betac * Deltac * (1 + h * Betac)
= 1.24 * 0 * 0 * 0 * (1 + 26 * 0) = 0.00 mm2
Omeacstar = ao^2 * ((roc^2 + 1) * (roc - 1) / 4 - (ros - 1) / 2) - Omegac
= 61.5^2 * ((1.24^2 + 1) * (1.24 - 1) / 4 - (1.24 - 1) / 2) - 0 = 117.52 mm2
yb = (Gc - Gs) / Do = (152 - 152) / 123 = 0.00 mm
Psstar = 0 = 0.00 MPa
Pcstar = 0 = 0.00 MPa

UHX-14.5.6 Step 6

Effective Pressure Pe
Pe = Ps - Pt = 2.82 - 1 = 1.8200 MPa

UHX-14.5.7 Step 7

Q2 = (Omeasstar * Ps - Omeacstar * Pt + yb) / (2 * PI * Wstar) / (1 + phi * Zm)
= (117.52 * 2.82 - 117.52 * 1 + 0) / (2 * 3.14) * 53000 / (1 + 0.1375 * 0.7493) = 193.90 N
Q3 = Q1 + 2 * Q2 / (Pe * ao^2)
= 0.1906 + 2 * 193.9 / (1.82 * 61.5^2) = 0.2469

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$F_m = \text{MAX}(F_m(x))$ (from Table UHX-13.1) = 0.3141

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$\text{Sigma} = 1.5 * F_m / M_{\text{ystar}} * (2 * a_o / (h - h_g)) ^ 2 * P_e$
 $= 1.5 * 0.3141 / 0.4479 * (2 * 61.5 / (26 - 0)) ^ 2 * 1.82 =$ 42.84 N/mm2

Tubesheet Bending Stress Sigma=42.84 <= 1.5 * S=251.28[N/mm2]	17.0%	OK
---	--------------	-----------

UHX-14.5.8 Step 8, Shear Stress in Tubesheet (Tau)

UHX-14.5.8(a) Tau is not required to be calculated since $\text{ABS}(P_e) < 1.6 * s_0 * m_y * H_1 / a_o$; 1.820 < 39.414 (MPa)

Tubesheet Shear Stress Tau=0 <= MIN(0.8*S, 0.533*Sy)=134.02[N/mm2]	0.0%	OK
--	-------------	-----------

UHX-14.5.9 Step 9, Tube Design

$F_{t\text{min}} = \text{MIN}(F_t(x))$ (from Table UHX-13.2) = 0.8300
 $F_{t\text{max}} = \text{MAX}(F_t(x))$ (from Table UHX-13.2) = 1.1559

Axial Tube Stress (Pe <= 0)

$\text{Sig}t1 = (P_s * x_s - P_t * x_t - P_e * F_{t\text{min}}) / (x_t - x_s)$
 $= (2.82 * 0.7323 - 1 * 0.7989 - 1.82 * 0.83) / (0.7989 - 0.7323) =$ -3.67 N/mm2
 $\text{Sig}t2 = (P_s * x_s - P_t * x_t - P_e * F_{t\text{max}}) / (x_t - x_s)$
 $= (2.82 * 0.7323 - 1 * 0.7989 - 1.82 * 1.16) / (0.7989 - 0.7323) =$ -12.57 N/mm2
 $\text{Sig}t\text{Max} = \text{MAX}(\text{Sig}t1, \text{Sig}t2) = \text{MAX}(-3.67, -12.57) =$ 12.57 N/mm2

Tube Axial Stress SigMax=12.57 <= St=115[N/mm2]	10.9%	OK
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Largest Tube-to-Tubesheet Joint Load, Wt

$W_t = \text{PI} * (d_t - t_t) * t_t * \text{Sig}t\text{Max}$
 $= 3.14 * (7.5 - 0.5) * 0.5 * 12.57 =$ 138.24 N

Tube Weld Max.Axial Load Wt=138.24 <= Lmax=1264.49[N] (UW-20)	10.9%	OK
---	--------------	-----------

UHX-14.5.9(b) Tube Buckling Check

$r_t = \text{Sqr}(d_t ^ 2 + (d_t - 2 * t_t) ^ 2) / 4$
 $= \text{Sqr}(7.5 ^ 2 + (7.5 - 2 * 0.5) ^ 2) / 4 =$ 2.4812 mm
 $F_t = l_t / r_t = 1 / 2.48 =$ 0.4030
 $C_t = \text{Sqr}(2 * \text{PI} ^ 2 * E_t / S_yt)$
 $= \text{Sqr}(2 * 3.14 ^ 2 * 186212 / 145) =$ 159.22
 $F_s = \text{MIN}(2.0, \text{MAX}(3.25 - 0.25 * (Z_d + Q_3 * Z_w) * X_a ^ 4, 1.25))$
 $= \text{MIN}(2.0, \text{MAX}(3.25 - 0.25 * (0.7123 + 0.2469 * 0.1859) * 1.32 ^ 4, 1.25)) =$ 2.0000

UHX-14.5.9(b)(3)(b) Maximum Permissible Buckling Stress Stb

$\text{St}b = \text{MIN}(S_yt / F_s * (1 - F_t / (2 * C_t)), \text{St})$
 $= \text{MIN}(145 / 2 * (1 - 0.403 / (2 * 159.22)), 115) =$ 72.41 N/mm2

Tube Buckling Stress SigMin=12.57 <= Stb=72.41[N/mm2]	17.3%	OK
---	--------------	-----------

UHX-14.5.10 Step 10, Stresses in Shell

Axial Membrane Stress Sigsm

$\text{Sig}sm = (a_o ^ 2 * (P_e + (r_o s ^ 2 - 1) * (P_s - P_t)) + a_s ^ 2 * P_t) / (G_s * t_s)$
 $= (61.5 ^ 2 * (1.82 + (1.24 ^ 2 - 1) * (2.82 - 1)) + 76 ^ 2 * 1) / (152 * 2.2) =$ 48.71 N/mm2

$\text{Temp}1 = \text{Betas} * \text{Deltas} * P_s = 0 * 0 * 2.82 =$ 0.00

$\text{Temp}2 = 6 * (1 - \nu_{\text{star}} ^ 2) / E_{\text{star}} * (a_o ^ 3 / h ^ 3) * (1 + h * \text{Betas} / 2)$
 $= 6 * (1 - 0.3032 ^ 2) / 90213.95 * (61.5 ^ 3 / 26 ^ 3) * (1 + 26 * 0 / 2) =$ 7,9927E-04

$\text{Temp}3 = P_e * (Z_v + Z_m * Q_1) + 2 / a_o ^ 2 * Z_m * Q_2$
 $= 1.82 * (0.1859 + 0.7493 * 0.1906) + 2 / 61.5 ^ 2 * 0.7493 * 193.9 =$ 0.6750

Axial Bending Stress Sigsb

$\text{Sig}sb = 6 * k_s / t_s ^ 2 * (\text{Temp}1 + \text{Temp}2 * \text{Temp}3)$
 $= 6 * 0 / 2.2 ^ 2 * (0 + 7.9927E-04 * 0.675) =$ 0.00 N/mm2

Total Axial Stress SigS

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Sigs = ABS(Sigsm) + ABS(Sigsb) =ABS(48.71)+ABS(0)= 48.71 N/mm2

Total Axial Shell Stress Sigs=48.71 <= 1.5 * Ss=207[N/mm2] 23.5% OK

Tubesheet Bending Stress(Option 3) Sigma_O3=0 <= 1.5*S=251.28[N/mm2] 0.0% OK

MAXIMUM ALLOWABLE PRESSURE SUMMARY

Table MAWP SUMMARY FOR T.1 :

Description	P(MPa)	LimitedBy
Max.Allow.Test Pressure (tubeside)	17.66	Tubesheet Bending Stress
Max.Allow.Test Pressure(shellside)	14.35	Tube Buckling Stress
Max.Allow.Pressure Hot&Corroded(tubeside)	10.68	Tubesheet Bending Stress
Max.Allow.Pressure Hot&Corroded(shellside)	10.68	Tubesheet Bending Stress
Max.Allow.Pressure New&Cold(tubeside)	12.10	Tubesheet Bending Stress
Max.Allow.Pressure New&Cold(shellside)	12.11	Tubesheet Bending Stress

TEST PRESSURES

TEST PRESSURE ON TUBESIDE

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

P_{tmin} = 1.1 * P_{td} * S_r / S =1.1*1*179/167.52= 1.1754 MPa

TEST PRESSURE ON SHELLSIDE

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

P_{tmin} = 1.1 * P_{sd} * S_r / S =1.1*2.82*179/167.52= 3.3146 MPa

CALCULATION SUMMARY

LOAD CASE:=LC1==LC1=

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

Sigma = 1.5 * F_m / M_{ystar} * (2 * a_o / (h - h_g)) ^ 2 * P_e
=1.5*0.3141/0.4479*(2*61.5/(26-0))^2*-1= -23.54 N/mm2

