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.: E0351-3AE111-P-02	Rev: 1	Date Rec'd 2013/09/04
Doc. Title: L53.51, L53.53 - THERMAL DESIGN CALCULATION - Tag:3A-E-111A-H			
Client Code:	Project: MEG Phase 3A EPC		
Reviewed by: SS Date: 11-Sept-2013	Document No P-5310-01-0035		Submittal 02

SEWON CELLONTECH	DOCUMENT FOR EQUIPMENT	SWC JOB NO	E-0351
		ITEM NO.	3A-E-111 A TO H
		SWC DOC. NO.	E0351-3AE111 A TO H-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-111 A TO H	SALES OIL / GLYCOL EXCHANGER

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

• Total Sheet 41 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	Sales Oil / Glycol Exchanger
ITEM NO.	3A-E-111 A to H (Max UA Case)

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

Total 8 Shells, Connected in 2 Parallel 4 Series Shells | Install ■ Hor. □ Vert. | Size 1,143.0 ID - 8,534.0 L

Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type BEU | TEMA Class R | Effective Area 556.41 m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			BP Frac Dilbit		TEG/Water (60%/40% wt)	
Total Fluid	kg/hr		444696		527298	
Vapor	kg/hr	MW				
Liquid	kg/hr	MW	444696	444696	527298	527298
Steam	kg/hr					
Water	kg/hr					
Noncondendable	kg/hr	MW				
Operating Temperature	℃		117.90	49.70	40.00	75.00
Operating Pressure	kPaa		984.014		994.015	
Density	kg/m3	L / V	875	921	1078.00	1052.00
Viscosity	cP	L / V	13.580	195.68	4.6600	2.0900
Thermal Conductivity	W/m·℃	L / V	0.1031	0.1167	0.3281	0.3371
Specific Heat	kJ/kg·℃	L / V	2.1040	1.8400	3.2231	3.3481
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPaa / ℃		/	/	/	/
Velocity	m/sec		0.31		0.98	
Pressure Drop	kPa.		Allow. 250.000	Calc. 217.538	Allow. 200.000	Calc. 174.675
Fouling Resistance	m2·℃/kW		0.616		0.18	
Film Coefficient	W/m2·K		318.71		1,446.88	
Overall Coefficient	W/m2·K		Clean 249.85	Calc. 206.70	Design 175.27	
Heat Duty	KW		12,630.00		LMTD ℃	MTD 21.6 ℃

CONSTRUCTION

Design Pressure / Design Temperature	1450.0 / FV kPa.G	-29 / 178 ℃	1500.0 / FV kPa.G	-29 / 178 ℃
No. of Passes	1		4	

Tubes No. 396U / Shell, Size 25.40 mm, Thickness 2.11 (Min.) mm (BWG : 14) Length 8,534.0 mm

Shell 1143 mm ID | Tube Pitch 31.75 mm, Layout angle 45 °, Leffective - mm

Baffles Cross Baffle 16 ea / Shell, Type Single Seg. (Hori.), Cut 24.5 % Dia., Spacing c/c 486.0 mm, End - mm

pv^2 Inlet Nozzle 2,031.69, Entrance 2,509.52, Outlet Nozzle 1,928.73 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	10		T1	1	8	
Outlet	S2	1	10		T2	1	8	
Vent				(Note 5)				(Note 5)
Drain				(Note 5)				(Note 5)
Thermowell								
Util. Con.								
RATING	RFWN 300#				RFWN 300#			

Remarks

1) Seller shall verify and guarantee thermal rating of the unit.
2) Mass flow and duty will be split into two parallel trains.
3) Exchangers shall be stacked two high.
4) Minimum 20 pass lane seal rods.
5) Each process nozzle shall be provided with one 1" 300# RFLWN (complete with blind flange, gasket, bolts & nuts).
6) Exchanger is to be designed for future field hydrotest in the fully corroded condition.
7) Seller is to design and install electrical heat tracing for hold temperature of 10℃.
CSA approval is required for electric components and installation. The heat exchanger is located in hazardous area class 1, Zone 2.
8) Seller is to supply and install 64mm thick mineral fiber insulation.
9) Exchangers that are to be stacked shall be hydrotested stacked.
10) Concentration of CO2 and H2S is the liquid phase is 73 ppmw and 8 ppmw respectively.
11) delete
12) All catergory D welds shall be spot ultrasonic examined.
13) Baffle to shell clearance shall be 4.8mm or less.
14) EHT design shall use voltage of 277 VAC.

SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

CUSTOMER	MEG Energy Corp.
LOCATION	CANADA
JOB NO.	511036
SERVICE	Sales Oil / Glycol Exchanger
ITEM NO.	3A-E-111 A to H (Max Duty Case)

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

Total 8 Shells, Connected in 2 Parallel 4 Series Shells | Install ■ Hor. □ Vert. | Size 1,143.0 ID - 8,534.0 L

Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type BEU | TEMA Class R | Effective Area 556.41 m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			BP Frac Dilbit		TEG/Water (60%/40% wt)	
Total Fluid	kg/hr		457483		589132	
Vapor	kg/hr	MW				
Liquid	kg/hr	MW	457483	457483	589132	589132
Steam	kg/hr					
Water	kg/hr					
Noncondendable	kg/hr	MW				
Operating Temperature	℃		126.00	52.70	40.00	75.00
Operating Pressure	kPaa		984.014		994.015	
Density	kg/m3	L / V	870.0	920	1078.00	1052.00
Viscosity	cP	L / V	9.4400	127.91	4.6600	2.0900
Thermal Conductivity	W/m·℃	L / V	0.1058	0.1193	0.3281	0.3371
Specific Heat	kJ/kg·℃	L / V	2.1330	1.8500	3.2231	3.3481
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPaa / ℃		/	/	/	/
Velocity	m/sec		0.33		1.10	
Pressure Drop	kPa.		Allow. 250.000	Calc. 175.705	Allow. 225.000	Calc. 212.167
Fouling Resistance	m2·℃/kW		0.616		0.18	
Film Coefficient	W/m2·K		339.86		1,678.93	
Overall Coefficient	W/m2·K		Clean 270.88	Calc. 220.83	Design 155.44	
Heat Duty	KW		14,112.00		LMTD ℃	MTD 27.2 ℃

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	2,162.01	Entrance	2,670.48	Outlet Nozzle	2,044.30	kg/m·sec2

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, ℃		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								
Thermowell								
Util. Con.								
RATING								

Remarks

SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 4 OF 47

CUSTOMER	MEG Energy Corp.
LOCATION	CANADA
JOB NO.	511036
SERVICE	Sales Oil / Glycol Exchanger
ITEM NO.	3A-E-111 A to H (Min Duty Case)

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

Total 8 Shells, Connected in 2 Parallel 4 Series Shells | Install ■ Hor. □ Vert. | Size 1,143.0 ID - 8,534.0 L

Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type BEU | TEMA Class R | Effective Area 556.41 m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			BP Frac Dilbit		TEG/Water (60%/40% wt)	
Total Fluid	kg/hr		404707		478370	
Vapor	kg/hr	MW				
Liquid	kg/hr	MW	404707	404707	478370	478370
Steam	kg/hr					
Water	kg/hr					
Noncondendable	kg/hr	MW				
Operating Temperature	℃		131.10	64.70	40.00	75.00
Operating Pressure	kPaa		984.014		994.015	
Density	kg/m3	L / V	884 /	927 /	1078.00 /	1052.00 /
Viscosity	cP	L / V	7.4200 /	61.730 /	4.6610 /	2.0890 /
Thermal Conductivity	W/m·℃	L / V	0.1133 /	0.1200 /	0.3281 /	0.3371 /
Specific Heat	kJ/kg·℃	L / V	2.1440 /	1.8890 /	3.2231 /	3.3481 /
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPaa / ℃		/	/	/	/
Velocity	m/sec		0.29		0.89	
Pressure Drop	kPa.		Allow. 250.000	Calc. 106.688	Allow. 275.000	Calc. 145.876
Fouling Resistance	m2·℃/kW		0.616		0.18	
Film Coefficient	W/m2·K		349.98		1,330.61	
Overall Coefficient	W/m2·K		Clean 263.80	Calc. 215.96	Design 89.89	
Heat Duty	KW		11,459.00		LMTD ℃	MTD 38.2 ℃

CONSTRUCTION

Design Pressure	Design Temperature	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

pv^2 Inlet Nozzle 1,665.51 , Entrance 2,057.22 , Outlet Nozzle 1,587.74 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, ℃ Shell	Tube	Pressure, kPa.G Shell	Tube
Normal Operating	-	-	-	-
Startup	-	-	-	-

