MEG ENERGY	CHRISTINA LAKE REGIONAL PROJECT Phase 3A EPC for Central Plant Facilities SLI Project No. 511036	SNC·LAVALIN

SNC·LAVALIN

Vendor's drawing review for conformity with specifications and design drawing.

This review does not relieve the vendor of his responsibility for errors in design and detailing as detailed in his contract.

☐ A1	Not suitable to initiate fabrication. modify as noted, resubmit for review
☐ B1	Suitable to initiate fabrication as noted. modify as noted, resubmit for review
☐ C1	Suitable to fabricate to completion as noted. submit final documents including as-builts as required
☐ D1	Suitable to fabricate to completion. submit final documents including as-built documents as required
☐ E1	Not suitable as final documents as noted. modify as noted and resubmit.
☒ F1	Suitable as final documents. no further resubmittal required (unless revised by vendor)

Vendor: Sewon Cellontech Co. Ltd. - P00007	No.: E0351-3AE105-P-02	Rev: 1	Date Rec'd 2013/09/04
Doc. Title: L53.51, L53.53 - THERMAL DESIGN CALCULATION - Tag:3A-E-105A/B			
Client Code:	Project: MEG Phase 3A EPC		
Reviewed by: SS Date: 11-Sept-2013	Document No P-5310-01-0034		Submittal 02

SEWON CELLONTECH	DOCUMENT FOR EQUIPMENT	SWC JOB NO	E-0351
		ITEM NO.	3A-E-105A/B
		SWC DOC. NO.	E0351-3AE105-P-02

ASME-U

FOR APPROVAL

MEG Energy Corp.	SNC·LAVALIN
P.O NO.	P-5310-01
PROJECT NAME	CLRP Phase 3A Central Plant Facility: EPC
PROJECT NO.	511036
DOCUMENT TITLE	THERMAL DESIGN CALCULATION
ITEM NO.	ITEM DESCRIPTION
3A-E-105A/B	EMULISION / GLYCOL EXCHANGER

SEWON CELLONTECH CORP. ISSUED 2013. 8. 23 Engineering Team KOREA

- Total Sheet 21 Sheet (Including This Cover)

REV	PREPARED BY	REVIEWED BY	APPROVED BY	DESCRIPTION
1	M.K.park 8/16/2013	T.W.Kim 8/18/13	Y.S.JI 8/21/2013	SECOND ISSUE
0	M.K.PARK	T.W.KIM	Y.S.JI	FIRST ISSUED

SEWON CELLONTECH CO.,LTD.

SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 2 OF 21

CUSTOMER	MEG Energy Corp.
LOCATION	CANADA
JOB NO.	511036
SERVICE	Emulsion / Glycol Exchanger
ITEM NO.	3A-E-105A/B (Max Case)

REV	MADE BY	CHECKED BY	APPROVED BY	DATE
0	-	-	-	07-01-2013
1	-	-	-	08-14-2013

Total 2 Shells, Connected in 1 Parallel 2 Series Shells | Install ■ Hor. □ Vert. | Size 1,200.0 ID - 6,096.0 L

Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type BJT (Note 1) | TEMA Class R | Effective Area 370.69 m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			Emulsion		TEG/Water(60/40wt%)	
Total Fluid	kg/hr		1244436		353423	
Vapor	kg/hr	MW				
Liquid	kg/hr	MW	1244436	1244436	353423	353423
Steam	kg/hr					
Water	kg/hr					
Noncondendable	kg/hr	MW				
Operating Temperature	℃		144.00	121.40	40.00	130.00
Operating Pressure	kPaa		1019.02		994.015	
Density	kg/m3	L / v	928.0	945.9	1078.40	1003.20
Viscosity	cP	L / v	0.5100	0.6100	4.6600	0.9800
Thermal Conductivity	W/m·℃	L / v	0.4601	0.4601	0.3301	0.3401
Specific Heat	kJ/kg·℃	L / v	3.8701	3.7801	3.2201	3.5401
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPaa / ℃		/	/	/	/
Velocity	m/sec		0.93 (Note 4)		1.35	
Pressure Drop	kPa.		Allow. 55.000	Calc. 46.598	Allow. 100.000	Calc. 88.510
Fouling Resistance	m2·℃/kW		(Note 3)		0.18	
Film Coefficient	W/m2·K		4,901.71		3,063.82	
Overall Coefficient	W/m2·K		Clean 1573.88	Calc. 1173.08	Design 1138.68	
Heat Duty	KW		29,874.00		LMTD ℃	MTD 35.4 ℃

CONSTRUCTION

Design Pressure	Design Temperature	2010.0 / FV kPa.G	-29 / 210 ℃	1550.0 / FV kPa.G	-29 / 210 ℃
No. of Passes		1		4	

Tubes No. 804 / Shell, Size 25.40 mm, Thickness 2.11 (Min.) mm (BWG : 14) Length 6,096.0 mm

Shell 1200 mm ID | Tube Pitch 31.75 mm, Layout angle 45 °, Leffective - mm

Baffles Cross Baffle 9+1S (Note 5) ea / Shell, Type Single Seg. (Hori.), Cut 28.0 % Dia., Spacing c/c 480.0 mm, End - mm

pv²	Inlet Nozzle	1,824.35	Entrance 3,026.87	Outlet Nozzle 1,789.82	kg/m·sec2	Impingement plate N/A
Material	Tube	SA 179	Shell & Cover	SA 516 GR. 70N		Channel & Cover SA 516 GR. 70N
	Tube Sheet	SA 266 Gr.2	Baffle	Carbon Steel		Expansion Joint N/A
Estimated Weight	Empty Weight - kg		Bundle Weight - kg			Full Water Weight kg
Corrosion Allowance	Shell side 3.2 mm		Tube side 3.2 mm			
Insulation	Shell side 64 mm		Tube side 64 mm			

Tube Joints : Rolled (two grooves) and Expanded

MEAN METAL TEMPERATURE	Temperature, ℃		Pressure, kPa.G	
	Shell	Tube	Shell	Tube
Normal Operating	-	-	-	-
Startup	-	-	-	-

NOZZLE	SHELL SIDE				TUBE SIDE			
	Tag	No	NPS	Remarks	Tag	No	NPS	Remarks
Inlet	S1	1	24		T1	1	10	
Outlet	S2	2	16		T2	1	10	
Vent				(Note 11 & 12)				(Note 12)
Drain				(Note 11 & 12)				(Note 12)
Thermowell								
Util. Con.								
RATING	RFWN 300#				RFWN 300#			

