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.: E0351-3AE324-P-02	Rev: 1	Date Rec'd
Doc. Title: L53.51, L53.53 - THERMAL DESIGN CALCULATION - Tag:3A-E-324A/B			2013/09/04
Client Code:	Project: MEG Phase 3A EPC		
Reviewed by: SS Date: 11-Sept-2013	Document No P-5310-01-0038		Submittal 02

SEWON CELLONTECH	DOCUMENT FOR EQUIPMENT	SWC JOB NO	E-0351
		ITEM NO.	3A-E-324A/B
		SWC DOC. NO.	E0351-3AE324-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-324A/B	MP BLOWDOWN / GLYCOL EXCHANGER

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

- Total Sheet : 21 Sheet (Including This Cover)

1	M. K. Park 8/16/2013	T. W. Kim 8/19 '13	Y. S. Ji 8/21/2013	SECOND ISSUE
0	M.K.PARK	T.W.KIM	Y.S.JI	FIRST ISSUED
REV	PREPARED BY	REVIEWED BY	APPROVED BY	DESCRIPTION

SEWON CELLONTECH CO.,LTD.

SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

CUSTOMER	MEG Energy Corp.
LOCATION	CANADA
JOB NO.	511036
SERVICE	MP Blowdown / Glycol Exchanger
ITEM NO.	3A-E-324A/B (Max Duty 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 850.0 ID - 4,877.0 L

Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type AET | TEMA Class R | Effective Area 129.43 m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			TEG/Water (60/40 wt%)		MP Blowdown	
Total Fluid	kg/hr		433727		207611	
Vapor	kg/hr	MW				
Liquid	kg/hr	MW	433727	433727	207611	207611
Steam	kg/hr					
Water	kg/hr				207611	207611
Noncondendable	kg/hr	MW				
Operating Temperature	℃		40.00	105.00	200.00	95.00
Operating Pressure	kPaa		994.015		1555.02	
Density	kg/m3	L / V	1078.0	1026.0	864.65	962.53
Viscosity	cP	L / V	4.6640	1.3460	0.1343	0.2976
Thermal Conductivity	W/m·℃	L / V	0.3281	0.3401	0.0635	0.0765
Specific Heat	kJ/kg·℃	L / V	3.2231	3.4561	4.4941	4.2075
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPaa / ℃		/	/	/	/
Velocity	m/sec		1.07		2.01	
Pressure Drop	kPa.		Allow. 100.000	Calc. 86.141	Allow. 120.000	Calc. 109.825
Fouling Resistance	m2·℃/kW		0.088		0.176	
Film Coefficient	W/m2·K		4,194.01		13,243.20	
Overall Coefficient	W/m2·K		Clean 2704.25	Calc. 1492.13	Design 1458.15	
Heat Duty	KW		26,147.00		LMTD ℃	MTD 69.3 ℃

CONSTRUCTION

Design Pressure / Design Temperature	1500.0 / FV kPa.G	-29 / 214 ℃	1950.0 / FV kPa.G	-29 / 214 ℃
No. of Passes	1		4	

Tubes No. 352 / Shell, Size 25.40 mm, Thickness 2.11 (Min.) mm (BWG : 14) Length 4,877.0 mm

Shell 850 mm ID | Tube Pitch 31.75 mm, Layout angle 90 °, Leffective - mm

Baffles Cross Baffle 8+1S (Note 9) ea / Shell, Type Single Seg. (Hori.), Cut 25.0 % Dia., Spacing c/c 450.0 mm, End - mm

ρv²	Inlet Nozzle	2,870.52, Entrance 3,098.62, Outlet Nozzle 3,016.01 kg/m·sec2		Impingement plate	Circular Plate
Material	Tube	SA 179 Seamless	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	Tube Joints :	Rolled (two grooves) and Expanded
Insulation	Shell side 64 mm		Tube side 64 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	S1	1	12		T1	1	8	
Outlet	S2	1	12		T2	1	8	
Vent				(Note 8)				(Note 8)
Drain				(Note 8)				(Note 8)
Thermowell								
Util. Con.								
RATING	RFWN 300#				RFWN 300#			

Remarks

1) Seller shall verify and guarantee thermal rating of the unit.
2) Ribbon flow pass arrangement shall be used.
3) Unit shell side inlet nozzle is located near the channel head.
4) Exchanger is to be designed for future field hydrotest in the fully corroded condition.
5) Exchangers to be designed for liquid full condition at S.G. = 1.079.
6) 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 a non-hazardous area.
7) Seller is to supply and install 64mm thick mineral fiber insulation.
8) Each process nozzle shall be provided with one 1" 300# RFLWN (complete with blind flange, gasket, bolts & nuts).
9) Seller to provide floating head support plate.
10) Exchangers shall be stacked. Per API 660, exchangers shall be hydrotested stacked.
11) 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.					
LOCATION	CANADA	0	-	-	-	07-01-2013
JOB NO.	511036	1	-	-	-	08-14-2013
SERVICE	MP Blowdown / Glycol Exchanger					
ITEM NO.	3A-E-324A/B (Min Duty Case)					