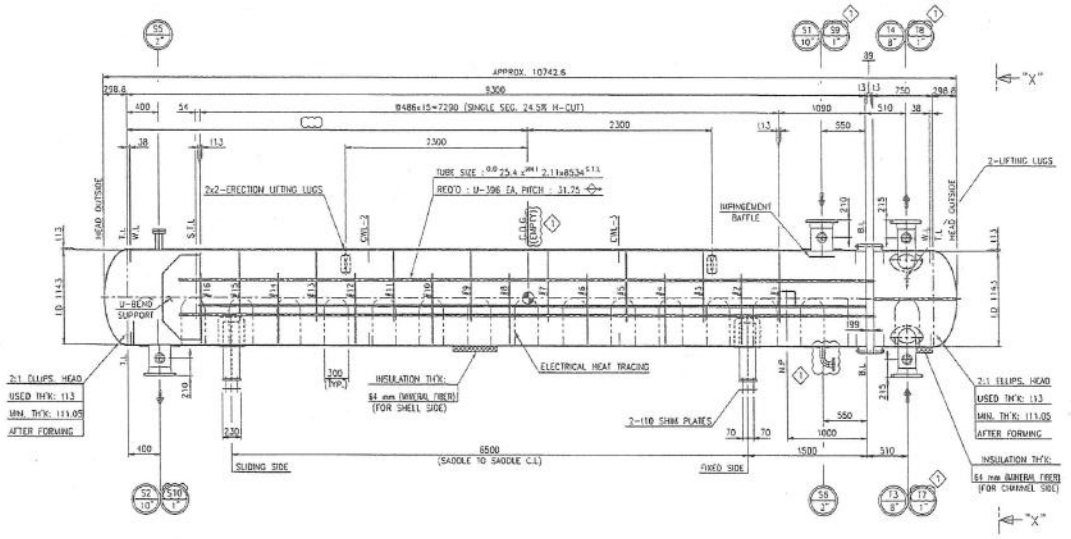
NOZZLE	SHELL SIDE Tag	No	NPS	Remarks	TUBE SIDE Tag	No	NPS	Remarks
Inlet								
Outlet								
Vent								
Drain								
Thermowell								
Util. Con.								
RATING								

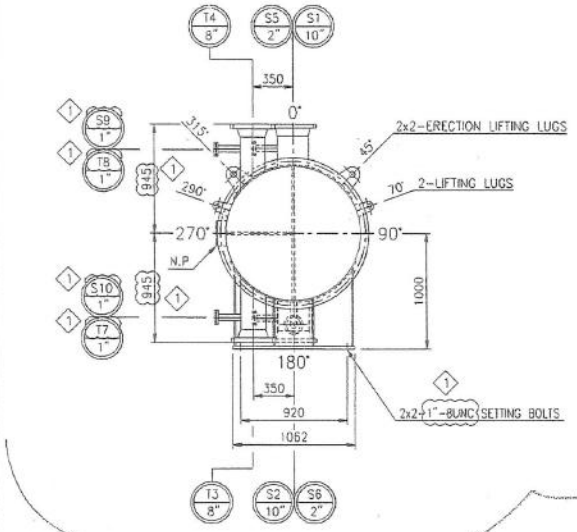
Remarks

SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

		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	Sales Oil / Glycol Exchanger					
ITEM NO.	3A-E-111 A to H					



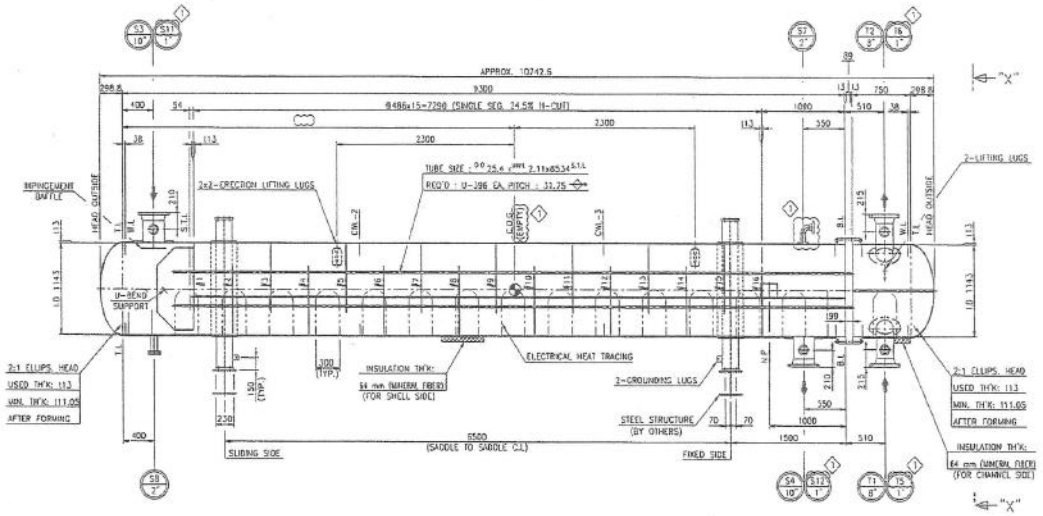


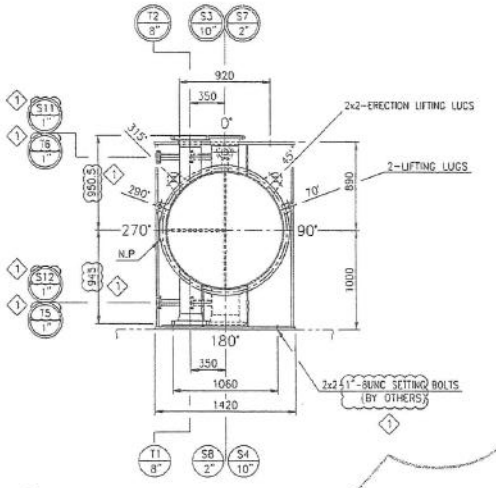
SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

CUSTOMER	MEG Energy Corp.
LOCATION	CANADA
JOB NO.	511036
SERVICE	Sales Oil / Glycol Exchanger
ITEM NO.	3A-E-111 A to H

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

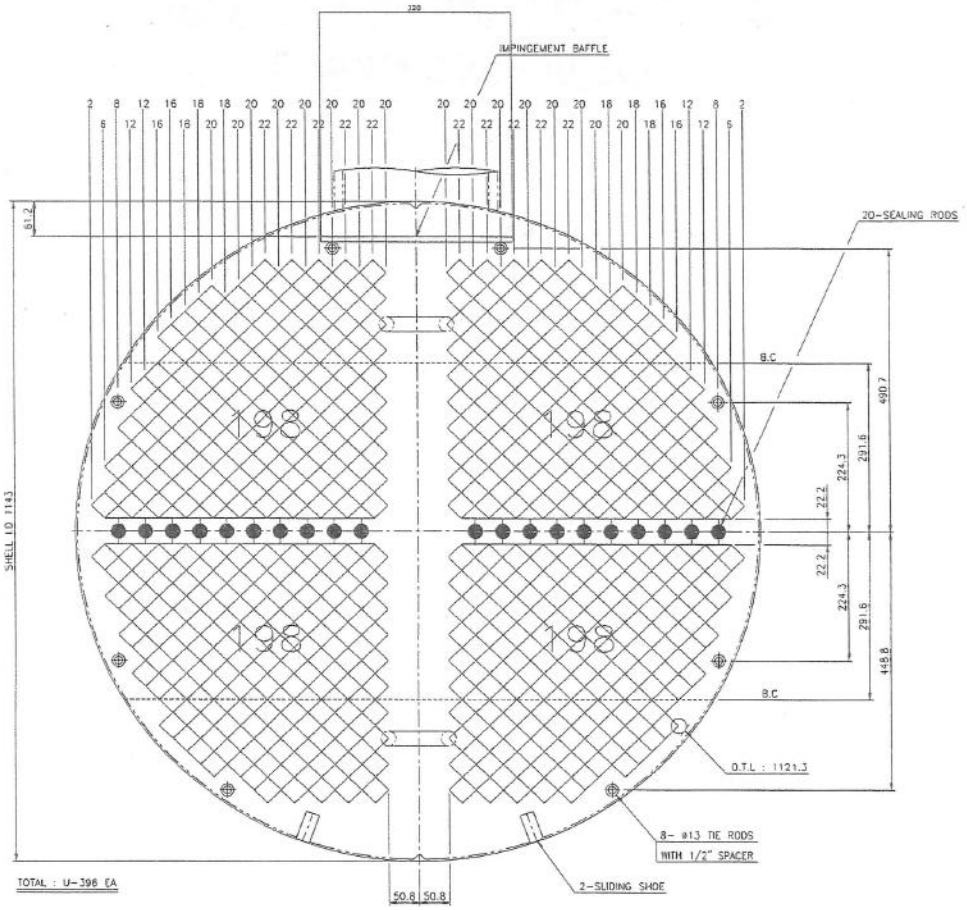




SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

		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	Sales Oil / Glycol Exchanger					
ITEM NO.	3A-E-111 A to H					



3A-E-111

1/5

I.D.-SHELL	1,143.0 ID	(BEU)
ALLOWABLE O.T.L	1105.8	mm
ACTUAL O.T.L	1121.3	mm
SEAL STRIP	N/A	Pairs
SEAL Rod	20 (Note 4)	ea

TOTAL 396U HOLES FOR 25.4 OD TUBES ON 31.75 SQUARE PITCH.
4 PASSES. BAFFLE CUT SINGLE SEGM. 25.4% DIA.

Remarks

Thermal/Hydraulic/ Vibration Verification Report

(Rev.1)

3A-E-111 A to H

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

3A-E-111 A to H (Max UA 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 :		17.93	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	217.538	<	250.000 kPa	----------	O.K
	tube-side	174.675	<	200.000 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-111 A to H (Max UA Case) - Shell 1

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

VALUE TO BE CHECKED	Inlet	Center	U-Bend	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1574.	972.	1401.	1881 (By TEMA)	O.K
Length / TEMA maximum span	0.837	0.517	0.579	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0758	0.0659	0.0873	< 0.8	O.K
Ave. crossflow velocity ratio	0.0692	0.0601	0.0796	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.062	0.140	0.135	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.108	0.214	< 0.8	O.K.
Vortex shedding ratio		0.311	0.292	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.69	1.06	< If velocity is exceed 2.07 / 2.05	O.K.
pv2 (kg/m-s2)		2509.52	0.00	< 5953 by TEMA	O.K.