Remarks

1) Shell 1 is a BJ12T with one 24" inlet nozzle and two 16" outlet nozzles. Shell 2 is a BJ21T with two 16" inlet nozzle and one 24" outlet nozzle.
2) Seller shall verify and guarantee thermal rating of the unit.
3) Emulsion fouling factor to be designed per paper "Reduce Fouling in shell and Tube Exchangers" by Nesta and Bennett (zero fouling factor with 0.83 safety factor on emulsion convective heat transfer coefficient).
4) Based on Nesta and Bennett's reduced Fouling Design, emulsion velocity to be minimum 0.6m/s and B-stream fraction to be minimum 0.65.
5) Floating head support shall be provided.
6) Water cut of emulsion at maximum sizing case is 73.1%. Expected chloride content of water phase of emulsion is 1140 ppm.
7) Water cut of emulsion at maximum sizing case is 67.04%. Expected chloride content of water phase of emulsion is 1140 ppm.
8) Exchanger is to be designed for future field hydrotest in fully corroded condition.
9) seller is to design and install electrical heat tracing for hold temperature of 10℃. CSA approval is required for electric components and installation. The exchanger is located in hazardous area Class 1, Zone 2.
10) Seller is to supply and install 64mm thick mineral fiber insulation.
11) Each shell shall be provided with a NPS 2 (300#, RFLWN) vent and drain. Vents and drains shall come complete with blind flange, gasket, bolts & nuts.
12) Each process nozzle shall be provided with one 1" 300# RFLWN (complete with blind flange, gasket, bolts & nuts).
13) Exchangers are not stacked.
14) EHT design shall use voltage of 277 VAC.

SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 3 OF 21

		REV	MADE BY	CHECKED BY	APPROVED BY	DATE
CUSTOMER	MEG Energy Corp.	0	-	-	-	07-01-2013
LOCATION	CANADA	1	-	-	-	08-14-2013
JOB NO.	511036					
SERVICE	Emulsion / Glycol Exchanger					
ITEM NO.	3A-E-105A/B (Min Case)					

Total 2 Shells, Connected in 1 Parallel 2 Series Shells		Install ■ Hor. □ Vert.		Size	1,200.0 ID - 6,096.0 L
Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660	TEMA Type BJT (Note 1)	TEMA Class	R	Effective Area	370.69 m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			Emulsion		TEG/Water(60/40wt%)	
Total Fluid	kg/hr		1011612		79329.3	
Vapor	kg/hr	MW				
Liquid	kg/hr	MW	1011612	1011612	79329.3	79329.3
Steam	kg/hr					
Water	kg/hr					
Noncondendable	kg/hr	MW				
Operating Temperature	℃		144.00	137.60	40.00	130.00
Operating Pressure	kPaa		1019.02		994.015	
Density	kg/m3	L / V	929.0	934.1	1078.40	1003.20
Viscosity	cP	L / V	0.6400	0.6700	4.6600	0.9800
Thermal Conductivity	W/m·℃	L / V	0.4201	0.4201	0.3301	0.3401
Specific Heat	kJ/kg·℃	L / V	3.7201	3.6901	3.2201	3.5401
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPaa / ℃		/	/	/	/
Velocity	m/sec		0.77		0.30	
Pressure Drop	kPa.		Allow. 55.000	Calc. 32.183	Allow. 100.000	Calc. 6.326
Fouling Resistance	m2·℃/kW		(Note 3)		0.18	
Film Coefficient	W/m2·K		3,852.36		585.62	
Overall Coefficient	W/m2·K		Clean 430.24	Calc. 389.94	Design 216.83	
Heat Duty	KW		6,705.00		LMTD ℃	MTD 41.7 ℃

CONSTRUCTION

Design Pressure	Design Temperature	/ kPa.G	/ ℃	/ kPa.G	/ ℃
No. of Passes					

Tubes No.	/ Shell, Size	mm ,	Thickness (Min.)	mm (BWG :)	Length	mm	
Shell	mm ID		Tube Pitch	mm ,	Layout angle	° , Leffective	- mm
Baffles Cross Baffle	ea / Shell , Type	,	Cut	- % Dia. ,	Spacing c/c	mm , End	- mm
ρv² Inlet Nozzle	1,204.27 , Entrance	1,998.06 ,	Outlet Nozzle	1,197.69	kg/m·sec2	Impingement plate	
Material Tube			Shell & Cover			Channel & Cover	
Material Tube Sheet			Baffle			Expansion Joint	
Estimated Weight	Empty Weight kg		Bundle Weight	kg		Full Water Weight	kg
Corrosion Allowance	Shell side mm		Tube side	mm	Tube Joints :		
Insulation	Shell side mm		Tube side	mm			

MEAN METAL TEMPERATURE	Temperature, ℃		Pressure, kPa.G	
	Shell	Tube	Shell	Tube
Normal Operating	-	-	-	-
Startup	-	-	-	-

NOZZLE	SHELL SIDE				TUBE SIDE			
	Tag	No	NPS	Remarks	Tag	No	NPS	Remarks
Inlet								
Outlet								
Vent								
Drain								
Liquid Outlet								
Thermowell								
Util. Con.								
RATING								