Total 2 Shells, Connected in 1 Parallel 2 Series Shells	Install ■ Hor. □ Vert.	Size	850.0 ID - 4,877.0 L
Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type AET	TEMA Class R	Effective Area	129.43 m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			TEG/Water (60/40 wt%)		MP Blowdown	
Total Fluid	kg/hr		322586		154412	
Vapor	kg/hr	MW				
Liquid	kg/hr	MW	322586	322586	154412	154412
Steam	kg/hr					
Water	kg/hr				154412	154412
Noncondendable	kg/hr	MW				
Operating Temperature	℃		40.00	105.00	200.00	95.00
Operating Pressure	kPaa		994.015		1555.02	
Density	kg/m3	L / V	1078.0	1026.0	864.65	962.54
Viscosity	cP	L / V	4.6610	1.3460	0.1343	0.2976
Thermal Conductivity	W/m·℃	L / V	0.3281	0.3401	0.6635	0.6765
Specific Heat	kJ/kg·℃	L / V	3.2231	3.4561	4.4941	4.2074
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPaa / ℃		/	/	/	/
Velocity	m/sec		0.81		1.50	
Pressure Drop	kPa.		Allow. 100.000	Calc. 49.135	Allow. 120.000	Calc. 62.423
Fouling Resistance	m2·℃/kW		0.088		0.176	
Film Coefficient	W/m2·K		3,458.90		10,464.30	
Overall Coefficient	W/m2·K		Clean 2251.73	Calc. 1342.45	Design 1084.37	
Heat Duty	KW		19,447.00		LMTD ℃	MTD 69.3 ℃

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

pv²	Inlet Nozzle	1,587.89 , Entrance 1,713.76 , Outlet Nozzle 1,668.36 kg/m·sec2			Impingement plate
Material	Tube		Shell & Cover		Channel & Cover
	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, ℃ Shell	Temperature, ℃ Tube	Pressure, kPa.G Shell	Pressure, kPa.G Tube
Normal Operating	-	-	-	-
Startup	-	-	-	-

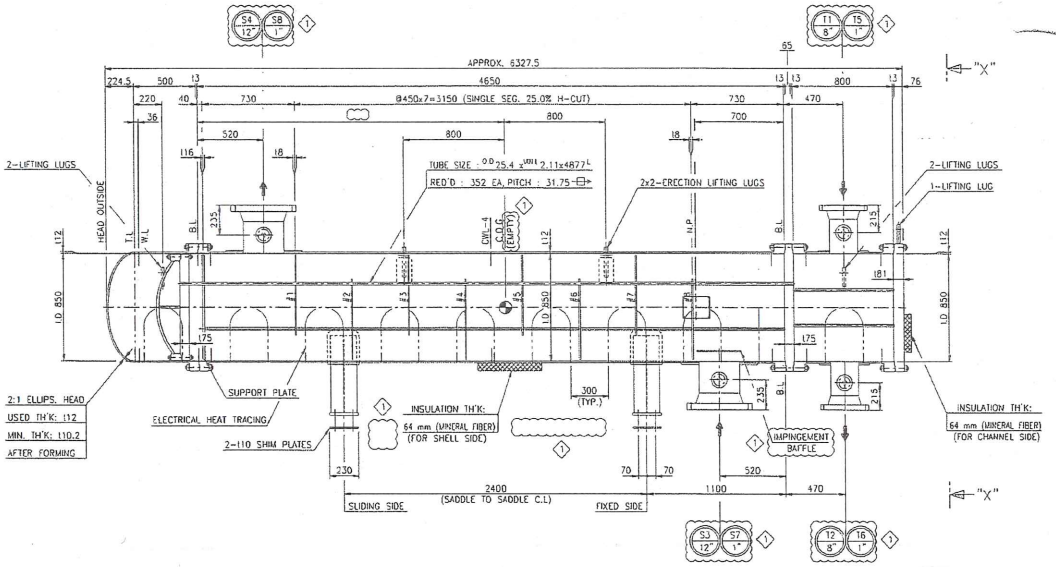
NOZZLE	SHELL SIDE Tag	No	NPS	Remarks	TUBE SIDE Tag	No	NPS	Remarks
Inlet								
Outlet								
Vent								
Drain								
Liquid Outlet								
Thermowell								
Util. Con.								
RATING								

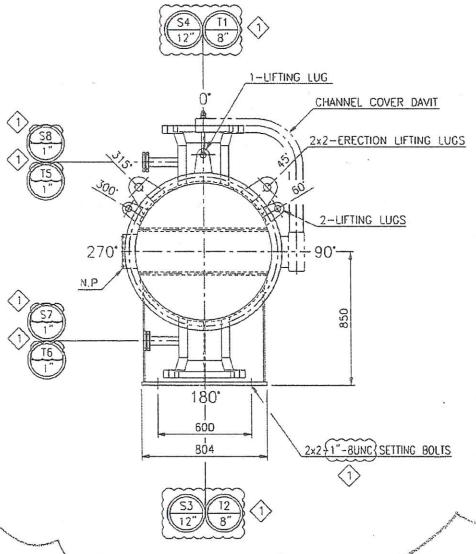
Blowdown Water Analysis

Water Analysis (mg/l as ion unless noted)	Normal	Max.
Ca^{++}	0.36	0.44
Mg^{++}	0.36	0.44
Na^{+}	3707	10709
K^{+}	5.82	36.12
Fe^{++}	4.47	8.29
Mn^{++}	0.22	0.75
Ba^{++}	0.31	3.04
Sr^{++}	0.89	8.22
HCO_3^-	0.0	0.0
CO_3^-	127	333
OH^-	305	775
SO_4^-	18.81	39.60
Cl^-	4929	14529
Silica ppm as SiO_2	214.1	262.1
Sulphides ppm as S^-	0.0	0.0
TOC ppm as TOC	0.48	4.83
TDS ppm as ion	9314	26706
TSS ppm TSS	0.0	0.0
Oil & Grease ppm oil in water	0.0	0.0
Total Hardness ppm as $CaCO_3$	2.36	2.89
P-Alk (ppm as $CaCO_3$)	1004	2559
M-Alk (ppm as $CaCO_3$)	1111	2837
Dissolved O_2	-	-
Estimated pH	12.16	12.61