Tubesheet Bending Stress Sigma=23.54 <= 1.5 * S=251.28[N/mm2] 9.3% OK

UHX-14.5.8 Step 8, Shear Stress in Tubesheet (Tau)

Tubesheet Shear Stress Tau=0 <= MIN(0.8*S, 0.533*Sy)=134.02[N/mm2] 0.0% OK

UHX-14.5.9 Step 9, Tube Design

Axial Tube Stress (P_e <> 0)

SigtMax = MAX(Sigt1 , Sigt2) =MAX(0.4658,5.36)= 5.3583 N/mm2

Tube Axial Stress SigtMax=5.36 <= St=115[N/mm2] 4.6% OK

Tube Weld Max.Axial Load Wt=58.92 <= Lmax=1264.49[N] (UW-20) 4.6% OK

Tube Buckling Stress SigtMin=0 <= Stb=100000[N/mm2] 0.0% OK

Total Axial Stress Sigs

Sigs = ABS(Sigsm) + ABS(Sigsb)

=ABS(-3.793E-07)+ABS(0)= 3.793E-07 N/mm2

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Total Axial Shell Stress Sigs=3.793E-07 <= 1.5 * Ss=207[N/mm2]	0.0%	OK
---	------	----

Tubesheet Bending Stress(Option 3) Sigma_O3=0 <= 1.5*S=251.28[N/mm2]	0.0%	OK
--	------	----

LOAD CASE:=LC2==LC2=

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$$\text{Sigma} = 1.5 * F_m / M_{\text{ystar}} * (2 * a_o / (h - h_g)) ^ 2 * P_e$$

$$= 1.5 * 0.3141 / 0.4479 * (2 * 61.5 / (26 - 0)) ^ 2 * 2.82 =$$

66.38 N/mm2

Tubesheet Bending Stress Sigma=66.38 <= 1.5 * S=251.28[N/mm2]	26.4%	OK
--	-------	----

UHX-14.5.8 Step 8, Shear Stress in Tubesheet (Tau)

Tubesheet Shear Stress Tau=0 <= MIN(0.8*S, 0.533*Sy)=134.02[N/mm2]	0.0%	OK
---	------	----

UHX-14.5.9 Step 9, Tube Design

Axial Tube Stress (Pe <> 0)

$$\text{SigtMax} = \text{MAX}(\text{Sigt1}, \text{Sigt2}) = \text{MAX}(-4.13, -17.93) =$$

17.93 N/mm2

Tube Axial Stress SigtMax=17.93 <= St=115[N/mm2]	15.5%	OK
--	-------	----

Tube Weld Max.Axial Load Wt=197.15 <= Lmax=1264.49[N] (UW-20)	15.5%	OK
--	-------	----

Tube Buckling Stress SigtMin=17.93 <= Stb=72.41[N/mm2]	24.7%	OK
--	-------	----

Total Axial Stress Sigs

$$\text{Sigs} = \text{ABS}(\text{SigsM}) + \text{ABS}(\text{SigsB}) = \text{ABS}(48.71) + \text{ABS}(0) =$$

48.71 N/mm2

Total Axial Shell Stress Sigs=48.71 <= 1.5 * Ss=207[N/mm2]	23.5%	OK
--	-------	----

Tubesheet Bending Stress(Option 3) Sigma_O3=0 <= 1.5*S=251.28[N/mm2]	0.0%	OK
--	------	----

LOAD CASE:=LC3==LC3=

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$$\text{Sigma} = 1.5 * F_m / M_{\text{ystar}} * (2 * a_o / (h - h_g)) ^ 2 * P_e$$

$$= 1.5 * 0.3141 / 0.4479 * (2 * 61.5 / (26 - 0)) ^ 2 * 1.82 =$$

42.84 N/mm2

Tubesheet Bending Stress Sigma=42.84 <= 1.5 * S=251.28[N/mm2]	17.0%	OK
--	-------	----

UHX-14.5.8 Step 8, Shear Stress in Tubesheet (Tau)

Tubesheet Shear Stress Tau=0 <= MIN(0.8*S, 0.533*Sy)=134.02[N/mm2]	0.0%	OK
---	------	----

UHX-14.5.9 Step 9, Tube Design

Axial Tube Stress (Pe <> 0)

$$\text{SigtMax} = \text{MAX}(\text{Sigt1}, \text{Sigt2}) = \text{MAX}(-3.67, -12.57) =$$

12.57 N/mm2

Tube Axial Stress SigtMax=12.57 <= St=115[N/mm2]	10.9%	OK
--	-------	----

Tube Weld Max.Axial Load Wt=138.24 <= Lmax=1264.49[N] (UW-20)	10.9%	OK
--	-------	----

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Tube Buckling Stress $\text{Sig}_{t\text{Min}}=12.57 \leq \text{Stb}=72.41[\text{N/mm}^2]$	17.3%	OK
Total Axial Stress Sigs $\text{Sigs} = \text{ABS}(\text{Sig}_{\text{sm}}) + \text{ABS}(\text{Sig}_{\text{sb}}) = \text{ABS}(48.71) + \text{ABS}(0) = 48.71 \text{ N/mm}^2$		
Total Axial Shell Stress $\text{Sigs}=48.71 \leq 1.5 * \text{Ss}=207[\text{N/mm}^2]$	23.5%	OK
Tubesheet Bending Stress(Option 3) $\text{Sigma}_{\text{O3}}=0 \leq 1.5 * \text{S}=251.28[\text{N/mm}^2]$	0.0%	OK

MAXIMUM ALLOWABLE PRESSURE SUMMARY

Table MAWP SUMMARY FOR T.1 :

Description	P(MPa)	LimitedBy
Max.Allow.Test Pressure (tubeside)	17.66	Tubesheet Bending Stress
Max.Allow.Test Pressure(shellside)	14.35	Tube Buckling Stress
Max.Allow.Pressure Hot&Corroded(tubeside)	10.68	Tubesheet Bending Stress
Max.Allow.Pressure Hot&Corroded(shellside)	10.68	Tubesheet Bending Stress
Max.Allow.Pressure New&Cold(tubeside)	12.10	Tubesheet Bending Stress
Max.Allow.Pressure New&Cold(shellside)	12.11	Tubesheet Bending Stress

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 210 FOR: 9 SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8 , the material must be re-selected from the material database.

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 210 FOR: 5 SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 , the material must be re-selected from the material database.

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 5 SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 , the material must be re-selected from the material database.

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

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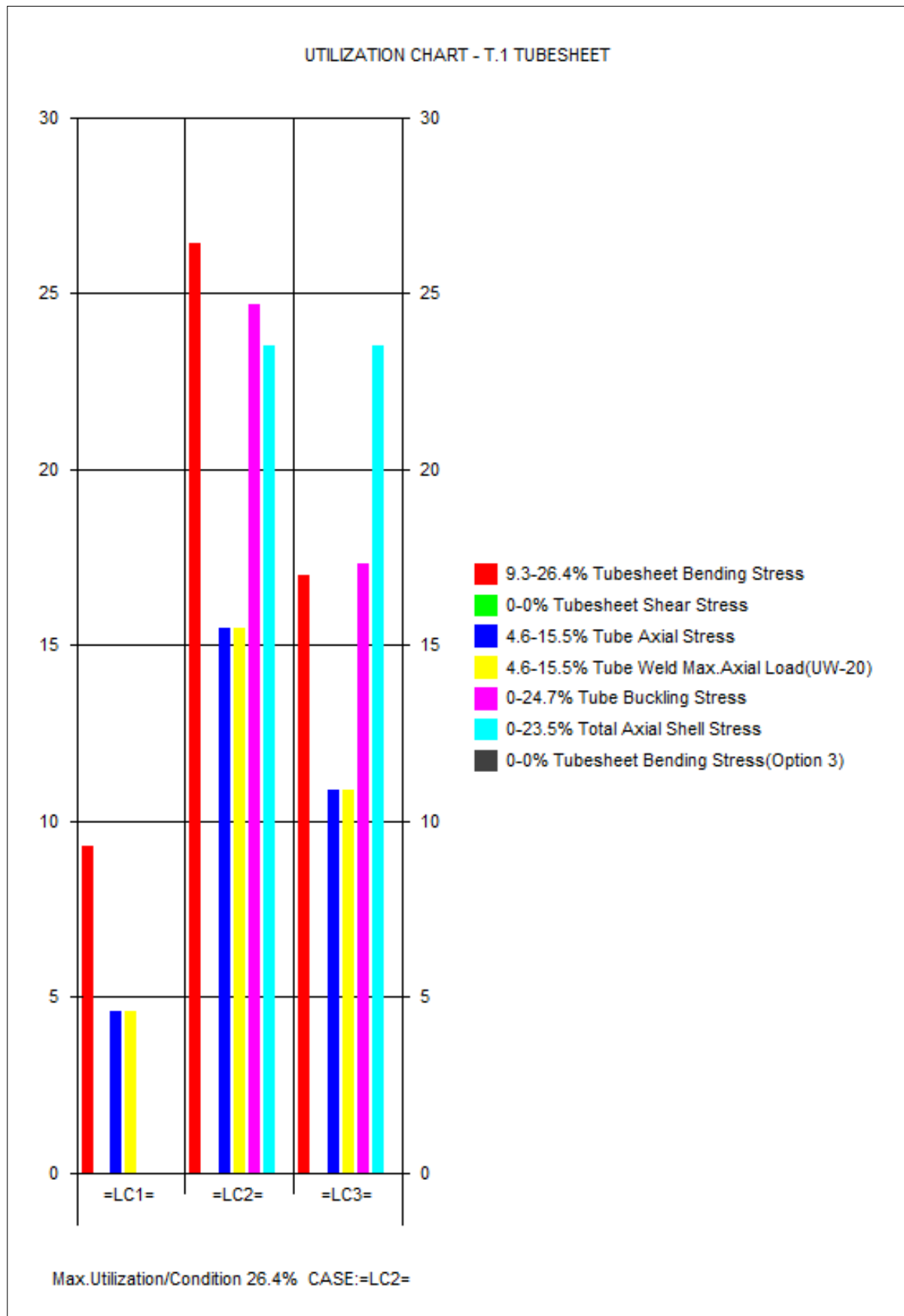
Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.1 Tubesheet