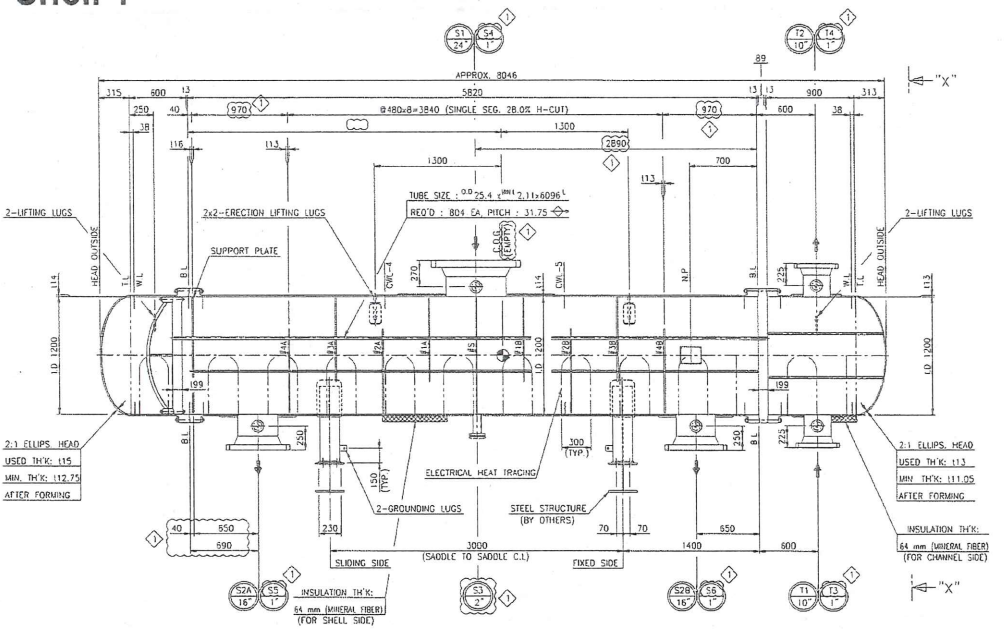
SEWON CELLONTECH

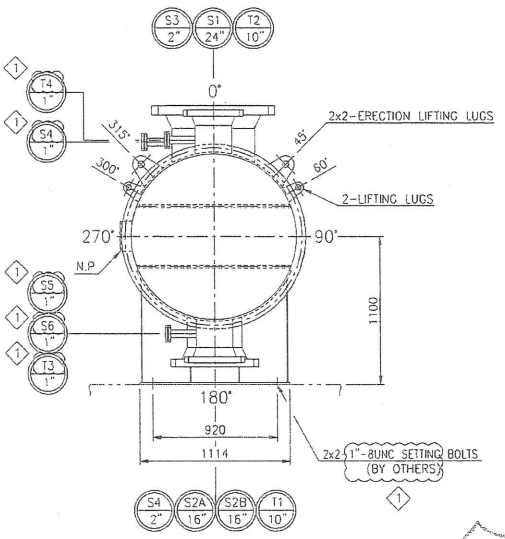
TUBULAR HEAT EXCHANGER

SHEET 4 OF 21

		REV	MADE BY	CHECKED BY	APPROVED BY	DATE
CUSTOMER	MEG Energy Corp.					
LOCATION	CANADA	0	-	-	-	07-01-2013
JOB NO.	511036	1	-	-	-	08-14-2013
SERVICE	Emulsion / Glycol Exchanger					
ITEM NO.	3A-E-105A/B					

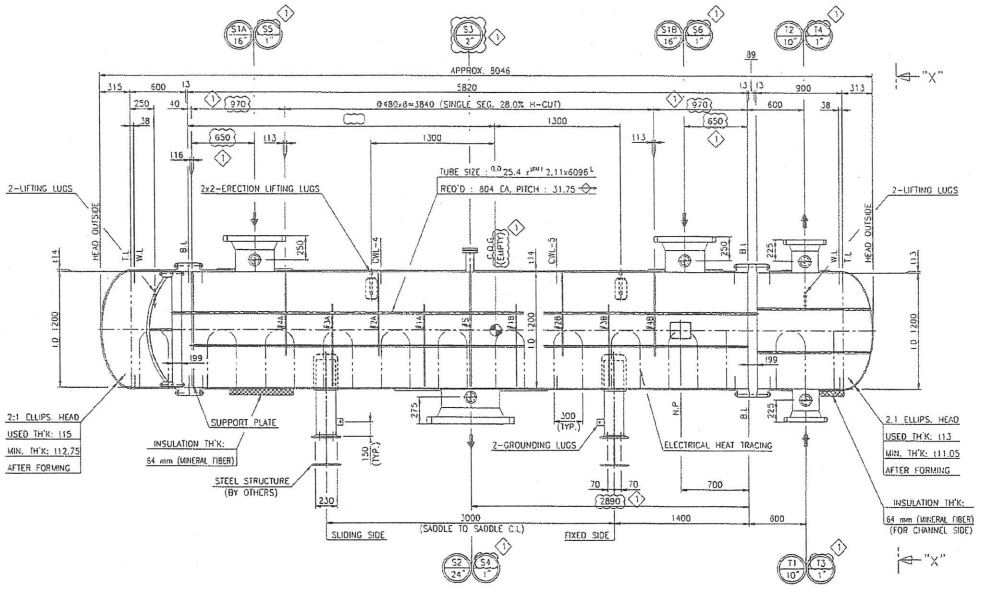
Shell 1

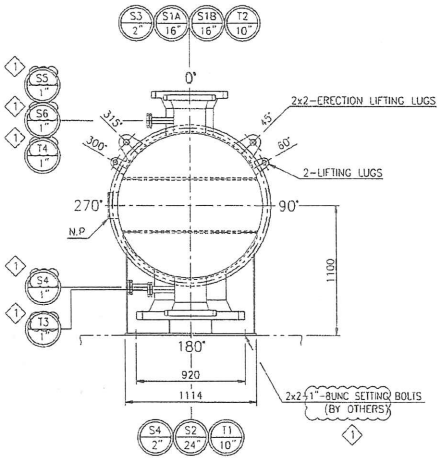




SEWON CELLONTECH	TUBULAR HEAT EXCHANGER				
					SHEET 5 OF 21
CUSTOMER	MEG Energy Corp.	REV	MADE BY	CHECKED BY	APPROVED BY	DATE
LOCATION	CANADA	0	-	-	-	07-01-2013
JOB NO.	511036	1	-	-	-	08-14-2013
SERVICE	Emulsion / Glycol Exchanger					
ITEM NO.	3A-E-105A/B					

Shell 2





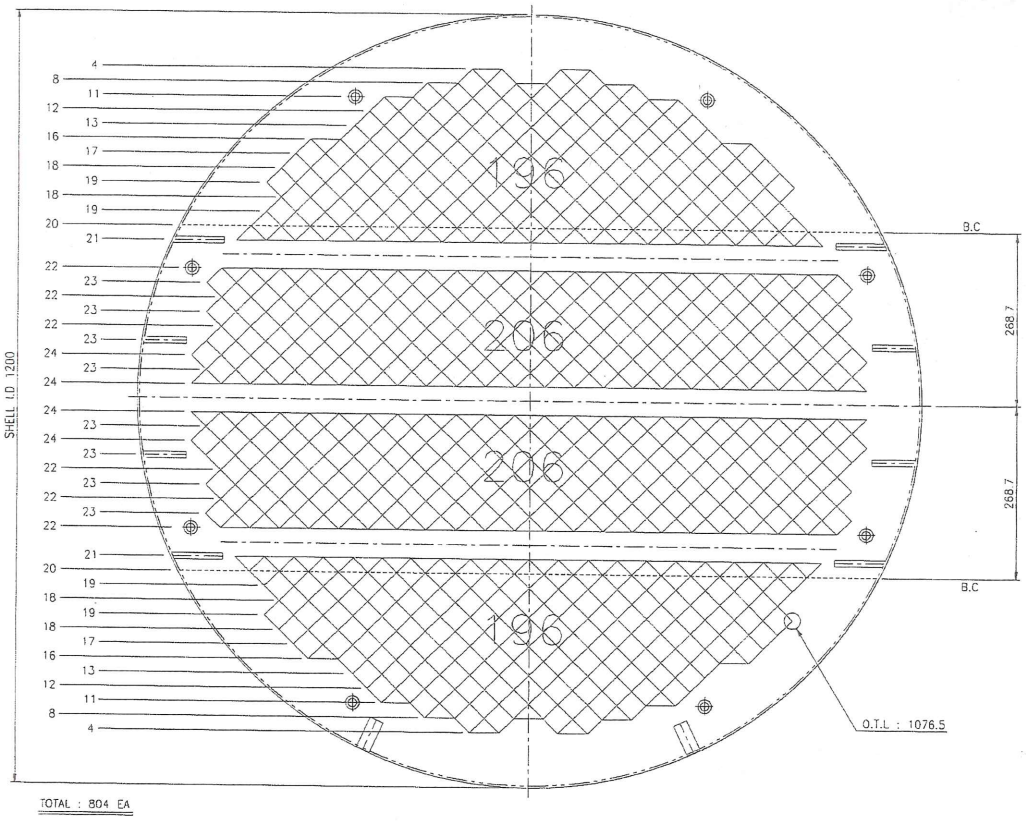
SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 6 OF 21