SEWON CELLONTECH	TUBULAR HEAT EXCHANGER				
					SHEET 4 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	MP Blowdown / Glycol Exchanger					
ITEM NO.	3A-E-324A/B					

Shell 1



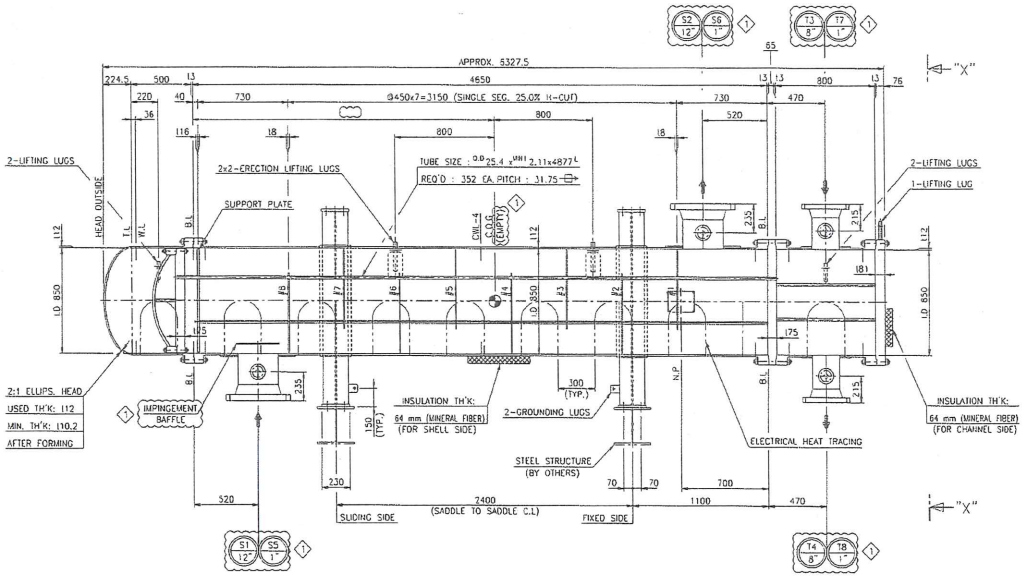


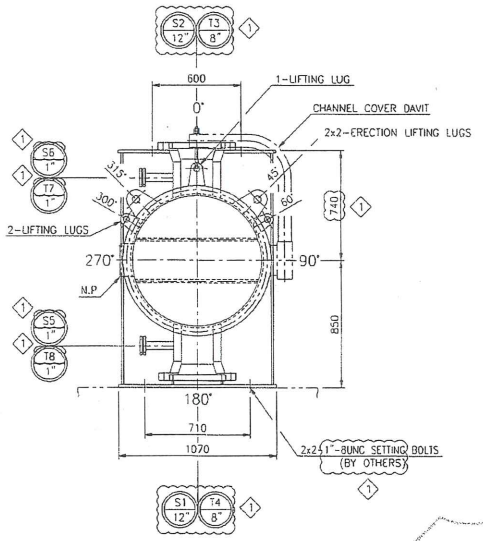
SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

		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	MP Blowdown / Glycol Exchanger					
ITEM NO.	3A-E-324A/B					

Shell 2





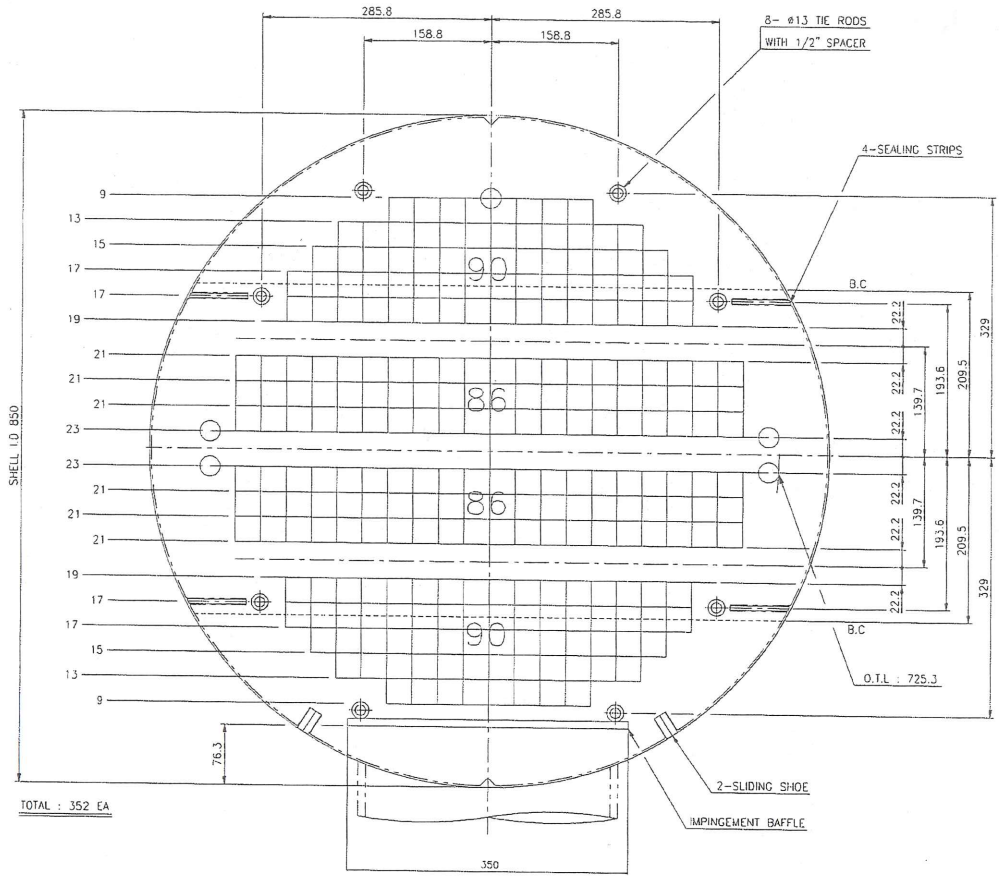
SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 6 OF 21