11/49

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 9:55 SN: 1500213869 — MEG Energy Units

Max.UA Case : Shell 1
Rating - Horizontal Multipass Flow TEMA BEU 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		3.745		

	Position In The Bundle		Inlet	Center	U-Bend
5	Length for natural frequency	(mm)	1574.	972.	1401.
6	Length/TEMA maximum span	(--)	0.837 *	0.517	0.579
7	Number of spans	(--)	9	9	2
8	Tube natural frequency	(Hz)	34.4	52.5	18.0 +
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**U-Bend**
11	Window parallel velocity	(m/s)	0.55	0.54	0.54
12	Bundle crossflow velocity	(m/s)	9.321e-2	0.21	0.11
13	Bundle/shell velocity	(m/s)	0.12	0.27	0.14
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**U-Bend**
15	Log decrement	HTRI	0.100	0.100	0.100
16	Critical velocity	(m/s)	2.07	5.40	2.05
17	Baffle tip cross velocity ratio	(--)	0.0758	0.0659	0.0873
18	Average crossflow velocity ratio	(--)	0.0692	0.0601	0.0796
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**U-Bend**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**U-Bend**
24	Vortex shedding ratio	(--)	0.062	0.140	0.135
25	Parallel flow amplitude	(mm)	0.001	0.001	0.005
26	Crossflow amplitude	(mm)	0.004	0.003	0.003
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	17.91	93.34	23.88

	Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
31	Fluidelastic instability ratio	(--)	0.108	0.214
32	Vortex shedding ratio	(--)	0.311	0.292
33	Crossflow amplitude	(mm)	0.02362	0.05740
34	Crossflow velocity	(m/s)	0.47	0.44
35	Tubesheet to inlet/outlet support	(mm)	None	None
36	**Shell Entrance/Exit Parameters**		**Entrance**	**Exit**
37	Impingement plate		Yes	
38	Flow area	(m2)	0.042	0.065
39	Velocity	(m/s)	1.69	1.06
40	RHO-V-SQ	(kg/m-s2)	2509.52	0.00

41	Shell type	BEU	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	45	Tube material	Carbon steel
45	Number U-Bend supports	1	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-111 A to H (Max UA Case) - Shell 2

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

VALUE TO BE CHECKED	U-Bend	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1401.	972.	1574.	2420 (By TEMA)	O.K
Length / TEMA maximum span	0.579	0.517	0.837	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0874	0.0653	0.0741	< 0.8	O.K
Ave. crossflow velocity ratio	0.0797	0.0595	0.0676	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.135	0.138	0.060	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.000	0.096	< 0.8	O.K.
Vortex shedding ratio		0.555	0.272	> 0.5	Check Below
				Tube OD = 25.400	
				Tube gap = 6.350	
Crossflow amplitude (mm)		0.05698	0.01805	< 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		23.83	17.24	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		6.735e-2	1.24	< If velocity is exceed 2.05 / 2.04	O.K.
pv2 (kg/m-s2)		0.00	1401.33	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 9:55 SN: 1500213869 — MEG Energy Units

Max.UA Case : Shell 2
Rating - Horizontal Multipass Flow TEMA BEU 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		U-Bend	Center	Outlet
Length for natural frequency	(mm)	1401.	972.	1574.
Length/TEMA maximum span	(--)	0.579	0.517	0.837 *
Number of spans	(--)	2	9	9
Tube natural frequency	(Hz)	18.1 +	52.5	34.3
Shell acoustic frequency	(Hz)			

Flow Velocities		U-Bend	Center	Outlet
Window parallel velocity	(m/s)	0.54	0.54	0.53
Bundle crossflow velocity	(m/s)	0.11	0.21	8.982e-2
Bundle/shell velocity	(m/s)	0.12	0.24	0.10

Fluidelastic Instability Check		U-Bend	Center	Outlet
Log decrement	HTRI	0.100	0.100	0.100
Critical velocity	(m/s)	2.05	5.36	2.04
Baffle tip cross velocity ratio	(--)	0.0874	0.0653	0.0741
Average crossflow velocity ratio	(--)	0.0797	0.0595	0.0676

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

Tube Vibration Check		U-Bend	Center	Outlet
Vortex shedding ratio	(--)	0.135	0.138	0.060
Parallel flow amplitude	(mm)	0.005	0.001	0.001
Crossflow amplitude	(mm)	0.003	0.003	0.004
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	23.83	91.66	17.24

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.000	0.096
Vortex shedding ratio	(--)	0.555	0.272
Crossflow amplitude	(mm)	0.05698	0.01805
Crossflow velocity	(m/s)	0.44	0.41
Tubesheet to inlet/outlet support	(mm)	None	None

Shell Entrance/Exit Parameters		Entrance	Exit
Impingement plate		No	
Flow area	(m2)	1.026	0.055
Velocity	(m/s)	6.735e-2	1.24
RHO-V-SQ	(kg/m-s2)	0.00	1401.33

Shell type	BEU	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
Number U-Bend supports	1	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-111 A to H (Max UA Case) - Shell 3

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

VALUE TO BE CHECKED	Inlet	Center	U-Bend	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1574.	972.	1401.	1881 (By TEMA)	O.K
Length / TEMA maximum span	0.837	0.517	0.579	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0731	0.0638	0.0848	< 0.8	O.K
Ave. crossflow velocity ratio	0.0666	0.0582	0.0773	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.059	0.135	0.130	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.106	0.210	< 0.8	O.K.
Vortex shedding ratio		0.301	0.285	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.63	1.03	< If velocity is exceed 2.05 / 2.04	O.K.
pv2 (kg/m-s2)		2420.99	0.00	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 9:55 SN: 1500213869 — MEG Energy Units

Max.UA Case : Shell 3
Rating - Horizontal Multipass Flow TEMA BEU 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		3.745		
4	**Position In The Bundle**		**Inlet**	**Center**	**U-Bend**
5	Length for natural frequency	(mm)	1574.	972.	1401.
6	Length/TEMA maximum span	(--)	0.837 *	0.517	0.579
7	Number of spans	(--)	9	9	2
8	Tube natural frequency	(Hz)	34.4	52.5	18.1 +
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**U-Bend**
11	Window parallel velocity	(m/s)	0.53	0.53	0.53
12	Bundle crossflow velocity	(m/s)	8.879e-2	0.20	0.10
13	Bundle/shell velocity	(m/s)	7.785e-2	0.18	9.002e-2
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**U-Bend**
15	Log decrement	HTRI	0.100	0.100	0.100
16	Critical velocity	(m/s)	2.05	5.35	2.04
17	Baffle tip cross velocity ratio	(--)	0.0731	0.0638	0.0848
18	Average crossflow velocity ratio	(--)	0.0666	0.0582	0.0773
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**U-Bend**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**U-Bend**
24	Vortex shedding ratio	(--)	0.059	0.135	0.130
25	Parallel flow amplitude	(mm)	0.001	0.001	0.005
26	Crossflow amplitude	(mm)	0.003	0.003	0.003
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	16.84	88.48	22.74
29	**Bundle Entrance/Exit**				
30	**(analysis at first tube row)**			**Entrance**	**Exit**
31	Fluidelastic instability ratio		(--)	0.106	0.210
32	Vortex shedding ratio		(--)	0.301	0.285
33	Crossflow amplitude		(mm)	0.02233	0.05509
34	Crossflow velocity		(m/s)	0.45	0.43
35	Tubesheet to inlet/outlet support		(mm)	None	None
36	**Shell Entrance/Exit Parameters**			**Entrance**	**Exit**
37	Impingement plate			Yes	
38	Flow area		(m2)	0.042	0.065
39	Velocity		(m/s)	1.63	1.03
40	RHO-V-SQ		(kg/m-s2)	2420.99	0.00

41	Shell type	BEU	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	45	Tube material	Carbon steel
45	Number U-Bend supports	1	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

16/44

3A-E-111 A to H (Max UA Case) - Shell 4

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

VALUE TO BE CHECKED	U-Bend	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1401.	972.	1574.	2420 (By TEMA)	O.K
Length / TEMA maximum span	0.579	0.517	0.837	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0802	0.0601	0.0684	< 0.8	O.K
Ave. crossflow velocity ratio	0.0731	0.0548	0.0624	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.123	0.127	0.055	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.000	0.095	< 0.8	O.K.
Vortex shedding ratio		0.542	0.268	> 0.5	Check Below
				Tube OD = 25.400	
				Tube gap = 6.350	
Crossflow amplitude (mm)		0.05491	0.01757	< 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		20.31	14.81	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		6.575e-2	1.22	< If velocity is exceed 2.04 / 2.03	O.K.
pv2 (kg/m-s2)		0.00	1378.96	< 5953 by TEMA	O.K.