CUSTOMER	MEG Energy Corp.
LOCATION	CANADA
JOB NO.	511036
SERVICE	Emulsion / Glycol Exchanger
ITEM NO.	3A-E-105A/B

REV	MADE BY	CHECKED BY	APPROVED BY	DATE
0	-	-	-	07-01-2013
1	-	-	-	08-14-2013



3A-E-105

1/5

I.D.-SHELL	1,200.0 ID	(BJT)
ALLOWABLE O.T.L	1076.5	mm
ACTUAL O.T.L	1076.5	mm
SEAL STRIP	4.0	Pairs
SEAL Rod	N/A	ea

TOTAL 804 HOLES FOR 25.4 OD TUBES ON 31.75 SQUARE PITCH.
4 PASSES. BAFFLE CUT SINGLE SEGM. 28% DIA.

Remarks

Thermal/Hydraulic/ Vibration Verification Report

(Rev.1)

3A-E-105A/B

Client :	MEG Energy Corp.
Project :	MEG Energy Christina Lake Regional Project Phase 3A-Central Plant Facilities
Date :	08-14-2013

3A-E-105A/B (Max Case)

The Thermal/Hydraulic/Vibration calculations are perfomed by using HTRI Xist Ver. 6.00 SP3.

The process condiiton and the physical properties are based on Buyer data sheet.

For the design result (the geometry data), please refer to the Equopment data sheet and Fabrication drawing.

1. Thermal and Hydraulic performance

- Thermal performance :		3.02	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	46.598	<	55.000 kPa	----------	O.K
	tube-side	88.51	<	100.000 kPa	----------	O.K

2. Vibration Analysis

- Fluidelastid instability :	characteristic values	<<	criteria	----------	O.K.
- Acoustic vibration :	characteristic values	<<	criteria	----------	O.K.
- Tube vibration check:	characteristic values	<<	criteria	----------	O.K.
- Bundle Entrance/Exit :	characteristic values	<<	criteria	----------	O.K.
- Shell Entrance /Exit:	characteristic values	<<	criteria	----------	O.K.

3A-E-105A/B (Max Case) - Shell 1

Used Program : HTRI Xist Ver.6.00 SP.3 Vibration Analysis

VALUE TO BE CHECKED	Inlet	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	960.	960.	1449.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.511	0.511	0.771	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.1908	0.1953	0.2070	< 0.8	O.K
Ave. crossflow velocity ratio	0.1779	0.1821	0.1930	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.342	0.350	0.168	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.066	0.159	< 0.8	O.K
Vortex shedding ratio		0.774	0.475	> 0.5	Check Below
				Tube OD = 25.400	
				Tube gap = 6.350	
Crossflow amplitude (mm)		0.01778	0.05797	< 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		774.96	188.99	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		1.81	1.62	< If velocity is exceed 5.14 / 2.33	O.K.
ρv2 (kg/m-s2)		3026.87	2457.22	< 5953 by TEMA	O.K.

10/21

Vibration Analysis

Released to the following HTRI Member Company:

Sewon Cellontech Co. Ltd,.

Kim Tae Wan

Xist Ver. 6.00 SP3 2013/07/29 17:04 SN: 1500213869 — MEG Energy Units

Max. Case. : Shell 1

Rating - Horizontal Multipass Flow TEMA BJ12T Shell With Single-Segmental Baffles

Shellside condition		Sens. Liquid	(Level 2.3)	
Axial stress loading	(MPa)	0.000	Added mass factor	1.517
Beta		3.745		

Position In The Bundle		Inlet	Center	Outlet
Length for natural frequency	(mm)	960.	960.	1449.
Length/TEMA maximum span	(--)	0.511	0.511	0.771
Number of spans	(--)	6	6	6
Tube natural frequency	(Hz)	55.5	55.5	39.8 +
Shell acoustic frequency	(Hz)			
Flow Velocities		**Inlet**	**Center**	**Outlet**
Window parallel velocity	(m/s)	0.97	0.96	0.96
Bundle crossflow velocity	(m/s)	0.60	0.61	0.29
Bundle/shell velocity	(m/s)	0.42	0.43	0.21
Fluidelastic Instability Check		**Inlet**	**Center**	**Outlet**
Log decrement	HTRI	0.093	0.094	0.100
Critical velocity	(m/s)	5.14	5.14	2.33
Baffle tip cross velocity ratio	(--)	0.1908	0.1953	0.2070
Average crossflow velocity ratio	(--)	0.1779	0.1821	0.1930
Acoustic Vibration Check		**Inlet**	**Center**	**Outlet**
Vortex shedding ratio	(--)			
Chen number	(--)			
Turbulent buffeting ratio	(--)			
Tube Vibration Check		**Inlet**	**Center**	**Outlet**
Vortex shedding ratio	(--)	0.342	0.350	0.168
Parallel flow amplitude	(mm)	0.004	0.004	0.003
Crossflow amplitude	(mm)	0.025	0.027	0.029
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	774.96	815.35	188.99

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.066	0.159
Vortex shedding ratio	(--)	0.774	0.475
Crossflow amplitude	(mm)	0.01778	0.05797
Crossflow velocity	(m/s)	1.35	0.83
Tubesheet to inlet/outlet support	(mm)	None	None
Shell Entrance/Exit Parameters		**Entrance**	**Exit**
Impingement plate		No	
Flow area	(m2)	0.206	0.114
Velocity	(m/s)	1.81	1.62
RHO-V-SQ	(kg/m-s2)	3026.87	2457.22

Shell type	BJ12T	Baffle type	Single-Seg.
Tube type	Plain	Baffle layout	Perpend.
Pitch ratio	1.2500	Tube diameter, (mm)	25.400
Layout angle	45	Tube material	Carbon steel
		Supports/baffle space	

Program Messages

+ Frequency ratios are based upon lowest natural or acoustic frequency

* Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case using the procedure described in Online Help; You may find that a vibration problem is unlikely.

3A-E-105A/B (Max Case) - Shell 2

Used Program : HTRI Xist Ver.6.00 SP.3 Vibration Analysis

VALUE TO BE CHECKED	Inlet	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1449.	960.	960.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.771	0.511	0.511	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.2068	0.1927	0.1863	< 0.8	O.K
Ave. crossflow velocity ratio	0.1928	0.1796	0.1737	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.169	0.347	0.336	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.158	0.064	< 0.8	O.K
Vortex shedding ratio		0.476	0.761	> 0.5	Check Below
				Tube OD = 25.400	
				Tube gap = 6.350	
Crossflow amplitude (mm)		0.05791	0.01657	< 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		188.92	760.04	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		1.62	1.77	< If velocity is exceed 2.33 / 5.16	O.K.
ρv2 (kg/m-s2)		2457.23	2969.59	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

Sewon Cellontech Co. Ltd,.