CUSTOMER	MEG Energy Corp.
LOCATION	CANADA
JOB NO.	511036
SERVICE	MP Blowdown / Glycol Exchanger
ITEM NO.	3A-E-324A/B

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



3A-E-324

1/4

I.D.-SHELL	850.0 ID	(AET)
ALLOWABLE O.T.L	725.3	mm
ACTUAL O.T.L	725.3	mm
SEAL STRIP	2.0	Pairs
SEAL Rod	N/A	ea

TOTAL 352 HOLES FOR 25.4 OD TUBES ON 31.75 SQUARE PITCH.
4 PASSES. BAFFLE CUT SINGLE SEGM. 25% DIA.

Remarks

7/21

Thermal/Hydraulic/ Vibration Verification Report

(Rev.1)

3A-E-324A/B

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

3A-E-324A/B (Max Duty 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 :		2.33	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	86.142	<	100.000 kPa	----------	O.K
	tube-side	109.825	<	120.000 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-324A/B (Max Duty 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)	1178.	900.	1180.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.627	0.479	0.628	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.3531	0.3481	0.3784	< 0.8	O.K
Ave. crossflow velocity ratio	0.3164	0.3119	0.3391	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.181	0.303	0.186	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.183	0.172	< 0.8	O.K
Vortex shedding ratio		0.275	0.247	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.71	1.34	< If velocity is exceed 2.03 / 1.94	O.K.
ρv2 (kg/m-s2)		3098.66	1851.54	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 12:45 SN: 1500213869 — MEG Energy Units

Max.Duty Case : Shell 1

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

1	Shellside condition		Sens. Liquid	(Level 2.3)	
2	Axial stress loading	(MPa)	0.000	Added mass factor	1.517
3	Beta		2.570		

4	Position In The Bundle		Inlet	Center	Outlet
5	Length for natural frequency	(mm)	1178.	900.	1180.
6	Length/TEMA maximum span	(--)	0.627	0.479	0.628
7	Number of spans	(--)	5	5	5
8	Tube natural frequency	(Hz)	57.9 +	63.2	58.0
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**Outlet**
11	Window parallel velocity	(m/s)	1.15	1.17	1.18
12	Bundle crossflow velocity	(m/s)	0.64	1.07	0.66
13	Bundle/shell velocity	(m/s)	0.30	0.50	0.31
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**Outlet**
15	Log decrement	HTRI	0.084	0.081	0.076
16	Critical velocity	(m/s)	2.03	3.44	1.94
17	Baffle tip cross velocity ratio	(--)	0.3531	0.3481	0.3784
18	Average crossflow velocity ratio	(--)	0.3164	0.3119	0.3391
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**Outlet**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**Outlet**
24	Vortex shedding ratio	(--)	0.181	0.303	0.186
25	Parallel flow amplitude	(mm)	0.004	0.005	0.004
26	Crossflow amplitude	(mm)	0.070	0.070	0.073
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	434.81	1197.37	445.15

29	**Bundle Entrance/Exit**			
30	**(analysis at first tube row)**		**Entrance**	**Exit**
31	Fluidelastic instability ratio	(--)	0.183	0.172
32	Vortex shedding ratio	(--)	0.275	0.247
33	Crossflow amplitude	(mm)	0.02472	0.01934
34	Crossflow velocity	(m/s)	0.97	0.88
35	Tubesheet to inlet/outlet support	(mm)	None	None
36	**Shell Entrance/Exit Parameters**		**Entrance**	**Exit**
37	Impingement plate		Yes	
38	Flow area	(m2)	0.067	0.087
39	Velocity	(m/s)	1.71	1.34
40	RHO-V-SQ	(kg/m-s2)	3098.66	1851.54

41	Shell type	AET	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	90	Tube material	Carbon steel
45			Supports/baffle space	

46 **Program Messages**

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

48 * Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case

49 using the procedure described in Online Help; You may find that a vibration problem is unlikely.

50

51

52

53

3A-E-324A/B (Max Duty 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)	1180.	900.	1178.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.628	0.479	0.627	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.3386	0.3336	0.3612	< 0.8	O.K
Ave. crossflow velocity ratio	0.3034	0.2990	0.3237	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.181	0.301	0.185	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.173	0.161	< 0.8	O.K
Vortex shedding ratio		0.269	0.241	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.68	1.31	< If velocity is exceed 2.11 / 2.02	O.K.
ρv2 (kg/m-s2)		3035.89	1798.67	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 12:45 SN: 1500213869 — **MEG Energy Units**

Max.Duty Case : Shell 2
Rating - Horizontal Multipass Flow TEMA AET Shell With Single-Segmental Baffles