17 Feb. 2022 13:08 ConnID:F.3 PC# 2



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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

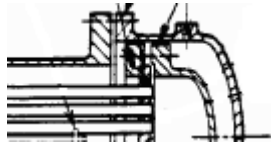
T.2 Tubesheet floating 17 Feb. 2022 13:08 ConnID:TB.1 PC# 2

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: TB.1 Tube Bundle Tube bundle T.1
 Location: Along z-axis z1= 496

GENERAL DESIGN DATA



Type of Heat Exchanger: UHX-14 Floating Tubesheet Heat Exchangers
 Type of Tubesheet: Floating Tubesheet
 Type of Floating Tubesheet Exchanger: With Immersed Floating Head
 Configuration Type: D Tubesheet Internally Sealed

LOAD CASES (LC)

Table LOAD CASES:

Description	ID	=LC1=	=LC2=	=LC3=
Shell-Side Pressure (MPa)	Ps	0	2.82	2.82
Tube-Side Pressure (MPa)	Pt	1	0	1
Shell-Side Corr.Allow. (mm)	cs	1	1	1
Tube-Side Corr.Allow. (mm)	ct	1	1	1

=LC1=: =LC1=
 =LC2=: =LC2=
 =LC3=: =LC3=

ALLOWABLE STRESS FOR EACH LOAD CASE

Material Design Temperatures:

Select material design temperatures from the process card.

Ttubesheet= 210, Tshell= 210, Ttube= 210, Tchannel= 95(all values in °C)

Table LOAD CASES:

Description	ID	=LC1=	=LC2=	=LC3=
Allowable Stress M Factor	Mf	1.0	1.0	1.0

DATA FOR TUBESHEET

SB-148(M), M01, C95820 Castings 204'C

ST=650 SY=270 Sy=259.84 S=167.52 Sr=179 Stest=243 (N/mm²)

OUTSIDE DIAMETER OF TUBESHEET(Ref. UHX-10(b)).....:A 132.20 mm
 NOMINAL THICKNESS OF TUBESHEET (uncorroded).....:hn 28.00 mm
 ELASTIC MODULUS OF TUBESHEET at tubesheet design temp.:E 1,894E05 N/mm²
 POISSON'S RATIO FOR TUBESHEET MATERIAL.....:v 0.3000

DATA FOR TUBES AND TUBES LAYOUT

Tube Layout: Triangular Pattern

SA-213(M) Gr.TP316L, S31603 Smls. tube, PNo=8 120'C

ST=485 SY=170 Syt=138.6 St=115 Sr=115 Stest=153 (N/mm²)

ELASTIC MODULUS OF TUBES at tube design temp.....:Et 1,8621E05 N/mm²
 NOMINAL OUTSIDE DIAMETER OF TUBES.....:dt 7.5000 mm
 TUBE SIZE & COMMENT: S1.2
 NOMINAL THICKNESS OF TUBES.....:tt 0.5000 mm
 TUBE PITCH (Spacing between centers).....:p 11.50 mm
 DIAMETER OF TUBEHOLE IN TUBESHEET.....:dh 8.0000 mm
 DIAMETER OF OUTER TUBE LIMIT CIRCLE.....:Do 123.00 mm

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NUMBER OF TUBEHOLES IN TUBESHEET.....:Nt	72.00	piec
TOTAL AREA OF UNTUBED LANES(UL1*Ll1+UL2*Ll2+...).....:AL	1600.00	mm2
TUBE EXPANSION DEPTH RATIO (0<=ro<=1.0).....:ro	1.0000	
TUBE-SIDE PASS PARTITION GROOVE DEPTH(Fig.UHX-11.1):hg	1.0000	mm
THERMAL EXPANSION COEF.OF TUBES at mean metal temp.:atm	1,614E-05	mm/mmC
TUBE BUCKLING LENGTH lt=1*k (Ref. UHX-13.5.9(b)(1)):lt	1.0000	mm
TUBE LENGTH BETWEEN INNER FACES OF TUBESHEETS.....:L	800.00	mm
POISSON'S RATIO FOR TUBE MATERIAL.....:vt	0.3000	
PERIMETER OF THE TUBE LAYOUT MEASURED CENTER ON OUTER MOST TUBES:Cp	0.00	mm
TOTAL AREA ENCLOSED BY Cp.....:Ap	0.00	mm2

DATA FOR TUBE TO TUBESHEET JOINT

Tube to Tubesheet Weld: Full Strength Weld to UW-20.4

Qualification of Tube-to-Tubesheet Joint: The Joint IS Qualified by Tests

FIG. UW-20.1 Weld Types: Sketch a) Fillet Weld

TUBE TO TUBESHEET FILLET WELD LEG.....:af 1.0000 mm

SHELL DATA

SA-312(M) Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 120'C

ST=515 SY=205 Sys=169.6 Ss=138 Sr=138 Stest=184.5 (N/mm2)

INSIDE DIAMETER OF SHELL(corroded).....:Ds 133.30 mm

THICKNESS OF SHELL (uncorroded).....:ts 3.2000 mm

ELASTIC MODULUS OF SHELL MATERIAL at shell design temp.:Es 1,8621E05 N/mm2

POISSON'S RATIO FOR SHELL MATERIAL.....:vs 0.3000

CHANNEL DATA

SA-312(M) Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8 100'C

ST=485 SY=170 Syc=145 Sc=115 Sr=115 Stest=153 (N/mm2)

INSIDE DIAMETER OF CHANNEL(corroded).....:Dc 133.30 mm

THICKNESS OF CHANNEL (uncorroded).....:tc 3.2000 mm

ELASTIC MODULUS OF CHANNEL at channel design temp.:Ec 1,8833E05 N/mm2

POISSON'S RATIO FOR CHANNEL MATERIAL.....:vc 0.3000

FLANGE DATA

DIAMETER OF SHELL GASKET LOAD REACTION.....:Gs 152.00 mm

SHELL FLANGE DESIGN BOLT LOAD FOR ASSEMBLY COND.....:Ws 53.00 kN

SHELL FLANGE DESIGN BOLT LOAD FOR OPERATING COND.....:Wmls 53.00 kN

DIAMETER OF CHANNEL GASKET LOAD REACTION.....:Gc 152.00 mm

CHANNEL FLANGE DESIGN BOLT LOAD FOR ASSEMBLY COND...:Wc 53.00 kN

CHANNEL FLANGE DESIGN BOLT LOAD FOR OPERATING COND...:Wmlc 53.00 kN

BOLT-CIRCLE DIAMETER.....:C 152.00 mm

CALCULATION DATA

LOAD CASE:=LC1==LC1=

PRELIMINARY CALCULATIONS

UW-20 TUBE-TO-TUBESHEET WELDS

Allowable Stress in Weld

Sw = MIN(S , St) =MIN(167.52,115)= 115.00 N/mm2

Weld Strength Factor

fw = St / Sw =115/115= 1.0000

Axial Tube Strength

Ft = PI * tt * (dt - tt) * St =3.14*0.5*(7.5-0.5)*115= 1264.49 N

Minimum Required Length of the Weld Leg

ar = Sqr((0.75*dt)^2+2.73*tt*(dt-tt)*fw*fd)-0.75*dt 0.7934 mm

=Sqr((0.75*7.5)^2+2.73*0.5*(7.5-0.5)*1*1)-0.75*7.5=

Minimum Required Size of Fillet Weld Leg

afmin = MAX(ar, tt) =MAX(0.7934,0.5)= 0.7934 mm

Fillet Weld Strength

Ff = MIN(0.55 * PI * af * (dt + 0.67 * af) * Sw , Ft) 1264.49 N

=MIN(0.55*3.14*1*(7.5+0.67*1)*115,1264.49)=

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TABLE UHX-8.1 TUBESHEET EFFECTIVE BOLT LOAD $W^*=0=$ 0.00kN