Kim Tae Wan

Xist Ver. 6.00 SP3 2013/07/29 17:04 SN: 1500213869 — MEG Energy Units

Max. Case. : Shell 2

Rating - Horizontal Multipass Flow TEMA BJ21T Shell With Single-Segmental Baffles

Shellside condition		Sens. Liquid	(Level 2.3)	
Axial stress loading	(MPa)	0.000	Added mass factor	1.517
Beta		3.745		

Position In The Bundle		Inlet	Center	Outlet
Length for natural frequency	(mm)	1449.	960.	960.
Length/TEMA maximum span	(--)	0.771	0.511	0.511
Number of spans	(--)	6	6	6
Tube natural frequency	(Hz)	39.7 +	55.3	55.2
Shell acoustic frequency	(Hz)			

Flow Velocities		Inlet	Center	Outlet
Window parallel velocity	(m/s)	0.96	0.95	0.95
Bundle crossflow velocity	(m/s)	0.29	0.60	0.58
Bundle/shell velocity	(m/s)	0.21	0.43	0.42

Fluidelastic Instability Check		Inlet	Center	Outlet
Log decrement	HTRI	0.100	0.094	0.095
Critical velocity	(m/s)	2.33	5.15	5.16
Baffle tip cross velocity ratio	(--)	0.2068	0.1927	0.1863
Average crossflow velocity ratio	(--)	0.1928	0.1796	0.1737

Acoustic Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)			
Chen number	(--)			
Turbulent buffeting ratio	(--)			

Tube Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	0.169	0.347	0.336
Parallel flow amplitude	(mm)	0.003	0.004	0.004
Crossflow amplitude	(mm)	0.029	0.026	0.025
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	188.92	806.10	760.04

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.158	0.064
Vortex shedding ratio	(--)	0.476	0.761
Crossflow amplitude	(mm)	0.05791	0.01657
Crossflow velocity	(m/s)	0.83	1.32
Tubesheet to inlet/outlet support	(mm)	None	None

Shell Entrance/Exit Parameters		Entrance	Exit
Impingement plate		No	
Flow area	(m2)	0.114	0.206
Velocity	(m/s)	1.62	1.77
RHO-V-SQ	(kg/m-s2)	2457.23	2969.59

Shell type	BJ21T	Baffle type	Single-Seg.
Tube type	Plain	Baffle layout	Perpend.
Pitch ratio	1.2500	Tube diameter, (mm)	25.400
Layout angle	45	Tube material	Carbon steel
		Supports/baffle space	

Program Messages

\+ Frequency ratios are based upon lowest natural or acoustic frequency

* Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case using the procedure described in Online Help; You may find that a vibration problem is unlikely.

Final Results

Released to the following HTRI Member Company:

Sewon Cellontech Co. Ltd,.

Kim Tae Wan

Xist Ver. 6.00 SP3 2013/07/29 17:04 SN: 1500213869 — MEG Energy Units

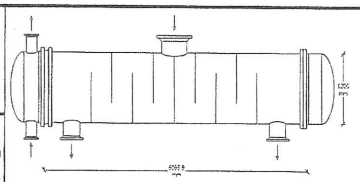
Max. Case. : Shell 1

Rating - Horizontal Multipass Flow TEMA BJ12T Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		Emulsion		TEG/Water(60/40wt%)	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		1244436		353423
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	144.00	136.86	102.37	130.00
Temperature, Average/Skin	(Deg C)	140.43	134.97	116.19	128.15
Wall temperature, Min/Max	(Deg C)	127.41	140.24	125.83	139.40
Pressure, In/Average	(kPa)	1019.02	1007.38	948.512	927.008
Pressure drop, Total/Allowed	(kPa)	23.262	55.000	43.007	100.000
Velocity, Mid/Max allow	(m/s)	0.94		1.37	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		4989.08		3496.60
Heat transfer safety factor	(--)		0.830		1.000
Fouling resistance	(m2-K/W)		0.000000		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	1206.11 /	1710.38 /	1249.17
Heat duty, Calculated/Specified	(kW)	9471. /		
Effective overall temperature difference	(Deg C)	21.2		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	21.26 *	0.9971 *	1.0000



Exchanger Fluid Volumes

Approximate shellside	(L)	4378.0
Approximate tubeside	(L)	3427.8

Shell Construction Information

TEMA shell type	BJ12T		Shell ID	(mm)	1200.00
Shells Series	1 Parallel	1	Total area	(m2)	391.093
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	370.691
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	4		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Head to support distance (mm)	114.000	
Weight estimation Wet/Dry/Bundle		22578.3 /	14777.9 /	7476.63	(kg/shell)

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	28.00	
Crosspasses/shellpass		10	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	480.000	1	24.89	264.000
Inlet spacing	(mm)	480.000	2	0.00	0.000
Outlet spacing	(mm)	968.969			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		804
Overall length	(mm)	6096.	Pct tubes removed (both)		0.25
Effective length	(mm)	5778.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	204.000	Wall thickness	(mm)	2.110
Area ratio	(out/in)	1.1992	Pitch (mm)	31.7500 Ratio	1.2500
Tube metal	Carbon steel		Tube pattern (deg)		45

Shellside Performance

Nom vel, X-flow/window 0.94 / 1.03

Flow fractions for heat transfer 0.814

A=0.0659 B=0.6704 C=0.1349 E=0.1288 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.982	0.920	1.068	0.918	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
37.93	15.58	28.07	Inlet	8.79	5.60
MOMENTUM		0.00	Outlet	9.62	3.64

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters

		Shell	Tube
Overall wall correction		0.993	1.005
Midpoint	Prandtl no.	4.37	11.67
Midpoint	Reynolds no.	48063	26026
Bundle inlet	Reynolds no.	52631	20359
Bundle outlet	Reynolds no.	24400	29858
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
25.04	42.84	26.97	5.15	3.57

Total fouling resistance 2.157e-4

Differential resistance 2.858e-5

Shell Nozzles

		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	581.600	380.400	
Velocity	(m/s)	1.40	1.63	
Pressure drop	(kPa)	2.044	2.239	
Height under nozzle	(mm)	71.687	71.687	
Nozzle R-V-SQ	(kg/m-s2)	1824.35	2476.69	
Shell ent.	(kg/m-s2)	3026.87	2457.22	

Tube Nozzle

		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	2.06	2.11	
Pressure drop	(kPa)	2.407	1.567	
Nozzle R-V-SQ	(kg/m-s2)	4375.19	4475.87	

Annular Distributor

		Inlet	Outlet
Length	(mm)		
Height	(mm)		
Slot area	(mm2)		

Diametral Clearances (mm)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
6.3500	123.500	0.3969

Final Results

Released to the following HTRI Member Company:

Sewon Cellontech Co. Ltd,.