1	Shellside condition		Sens. Liquid	(Level 2.3)	
2	Axial stress loading	(MPa)	0.000	Added mass factor	1.517
3	Beta		2.570		
4	**Position In The Bundle**		**Inlet**	**Center**	**Outlet**
5	Length for natural frequency	(mm)	1180.	900.	1178.
6	Length/TEMA maximum span	(--)	0.628	0.479	0.627
7	Number of spans	(--)	5	5	5
8	Tube natural frequency	(Hz)	57.8 +	63.3	58.2
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**Outlet**
11	Window parallel velocity	(m/s)	1.15	1.16	1.17
12	Bundle crossflow velocity	(m/s)	0.64	1.07	0.65
13	Bundle/shell velocity	(m/s)	0.30	0.49	0.30
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**Outlet**
15	Log decrement	HTRI	0.091	0.088	0.083
16	Critical velocity	(m/s)	2.11	3.57	2.02
17	Baffle tip cross velocity ratio	(--)	0.3386	0.3336	0.3612
18	Average crossflow velocity ratio	(--)	0.3034	0.2990	0.3237
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**Outlet**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**Outlet**
24	Vortex shedding ratio	(--)	0.181	0.301	0.185
25	Parallel flow amplitude	(mm)	0.004	0.005	0.004
26	Crossflow amplitude	(mm)	0.070	0.070	0.072
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	440.31	1213.53	451.89
29	**Bundle Entrance/Exit**				
30	**(analysis at first tube row)**			**Entrance**	**Exit**
31	Fluidelastic instability ratio		(--)	0.173	0.161
32	Vortex shedding ratio		(--)	0.269	0.241
33	Crossflow amplitude		(mm)	0.02377	0.01826
34	Crossflow velocity		(m/s)	0.95	0.85
35	Tubesheet to inlet/outlet support		(mm)	None	None
36	**Shell Entrance/Exit Parameters**			**Entrance**	**Exit**
37	Impingement plate			Yes	
38	Flow area		(m2)	0.067	0.087
39	Velocity		(m/s)	1.68	1.31
40	RHO-V-SQ		(kg/m-s2)	3035.89	1798.67

41	Shell type	AET	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	90	Tube material	Carbon steel
45			Supports/baffle space	

46 **Program Messages**

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

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 12:45 SN: 1500213869 **MEG Energy Units**

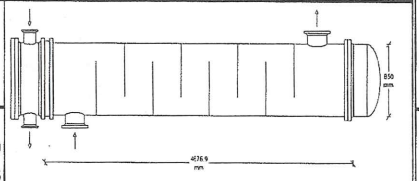
Max.Duty Case : Shell 1

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

Process Data		Cold Shellside		Hot Tubeside	
Fluid name		TEG/Water (60/40 wt%)		MP Blowdown	
Fluid condition		Sens. Liquid		Sens. Liquid	
Total flow rate	(kg/hr)	433727		207611	
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	67.30	105.00	200.00	138.99
Temperature, Average/Skin	(Deg C)	86.15	113.85	169.50	155.79
Wall temperature, Min/Max	(Deg C)	105.16	143.14	109.66	148.43
Pressure, In/Average	(kPa)	949.975	928.928	1555.02	1527.35
Pressure drop, Total/Allowed	(kPa)	42.102	100.000	55.338	120.000
Velocity, Mid/Max allow	(m/s)	1.07		2.06	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		4699.02		14342.3
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000088		0.000176

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	1522.79 /	2945.84 /	1566.09
Heat duty, Calculated/Specified	(kW)	15388. /		
Effective overall temperature difference	(Deg C)	78.1		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	78.29 *	0.9973 *	1.0000



Exchanger Fluid Volumes

Approximate shellside	(L)	1855.0
Approximate tubeside	(L)	1231.6

Shell Construction Information

TEMA shell type	AET		Shell ID	(mm)	850.000
Shells Series	1 Parallel	1	Total area	(m2)	136.985
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	129.430
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	2		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Head to support distance (mm)		113.000
Weight estimation Wet/Dry/Bundle		9874.76 /	6790.28 /	2768.55	(kg/shell)

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	25.00	
Crosspasses/shellpass		9	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	450.000	1	22.33	212.500
Inlet spacing	(mm)	727.975	2	0.00	0.000
Outlet spacing	(mm)	729.975			
Baffle thickness	(mm)	7.938			

Tube Information

Tube type		Plain	Tubecount per shell		352
Overall length	(mm)	4877.	Pct tubes removed (both)		2.27
Effective length	(mm)	4608.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	156.000	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)		90

Shellside Performance

Nom vel, X-flow/window 0.99 / 1.33

Flow fractions for heat transfer 0.804

A=0.1235 B=0.5372 C=0.2368 E=0.1026 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.981	0.919	1.067	0.916	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
48.58	25.15	12.52	Inlet	8.04	4.41
MOMENTUM		0.00	Outlet	5.72	2.61

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters

		Shell	Tube
Overall wall correction		1.065	0.990
Midpoint	Prandtl no.	18.01	1.05
Midpoint	Reynolds no.	21762	239302
Bundle inlet	Reynolds no.	9968	290578
Bundle outlet	Reynolds no.	19291	199962
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
33.33	13.10	46.84	6.74	2.84

Total fouling resistance 2.989e-4

Differential resistance 1.815e-5

Shell Nozzles

		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	295.301	295.301	
Velocity	(m/s)	1.67	1.71	
Pressure drop	(kPa)	3.384	2.407	
Height under nozzle	(mm)	76.350	91.700	
Nozzle R-V-SQ	(kg/m-s2)	2929.88	3016.01	
Shell ent.	(kg/m-s2)	3098.66	1851.54	

Tube Nozzle		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.26	2.11	
Pressure drop	(kPa)	2.438	1.446	
Nozzle R-V-SQ	(kg/m-s2)	4431.71	4130.66	

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

Diametral Clearances (mm)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
4.7625	124.700	0.7938