Tubesheet Analysis Thickness h

$$h = h_n - c_t - c_s = 28 - 1 - 1 = 26.00 \text{ mm}$$

UHX-11.5.1 Determination of Effective Dimensions and Ligament Efficiency

Basic efficiency for shear

$$m_y = (p - dt) / p = (11.5 - 7.5) / 11.5 = 0.3478$$

Effective Tube Hole Diameter (dstar)

$$d_{star} = \text{MAX}(dt - 2 \cdot t_t \cdot (E_t / E) \cdot (S_t / S) \cdot r_o, dt - 2 \cdot t_t) \\ = \text{MAX}(7.5 - 2 \cdot 0.5 \cdot (186212 / 189400) \cdot (115 / 167.52) \cdot 1, 7.5 - 2 \cdot 0.5) = 6.8251 \text{ mm}$$

Effective Pitch(pstar)

$$p_{star} = p / \text{Sqr}(1 - 4 \cdot \text{MIN}(A_L, 4 \cdot D_o \cdot p) / (\pi \cdot D_o^2)) \\ = 11.5 / \text{Sqr}(1 - 4 \cdot \text{MIN}(1600, 4 \cdot 123 \cdot 11.5) / (3.14 \cdot 123^2)) = 12.36 \text{ mm}$$

$$M_{ystar} = (p_{star} - d_{star}) / p_{star} = (12.36 - 6.83) / 12.36 = 0.4479$$

UHX-11.5.2 Determination of Effective Elastic Properties Estar and vstar

EstarOverE(Estar/E) from figure UHX-11.3a) = 0.4763(h/p=2.26)

$$E_{star} = \text{EstarOverE} \cdot E = 0.4763 \cdot 189400 = 90213.95 \text{ N/mm}^2$$

vstar from figure UHX-11.3b) = 0.3032(h/p=2.26)

UHX-14.5.1 Step 1

Radial Channel Dimension ac

$$a_c = A / 2 = 132.2 / 2 = 66.10 \text{ mm}$$

Radial Shell Dimension as

$$a_s = a_c = 66.1 = 66.10 \text{ mm}$$

Parameters

$$a_o = D_o / 2 = 123 / 2 = 61.50 \text{ mm}$$

Diameter Ratio ros for Shell

$$r_{os} = a_s / a_o = 66.1 / 61.5 = 1.0748$$

Diameter Ratio roc for Channel

$$r_{oc} = a_c / a_o = 66.1 / 61.5 = 1.0748$$

Tubesheet Drilling Coefficients

$$x_s = 1 - N_t \cdot (dt / (2 \cdot a_o))^2 \\ = 1 - 72 \cdot (7.5 / (2 \cdot 61.5))^2 = 0.7323$$

$$x_t = 1 - N_t \cdot ((dt - 2 \cdot t_t) / (2 \cdot a_o))^2 \\ = 1 - 72 \cdot ((7.5 - 2 \cdot 0.5) / (2 \cdot 61.5))^2 = 0.7989$$

UHX-14.5.2 Step 2, Shell and Tube Axial Stiffness

UHX-14.5.3 Step 3, Tube Bundle to Tubesheet Rigidity Ratio

$$X_a = (24 \cdot (1 - v_{star})^2 \cdot N_t \cdot E_t \cdot t_t \cdot (dt - t_t) \cdot a_o^2 / (E_{star} \cdot L \cdot h^3))^0.25 \\ = (24 \cdot (1 - 0.3032)^2 \cdot 72 \cdot 186212 \cdot 0.5 \cdot (7.5 - 0.5) \cdot 61.5^2 / (90213.95 \cdot 800 \cdot 26^3))^0.25 \\ = 1.3214$$

$$Z_d \text{ (from figure UHX-13.2)} = 0.7123$$

$$Z_v \text{ (from figure UHX-13.2)} = 0.1859$$

$$Z_w \text{ (from figure UHX-13.2)} = 0.1859$$

$$Z_m \text{ (from figure UHX-13.2)} = 0.7493$$

UHX-14.5.4 Step 4, Ratio K and Parameters F, Phi, Q and U

Diameter Ratio K

$$K = A / D_o = 132.2 / 123 = 1.0748$$

$$F = (1 - v_{star}) / E_{star} \cdot (\text{Lamda}_S + \text{Lamda}_C + E \cdot \text{Log}(K)) \\ = (1 - 0.3032) / 90213.95 \cdot (0 + 0 + 189400 \cdot \text{Log}(1.07)) = 0.1055$$

$$\phi = (1 + v_{star}) \cdot F = (1 + 0.3032) \cdot 0.1055 = 0.1375$$

$$Q_1 = (r_{os} - 1 - \phi \cdot Z_v) / (1 + \phi \cdot Z_m) \\ = (1.07 - 1 - 0.1375 \cdot 0.1859) / (1 + 0.1375 \cdot 0.7493) = 0.0446$$

UHX-14.5.5 Step 5

$$\Omega_{gas} = r_{os} \cdot k_s \cdot \text{Betas} \cdot \text{Deltas} \cdot (1 + h \cdot \text{Betas}) \\ = 1.07 \cdot 0 \cdot 0 \cdot 0 \cdot (1 + 26 \cdot 0) = 0.00 \text{ mm}^2$$

$$\Omega_{gasstar} = a_o^2 \cdot (r_{os}^2 - 1) \cdot (r_{os} - 1) / 4 - \Omega_{gas} \\ = 61.5^2 \cdot (1.07^2 - 1) \cdot (1.07 - 1) / 4 - 0 = 10.98 \text{ mm}^2$$

$$\Omega_{gac} = r_{oc} \cdot k_c \cdot \text{Betac} \cdot \text{Deltac} \cdot (1 + h \cdot \text{Betac}) \\ = 1.07 \cdot 0 \cdot 0 \cdot 0 \cdot (1 + 26 \cdot 0) = 0.00 \text{ mm}^2$$

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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$\Omega_{gacstar} = a_o^2 * ((r_{oc}^2 + 1) * (r_{oc} - 1) / 4 - (r_{os} - 1) / 2) - \Omega_{gac}$
 $= 61.5^2 * ((1.07^2 + 1) * (1.07 - 1) / 4 - (1.07 - 1) / 2) - 0 = 10.98 \text{ mm}^2$
 $Z_m \text{ (from figure UHX-13.2)} = 0.7493 = 0.7493 = 0.00 \text{ mm}$
 $P_{sstar} = 0 = 0 = 0.00 \text{ MPa}$
 $P_{cstar} = 0 = 0 = 0.00 \text{ MPa}$

UHX-14.5.6 Step 6

Effective Pressure P_e

$P_e = P_s - P_t = 0 - 1 = -1 \text{ MPa}$

UHX-14.5.7 Step 7

$Q_2 = (\Omega_{gasstar} * P_s - \Omega_{gacstar} * P_t + y_b / (2 * \pi) * W_{star}) / (1 + \phi * Z_m)$
 $= (10.98 * 0 - 10.98 * 1 + 0 / (2 * 3.14) * 0) / (1 + 0.1375 * 0.7493) = -9.95 \text{ N}$
 $Q_3 = Q_1 + 2 * Q_2 / (P_e * a_o^2)$
 $= 0.0446 + 2 * -9.95 / (-1 * 61.5^2) = 0.0499$
 $F_m = \text{MAX}(F_m(x)) \text{ (from Table UHX-13.1)} = 0.2209$

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$\sigma = 1.5 * F_m / M_{ystar} * (2 * a_o / (h - h_g))^2 * P_e$
 $= 1.5 * 0.2209 / 0.4479 * (2 * 61.5 / (26 - 0))^2 * -1 = -16.55 \text{ N/mm}^2$

Tubesheet Bending Stress Sigma=16.55 <= 1.5 * S=251.28[N/mm2]	6.5%	OK
---	------	----

Tubesheet Bending Stress(Option 3) Sigma_O3=0 <= 1.5*S=251.28[N/mm2]	0.0%	OK
--	------	----