Kim Tae Wan

Xist Ver. 6.00 SP3 2013/07/29 17:04 SN: 1500213869 — MEG Energy Units

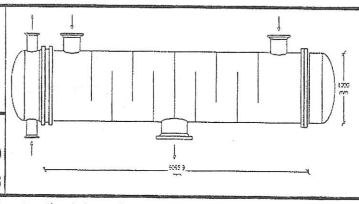
Max. Case. : Shell 2

Rating - Horizontal Multipass Flow TEMA BJ21T Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		Emulsion		TEG/Water(60/40wt%)	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		1244436		353423
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	136.86	121.40	40.00	102.37
Temperature, Average/Skin	(Deg C)	129.13	117.08	71.19	102.57
Wall temperature, Min/Max	(Deg C)	106.43	127.59	103.63	125.89
Pressure, In/Average	(kPa)	995.768	984.099	994.015	971.263
Pressure drop, Total/Allowed	(kPa)	23.336	55.000	45.503	100.000
Velocity, Mid/Max allow	(m/s)	0.93		1.32	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		4805.87		2685.34
Heat transfer safety factor	(--)		0.830		1.000
Fouling resistance	(m2-K/W)		0.000000		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	1071.26 /	1437.38 /	1097.00
Heat duty, Calculated/Specified	(kW)	20403. /		
Effective overall temperature difference	(Deg C)	51.4		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	51.55 *	0.9975 *	1.0000



Exchanger Fluid Volumes

Approximate shellside	(L)	4378.0
Approximate tubeside	(L)	3427.8

Shell Construction Information

TEMA shell type	BJ21T		Shell ID	(mm)	1200.00
Shells Series	1 Parallel	1	Total area	(m2)	391.093
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	370.691
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	4		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Head to support distance (mm)	114.000	
Weight estimation Wet/Dry/Bundle			22580.4 / 14780.0 / 7478.73 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	28.00	
Crosspasses/shellpass		10	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	480.000	1	24.89	264.000
Inlet spacing	(mm)	968.969	2	0.00	0.000
Outlet spacing	(mm)	480.000			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		804
Overall length	(mm)	6096.	Pct tubes removed (both)		0.25
Effective length	(mm)	5778.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	204.000	Wall thickness	(mm)	2.110
Area ratio	(out/in)	1.1992	Pitch (mm)	31.7500 Ratio	1.2500
Tube metal	Carbon steel		Tube pattern (deg)		45

Shellside Performance

Nom vel, X-flow/window 0.93 / 1.02

Flow fractions for heat transfer 0.814

A=0.0637 B=0.6703 C=0.1361 E=0.1300 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.982	0.920	1.068	1.019	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
38.13	15.53	28.11	Inlet	9.59	5.03
MOMENTUM		0.00	Outlet	8.63	3.37

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.983	1.026
Midpoint	Prandtl no.	4.79	22.21
Midpoint	Reynolds no.	43359	13269
Bundle inlet	Reynolds no.	24418	6563
Bundle outlet	Reynolds no.	44035	19816
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
22.83	48.99	23.68	4.50	2.40

Total fouling resistance 2.157e-4

Differential resistance 2.19e-5

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	380.400	581.600	
Velocity	(m/s)	1.63	1.38	
Pressure drop	(kPa)	2.239	2.015	
Height under nozzle	(mm)	71.687	71.687	
Nozzle R-V-SQ	(kg/m-s2)	2476.69	1789.82	
Shell ent.	(kg/m-s2)	2457.23	2969.59	

Tube Nozzle		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.96	2.06	
Pressure drop	(kPa)	2.290	1.532	
Nozzle R-V-SQ	(kg/m-s2)	4163.76	4375.20	

Annular Distributor		Inlet	Outlet
Length	(mm)		
Height	(mm)		
Slot area	(mm2)		

Diametral Clearances (mm)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
6.3500	123.500	0.3969

3A-E-105A/B (Min Case)

The Thermal/Hydraulic/Vibration calculations are perfomed by using HTRI Xist Ver. 6.00 SP3.

The process condiiton and the physical properties are based on Buyer DATA SHEET (2).

For the design result (the geometry data), please refer to the Equopment DATA SHEET (2) and Fabrication drawing.

1. Thermal and Hydraulic performance

- Thermal performance :		79.84	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	32.183	<	55.000 kPa	----------	O.K
	tube-side	6.326	<	100.000 kPa	----------	O.K

2. Vibration Analysis

- Fluidelastid instability :	characteristic values	<<	criteria	----------	O.K.
- Acoustic vibration :	characteristic values	<<	criteria	----------	O.K.
- Tube vibration check:	characteristic values	<<	criteria	----------	O.K.
- Bundle Entrance/Exit :	characteristic values	<<	criteria	----------	O.K.
- Shell Entrance /Exit:	characteristic values	<<	criteria	----------	O.K.

3A-E-105A/B (Min Case) - Shell 1

Used Program : HTRI Xist Ver.6.00 SP.3 Vibration Analysis

VALUE TO BE CHECKED	Inlet	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	960.	960.	1449.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.511	0.511	0.771	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.1551	0.1592	0.1699	< 0.8	O.K
Ave. crossflow velocity ratio	0.1446	0.1484	0.1584	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.280	0.287	0.138	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.053	0.129	< 0.8	O.K
Vortex shedding ratio		0.629	0.387	> 0.5	Check Below
Crossflow amplitude (mm)		0.00779	0.03500	Tube OD = 25.400 Tube gap = 6.350 < 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		519.60	127.20	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		1.47	1.32	< If velocity is exceed 5.17 / 2.33	O.K.
ρv2 (kg/m-s2)		1998.06	1628.23	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/07/30 8:30 SN: 1500213869 — MEG Energy Units

Min. Case. : Shell 1

Rating - Horizontal Multipass Flow TEMA BJ12T Shell With Single-Segmental Baffles

Shellside condition		Sens. Liquid	(Level 2.3)	
Axial stress loading	(MPa)	0.000	Added mass factor	1.517
Beta		3.745		

Position In The Bundle		Inlet	Center	Outlet
Length for natural frequency	(mm)	960.	960.	1449.
Length/TEMA maximum span	(--)	0.511	0.511	0.771
Number of spans	(--)	6	6	6
Tube natural frequency	(Hz)	55.5	55.5	39.8 +
Shell acoustic frequency	(Hz)			

Flow Velocities		Inlet	Center	Outlet
Window parallel velocity	(m/s)	0.79	0.79	0.79
Bundle crossflow velocity	(m/s)	0.49	0.50	0.24
Bundle/shell velocity	(m/s)	0.35	0.36	0.17

Fluidelastic Instability Check		Inlet	Center	Outlet
Log decrement	HTRI	0.094	0.095	0.100
Critical velocity	(m/s)	5.17	5.17	2.33
Baffle tip cross velocity ratio	(--)	0.1551	0.1592	0.1699
Average crossflow velocity ratio	(--)	0.1446	0.1484	0.1584