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 12:45 SN: 1500213869 **MEG Energy Units**

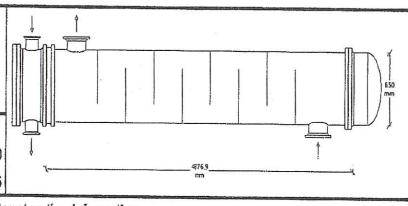
Max.Duty Case : Shell 2

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

Process Data		Cold Shellside		Hot Tubeside	
Fluid name		TEG/Water (60/40 wt%)		MP Blowdown	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		433727		207611
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	40.00	67.30	138.99	95.00
Temperature, Average/Skin	(Deg C)	53.65	77.32	117.00	106.16
Wall temperature, Min/Max	(Deg C)	71.56	105.55	74.82	109.46
Pressure, In/Average	(kPa)	994.015	971.995	1499.70	1472.46
Pressure drop, Total/Allowed	(kPa)	44.040	100.000	54.486	120.000
Velocity, Mid/Max allow	(m/s)	1.07		1.96	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		3749.26		12209.9
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000088		0.000176

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	1393.52 /	2462.80 /	1418.21
Heat duty, Calculated/Specified	(kW)	10759. /		
Effective overall temperature difference	(Deg C)	59.7		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	59.82 *	0.9974 *	1.0000



Exchanger Fluid Volumes

Approximate shellside	(L)	1855.0
Approximate tubeside	(L)	1231.6

Shell Construction Information

TEMA shell type	AET		Shell ID	(mm)	850.000
Shells Series	1 Parallel	1	Total area	(m2)	136.985
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	129.430
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	2		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Head to support distance (mm)		113.000
Weight estimation Wet/Dry/Bundle		9881.56 /	6797.08 /	2775.36	(kg/shell)

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	25.00	
Crosspasses/shellpass		9	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	450.000	1	22.33	212.500
Inlet spacing	(mm)	729.975	2	0.00	0.000
Outlet spacing	(mm)	727.975			
Baffle thickness	(mm)	7.938			

Tube Information

Tube type		Plain	Tubecount per shell		352
Overall length	(mm)	4877.	Pct tubes removed (both)		2.27
Effective length	(mm)	4608.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	156.000	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)		90

Shellside Performance

Nom vel, X-flow/window 0.97 / 1.30

Flow fractions for heat transfer 0.814

A=0.1055 B=0.5476 C=0.2409 E=0.1060 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.981	0.919	1.067	0.900	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
50.10	24.75	11.97	Inlet	7.78	4.17
MOMENTUM		0.00	Outlet	5.39	2.56

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters

		Shell	Tube
Overall wall correction		1.068	0.992
Midpoint	Prandtl no.	33.39	1.53
Midpoint	Reynolds no.	11678	160129
Bundle inlet	Reynolds no.	5638	197031
Bundle outlet	Reynolds no.	10094	132903
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
37.83	13.93	42.41	5.83	1.77

Total fouling resistance 2.989e-4

Differential resistance 1.249e-5

Shell Nozzles

Inlet at channel end-No		Inlet	Outlet	Liquid Outlet
Number at each position		1	1	0
Diameter	(mm)	295.301	295.301	
Velocity	(m/s)	1.63	1.67	
Pressure drop	(kPa)	3.426	2.375	
Height under nozzle	(mm)	76.350	91.700	
Nozzle R-V-SQ	(kg/m-s2)	2870.52	2929.88	
Shell ent.	(kg/m-s2)	3035.89	1798.67	

Tube Nozzle

		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.11	2.03	
Pressure drop	(kPa)	2.272	1.394	
Nozzle R-V-SQ	(kg/m-s2)	4130.80	3981.05	

Annular Distributor

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

Diametral Clearances (mm)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
4.7625	124.700	0.7938

3A-E-324A/B (Min Duty 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 :		**23.80**	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	**49.135**	<	**100.000 kPa**	----------	O.K
	tube-side	**62.423**	<	**120.000 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-324A/B (Min Duty 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)	1178.	900.	1180.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.627	0.479	0.628	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.2640	0.2602	0.2830	< 0.8	O.K
Ave. crossflow velocity ratio	0.2365	0.2332	0.2536	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.135	0.227	0.139	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.136	0.128	< 0.8	O.K
Vortex shedding ratio		0.204	0.184	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.27	1.00	< If velocity is exceed 2.03 / 1.94	O.K.
pv2 (kg/m-s2)		1713.76	1024.22	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 12:47 SN: 1500213869 — **MEG Energy Units**

Min.Duty Case : Shell 1

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

Shellside condition		Sens. Liquid	(Level 2.3)	
Axial stress loading	(MPa)	0.000	Added mass factor	1.517
Beta		2.570		

Position In The Bundle		Inlet	Center	Outlet
Length for natural frequency	(mm)	1178.	900.	1180.
Length/TEMA maximum span	(--)	0.627	0.479	0.628
Number of spans	(--)	5	5	5
Tube natural frequency	(Hz)	57.9 +	63.2	58.0
Shell acoustic frequency	(Hz)			

Flow Velocities		Inlet	Center	Outlet
Window parallel velocity	(m/s)	0.86	0.88	0.89
Bundle crossflow velocity	(m/s)	0.48	0.80	0.49
Bundle/shell velocity	(m/s)	0.22	0.37	0.23

Fluidelastic Instability Check		Inlet	Center	Outlet
Log decrement	HTRI	0.084	0.081	0.076
Critical velocity	(m/s)	2.03	3.44	1.94
Baffle tip cross velocity ratio	(--)	0.2640	0.2602	0.2830
Average crossflow velocity ratio	(--)	0.2365	0.2332	0.2536