LOAD CASE:=LC2==LC2=

PRELIMINARY CALCULATIONS

UW-20 TUBE-TO-TUBESHEET WELDS

Allowable Stress in Weld
 $S_w = \text{MIN}(S, S_t) = \text{MIN}(167.52, 115) = 115.00 \text{ N/mm}^2$
 Weld Strength Factor
 $f_w = S_t / S_w = 115 / 115 = 1.0000$
 Axial Tube Strength
 $F_t = \pi * t_t * (d_t - t_t) * S_t = 3.14 * 0.5 * (7.5 - 0.5) * 115 = 1264.49 \text{ N}$
 Minimum Required Length of the Weld Leg
 $a_r = \text{Sqr}((0.75 * d_t)^2 + 2.73 * t_t * (d_t - t_t) * f_w * f_d) - 0.75 * d_t$
 $= \text{Sqr}((0.75 * 7.5)^2 + 2.73 * 0.5 * (7.5 - 0.5) * 1 * 1) - 0.75 * 7.5 = 0.7934 \text{ mm}$
 Minimum Required Size of Fillet Weld Leg
 $a_{fmin} = \text{MAX}(a_r, t_t) = \text{MAX}(0.7934, 0.5) = 0.7934 \text{ mm}$
 Fillet Weld Strength
 $F_f = \text{MIN}(0.55 * \pi * a_f * (d_t + 0.67 * a_f) * S_w, F_t)$
 $= \text{MIN}(0.55 * 3.14 * 1 * (7.5 + 0.67 * 1) * 115, 1264.49) = 1264.49 \text{ N}$

TABLE UHX-8.1 TUBESHEET EFFECTIVE BOLT LOAD $W^*=0= 0.00\text{kN}$

Tubesheet Analysis Thickness h
 $h = h_n - c_t - c_s = 28 - 1 - 1 = 26.00 \text{ mm}$

UHX-11.5.1 Determination of Effective Dimensions and Ligament Efficiency

Basic efficiency for shear
 $m_y = (p - d_t) / p = (11.5 - 7.5) / 11.5 = 0.3478$
 Effective Tube Hole Diameter (d_{star})
 $d_{star} = \text{MAX}(d_t - 2 * t_t * (E_t / E) * (S_t / S) * r_o, d_t - 2 * t_t)$
 $= \text{MAX}(7.5 - 2 * 0.5 * (186212 / 189400) * (115 / 167.52) * 1, 7.5 - 2 * 0.5) = 6.8251 \text{ mm}$
 Effective Pitch (p_{star})
 $p_{star} = p / \text{Sqr}(1 - 4 * \text{MIN}(A_L, 4 * D_o * p) / (\pi * D_o^2))$

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Vessel Tag No.:K12-3102/ RLP 800/140

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$$=11.5/\text{Sqr}(1-4*\text{MIN}(1600,4*123*11.5)/(3.14*123^2))= 12.36 \text{ mm}$$
$$\text{Mystar} = (\text{pstar} - \text{dstar}) / \text{pstar} = (12.36-6.83)/12.36= 0.4479$$

UHX-11.5.2 Determination of Effective Elastic Properties Estar and vstar

$$\text{EstarOverE}(\text{Estar}/\text{E}) \text{ from figure UHX-11.3a) } = 0.4763(\text{h}/\text{p}=2.26)$$
$$\text{Estar} = \text{EstarOverE} * \text{E} = 0.4763*189400= 90213.95 \text{ N/mm}^2$$
$$\text{vstar from figure UHX-11.3b) } = 0.3032(\text{h}/\text{p}=2.26)$$

UHX-14.5.1 Step 1

Radial Channel Dimension ac

$$\text{ac} = \text{A} / 2 = 132.2/2= 66.10 \text{ mm}$$

Radial Shell Dimension as

$$\text{as} = \text{ac} = 66.1= 66.10 \text{ mm}$$

Parameters

$$\text{ao} = \text{Do} / 2 = 123/2= 61.50 \text{ mm}$$

Diameter Ratio ros for Shell

$$\text{ros} = \text{as} / \text{ao} = 66.1/61.5= 1.0748$$

Diameter Ratio roc for Channel

$$\text{roc} = \text{ac} / \text{ao} = 66.1/61.5= 1.0748$$

Tubesheet Drilling Coefficients

$$\text{xs} = 1 - \text{Nt} * (\text{dt} / (2 * \text{ao})) ^ 2$$
$$= 1 - 72 * (7.5 / (2 * 61.5)) ^ 2 = 0.7323$$
$$\text{xt} = 1 - \text{Nt} * ((\text{dt} - 2 * \text{tt}) / (2 * \text{ao})) ^ 2$$
$$= 1 - 72 * ((7.5 - 2 * 0.5) / (2 * 61.5)) ^ 2 = 0.7989$$

UHX-14.5.2 Step 2, Shell and Tube Axial Stiffness

UHX-14.5.3 Step 3, Tube Bundle to Tubesheet Rigidity Ratio

$$\text{Xa} = (24 * (1 - \text{vstar}^2) * \text{Nt} * \text{Et} * \text{tt} * (\text{dt} - \text{tt}) * \text{ao}^2 / (\text{Estar} * \text{L} * \text{h}^3)) ^ 0.25$$
$$= (24 * (1 - 0.3032^2) * 72 * 186212 * 0.5 * (7.5 - 0.5) * 61.5^2 / (90213.95 * 800 * 26^3)) ^ 0.25$$
$$= 1.3214$$

Zd (from figure UHX-13.2) = 0.7123

Zv (from figure UHX-13.2) = 0.1859

Zw (from figure UHX-13.2) = 0.1859

Zm (from figure UHX-13.2) = 0.7493

UHX-14.5.4 Step 4, Ratio K and Parameters F, Phi, Q and U

Diameter Ratio K

$$\text{K} = \text{A} / \text{Do} = 132.2/123= 1.0748$$
$$\text{F} = (1 - \text{vstar}) / \text{Estar} * (\text{LamdaS} + \text{LamdaC} + \text{E} * \text{Log}(\text{K}))$$
$$= (1 - 0.3032) / 90213.95 * (0 + 0 + 189400 * \text{Log}(1.07)) = 0.1055$$
$$\text{phi} = (1 + \text{vstar}) * \text{F} = (1 + 0.3032) * 0.1055 = 0.1375$$
$$\text{Q1} = (\text{ros} - 1 - \text{phi} * \text{Zv}) / (1 + \text{phi} * \text{Zm})$$
$$= (1.07 - 1 - 0.1375 * 0.1859) / (1 + 0.1375 * 0.7493) = 0.0446$$

UHX-14.5.5 Step 5

$$\text{Omegas} = \text{ros} * \text{ks} * \text{Betas} * \text{Deltas} * (1 + \text{h} * \text{Betas})$$
$$= 1.07 * 0 * 0 * 0 * (1 + 26 * 0) = 0.00 \text{ mm}^2$$
$$\text{Omegasstar} = \text{ao} ^ 2 * (\text{ros} ^ 2 - 1) * (\text{ros} - 1) / 4 - \text{Omegas}$$
$$= 61.5^2 * (1.07^2 - 1) * (1.07 - 1) / 4 - 0 = 10.98 \text{ mm}^2$$
$$\text{Omeagac} = \text{roc} * \text{kc} * \text{Betac} * \text{Deltac} * (1 + \text{h} * \text{Betac})$$
$$= 1.07 * 0 * 0 * 0 * (1 + 26 * 0) = 0.00 \text{ mm}^2$$
$$\text{Omeagacstar} = \text{ao}^2 * ((\text{roc}^2 + 1) * (\text{roc} - 1) / 4 - (\text{ros} - 1) / 2) - \text{Omeagac}$$
$$= 61.5^2 * ((1.07^2 + 1) * (1.07 - 1) / 4 - (1.07 - 1) / 2) - 0 = 10.98 \text{ mm}^2$$

Zm (from figure UHX-13.2) = 0.7493 = 0.7493 = 0.00 mm

Psstar = 0 = 0 = 0.00 MPa

Pcstar = 0 = 0 = 0.00 MPa

UHX-14.5.6 Step 6

Effective Pressure Pe

$$\text{Pe} = \text{Ps} - \text{Pt} = 2.82 - 0 = 2.8200 \text{ MPa}$$

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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UHX-14.5.7 Step 7

$$Q2 = (\text{Omegasstar} * P_s - \text{Omeacstar} * P_t + y_b / (2 * \text{PI}) * W_{\text{star}}) / (1 + \text{phi} * Z_m)$$

$$= (10.98 * 2.82 - 10.98 * 0 + 0 / (2 * 3.14) * 0) / (1 + 0.1375 * 0.7493) = 28.06 \text{ N}$$

$$Q3 = Q1 + 2 * Q2 / (P_e * a_o^2)$$

$$= 0.0446 + 2 * 28.06 / (2.82 * 61.5^2) = 0.0499$$

$$F_m = \text{MAX}(F_m(x)) \text{ (from Table UHX-13.1)} = 0.2209$$

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$$\text{Sigma} = 1.5 * F_m / M_{\text{ystar}} * (2 * a_o / (h - h_g))^2 * P_e$$

$$= 1.5 * 0.2209 / 0.4479 * (2 * 61.5 / (26 - 0))^2 * 2.82 = 46.68 \text{ N/mm}^2$$