Acoustic Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)			
Chen number	(--)			
Turbulent buffeting ratio	(--)			

Tube Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	0.280	0.287	0.138
Parallel flow amplitude	(mm)	0.002	0.002	0.002
Crossflow amplitude	(mm)	0.016	0.017	0.019
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	519.60	547.70	127.20

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.053	0.129
Vortex shedding ratio	(--)	0.629	0.387
Crossflow amplitude	(mm)	0.00779	0.03500
Crossflow velocity	(m/s)	1.09	0.67
Tubesheet to inlet/outlet support	(mm)	None	None

Shell Entrance/Exit Parameters		Entrance	Exit
Impingement plate		No	
Flow area	(m2)	0.206	0.114
Velocity	(m/s)	1.47	1.32
RHO-V-SQ	(kg/m-s2)	1998.06	1628.23

Shell type	BJ12T	Baffle type	Single-Seg.
Tube type	Plain	Baffle layout	Perpend.
Pitch ratio	1.2500	Tube diameter, (mm)	25.400
Layout angle	45	Tube material	Carbon steel
		Supports/baffle space	

Program Messages

+ Frequency ratios are based upon lowest natural or acoustic frequency
* Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case using the procedure described in Online Help; You may find that a vibration problem is unlikely.

3A-E-105A/B (Min Case) - Shell 2

Used Program : HTRI Xist Ver.6.00 SP.3 Vibration Analysis

VALUE TO BE CHECKED	Inlet	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1449.	960.	960.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.771	0.511	0.511	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.1699	0.1588	0.1543	< 0.8	O.K
Ave. crossflow velocity ratio	0.1584	0.1480	0.1439	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.139	0.287	0.279	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.129	0.053	< 0.8	O.K
Vortex shedding ratio		0.388	0.627	> 0.5	Check Below
				Tube OD = 25.400	
				Tube gap = 6.350	
Crossflow amplitude (mm)		0.03500	0.00771	< 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		127.29	517.14	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		1.32	1.46	< If velocity is exceed 2.33 / 5.17	O.K.
pv2 (kg/m-s2)		1628.24	1987.16	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/07/30 8:30 SN: 1500213869 — MEG Energy Units

Min. Case. : Shell 2

Rating - Horizontal Multipass Flow TEMA BJ21T Shell With Single-Segmental Baffles

Shellside condition		Sens. Liquid	(Level 2.3)	
Axial stress loading	(MPa)	0.000	Added mass factor	1.517
Beta		3.745		

Position In The Bundle		Inlet	Center	Outlet
Length for natural frequency	(mm)	1449.	960.	960.
Length/TEMA maximum span	(--)	0.771	0.511	0.511
Number of spans	(--)	6	6	6
Tube natural frequency	(Hz)	39.7 +	55.3	55.3
Shell acoustic frequency	(Hz)			

Flow Velocities		Inlet	Center	Outlet
Window parallel velocity	(m/s)	0.79	0.79	0.79
Bundle crossflow velocity	(m/s)	0.24	0.50	0.48
Bundle/shell velocity	(m/s)	0.17	0.36	0.35

Fluidelastic Instability Check		Inlet	Center	Outlet
Log decrement	HTRI	0.100	0.095	0.095
Critical velocity	(m/s)	2.33	5.17	5.17
Baffle tip cross velocity ratio	(--)	0.1699	0.1588	0.1543
Average crossflow velocity ratio	(--)	0.1584	0.1480	0.1439

Acoustic Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)			
Chen number	(--)			
Turbulent buffeting ratio	(--)			

Tube Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	0.139	0.287	0.279
Parallel flow amplitude	(mm)	0.002	0.002	0.002
Crossflow amplitude	(mm)	0.019	0.017	0.016
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	127.29	546.25	517.14

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.129	0.053
Vortex shedding ratio	(--)	0.388	0.627
Crossflow amplitude	(mm)	0.03500	0.00771
Crossflow velocity	(m/s)	0.67	1.09
Tubesheet to inlet/outlet support	(mm)	None	None

Shell Entrance/Exit Parameters		Entrance	Exit
Impingement plate		No	
Flow area	(m2)	0.114	0.206
Velocity	(m/s)	1.32	1.46
RHO-V-SQ	(kg/m-s2)	1628.24	1987.16

Shell type	BJ21T	Baffle type	Single-Seg.
Tube type	Plain	Baffle layout	Perpend.
Pitch ratio	1.2500	Tube diameter, (mm)	25.400
Layout angle	45	Tube material	Carbon steel
		Supports/baffle space	

Program Messages

\+ Frequency ratios are based upon lowest natural or acoustic frequency

* Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case using the procedure described in Online Help; You may find that a vibration problem is unlikely.

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

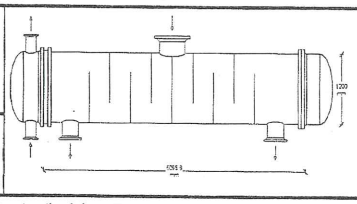
Xist Ver. 6.00 SP3 2013/07/30 8:30 SN: 1500213869 — MEG Energy Units

Min. Case. : Shell 1

Rating - Horizontal Multipass Flow TEMA BJ12T Shell With Single-Segmental Baffles

Process Data			Hot Shellside		Cold Tubeside	
Fluid name		Emulsion		TEG/Water(60/40wt%)		
Fluid condition			Sens. Liquid		Sens. Liquid	
Total flow rate	(kg/hr)		1011612		79329.3	
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000	
Temperature, In/Out	(Deg C)	144.00	141.20	92.25	130.00	
Temperature, Average/Skin	(Deg C)	142.60	138.97	111.13	135.36	
Wall temperature, Min/Max	(Deg C)	134.56	141.79	133.71	141.40	
Pressure, In/Average	(kPa)	1019.02	1010.97	990.707	989.198	
Pressure drop, Total/Allowed	(kPa)	16.087	55.000	3.019	100.000	
Velocity, Mid/Max allow	(m/s)	0.77		0.31		
Mole fraction inert	(--)					
Average film coef.	(W/m2-K)		3873.83		842.63	
Heat transfer safety factor	(--)		0.830		1.000	
Fouling resistance	(m2-K/W)		0.000000		0.000180	

Overall Performance Data					
Overall coef., Reqd/Clean/Actual	(W/m2-K)	285.97	/ 580.51	/ 515.87	
Heat duty, Calculated/Specified	(kW)	2891.	/		
Effective overall temperature difference	(Deg C)	27.3			
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	27.31	* 0.9992	* 1.0000	



Exchanger Fluid Volumes		
Approximate shellside	(L)	4378.0
Approximate tubeside	(L)	3427.8

Shell Construction Information						
TEMA shell type		BJ12T		Shell ID	(mm)	1200.00
Shells Series	1	Parallel	1	Total area	(m2)	391.093
Passes Shell	1	Tube	4	Eff. area	(m2/shell)	370.691
Shell orientation angle (deg)		0.00				
Impingement present		No				
Pairs seal strips		4		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint		No		Head to support distance (mm)		114.000
Weight estimation Wet/Dry/Bundle				22578.3 / 14777.9 / 7476.63		(kg/shell)