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

Tube Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	0.135	0.227	0.139
Parallel flow amplitude	(mm)	0.002	0.003	0.002
Crossflow amplitude	(mm)	0.039	0.038	0.040
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	243.19	669.67	249.01

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.136	0.128
Vortex shedding ratio	(--)	0.204	0.184
Crossflow amplitude	(mm)	0.01319	0.01040
Crossflow velocity	(m/s)	0.72	0.65
Tubesheet to inlet/outlet support	(mm)	None	None

Shell Entrance/Exit Parameters		Entrance	Exit
Impingement plate		Yes	
Flow area	(m2)	0.067	0.087
Velocity	(m/s)	1.27	1.00
RHO-V-SQ	(kg/m-s2)	1713.76	1024.22

Shell type	AET	Baffle type	Single-Seg.
Tube type	Plain	Baffle layout	Perpend.
Pitch ratio	1.2500	Tube diameter, (mm)	25.400
Layout angle	90	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-324A/B (Min Duty 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)	1180.	900.	1178.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.628	0.479	0.627	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.2569	0.2530	0.2739	< 0.8	O.K
Ave. crossflow velocity ratio	0.2302	0.2267	0.2454	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.137	0.229	0.140	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.128	0.120	< 0.8	O.K
Vortex shedding ratio		0.200	0.179	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.25	0.97	< If velocity is exceed 2.11 / 2.02	O.K.
pv2 (kg/m-s2)		1679.36	994.78	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 12:47 SN: 1500213869 — **MEG Energy Units**

Min.Duty Case : Shell 2

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

1	Shellside condition		Sens. Liquid	(Level 2.3)	
2	Axial stress loading	(MPa)	0.000	Added mass factor	1.517
3	Beta		2.570		

4	**Position In The Bundle**		**Inlet**	**Center**	**Outlet**
5	Length for natural frequency	(mm)	1180.	900.	1178.
6	Length/TEMA maximum span	(--)	0.628	0.479	0.627
7	Number of spans	(--)	5	5	5
8	Tube natural frequency	(Hz)	57.8 +	63.3	58.2
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**Outlet**
11	Window parallel velocity	(m/s)	0.87	0.88	0.88
12	Bundle crossflow velocity	(m/s)	0.48	0.81	0.50
13	Bundle/shell velocity	(m/s)	0.22	0.37	0.22
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**Outlet**
15	Log decrement	HTRI	0.091	0.088	0.083
16	Critical velocity	(m/s)	2.11	3.57	2.02
17	Baffle tip cross velocity ratio	(--)	0.2569	0.2530	0.2739
18	Average crossflow velocity ratio	(--)	0.2302	0.2267	0.2454
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**Outlet**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**Outlet**
24	Vortex shedding ratio	(--)	0.137	0.229	0.140
25	Parallel flow amplitude	(mm)	0.002	0.003	0.002
26	Crossflow amplitude	(mm)	0.040	0.039	0.041
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	253.46	698.42	260.07

29	**Bundle Entrance/Exit**			
30	**(analysis at first tube row)**		**Entrance**	**Exit**
31	Fluidelastic instability ratio	(--)	0.128	0.120
32	Vortex shedding ratio	(--)	0.200	0.179
33	Crossflow amplitude	(mm)	0.01271	0.00983
34	Crossflow velocity	(m/s)	0.71	0.63
35	Tubesheet to inlet/outlet support	(mm)	None	None
36	**Shell Entrance/Exit Parameters**		**Entrance**	**Exit**
37	Impingement plate		Yes	
38	Flow area	(m2)	0.067	0.087
39	Velocity	(m/s)	1.25	0.97
40	RHO-V-SQ	(kg/m-s2)	1679.36	994.78

41	Shell type	AET	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	90	Tube material	Carbon steel
45			Supports/baffle space	

46 **Program Messages**

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

48 * Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case

49 using the procedure described in Online Help; You may find that a vibration problem is unlikely.

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Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 12:47 SN: 1500213869 **MEG Energy Units**

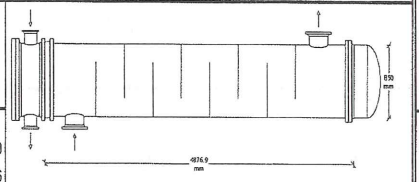
Min.Duty Case : Shell 1

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

Process Data		Cold Shellside		Hot Tubeside	
Fluid name		TEG/Water (60/40 wt%)		MP Blowdown	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		322586		154412
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	67.05	105.00	200.00	138.58
Temperature, Average/Skin	(Deg C)	86.02	116.08	169.29	154.08
Wall temperature, Min/Max	(Deg C)	105.53	144.47	109.64	150.90
Pressure, In/Average	(kPa)	968.938	956.911	1555.02	1539.32
Pressure drop, Total/Allowed	(kPa)	24.059	100.000	31.397	120.000
Velocity, Mid/Max allow	(m/s)	0.80		1.53	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		3915.43		11324.3
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000088		0.000176

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	1141.45 /	2473.20 /	1421.65
Heat duty, Calculated/Specified	(kW)	11520. /		
Effective overall temperature difference	(Deg C)	78.0		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	78.20 *	0.9973 *	1.0000



Exchanger Fluid Volumes

Approximate shellside	(L)	1855.0
Approximate tubeside	(L)	1231.6

Shell Construction Information

TEMA shell type	AET		Shell ID	(mm)	850.000
Shells Series	1 Parallel	1	Total area	(m2)	136.985
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	129.430
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	2		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Head to support distance (mm)		113.000
Weight estimation Wet/Dry/Bundle		9874.76 /	6790.28 /	2768.55	(kg/shell)