Tubesheet Bending Stress Sigma=46.68 <= 1.5 * S=251.28[N/mm2]	18.5%	OK
Tubesheet Bending Stress (Option 3) Sigma_O3=0 <= 1.5*S=251.28[N/mm2]	0.0%	OK

LOAD CASE:=LC3==LC3=

PRELIMINARY CALCULATIONS

UW-20 TUBE-TO-TUBESHEET WELDS

Allowable Stress in Weld
 $S_w = \text{MIN}(S, S_t) = \text{MIN}(167.52, 115) = 115.00 \text{ N/mm}^2$

Weld Strength Factor
 $f_w = S_t / S_w = 115 / 115 = 1.0000$

Axial Tube Strength
 $F_t = \text{PI} * t_t * (d_t - t_t) * S_t = 3.14 * 0.5 * (7.5 - 0.5) * 115 = 1264.49 \text{ N}$

Minimum Required Length of the Weld Leg
 $a_r = \text{Sqr}((0.75 * d_t)^2 + 2.73 * t_t * (d_t - t_t) * f_w * f_d) - 0.75 * d_t$
 $= \text{Sqr}((0.75 * 7.5)^2 + 2.73 * 0.5 * (7.5 - 0.5) * 1 * 1) - 0.75 * 7.5 = 0.7934 \text{ mm}$

Minimum Required Size of Fillet Weld Leg
 $a_{\text{fmin}} = \text{MAX}(a_r, t_t) = \text{MAX}(0.7934, 0.5) = 0.7934 \text{ mm}$

Fillet Weld Strength
 $F_f = \text{MIN}(0.55 * \text{PI} * a_f * (d_t + 0.67 * a_f) * S_w, F_t)$
 $= \text{MIN}(0.55 * 3.14 * 1 * (7.5 + 0.67 * 1) * 115, 1264.49) = 1264.49 \text{ N}$

TABLE UHX-8.1 TUBESHEET EFFECTIVE BOLT LOAD W*=0= 0.00kN

Tubesheet Analysis Thickness h
 $h = h_n - c_t - c_s = 28 - 1 - 1 = 26.00 \text{ mm}$

UHX-11.5.1 Determination of Effective Dimensions and Ligament Efficiency

Basic efficiency for shear
 $m_y = (p - d_t) / p = (11.5 - 7.5) / 11.5 = 0.3478$

Effective Tube Hole Diameter (dstar)
 $d_{\text{star}} = \text{MAX}(d_t - 2 * t_t * (E_t / E) * (S_t / S), d_t - 2 * t_t)$
 $= \text{MAX}(7.5 - 2 * 0.5 * (186212 / 189400) * (115 / 167.52) * 1, 7.5 - 2 * 0.5) = 6.8251 \text{ mm}$

Effective Pitch (pstar)
 $p_{\text{star}} = p / \text{Sqr}(1 - 4 * \text{MIN}(A_L, 4 * D_o * p) / (\text{PI} * D_o^2))$
 $= 11.5 / \text{Sqr}(1 - 4 * \text{MIN}(1600, 4 * 123 * 11.5) / (3.14 * 123^2)) = 12.36 \text{ mm}$

$M_{\text{ystar}} = (p_{\text{star}} - d_{\text{star}}) / p_{\text{star}} = (12.36 - 6.83) / 12.36 = 0.4479$

UHX-11.5.2 Determination of Effective Elastic Properties Estar and vstar

EstarOverE (Estar/E) from figure UHX-11.3a) = 0.4763 (h/p=2.26)
 $E_{\text{star}} = \text{EstarOverE} * E = 0.4763 * 189400 = 90213.95 \text{ N/mm}^2$

vstar from figure UHX-11.3b) = 0.3032 (h/p=2.26)

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.2 Tubesheet floating 17 Feb. 2022 13:08 ConnID:TB.1 PC# 2

UHX-14.5.1 Step 1

Radial Channel Dimension ac
 $ac = A / 2 = 132.2/2 = 66.10 \text{ mm}$
Radial Shell Dimension as
 $as = ac = 66.1 = 66.10 \text{ mm}$
Parameters
 $ao = Do / 2 = 123/2 = 61.50 \text{ mm}$
Diameter Ratio ros for Shell
 $ros = as / ao = 66.1/61.5 = 1.0748$
Diameter Ratio roc for Channel
 $roc = ac / ao = 66.1/61.5 = 1.0748$
Tubesheet Drilling Coefficients
 $xs = 1 - Nt * (dt / (2 * ao)) ^ 2$
 $= 1 - 72 * (7.5 / (2 * 61.5)) ^ 2 = 0.7323$
 $xt = 1 - Nt * ((dt - 2 * tt) / (2 * ao)) ^ 2$
 $= 1 - 72 * ((7.5 - 2 * 0.5) / (2 * 61.5)) ^ 2 = 0.7989$

UHX-14.5.2 Step 2, Shell and Tube Axial Stiffness

UHX-14.5.3 Step 3, Tube Bundle to Tubesheet Rigidity Ratio

$Xa = (24 * (1 - vstar^2) * Nt * Et * tt * (dt - tt) * ao^2 / (Estar * L * h^3)) ^ 0.25$
 $= (24 * (1 - 0.3032^2) * 72 * 186212 * 0.5 * (7.5 - 0.5) * 61.5^2 / (90213.95 * 800 * 26^3)) ^ 0.25$
 $= 1.3214$
 $Zd \text{ (from figure UHX-13.2)} = 0.7123$
 $Zv \text{ (from figure UHX-13.2)} = 0.1859$
 $Zw \text{ (from figure UHX-13.2)} = 0.1859$
 $Zm \text{ (from figure UHX-13.2)} = 0.7493$

UHX-14.5.4 Step 4, Ratio K and Parameters F, Phi, Q and U

Diameter Ratio K
 $K = A / Do = 132.2/123 = 1.0748$
 $F = (1 - vstar) / Estar * (LamdaS + LamdaC + E * Log(K))$
 $= (1 - 0.3032) / 90213.95 * (0 + 0 + 189400 * Log(1.07)) = 0.1055$
 $\phi = (1 + vstar) * F = (1 + 0.3032) * 0.1055 = 0.1375$
 $Q1 = (ros - 1 - \phi * Zv) / (1 + \phi * Zm)$
 $= (1.07 - 1 - 0.1375 * 0.1859) / (1 + 0.1375 * 0.7493) = 0.0446$

UHX-14.5.5 Step 5

$\Omega_{gas} = ros * ks * Betas * Deltas * (1 + h * Betas)$
 $= 1.07 * 0 * 0 * 0 * (1 + 26 * 0) = 0.00 \text{ mm}^2$
 $\Omega_{gasstar} = ao^2 * (ros^2 - 1) * (ros - 1) / 4 - \Omega_{gas}$
 $= 61.5^2 * (1.07^2 - 1) * (1.07 - 1) / 4 - 0 = 10.98 \text{ mm}^2$
 $\Omega_{gac} = roc * kc * Betac * Deltac * (1 + h * Betac)$
 $= 1.07 * 0 * 0 * 0 * (1 + 26 * 0) = 0.00 \text{ mm}^2$
 $\Omega_{gacstar} = ao^2 * ((roc^2 + 1) * (roc - 1) / 4 - (ros - 1) / 2) - \Omega_{gac}$
 $= 61.5^2 * ((1.07^2 + 1) * (1.07 - 1) / 4 - (1.07 - 1) / 2) - 0 = 10.98 \text{ mm}^2$
 $Zm \text{ (from figure UHX-13.2)} = 0.7493 = 0.7493 = 0.00 \text{ mm}$
 $Psstar = 0 = 0 = 0.00 \text{ MPa}$
 $Pcstar = 0 = 0 = 0.00 \text{ MPa}$

UHX-14.5.6 Step 6

Effective Pressure P_e
 $P_e = P_s - P_t = 2.82 - 1 = 1.8200 \text{ MPa}$

UHX-14.5.7 Step 7

$Q2 = (\Omega_{gasstar} * P_s - \Omega_{gacstar} * P_t + yb / (2 * \pi) * Wstar) / (1 + \phi * Zm)$
 $= (10.98 * 2.82 - 10.98 * 1 + 0 / (2 * 3.14) * 0) / (1 + 0.1375 * 0.7493) = 18.11 \text{ N}$
 $Q3 = Q1 + 2 * Q2 / (P_e * ao^2)$
 $= 0.0446 + 2 * 18.11 / (1.82 * 61.5^2) = 0.0499$
 $Fm = \text{MAX}(Fm(x)) \text{ (from Table UHX-13.1)} = 0.2209$