Baffle Information						
Type		Perpend.	Single-Seg.	Baffle cut (% dia)	28.00	
Crosspasses/shellpass			10	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)		480.000	1	24.89	264.000
Inlet spacing	(mm)		480.000	2	0.00	0.000
Outlet spacing	(mm)		968.969			
Baffle thickness	(mm)		12.700			

Tube Information						
Tube type		Plain	Tubecount per shell			804
Overall length	(mm)	6096.	Pct tubes removed (both)			0.25
Effective length	(mm)	5778.	Outside diameter		(mm)	25.400
Total tubesheet	(mm)	204.000	Wall thickness		(mm)	2.110
Area ratio	(out/in)	1.1992	Pitch (mm)	31.7500	Ratio	1.2500
Tube metal		Carbon steel	Tube pattern (deg)			45

Shellside Performance	
Nom vel, X-flow/window	0.77 / 0.84
Flow fractions for heat transfer	0.819
A=0.0548 B=0.6756 C=0.1375 E=0.1321 F=0.0000	

Shellside Heat Transfer Corrections				
Total	Beta	Gamma	End	Fin
0.982	0.920	1.068	0.918	1.000

Pressure Drops (Percent of Total)					
Cross	Window	Ends	Nozzle	Shell	Tube
38.69	15.50	28.03	Inlet	8.49	3.98
MOMENTUM		0.00	Outlet	9.30	2.61

Two-Phase Parameters				
Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.995	1.012
Midpoint	Prandtl no.	5.66	12.42
Midpoint	Reynolds no.	32047	5471
Bundle inlet	Reynolds no.	34324	3911
Bundle outlet	Reynolds no.	16515	6688
Fouling layer	(mm)		

Thermal Resistance				
Shell	Tube	Fouling	Metal	Over Des
13.32	73.42	11.14	2.13	80.39
Total fouling resistance				2.157e-4
Differential resistance				0.00156

Shell Nozzles				Liquid
Inlet at channel end-Yes		Inlet	Outlet	Outlet
Number at each position		1	1	0
Diameter	(mm)	581.600	380.400	
Velocity	(m/s)	1.14	1.33	
Pressure drop	(kPa)	1.365	1.495	
Height under nozzle	(mm)	71.687	71.687	
Nozzle R-V-SQ	(kg/m-s2)	1204.27	1641.14	
Shell ent.	(kg/m-s2)	1998.06	1628.23	

Tube Nozzle		Inlet	Outlet	Liquid
		RADIAL	RADIAL	Outlet
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	0.46	0.47	
Pressure drop	(kPa)	0.120	0.079	
Nozzle R-V-SQ	(kg/m-s2)	218.63	225.50	

Annular Distributor		Inlet	Outlet
Length	(mm)		
Height	(mm)		
Slot area	(mm2)		

Diametral Clearances (mm)		
Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
6.3500	123.500	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/07/30 8:30 SN: 1500213869 — MEG Energy Units

Min. Case. : Shell 2

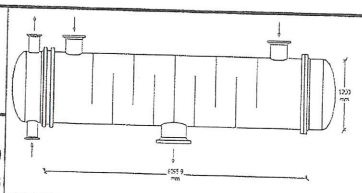
Rating - Horizontal Multipass Flow TEMA BJ21T Shell With Single-Segmental Baffles

Process Data

		Hot Shellside		Cold Tubeside	
Fluid name		Emulsion		TEG/Water(60/40wt%)	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		1011612		79329.3
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	141.20	137.60	40.00	92.25
Temperature, Average/Skin	(Deg C)	139.40	134.52	66.13	129.78
Wall temperature, Min/Max	(Deg C)	132.64	136.92	131.72	136.33
Pressure, In/Average	(kPa)	1002.95	994.897	994.015	992.361
Pressure drop, Total/Allowed	(kPa)	16.095	55.000	3.307	100.000
Velocity, Mid/Max allow	(m/s)	0.77		0.29	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		3811.09		366.94
Heat transfer safety factor	(--)		0.830		1.000
Fouling resistance	(m2-K/W)		0.000000		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	147.69 /	279.97 /	264.02
Heat duty, Calculated/Specified	(kW)	3814. /		
Effective overall temperature difference	(Deg C)	69.8		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	69.78 *	0.9996 *	1.0000



Exchanger Fluid Volumes

Approximate shellside	(L)	4378.0
Approximate tubeside	(L)	3427.8

Shell Construction Information

TEMA shell type	BJ21T		Shell ID	(mm)	1200.00
Shells Series	1 Parallel	1	Total area	(m2)	391.093
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	370.691
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	4		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Head to support distance (mm)	114.000	
Weight estimation Wet/Dry/Bundle	22579.2 /	14778.7 /	7477.46 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	28.00	
Crosspasses/shellpass		10	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	480.000	1	24.89	264.000
Inlet spacing	(mm)	968.969	2	0.00	0.000
Outlet spacing	(mm)	480.000			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		804
Overall length	(mm)	6096.	Pct tubes removed (both)		0.25
Effective length	(mm)	5778.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	204.000	Wall thickness	(mm)	2.110
Area ratio	(out/in)	1.1992	Pitch (mm)	31.7500 Ratio	1.2500
Tube metal	Carbon steel		Tube pattern (deg)		45

Shellside Performance

Nom vel, X-flow/window 0.77 / 0.84

Flow fractions for heat transfer 0.819

A=0.0541 B=0.6759 C=0.1377 E=0.1323 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.982	0.920	1.068	1.019	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
38.74	15.49	28.03	Inlet	9.29	3.49
MOMENTUM		0.00	Outlet	8.45	2.31

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters

		Shell	Tube
Overall wall correction		0.994	1.065
Midpoint	Prandtl no.	5.82	28.59
Midpoint	Reynolds no.	31099	2290
Bundle inlet	Reynolds no.	16521	1456
Bundle outlet	Reynolds no.	32800	3768
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
6.93	86.29	5.70	1.09	78.77

Total fouling resistance 2.157e-4

Differential resistance 0.00298

Shell Nozzles

		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	380.400	581.600	
Velocity	(m/s)	1.33	1.13	
Pressure drop	(kPa)	1.495	1.359	
Height under nozzle	(mm)	71.687	71.687	
Nozzle R-V-SQ	(kg/m-s2)	1641.14	1197.69	
Shell ent.	(kg/m-s2)	1628.24	1987.16	

Tube Nozzle

		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	0.44	0.46	
Pressure drop	(kPa)	0.115	0.077	
Nozzle R-V-SQ	(kg/m-s2)	209.78	218.63	

Annular Distributor

		Inlet	Outlet
Length	(mm)		
Height	(mm)		
Slot area	(mm2)		

Diametral Clearances (mm)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
6.3500	123.500	0.3969