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	25.00	
Crosspasses/shellpass		9	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	450.000	1	22.33	212.500
Inlet spacing	(mm)	727.975	2	0.00	0.000
Outlet spacing	(mm)	729.975			
Baffle thickness	(mm)	7.938			

Tube Information

Tube type		Plain	Tubecount per shell		352
Overall length	(mm)	4877.	Pct tubes removed (both)		2.27
Effective length	(mm)	4608.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	156.000	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)		90

Shellside Performance

Nom vel, X-flow/window 0.74 / 0.99

Flow fractions for heat transfer 0.808

A=0.1162 B=0.5402 C=0.2393 E=0.1044 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.981	0.919	1.067	0.916	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
49.36	24.89	12.27	Inlet	7.90	4.29
MOMENTUM		0.00	Outlet	5.57	2.55

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		1.070	0.988
Midpoint	Prandtl no.	18.08	1.05
Midpoint	Reynolds no.	16193	177705
Bundle inlet	Reynolds no.	7414	216168
Bundle outlet	Reynolds no.	14414	148231
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
36.31	15.06	42.52	6.12	24.55
Total fouling resistance				2.989e-4
Differential resistance				1.727e-4

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	295.301	295.301	
Velocity	(m/s)	1.24	1.28	
Pressure drop	(kPa)	1.902	1.340	
Height under nozzle	(mm)	76.350	91.700	
Nozzle R-V-SQ	(kg/m-s2)	1620.41	1668.36	
Shell ent.	(kg/m-s2)	1713.76	1024.22	

Tube Nozzle		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	1.68	1.57	
Pressure drop	(kPa)	1.348	0.800	
Nozzle R-V-SQ	(kg/m-s2)	2451.49	2284.07	

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

Diametral Clearances (mm)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
4.7625	124.700	0.7938

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 12:47 SN: 1500213869 **MEG Energy Units**

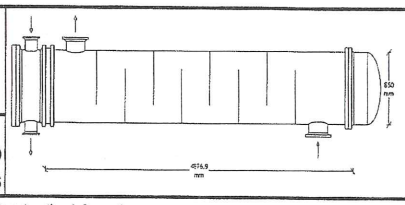
Min.Duty Case : Shell 2

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

Process Data		Cold Shellside		Hot Tubeside	
Fluid name		TEG/Water (60/40 wt%)		MP Blowdown	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		322586		154412
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	40.00	67.05	138.58	95.00
Temperature, Average/Skin	(Deg C)	53.52	79.26	116.79	104.93
Wall temperature, Min/Max	(Deg C)	72.80	106.95	75.69	110.39
Pressure, In/Average	(kPa)	994.015	981.476	1523.65	1508.14
Pressure drop, Total/Allowed	(kPa)	25.076	100.000	31.026	120.000
Velocity, Mid/Max allow	(m/s)	0.81		1.46	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		3057.91		9640.41
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000088		0.000176

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	1027.30 /	2030.42 /	1263.29
Heat duty, Calculated/Specified	(kW)	7927. /		
Effective overall temperature difference	(Deg C)	59.6		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	59.78 *	0.9974 *	1.0000



Exchanger Fluid Volumes

Approximate shellside	(L)	1855.0
Approximate tubeside	(L)	1231.6

Shell Construction Information

TEMA shell type	AET		Shell ID	(mm)	850.000
Shells Series	1 Parallel	1	Total area	(m2)	136.985
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	129.430
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	2		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Head to support distance (mm)		113.000
Weight estimation Wet/Dry/Bundle		9881.61 /	6797.13 /	2775.40	(kg/shell)

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	25.00	
Crosspasses/shellpass		9	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	450.000	1	22.33	212.500
Inlet spacing	(mm)	729.975	2	0.00	0.000
Outlet spacing	(mm)	727.975			
Baffle thickness	(mm)	7.938			

Tube Information

Tube type		Plain	Tubecount per shell		352
Overall length	(mm)	4877.	Pct tubes removed (both)		2.27
Effective length	(mm)	4608.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	156.000	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)		90

Shellside Performance

Nom vel, X-flow/window 0.72 / 0.97

Flow fractions for heat transfer 0.822

A=0.0941 B=0.5586 C=0.2400 E=0.1072 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.981	0.919	1.067	0.904	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
50.43	24.80	11.78	Inlet	7.71	4.05
MOMENTUM		0.00	Outlet	5.28	2.48

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters

		Shell	Tube
Overall wall correction		1.073	0.991
Midpoint	Prandtl no.	33.55	1.53
Midpoint	Reynolds no.	8724	118899
Bundle inlet	Reynolds no.	4234	146086
Bundle outlet	Reynolds no.	7541	98837
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
41.31	15.72	37.78	5.19	22.97
Total fouling resistance				2.989e-4
Differential resistance				1.818e-4

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-No		1	1	0
Number at each position				
Diameter	(mm)	295.301	295.301	
Velocity	(m/s)	1.21	1.24	
Pressure drop	(kPa)	1.932	1.325	
Height under nozzle	(mm)	76.350	91.700	
Nozzle R-V-SQ	(kg/m-s2)	1587.89	1620.41	
Shell ent.	(kg/m-s2)	1679.36	994.78	

Tube Nozzle		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	1.57	1.51	
Pressure drop	(kPa)	1.256	0.771	
Nozzle R-V-SQ	(kg/m-s2)	2284.12	2202.18	

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

Diametral Clearances (mm)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
4.7625	124.700	0.7938