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Client : IWS Monje

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ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.2 Tubesheet floating 17 Feb. 2022 13:08 ConnID:TB.1 PC# 2

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$$\text{Sigma} = 1.5 * F_m / M_{y\text{star}} * (2 * a_o / (h - h_g)) ^ 2 * P_e$$
$$= 1.5 * 0.2209 / 0.4479 * (2 * 61.5 / (26 - 0)) ^ 2 * 1.82 =$$

30.13 N/mm2

Tubesheet Bending Stress Sigma=30.13 <= 1.5 *
S=251.28[N/mm2]

11.9%

OK

Tubesheet Bending Stress(Option 3) Sigma_O3=0 <=
1.5*S=251.28[N/mm2]

0.0%

OK

MAXIMUM ALLOWABLE PRESSURE SUMMARY

Table MAWP SUMMARY FOR T.2 :

Description	P(MPa)	LimitedBy
Max.Allow.Test Pressure (tubeside)	25.13	Tubesheet Bending Stress
Max.Allow.Test Pressure(shellside)	25.13	Tubesheet Bending Stress
Max.Allow.Pressure Hot&Corroded(tubeside)	15.18	Tubesheet Bending Stress
Max.Allow.Pressure Hot&Corroded(shellside)	15.18	Tubesheet Bending Stress
Max.Allow.Pressure New&Cold(tubeside)	17.22	Tubesheet Bending Stress
Max.Allow.Pressure New&Cold(shellside)	17.23	Tubesheet Bending Stress

TEST PRESSURES

TEST PRESSURE ON TUBESIDE

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

$$P_{t\text{min}} = 1.1 * P_{td} * S_r / S = 1.1 * 1 * 179 / 167.52 =$$

1.1754 MPa

TEST PRESSURE ON SHELLSIDE

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

$$P_{t\text{min}} = 1.1 * P_{sd} * S_r / S = 1.1 * 2.82 * 179 / 167.52 =$$

3.3146 MPa

CALCULATION SUMMARY

LOAD CASE:=LC1==LC1=

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$$\text{Sigma} = 1.5 * F_m / M_{y\text{star}} * (2 * a_o / (h - h_g)) ^ 2 * P_e$$
$$= 1.5 * 0.2209 / 0.4479 * (2 * 61.5 / (26 - 0)) ^ 2 * -1 =$$

-16.55 N/mm2

Tubesheet Bending Stress Sigma=16.55 <= 1.5 *
S=251.28[N/mm2]

6.5%

OK

Tubesheet Bending Stress(Option 3) Sigma_O3=0 <=
1.5*S=251.28[N/mm2]

0.0%

OK

LOAD CASE:=LC2==LC2=

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$$\text{Sigma} = 1.5 * F_m / M_{y\text{star}} * (2 * a_o / (h - h_g)) ^ 2 * P_e$$
$$= 1.5 * 0.2209 / 0.4479 * (2 * 61.5 / (26 - 0)) ^ 2 * 2.82 =$$

46.68 N/mm2

Tubesheet Bending Stress Sigma=46.68 <= 1.5 *
S=251.28[N/mm2]

18.5%

OK

Tubesheet Bending Stress(Option 3) Sigma_O3=0 <=
1.5*S=251.28[N/mm2]

0.0%

OK

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.2 Tubesheet floating 17 Feb. 2022 13:08 ConnID:TB.1 PC# 2

LOAD CASE:=LC3==LC3=

UHX-14.5.7 Bending Stress in Tubesheet (Sigma)

$$\text{Sigma} = 1.5 * F_m / \text{Mystar} * (2 * a_o / (h - h_g)) ^ 2 * P_e$$
$$= 1.5 * 0.2209 / 0.4479 * (2 * 61.5 / (26 - 0)) ^ 2 * 1.82 =$$

30.13 N/mm2

Tubesheet Bending Stress Sigma=30.13 <= 1.5 *
S=251.28[N/mm2]

11.9%

OK

Tubesheet Bending Stress(Option 3) Sigma_O3=0 <=
1.5*S=251.28[N/mm2]

0.0%

OK

MAXIMUM ALLOWABLE PRESSURE SUMMARY

Table MAWP SUMMARY FOR T.2 :

Description	P(MPa)	LimitedBy
Max.Allow.Test Pressure (tubeside)	25.13	Tubesheet Bending Stress
Max.Allow.Test Pressure(shellside)	25.13	Tubesheet Bending Stress
Max.Allow.Pressure Hot&Corroded(tubeside)	15.18	Tubesheet Bending Stress
Max.Allow.Pressure Hot&Corroded(shellside)	15.18	Tubesheet Bending Stress
Max.Allow.Pressure New&Cold(tubeside)	17.22	Tubesheet Bending Stress
Max.Allow.Pressure New&Cold(shellside)	17.23	Tubesheet Bending Stress

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 210 FOR: 1 SA-213(M)
Gr.TP316L, S31603 Smls. tube, PNo=8 , the material must be re-selected from the material database.

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 210 FOR: 5 SA-312(M)
Gr.TP316, S31600 Smls. & wld. pipe, PNo=8 , the material must be re-selected from the material database.

WARNING: UNABLE TO UPDATE MATERIAL PROPERTIES AT TEMP= 95 FOR: 9 SA-312(M)
Gr.TP316L, S31603 Smls. & wld. pipe, PNo=8 , the material must be re-selected from the material database.

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

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Client : IWS Monje

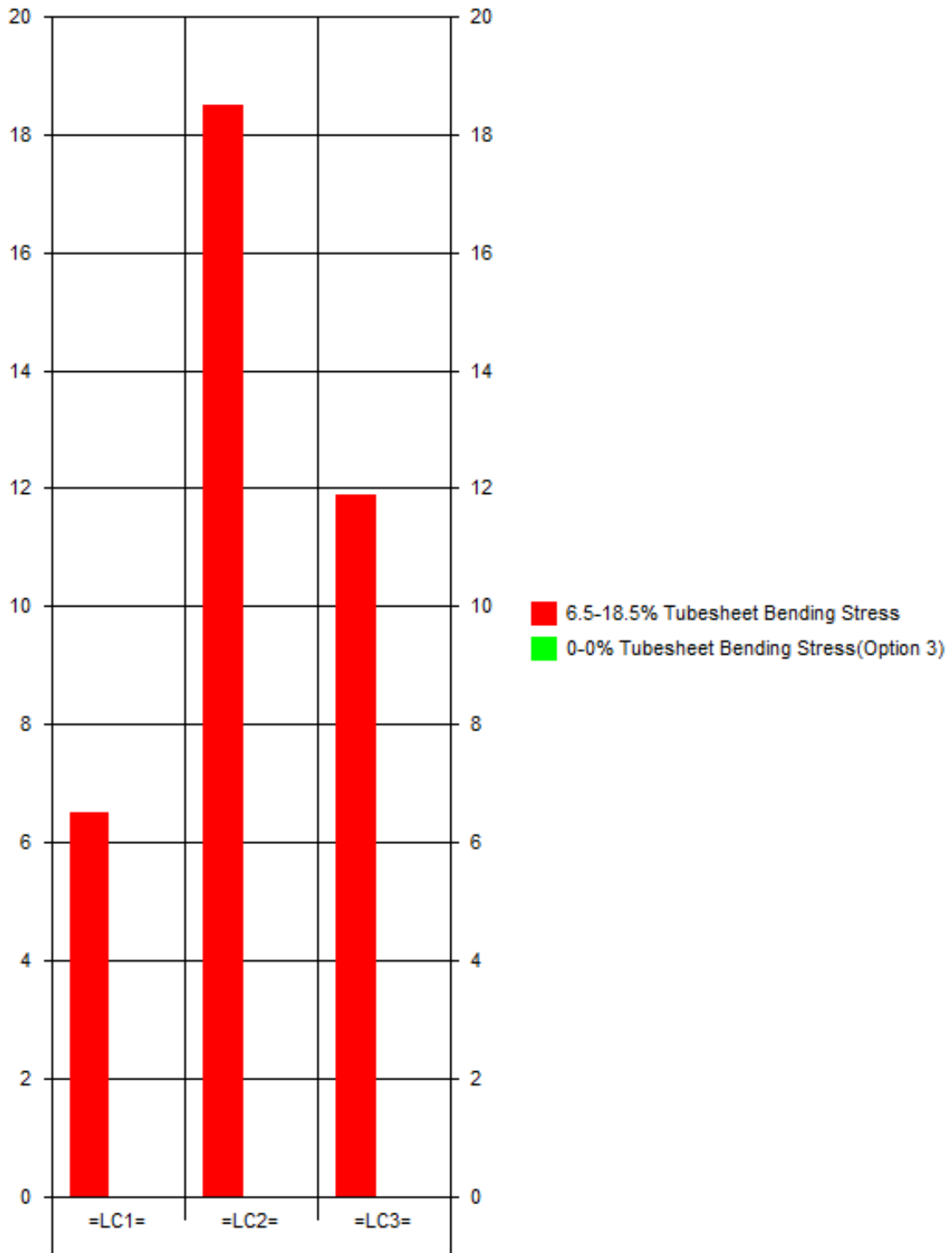
Vessel Tag No.:K12-3102/ RLP 800/140

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ASME VIII Div.1:2019 - UHX-14 Floating Tubesheet Heat Exchangers