4

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 9:55 SN: 1500213869 — MEG Energy Units

Max.UA Case : Shell 4
Rating - Horizontal Multipass Flow TEMA BEU 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		U-Bend	Center	Outlet
Length for natural frequency	(mm)	1401.	972.	1574.
Length/TEMA maximum span	(--)	0.579	0.517	0.837 *
Number of spans	(--)	2	9	9
Tube natural frequency	(Hz)	18.1 +	52.5	34.4
Shell acoustic frequency	(Hz)			

Flow Velocities		U-Bend	Center	Outlet
Window parallel velocity	(m/s)	0.53	0.53	0.53
Bundle crossflow velocity	(m/s)	9.705e-2	0.19	8.259e-2
Bundle/shell velocity	(m/s)	8.063e-2	0.16	6.862e-2

Fluidelastic Instability Check		U-Bend	Center	Outlet
Log decrement	HTRI	0.100	0.100	0.100
Critical velocity	(m/s)	2.04	5.33	2.03
Baffle tip cross velocity ratio	(--)	0.0802	0.0601	0.0684
Average crossflow velocity ratio	(--)	0.0731	0.0548	0.0624

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

Tube Vibration Check		U-Bend	Center	Outlet
Vortex shedding ratio	(--)	0.123	0.127	0.055
Parallel flow amplitude	(mm)	0.005	0.001	0.001
Crossflow amplitude	(mm)	0.003	0.002	0.003
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	20.31	78.48	14.81

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.000	0.095
Vortex shedding ratio	(--)	0.542	0.268
Crossflow amplitude	(mm)	0.05491	0.01757
Crossflow velocity	(m/s)	0.43	0.40
Tubesheet to inlet/outlet support	(mm)	None	None

Shell Entrance/Exit Parameters		Entrance	Exit
Impingement plate		No	
Flow area	(m2)	1.026	0.055
Velocity	(m/s)	6.575e-2	1.22
RHO-V-SQ	(kg/m-s2)	0.00	1378.96

Shell type	BEU	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
Number U-Bend supports	1	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 2013/08/16 9:55 SN: 1500213869 — MEG Energy Units

Max.UA Case : Shell 1

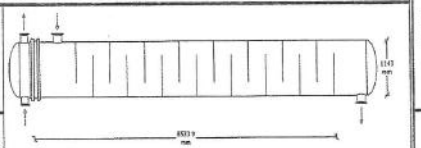
Rating - Horizontal Multipass Flow TEMA BEU Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dibit		TEG/Water (60%/40% wt)	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		444696		527298
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	117.90	90.09	60.26	75.00
Temperature, Average/Skin	(Deg C)	104.00	79.60	67.63	72.82
Wall temperature, Min/Max	(Deg C)	68.67	83.21	68.48	82.79
Pressure, In/Average	(kPa)	984.014	968.540	860.223	839.787
Pressure drop, Total/Allowed	(kPa)	30.949	250.000	40.873	200.000
Velocity, Mid/Max allow	(m/s)	0.32		0.99	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		340.88		1982.25
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	190.69 /	279.40 /	226.71
Heat duty, Calculated/Specified	(kW)	5379. /		
Effective overall temperature difference	(Deg C)	33.8		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	34.16 *	0.9895 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle	26898.8 /	17365.6 /	10099.0 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.45	291.465
Inlet spacing	(mm)	1088.00	2	0.00	0.000
Outlet spacing	(mm)	932.000			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		4.42
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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 0.41 / 0.55

Flow fractions for heat transfer 0.662

A=0.0028 B=0.6030 C=0.0402 E=0.1911 F=0.1628

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.919	0.919	1.000	0.954	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
65.29	16.63	5.79	Inlet	10.69	7.82
MOMENTUM		0.00	Outlet	1.61	5.03

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.853	1.013
Midpoint	Prandtl no.	443.63	23.98
Midpoint	Reynolds no.	347	9198
Bundle inlet	Reynolds no.	260	7802
Bundle outlet	Reynolds no.	126	10581
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
66.51	13.72	18.86	0.92	18.89

Total fouling resistance	8.313e-4
Differential resistance	8.333e-4

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.52	1.49	
Pressure drop	(kPa)	3.308	0.497	
Height under nozzle	(mm)	61.187	1143.00	
Nozzle R-V-SQ	(kg/m-s2)	2031.69	1988.43	
Shell ent.	(kg/m-s2)	2509.52	0.00	

Tube Nozzle		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.34	2.36	
Pressure drop	(kPa)	3.198	2.056	
Nozzle R-V-SQ	(kg/m-s2)	5813.69	5874.22	

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	21.7000	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 9:55 SN: 1500213869 — MEG Energy Units

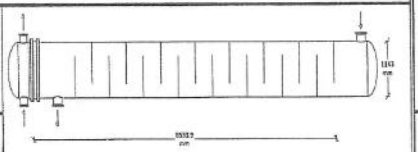
Max.UA Case : Shell 2

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

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		444696		527298
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	90.09	71.17	50.62	60.26
Temperature, Average/Skin	(Deg C)	80.63	63.84	55.44	59.54
Wall temperature, Min/Max	(Deg C)	54.66	65.10	54.52	64.82
Pressure, In/Average	(kPa)	953.080	932.753	903.144	881.681
Pressure drop, Total/Allowed	(kPa)	40.653	250.000	42.927	200.000
Velocity, Mid/Max allow	(m/s)	0.32		0.98	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		314.98		1565.75
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data					
Overall coef., Reqd/Clean/Actual	(W/m2-K)	177.51	/ 251.23	/ 207.80	
Heat duty, Calculated/Specified	(kW)	3470.	/		
Effective overall temperature difference	(Deg C)	23.4			
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	23.71	* 0.9878	* 1.0000	

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes		
Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information					
TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle	26909.4	/ 17376.3	/ 10109.7	(kg/shell)	

Baffle Information					
Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.35	291.465
Inlet spacing	(mm)	932.000	2	0.00	0.000
Outlet spacing	(mm)	1088.00			
Baffle thickness	(mm)	12.700			

Tube Information					
Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		3.91
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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		0.41 / 0.54			
Flow fractions for heat transfer		0.658			
A=0.0018	B=0.6024	C=0.0352	E=0.2051	F=0.1554	

Shellside Heat Transfer Corrections				
Total	Beta	Gamma	End	Fin
0.920	0.920	1.000	0.957	1.000

Pressure Drops (Percent of Total)					
Cross	Window	Ends	Nozzle	Shell	Tube
69.84	16.12	6.60	Inlet	2.45	7.40
MOMENTUM		0.00	Outlet	5.00	4.74

Two-Phase Parameters				
Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.876	1.004
Midpoint	Prandtl no.	863.31	31.39
Midpoint	Reynolds no.	165	6999
Bundle inlet	Reynolds no.	125	6213
Bundle outlet	Reynolds no.	51	7733
Fouling layer	(mm)		

Thermal Resistance				
Shell	Tube	Fouling	Metal	Over Des
65.97	15.92	17.29	0.83	17.07
Total fouling resistance				8.313e-4
Differential resistance				8.212e-4

Shell Nozzles				Liquid
Inlet at channel end-No		Inlet	Outlet	Outlet
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.49	1.47	
Pressure drop	(kPa)	0.994	2.032	
Height under nozzle	(mm)	1143.00	61.187	
Nozzle R-V-SQ	(kg/m-s2)	1988.44	1960.02	
Shell ent.	(kg/m-s2)	0.00	1401.33	

Tube Nozzle		Inlet	Outlet	Liquid
		RADIAL	RADIAL	Outlet
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.32	2.34	
Pressure drop	(kPa)	3.177	2.035	
Nozzle R-V-SQ	(kg/m-s2)	5774.80	5813.70	

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	21.7000	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 9:55 SN: 1500213869 — MEG Energy Units

Max.UA Case : Shell 3

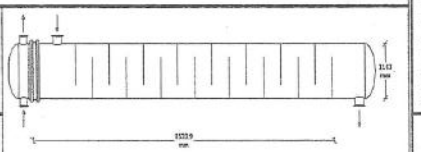
Rating - Horizontal Multipass Flow TEMA BEU Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition		Sens. Liquid		Sens. Liquid	
Total flow rate	(kg/hr)		444696		527298
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	71.17	58.47	44.30	50.62
Temperature, Average/Skin	(Deg C)	64.82	53.48	47.46	50.64
Wall temperature, Min/Max	(Deg C)	48.75	55.21	48.67	55.05
Pressure, In/Average	(kPa)	912.440	881.711	947.899	925.519
Pressure drop, Total/Allowed	(kPa)	61.459	250.000	44.759	200.000
Velocity, Mid/Max allow	(m/s)	0.31		0.98	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		305.59		1300.78
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	166.89 /	236.21 /	197.42
Heat duty, Calculated/Specified	(kW)	2254. /		
Effective overall temperature difference	(Deg C)	16.2		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	16.44 *	0.9847 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle	26916.5 /	17383.4 /	10116.8 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50		
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L	
Central spacing	(mm)	486.000	1	20.45	291.465	
Inlet spacing	(mm)	1088.00	2	0.00	0.000	
Outlet spacing	(mm)	932.000				
Baffle thickness	(mm)	12.700				

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		4.42
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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 0.40 / 0.53

Flow fractions for heat transfer 0.651

A=0.0014 B=0.5955 C=0.0270 E=0.2179 F=0.1582

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.920	0.920	1.000	0.967	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
70.54	14.51	7.34	Inlet	6.81	7.07
MOMENTUM		0.00	Outlet	0.79	4.52

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.906	1.009
Midpoint	Prandtl no.	1617.65	38.00
Midpoint	Reynolds no.	81	5766
Bundle inlet	Reynolds no.	51	5333
Bundle outlet	Reynolds no.	33	6180
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
64.60	18.20	16.42	0.77	18.29

Total fouling resistance 8.313e-4

Differential resistance 9.264e-4

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.47	1.46	
Pressure drop	(kPa)	4.188	0.485	
Height under nozzle	(mm)	61.187	1143.00	
Nozzle R-V-SQ	(kg/m-s2)	1960.02	1941.40	
Shell ent.	(kg/m-s2)	2420.99	0.00	

Tube Nozzle		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.31	2.32	
Pressure drop	(kPa)	3.163	2.021	
Nozzle R-V-SQ	(kg/m-s2)	5749.59	5774.80	

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	21.7000	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 9:55 SN: 1500213869 **MEG Energy Units**

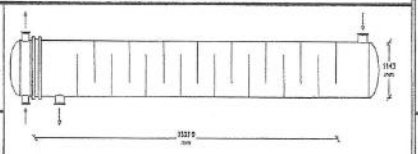
Max.UA Case : Shell 4

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

Process Data		Hot Shellside	Cold Tubeside
Fluid name		BP Frac Dilbit	TEG/Water (60%/40% wt)
Fluid condition		Sens. Liquid	Sens. Liquid
Total flow rate	(kg/hr)	444696	527298
Weight fraction vapor, In/Out	(--)	0.000 / 0.000	0.000 / 0.000
Temperature, In/Out	(Deg C)	58.47 / 49.70	40.00 / 44.31
Temperature, Average/Skin	(Deg C)	54.08 / 46.54	42.15 / 44.62
Wall temperature, Min/Max	(Deg C)	42.35 / 47.21	42.29 / 47.09
Pressure, In/Average	(kPa)	850.993 / 808.755	994.015 / 970.957
Pressure drop, Total/Allowed	(kPa)	84.477 / 250.000	46.116 / 200.000
Velocity, Mid/Max allow	(m/s)	0.29 /	0.98 /
Mole fraction inert	(--)		
Average film coef.	(W/m2-K)	312.61	1129.15
Heat transfer safety factor	(--)	1.000	1.000
Fouling resistance	(m2-K/W)	0.000616	0.000180

Overall Performance Data			
Overall coef., Reqd/Clean/Actual	(W/m2-K)	165.98 / 232.57 /	194.87
Heat duty, Calculated/Specified	(kW)	1527. /	
Effective overall temperature difference	(Deg C)	11.0	
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	11.27 * 0.9781 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes		
Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information					
TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle			26921.2 / 17388.1 / 10121.5	(kg/shell)	

Baffle Information					
Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.35	291.465
Inlet spacing	(mm)	932.000	2	0.00	0.000
Outlet spacing	(mm)	1088.00			
Baffle thickness	(mm)	12.700			

Tube Information					
Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		3.91
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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	0.40 / 0.53
Flow fractions for heat transfer	0.623
A=0.0013 B=0.5629 C=0.0242 E=0.2380 F=0.1736	

Shellside Heat Transfer Corrections				
Total	Beta	Gamma	End	Fin
0.917	0.920	0.997	0.966	1.000

Pressure Drops (Percent of Total)					
Cross	Window	Ends	Nozzle	Shell	Tube
74.13	14.30	7.73	Inlet	1.15	6.84
MOMENTUM		0.00	Outlet	2.68	4.36

Two-Phase Parameters				
Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.937	1.003
Midpoint	Prandtl no.	2532.88	43.26
Midpoint	Reynolds no.	48	5057
Bundle inlet	Reynolds no.	32	4776
Bundle outlet	Reynolds no.	17	5310
Fouling layer	(mm)		

Thermal Resistance				
Shell	Tube	Fouling	Metal	Over Des
62.34	20.70	16.21	0.76	17.40
Total fouling resistance				8.313e-4
Differential resistance				8.93e-4

Shell Nozzles				Liquid
Inlet at channel end-No		Inlet	Outlet	Outlet
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.46	1.45	
Pressure drop	(kPa)	0.971	2.268	
Height under nozzle	(mm)	1143.00	61.187	
Nozzle R-V-SQ	(kg/m-s2)	1941.40	1928.73	
Shell ent.	(kg/m-s2)	0.00	1378.96	

Tube Nozzle		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.31	2.31	
Pressure drop	(kPa)	3.153	2.013	
Nozzle R-V-SQ	(kg/m-s2)	5732.54	5749.60	

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	21.7000	0.3969

3A-E-111 A to H (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 :		42.07	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	175.705	<	250.000 kPa	----------	O.K
	tube-side	212.167	<	225.000 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-111 A to H (Max Duty Case) - Shell 1

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

VALUE TO BE CHECKED	Inlet	Center	U-Bend	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1574.	972.	1401.	1881 (By TEMA)	O.K
Length / TEMA maximum span	0.837	0.517	0.579	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0795	0.0690	0.0914	< 0.8	O.K
Ave. crossflow velocity ratio	0.0725	0.0629	0.0834	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.065	0.147	0.142	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.112	0.221	< 0.8	O.K.
Vortex shedding ratio		0.322	0.301	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.75	1.09	< If velocity is exceed 2.07 / 2.06	O.K.
pv2 (kg/m-s2)		2670.48	0.00	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:00 SN: 1500213869 — MEG Energy Units

Max.Duty Case : Shell 1
Rating - Horizontal Multipass Flow TEMA BEU 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		3.745		
4	**Position In The Bundle**		**Inlet**	**Center**	**U-Bend**
5	Length for natural frequency	(mm)	1574.	972.	1401.
6	Length/TEMA maximum span	(--)	0.837 *	0.517	0.579
7	Number of spans	(--)	9	9	2
8	Tube natural frequency	(Hz)	34.4	52.5	18.0 +
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**U-Bend**
11	Window parallel velocity	(m/s)	0.57	0.56	0.56
12	Bundle crossflow velocity	(m/s)	9.781e-2	0.22	0.11
13	Bundle/shell velocity	(m/s)	0.13	0.29	0.15
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**U-Bend**
15	Log decrement	HTRI	0.100	0.100	0.100
16	Critical velocity	(m/s)	2.07	5.41	2.06
17	Baffle tip cross velocity ratio	(--)	0.0795	0.0690	0.0914
18	Average crossflow velocity ratio	(--)	0.0725	0.0629	0.0834
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**U-Bend**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**U-Bend**
24	Vortex shedding ratio	(--)	0.065	0.147	0.142
25	Parallel flow amplitude	(mm)	0.001	0.001	0.005
26	Crossflow amplitude	(mm)	0.004	0.003	0.003
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	19.61	102.19	26.13
29	**Bundle Entrance/Exit**				
30	**(analysis at first tube row)**			**Entrance**	**Exit**
31	Fluidelastic instability ratio		(--)	0.112	0.221
32	Vortex shedding ratio		(--)	0.322	0.301
33	Crossflow amplitude		(mm)	0.02538	0.06154
34	Crossflow velocity		(m/s)	0.48	0.45
35	Tubesheet to inlet/outlet support		(mm)	None	None
36	**Shell Entrance/Exit Parameters**			**Entrance**	**Exit**
37	Impingement plate			Yes	
38	Flow area		(m2)	0.042	0.065
39	Velocity		(m/s)	1.75	1.09
40	RHO-V-SQ		(kg/m-s2)	2670.48	0.00

41	Shell type	BEU	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	45	Tube material	Carbon steel
45	Number U-Bend supports	1	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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51
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3A-E-111 A to H (Max Duty Case) - Shell 2

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

VALUE TO BE CHECKED	U-Bend	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1401.	972.	1574.	2420 (By TEMA)	O.K
Length / TEMA maximum span	0.579	0.517	0.837	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0900	0.0672	0.0763	< 0.8	O.K
Ave. crossflow velocity ratio	0.0821	0.0613	0.0696	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.139	0.143	0.062	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.000	0.099	< 0.8	O.K.
Vortex shedding ratio		0.574	0.281	> 0.5	Check Below
				Tube OD = 25.400	
				Tube gap = 6.350	
Crossflow amplitude (mm)		0.06107	0.01931	< 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		25.25	18.24	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		6.958e-2	1.28	< If velocity is exceed 2.05 / 2.04	O.K.
ρv2 (kg/m-s2)		0.00	1487.86	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:00 SN: 1500213869 — MEG Energy Units

Max.Duty Case : Shell 2
Rating - Horizontal Multipass Flow TEMA BEU 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		U-Bend	Center	Outlet
Length for natural frequency	(mm)	1401.	972.	1574.
Length/TEMA maximum span	(--)	0.579	0.517	0.837 *
Number of spans	(--)	2	9	9
Tube natural frequency	(Hz)	18.1 +	52.5	34.3
Shell acoustic frequency	(Hz)			

Flow Velocities		U-Bend	Center	Outlet
Window parallel velocity	(m/s)	0.56	0.56	0.55
Bundle crossflow velocity	(m/s)	0.11	0.21	9.255e-2
Bundle/shell velocity	(m/s)	0.14	0.27	0.12

Fluidelastic Instability Check		U-Bend	Center	Outlet
Log decrement	HTRI	0.100	0.100	0.100
Critical velocity	(m/s)	2.05	5.37	2.04
Baffle tip cross velocity ratio	(--)	0.0900	0.0672	0.0763
Average crossflow velocity ratio	(--)	0.0821	0.0613	0.0696

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

Tube Vibration Check		U-Bend	Center	Outlet
Vortex shedding ratio	(--)	0.139	0.143	0.062
Parallel flow amplitude	(mm)	0.005	0.001	0.001
Crossflow amplitude	(mm)	0.003	0.003	0.004
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	25.25	97.07	18.24

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.000	0.099
Vortex shedding ratio	(--)	0.574	0.281
Crossflow amplitude	(mm)	0.06107	0.01931
Crossflow velocity	(m/s)	0.45	0.42
Tubesheet to inlet/outlet support	(mm)	None	None