T.2 Tubesheet floating 17 Feb. 2022 13:08 ConnID:TB.1 PC# 2

UTILIZATION CHART - T.2 TUBESHEET FLOATING



Max.Utilization/Condition 18.5% CASE: =LC2=

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

TB.1 Tube bundle 17 Feb. 2022 13:08 ConnID:T.1 PC# 2

INPUT DATA

COMPONENT ATTACHMENT/LOCATION

Attachment: T.1 Tubesheet Tubesheet F.3
Location: Along z-axis zo= -54

GENERAL DESIGN DATA

DESIGN PRESSURE.....:P 1.1000 MPa
EXTERNAL DESIGN PRESSURE.....:Pext 2.6000 MPa
CORROSION ALLOWANCE FOR TUBES.....:c 0.00 mm

TUBE BUNDLE DATA

U-TUBES - CHECK THINNING OF TUBES DUE TO BENDING: NO
SB-111(M), O61, C70600 Smls. cond. tube 95'C
ST=275 SY=100 SYd=97.91 S=68.9 Sr=68.9 Stest=90 (N/mm2)
NOMINAL THICKNESS OF TUBES.....:tt 0.5000 mm
TUBE PITCH (Spacing between centers).....:p 11.50 mm
NOMINAL OUTSIDE DIAMETER OF TUBES.....:dt 7.5000 mm
DIAMETER OF OUTER TUBE LIMIT CIRCLE.....:Do 123.00 mm
NUMBER OF TUBEHOLES IN TUBESHEET.....:Nt 72.00 piec
TUBE LENGTH BETWEEN INNER FACES OF TUBESHEETS.....:L 550.00 mm
NOMINAL THICKNESS OF TUBESHEET (uncorroded).....:hn 28.00 mm
NEGATIVE DEVIATION/TOLERANCE.....: 12.50 %

DATA FOR BAFFLE PLATES

BAFFLE PLATES: Excluded

CALCULATION DATA

UG-27 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

Outside Radius of Tube
 $R_o = dt / 2 = 7.5/2 = 3.7500$ mm

»Thin Cylinder Check $P=1.1 \leq 0.385 * S * E=26.53$ [MPa] « » OK«

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

$t_{min} = P * R_o / (S * E + 0.4 * P) = 1.1 * 3.75 / (68.9 * 1 + 0.4 * 1.1) = 0.0595$ mm

»Thin Cylinder Check $t_{min}=0.0595 < 0.5 * R=1.875$ [mm] « » OK«

Required Minimum Tube Thickness Incl.Allow. :

$t_{mina} = (t_{min} + c + th) * (1 + th_{bend} / 100) = (0.0595 + 0 + 0.0625) * (1 + 0/100) = 0.1220$ mm

Analysis Thickness

$t_a = t_n / (1 + th_{bend} / 100) - c - th = 0.5 / (1 + 0/100) - 0 - 0.0625 = 0.4375$ mm

Internal Pressure $t_{mina}=0.122 \leq t_n=0.5$ [mm]	24.3%	OK
--	-------	----

MAXIMUM ALLOWABLE WORKING PRESSURE MAWP :

Inside Diameter of Shell
 $D_i = dt - 2 * t_a = 7.5 - 2 * 0.4375 = 6.6250$ mm

Inside Radius of Shell
 $R = D_i / 2 = 6.625/2 = 3.3125$ mm

MAWP HOT & CORR. (Corroded condition at design temp.)

$MAWPHC = S * E * t_a / (R + 0.6 * t_a) = 68.9 * 1 * 0.4375 / (3.3125 + 0.6 * 0.4375) = 8.4318$ MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)

$MAWPNC = S_r * E * (t_a + c) / (R + 0.6 * (t_a + c)) = 68.9 * 1 * (0.4375 + 0) / (3.3125 + 0.6 * (0.4375 + 0)) = 8.4318$ MPa

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Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

TB.1 Tube bundle 17 Feb. 2022 13:08 ConnID:T.1 PC# 2

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

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

$$P_{tmax} = S_{Ytest} * E_{test} * (t_a + c) / (R + 0.6 * (t_a + c))$$
$$= 90 * 1 * (0.4375 + 0) / (3.3125 + 0.6 * (0.4375 + 0)) =$$

11.01 MPa

UG-100(b) REQUIRED MINIMUM PNEUMATIC TEST PRESSURE: NEW AT AMBIENT TEMP. P_{tmin}

$$P_{tmin} = 1.1 * P_d * S_r / S = 1.1 * 1.1 * 68.9 / 68.9 =$$

1.2100 MPa

Test Pressure P_{tmin}=1.21 <= P_{tmax}=11.01[MPa]

10.9%

OK

SECT. UG28 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

Preliminary Calculations

$$Ratio1 = dt / t = 7.5 / 0.4375 =$$

17.14

$$Ratio2 = L / dt = 550 / 7.5 =$$

73.33

Value of A from Fig.G (Part D), A = 0.003979

Value of B from External Pressure Chart NFC-3(based on Temp=95) B = 34.83

$$P_{max} = (4 / 3) * B / (dt / t)$$

$$= (4 / 3) * 34.83 / (7.5 / 0.4375) =$$

2.7087 MPa

External Pressure P_{max}=2.71 >= P_{ext}=2.6[MPa]

95.9%

OK

Max. External Test Pressure

Max. External Test Pressure (Uncorroded cond.at ambient temp.)

$$P_{tmax}(20) = ==$$

3.3165 MPa

CALCULATION SUMMARY

UG-27 - CYLINDRICAL SHELLS UNDER INTERNAL PRESSURE

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

$$t_{min} = P * R_o / (S * E + 0.4 * P)$$

$$= 1.1 * 3.75 / (68.9 * 1 + 0.4 * 1.1) =$$

0.0595 mm

Required Minimum Tube Thickness Incl.Allow. :

$$t_{mina} = (t_{min} + c + t_h) * (1 + t_{hbend} / 100)$$

$$= (0.0595 + 0 + 0.0625) * (1 + 0 / 100) =$$

0.1220 mm

Internal Pressure t_{mina}=0.122 <= t_n=0.5[mm]

24.3%

OK

MAWP HOT & CORR. (Corroded condition at design temp.)

$$MAWPHC = S * E * t_a / (R + 0.6 * t_a)$$

$$= 68.9 * 1 * 0.4375 / (3.3125 + 0.6 * 0.4375) =$$

8.4318 MPa

MAWP NEW & COLD (Uncorroded condition at ambient temp.)

$$MAWPNC = S_r * E * (t_a + c) / (R + 0.6 * (t_a + c))$$

$$= 68.9 * 1 * (0.4375 + 0) / (3.3125 + 0.6 * (0.4375 + 0)) =$$

8.4318 MPa

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

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

$$P_{tmax} = S_{Ytest} * E_{test} * (t_a + c) / (R + 0.6 * (t_a + c))$$

$$= 90 * 1 * (0.4375 + 0) / (3.3125 + 0.6 * (0.4375 + 0)) =$$

11.01 MPa

Test Pressure P_{tmin}=1.21 <= P_{tmax}=11.01[MPa]

10.9%

OK

SECT. UG28 - CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

$$P_{max} = (4 / 3) * B / (dt / t)$$

$$= (4 / 3) * 34.83 / (7.5 / 0.4375) =$$

2.7087 MPa

External Pressure P_{max}=2.71 >= P_{ext}=2.6[MPa]

95.9%

OK

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Client : IWS Monje

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ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

TB.1 Tube bundle 17 Feb. 2022 13:08 ConnID:T.1 PC# 2

Max. External Test Pressure

Max. External Test Pressure (Uncorroded cond.at ambient temp.)

P_{temax}(20) = ==

3.3165 MPa

Volume:0.0014 m³ Weight:3.8 kg (SG= 7.85)

SEAB GmbH -

Client : IWS Monje

Vessel Tag No.:K12-3102/ RLP 800/140

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

ASME VIII Div.1:2019 - UG-27 CYLINDRICAL SHELL

TB.1 Tube bundle

17 Feb. 2022 13:08 ConnID:T.1 PC# 2