Shell Entrance/Exit Parameters		Entrance	Exit
Impingement plate		No	
Flow area	(m2)	1.026	0.055
Velocity	(m/s)	6.958e-2	1.28
RHO-V-SQ	(kg/m-s2)	0.00	1487.86

Shell type	BEU	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
Number U-Bend supports	1	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-111 A to H (Max Duty Case) - Shell 3

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

VALUE TO BE CHECKED	Inlet	Center	U-Bend	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1574.	972.	1401.	1881 (By TEMA)	O.K
Length / TEMA maximum span	0.837	0.517	0.579	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0768	0.0670	0.0890	< 0.8	O.K
Ave. crossflow velocity ratio	0.0700	0.0611	0.0812	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.062	0.142	0.137	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.109	0.217	< 0.8	O.K.
Vortex shedding ratio		0.310	0.294	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.69	1.07	< If velocity is exceed 2.05 / 2.04	O.K.
ρv2 (kg/m-s2)		2570.48	0.00	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:00 SN: 1500213869 — MEG Energy Units

Max.Duty Case : Shell 3

Rating - Horizontal Multipass Flow TEMA BEU 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	U-Bend
Length for natural frequency	(mm)	1574.	972.	1401.
Length/TEMA maximum span	(--)	0.837 *	0.517	0.579
Number of spans	(--)	9	9	2
Tube natural frequency	(Hz)	34.4	52.5	18.1 +
Shell acoustic frequency	(Hz)			

Flow Velocities		Inlet	Center	U-Bend
Window parallel velocity	(m/s)	0.55	0.55	0.54
Bundle crossflow velocity	(m/s)	9.334e-2	0.21	0.11
Bundle/shell velocity	(m/s)	9.391e-2	0.21	0.11

Fluidelastic Instability Check		Inlet	Center	U-Bend
Log decrement	HTRI	0.100	0.100	0.100
Critical velocity	(m/s)	2.05	5.36	2.04
Baffle tip cross velocity ratio	(--)	0.0768	0.0670	0.0890
Average crossflow velocity ratio	(--)	0.0700	0.0611	0.0812

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

Tube Vibration Check		Inlet	Center	U-Bend
Vortex shedding ratio	(--)	0.062	0.142	0.137
Parallel flow amplitude	(mm)	0.001	0.001	0.005
Crossflow amplitude	(mm)	0.004	0.003	0.003
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	18.55	97.41	25.02

Bundle Entrance/Exit (analysis at first tube row)			Entrance	Exit
Fluidelastic instability ratio		(--)	0.109	0.217
Vortex shedding ratio		(--)	0.310	0.294
Crossflow amplitude		(mm)	0.02390	0.05885
Crossflow velocity		(m/s)	0.47	0.44
Tubesheet to inlet/outlet support		(mm)	None	None

Shell Entrance/Exit Parameters			Entrance	Exit
Impingement plate			Yes	
Flow area		(m2)	0.042	0.065
Velocity		(m/s)	1.69	1.07
RHO-V-SQ		(kg/m-s2)	2570.48	0.00

Shell type	BEU	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
Number U-Bend supports	1	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-111 A to H (Max Duty Case) - Shell 4

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

VALUE TO BE CHECKED	U-Bend	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1401.	972.	1574.	2420 (By TEMA)	O.K
Length / TEMA maximum span	0.579	0.517	0.837	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0872	0.0653	0.0743	< 0.8	O.K
Ave. crossflow velocity ratio	0.0795	0.0595	0.0678	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.134	0.138	0.060	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.000	0.097	< 0.8	O.K.
Vortex shedding ratio		0.559	0.276	> 0.5	Check Below
				Tube OD = 25.400	
				Tube gap = 6.350	
Crossflow amplitude (mm)		0.05864	0.01873	< 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		23.97	17.46	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		6.780e-2	1.26	< If velocity is exceed 2.04 / 2.03	O.K.
ρv2 (kg/m-s2)		0.00	1461.59	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:00 SN: 1500213869 — MEG Energy Units

Max.Duty Case : Shell 4
Rating - Horizontal Multipass Flow TEMA BEU 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		U-Bend	Center	Outlet
Length for natural frequency	(mm)	1401.	972.	1574.
Length/TEMA maximum span	(--)	0.579	0.517	0.837 *
Number of spans	(--)	2	9	9
Tube natural frequency	(Hz)	18.1 +	52.5	34.4
Shell acoustic frequency	(Hz)			

Flow Velocities		U-Bend	Center	Outlet
Window parallel velocity	(m/s)	0.55	0.54	0.54
Bundle crossflow velocity	(m/s)	0.11	0.21	8.975e-2
Bundle/shell velocity	(m/s)	9.027e-2	0.18	7.676e-2

Fluidelastic Instability Check		U-Bend	Center	Outlet
Log decrement	HTRI	0.100	0.100	0.100
Critical velocity	(m/s)	2.04	5.34	2.03
Baffle tip cross velocity ratio	(--)	0.0872	0.0653	0.0743
Average crossflow velocity ratio	(--)	0.0795	0.0595	0.0678

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

Tube Vibration Check		U-Bend	Center	Outlet
Vortex shedding ratio	(--)	0.134	0.138	0.060
Parallel flow amplitude	(mm)	0.005	0.001	0.001
Crossflow amplitude	(mm)	0.003	0.003	0.004
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	23.97	92.59	17.46

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.000	0.097
Vortex shedding ratio	(--)	0.559	0.276
Crossflow amplitude	(mm)	0.05864	0.01873
Crossflow velocity	(m/s)	0.44	0.41
Tubesheet to inlet/outlet support	(mm)	None	None

Shell Entrance/Exit Parameters		Entrance	Exit
Impingement plate		No	
Flow area	(m2)	1.026	0.055
Velocity	(m/s)	6.780e-2	1.26
RHO-V-SQ	(kg/m-s2)	0.00	1461.59

Shell type	BEU	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
Number U-Bend supports	1	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 2013/08/16 10:00 SN: 1500213869 **MEG Energy Units**

Max.Duty Case : Shell 1

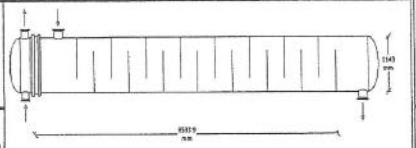
Rating - Horizontal Multipass Flow TEMA BEU Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		457483		589132
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	126.00	96.79	60.52	75.00
Temperature, Average/Skin	(Deg C)	111.40	82.56	67.76	73.65
Wall temperature, Min/Max	(Deg C)	69.77	84.90	69.50	84.36
Pressure, In/Average	(kPa)	984.014	969.662	831.682	806.768
Pressure drop, Total/Allowed	(kPa)	28.704	250.000	49.827	225.000
Velocity, Mid/Max allow	(m/s)	0.34		1.11	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		372.60		2227.21
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	170.89 /	306.46 /	244.21
Heat duty, Calculated/Specified	(kW)	5902. /		
Effective overall temperature difference	(Deg C)	41.4		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	41.72 *	0.9920 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle		26895.6 /	17362.4 /	10095.9	(kg/shell)

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.45	291.465
Inlet spacing	(mm)	1088.00	2	0.00	0.000
Outlet spacing	(mm)	932.000			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		4.42
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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 0.43 / 0.56

Flow fractions for heat transfer 0.670

A=0.0035 B=0.6118 C=0.0416 E=0.1845 F=0.1586

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.919	0.919	1.000	0.954	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
62.71	17.88	5.89	Inlet	11.68	8.01
MOMENTUM		0.00	Outlet	1.84	5.15

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters

		Shell	Tube
Overall wall correction		0.844	1.015
Midpoint	Prandtl no.	294.53	23.97
Midpoint	Reynolds no.	540	10278
Bundle inlet	Reynolds no.	389	8764
Bundle outlet	Reynolds no.	196	11825
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
65.54	13.15	20.31	0.99	42.91

Total fouling resistance 8.313e-4

Differential resistance 0.00176

Shell Nozzles

		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.58	1.54	
Pressure drop	(kPa)	3.354	0.528	
Height under nozzle	(mm)	61.187	1143.00	
Nozzle R-V-SQ	(kg/m-s2)	2162.01	2113.49	
Shell ent.	(kg/m-s2)	2670.48	0.00	

Tube Nozzle

		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.61	2.64	
Pressure drop	(kPa)	3.993	2.567	
Nozzle R-V-SQ	(kg/m-s2)	7258.48	7332.68	

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	21.7000	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:00 SN: 1500213869 — MEG Energy Units

Max.Duty Case : Shell 2

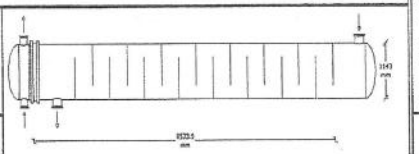
Rating - Horizontal Multipass Flow TEMA BEU Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition		Sens. Liquid		Sens. Liquid	
Total flow rate	(kg/hr)	457483		589132	
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	96.80	76.43	50.87	60.52
Temperature, Average/Skin	(Deg C)	86.61	66.14	55.70	60.34
Wall temperature, Min/Max	(Deg C)	55.47	66.49	55.28	66.13
Pressure, In/Average	(kPa)	955.324	937.613	883.918	857.799
Pressure drop, Total/Allowed	(kPa)	35.422	250.000	52.239	225.000
Velocity, Mid/Max allow	(m/s)	0.33		1.10	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		340.90		1811.83
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	158.66 /	275.09 /	223.86
Heat duty, Calculated/Specified	(kW)	3884. /		
Effective overall temperature difference	(Deg C)	29.3		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	29.60 *	0.9911 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle	26906.9 /	17373.7 /	10107.2 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.35	291.465
Inlet spacing	(mm)	932.000	2	0.00	0.000
Outlet spacing	(mm)	1088.00			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		3.91
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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 0.42 / 0.56

Flow fractions for heat transfer 0.659

A=0.0023 B=0.6014 C=0.0394 E=0.1976 F=0.1593

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.919	0.919	1.000	0.952	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
68.39	16.77	6.02	Inlet	2.98	7.59
MOMENTUM		0.00	Outlet	5.83	4.86

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters

		Shell	Tube
Overall wall correction		0.866	1.005
Midpoint	Prandtl no.	559.56	31.27
Midpoint	Reynolds no.	259	7850
Bundle inlet	Reynolds no.	193	6983
Bundle outlet	Reynolds no.	81	8690
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
65.67	14.82	18.62	0.89	41.09

Total fouling resistance 8.313e-4

Differential resistance 0.00184

Shell Nozzles

Inlet at channel end-No		Inlet	Outlet	Liquid Outlet
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.54	1.52	
Pressure drop	(kPa)	1.057	2.066	
Height under nozzle	(mm)	1143.00	61.187	
Nozzle R-V-SQ	(kg/m-s2)	2113.49	2081.05	
Shell ent.	(kg/m-s2)	0.00	1487.86	

Tube Nozzle		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.60	2.61	
Pressure drop	(kPa)	3.966	2.541	
Nozzle R-V-SQ	(kg/m-s2)	7209.84	7258.48	

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	21.7000	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:00 SN: 1500213869 — MEG Energy Units

Max.Duty Case : Shell 3

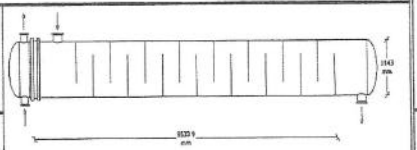
Rating - Horizontal Multipass Flow TEMA BEU Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		457483		589132
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	76.44	62.57	44.46	50.87
Temperature, Average/Skin	(Deg C)	69.50	55.16	47.66	51.30
Wall temperature, Min/Max	(Deg C)	49.46	56.43	49.34	56.21
Pressure, In/Average	(kPa)	919.915	895.732	938.108	911.011
Pressure drop, Total/Allowed	(kPa)	48.367	250.000	54.193	225.000
Velocity, Mid/Max allow	(m/s)	0.33		1.09	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		323.31		1519.09
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	147.58 /	254.99 /	210.36
Heat duty, Calculated/Specified	(kW)	2559. /		
Effective overall temperature difference	(Deg C)	20.8		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	20.98 *	0.9901 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle	26914.6 /	17381.4 /	10114.9 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.45	291.465
Inlet spacing	(mm)	1088.00	2	0.00	0.000
Outlet spacing	(mm)	932.000			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		4.42
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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 0.42 / 0.55

Flow fractions for heat transfer 0.661

A=0.0017 B=0.6065 C=0.0315 E=0.2058 F=0.1545

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.920	0.920	1.000	0.962	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
68.49	15.32	6.71	Inlet	8.41	7.29
MOMENTUM		0.00	Outlet	1.06	4.66

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.895	1.011
Midpoint	Prandtl no.	1038.17	37.86
Midpoint	Reynolds no.	131	6466
Bundle inlet	Reynolds no.	81	5979
Bundle outlet	Reynolds no.	53	6947
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
65.07	16.61	17.50	0.83	42.54

Total fouling resistance 8.313e-4

Differential resistance 0.00202

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.52	1.50	
Pressure drop	(kPa)	4.068	0.515	
Height under nozzle	(mm)	61.187	1143.00	
Nozzle R-V-SQ	(kg/m-s2)	2081.05	2059.43	
Shell ent.	(kg/m-s2)	2570.48	0.00	

Tube Nozzle		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.58	2.60	
Pressure drop	(kPa)	3.948	2.524	
Nozzle R-V-SQ	(kg/m-s2)	7177.87	7209.84	

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	21.7000	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K Park

Xist Ver. 6.00 SP3 2013/08/16 10:00 SN: 1500213869 — MEG Energy Units

Max.Duty Case : Shell 4

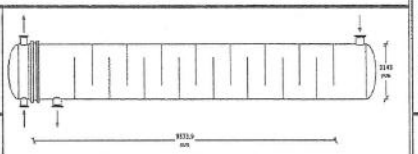
Rating - Horizontal Multipass Flow TEMA BEU Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		457483		589132
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	62.57	52.70	40.00	44.46
Temperature, Average/Skin	(Deg C)	57.63	47.74	42.23	45.08
Wall temperature, Min/Max	(Deg C)	42.83	47.97	42.74	47.82
Pressure, In/Average	(kPa)	871.561	839.955	994.015	966.061
Pressure drop, Total/Allowed	(kPa)	63.212	250.000	55.906	225.000
Velocity, Mid/Max allow	(m/s)	0.32		1.09	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		322.00		1326.70
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	144.64 /	247.00 /	204.90
Heat duty, Calculated/Specified	(kW)	1767. /		
Effective overall temperature difference	(Deg C)	14.6		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	14.82 *	0.9870 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle	26919.7 /	17386.6 /	10120.0	(kg/shell)	

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.35	291.465
Inlet spacing	(mm)	932.000	2	0.00	0.000
Outlet spacing	(mm)	1088.00			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		3.91
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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 0.41 / 0.54

Flow fractions for heat transfer 0.650

A=0.0014 B=0.5937 C=0.0262 E=0.2177 F=0.1609

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.920	0.920	1.000	0.966	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
72.39	14.91	7.49	Inlet	1.63	7.04
MOMENTUM		0.00	Outlet	3.59	4.49

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.926	1.004
Midpoint	Prandtl no.	1616.37	43.22
Midpoint	Reynolds no.	80	5655
Bundle inlet	Reynolds no.	52	5337
Bundle outlet	Reynolds no.	28	5955
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
63.63	18.52	17.05	0.80	41.66
Total fouling resistance				8.313e-4
Differential resistance				0.00203

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-No		1	1	0
Number at each position				
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.50	1.49	
Pressure drop	(kPa)	1.030	2.266	
Height under nozzle	(mm)	1143.00	61.187	
Nozzle R-V-SQ	(kg/m-s2)	2059.43	2044.30	
Shell ent.	(kg/m-s2)	0.00	1461.59	

Tube Nozzle		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.58	2.58	
Pressure drop	(kPa)	3.936	2.513	
Nozzle R-V-SQ	(kg/m-s2)	7155.83	7177.88	

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	21.7000	0.3969

3A-E-111 A to H (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.

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

1. Thermal and Hydraulic performance

- Thermal performance :		140.24	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	106.688	<	250.000 kPa	----------	O.K
	tube-side	145.876	<	275.000 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-111 A to H (Min Duty Case) - Shell 1

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

VALUE TO BE CHECKED	Inlet	Center	U-Bend	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1574.	972.	1401.	1881 (By TEMA)	O.K
Length / TEMA maximum span	0.837	0.517	0.579	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0707	0.0615	0.0816	< 0.8	O.K
Ave. crossflow velocity ratio	0.0644	0.0561	0.0744	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.057	0.131	0.126	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.098	0.195	< 0.8	O.K.
Vortex shedding ratio		0.281	0.265	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.53	0.96	< If velocity is exceed 2.05 / 2.04	O.K.
pv2 (kg/m-s2)		2057.22	0.00	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:01 SN: 1500213869 — MEG Energy Units

Min.Duty Case : Shell 1
Rating - Horizontal Multipass Flow TEMA BEU 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		3.745		

4	Position In The Bundle		Inlet	Center	U-Bend
5	Length for natural frequency	(mm)	1574.	972.	1401.
6	Length/TEMA maximum span	(--)	0.837 *	0.517	0.579
7	Number of spans	(--)	9	9	2
8	Tube natural frequency	(Hz)	34.3	52.3	18.0 +
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**U-Bend**
11	Window parallel velocity	(m/s)	0.50	0.49	0.49
12	Bundle crossflow velocity	(m/s)	8.623e-2	0.20	9.897e-2
13	Bundle/shell velocity	(m/s)	0.11	0.26	0.13
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**U-Bend**
15	Log decrement	HTRI	0.100	0.100	0.100
16	Critical velocity	(m/s)	2.05	5.37	2.04
17	Baffle tip cross velocity ratio	(--)	0.0707	0.0615	0.0816
18	Average crossflow velocity ratio	(--)	0.0644	0.0561	0.0744
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**U-Bend**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**U-Bend**
24	Vortex shedding ratio	(--)	0.057	0.131	0.126
25	Parallel flow amplitude	(mm)	0.001	0.001	0.004
26	Crossflow amplitude	(mm)	0.003	0.002	0.003
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	15.48	81.01	20.75

29	**Bundle Entrance/Exit**				
30	**(analysis at first tube row)**			**Entrance**	**Exit**
31	Fluidelastic instability ratio		(--)	0.098	0.195
32	Vortex shedding ratio		(--)	0.281	0.265
33	Crossflow amplitude		(mm)	0.01906	0.04669
34	Crossflow velocity		(m/s)	0.42	0.40
35	Tubesheet to inlet/outlet support		(mm)	None	None
36	**Shell Entrance/Exit Parameters**			**Entrance**	**Exit**
37	Impingement plate			Yes	
38	Flow area		(m2)	0.042	0.065
39	Velocity		(m/s)	1.53	0.96
40	RHO-V-SQ		(kg/m-s2)	2057.22	0.00

41	Shell type	BEU	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	45	Tube material	Carbon steel
45	Number U-Bend supports	1	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
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3A-E-111 A to H (Min Duty Case) - Shell 2

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

VALUE TO BE CHECKED	U-Bend	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1401.	972.	1574.	2420 (By TEMA)	O.K
Length / TEMA maximum span	0.579	0.517	0.837	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0797	0.0596	0.0677	< 0.8	O.K
Ave. crossflow velocity ratio	0.0726	0.0543	0.0617	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.122	0.126	0.055	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.000	0.087	< 0.8	O.K.
Vortex shedding ratio		0.504	0.248	> 0.5	Check Below
				Tube OD = 25.400	
				Tube gap = 6.350	
Crossflow amplitude (mm)		0.04640	0.01476	< 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		19.73	14.29	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		6.094e-2	1.13	< If velocity is exceed 2.04 / 2.03	O.K.
ρv2 (kg/m-s2)		0.00	1155.68	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:01 SN: 1500213869 — MEG Energy Units

Min.Duty Case : Shell 2
Rating - Horizontal Multipass Flow TEMA BEU 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		3.745		

	Position In The Bundle		U-Bend	Center	Outlet
5	Length for natural frequency	(mm)	1401.	972.	1574.
6	Length/TEMA maximum span	(--)	0.579	0.517	0.837 *
7	Number of spans	(--)	2	9	9
8	Tube natural frequency	(Hz)	18.0 +	52.4	34.2
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**U-Bend**	**Center**	**Outlet**
11	Window parallel velocity	(m/s)	0.49	0.49	0.48
12	Bundle crossflow velocity	(m/s)	9.653e-2	0.19	8.162e-2
13	Bundle/shell velocity	(m/s)	0.12	0.24	0.11
14	**Fluidelastic Instability Check**		**U-Bend**	**Center**	**Outlet**
15	Log decrement	HTRI	0.100	0.100	0.100
16	Critical velocity	(m/s)	2.04	5.34	2.03
17	Baffle tip cross velocity ratio	(--)	0.0797	0.0596	0.0677
18	Average crossflow velocity ratio	(--)	0.0726	0.0543	0.0617
19	**Acoustic Vibration Check**		**U-Bend**	**Center**	**Outlet**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**U-Bend**	**Center**	**Outlet**
24	Vortex shedding ratio	(--)	0.122	0.126	0.055
25	Parallel flow amplitude	(mm)	0.004	0.001	0.001
26	Crossflow amplitude	(mm)	0.003	0.002	0.003
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	19.73	76.00	14.29

	Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
31	Fluidelastic instability ratio	(--)	0.000	0.087
32	Vortex shedding ratio	(--)	0.504	0.248
33	Crossflow amplitude	(mm)	0.04640	0.01476
34	Crossflow velocity	(m/s)	0.40	0.37
35	Tubesheet to inlet/outlet support	(mm)	None	None
36	**Shell Entrance/Exit Parameters**		**Entrance**	**Exit**
37	Impingement plate		No	
38	Flow area	(m2)	1.026	0.055
39	Velocity	(m/s)	6.094e-2	1.13
40	RHO-V-SQ	(kg/m-s2)	0.00	1155.68

41	Shell type	BEU	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	45	Tube material	Carbon steel
45	Number U-Bend supports	1	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-111 A to H (Min Duty Case) - Shell 3

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

VALUE TO BE CHECKED	Inlet	Center	U-Bend	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1574.	972.	1401.	1881 (By TEMA)	O.K
Length / TEMA maximum span	0.837	0.517	0.579	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0672	0.0587	0.0779	< 0.8	O.K
Ave. crossflow velocity ratio	0.0613	0.0535	0.0711	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.054	0.124	0.119	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.096	0.191	< 0.8	O.K.
Vortex shedding ratio		0.273	0.259	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.48	0.94	< If velocity is exceed 2.04 / 2.03	O.K.
ρv2 (kg/m-s2)		1996.60	0.00	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:01 SN: 1500213869 — MEG Energy Units

Min.Duty Case : Shell 3
Rating - Horizontal Multipass Flow TEMA BEU 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		3.745		

	Position In The Bundle		Inlet	Center	U-Bend
5	Length for natural frequency	(mm)	1574.	972.	1401.
6	Length/TEMA maximum span	(--)	0.837 *	0.517	0.579
7	Number of spans	(--)	9	9	2
8	Tube natural frequency	(Hz)	34.3	52.4	18.0 +
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**U-Bend**
11	Window parallel velocity	(m/s)	0.48	0.48	0.48
12	Bundle crossflow velocity	(m/s)	8.126e-2	0.19	9.391e-2
13	Bundle/shell velocity	(m/s)	0.10	0.23	0.12
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**U-Bend**
15	Log decrement	HTRI	0.100	0.100	0.100
16	Critical velocity	(m/s)	2.04	5.33	2.03
17	Baffle tip cross velocity ratio	(--)	0.0672	0.0587	0.0779
18	Average crossflow velocity ratio	(--)	0.0613	0.0535	0.0711
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**U-Bend**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**U-Bend**
24	Vortex shedding ratio	(--)	0.054	0.124	0.119
25	Parallel flow amplitude	(mm)	0.001	0.001	0.004
26	Crossflow amplitude	(mm)	0.003	0.002	0.002
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	14.17	74.43	19.12

	Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
31	Fluidelastic instability ratio	(--)	0.096	0.191
32	Vortex shedding ratio	(--)	0.273	0.259
33	Crossflow amplitude	(mm)	0.01819	0.04495
34	Crossflow velocity	(m/s)	0.41	0.39
35	Tubesheet to inlet/outlet support	(mm)	None	None
36	**Shell Entrance/Exit Parameters**		**Entrance**	**Exit**
37	Impingement plate		Yes	
38	Flow area	(m2)	0.042	0.065
39	Velocity	(m/s)	1.48	0.94
40	RHO-V-SQ	(kg/m-s2)	1996.60	0.00

41	Shell type	BEU	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	45	Tube material	Carbon steel
45	Number U-Bend supports	1	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-111 A to H (Min Duty Case) - Shell 4

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

VALUE TO BE CHECKED	U-Bend	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1401.	972.	1574.	2420 (By TEMA)	O.K
Length / TEMA maximum span	0.579	0.517	0.837	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.0785	0.0588	0.0669	< 0.8	O.K
Ave. crossflow velocity ratio	0.0716	0.0536	0.0610	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.120	0.124	0.054	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.000	0.086	< 0.8	O.K.
Vortex shedding ratio		0.492	0.243	> 0.5	Check Below
				Tube OD = 25.400	
				Tube gap = 6.350	
Crossflow amplitude (mm)		0.04478	0.01433	< 0.1 X Tube gap = 0.635 < 0.02 X Tube OD = 0.508	O.K.
Crossflow RHO-V-SQ (kg/m-s2)		19.38	14.11	< 5953 by TEMA	O.K.
Shell Entrance / Exit					
Velocity (m/sec)		5.956e-2	1.11	< If velocity is exceed 2.03 / 2.02	O.K.
ρv2 (kg/m-s2)		0.00	1135.17	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:01 SN: 1500213869 — MEG Energy Units

Min.Duty Case : Shell 4
Rating - Horizontal Multipass Flow TEMA BEU 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		3.745		
4	**Position In The Bundle**		**U-Bend**	**Center**	**Outlet**
5	Length for natural frequency	(mm)	1401.	972.	1574.
6	Length/TEMA maximum span	(--)	0.579	0.517	0.837 *
7	Number of spans	(--)	2	9	9
8	Tube natural frequency	(Hz)	18.0 +	52.4	34.3
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**U-Bend**	**Center**	**Outlet**
11	Window parallel velocity	(m/s)	0.48	0.48	0.48
12	Bundle crossflow velocity	(m/s)	9.457e-2	0.19	8.038e-2
13	Bundle/shell velocity	(m/s)	9.900e-2	0.19	8.414e-2
14	**Fluidelastic Instability Check**		**U-Bend**	**Center**	**Outlet**
15	Log decrement	HTRI	0.100	0.100	0.100
16	Critical velocity	(m/s)	2.03	5.31	2.02
17	Baffle tip cross velocity ratio	(--)	0.0785	0.0588	0.0669
18	Average crossflow velocity ratio	(--)	0.0716	0.0536	0.0610
19	**Acoustic Vibration Check**		**U-Bend**	**Center**	**Outlet**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**U-Bend**	**Center**	**Outlet**
24	Vortex shedding ratio	(--)	0.120	0.124	0.054
25	Parallel flow amplitude	(mm)	0.004	0.001	0.001
26	Crossflow amplitude	(mm)	0.002	0.002	0.003
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	19.38	74.85	14.11
29	**Bundle Entrance/Exit**				
30	**(analysis at first tube row)**			**Entrance**	**Exit**
31	Fluidelastic instability ratio		(--)	0.000	0.086
32	Vortex shedding ratio		(--)	0.492	0.243
33	Crossflow amplitude		(mm)	0.04478	0.01433
34	Crossflow velocity		(m/s)	0.39	0.36
35	Tubesheet to inlet/outlet support		(mm)	None	None
36	**Shell Entrance/Exit Parameters**			**Entrance**	**Exit**
37	Impingement plate			No	
38	Flow area		(m2)	1.026	0.055
39	Velocity		(m/s)	5.956e-2	1.11
40	RHO-V-SQ		(kg/m-s2)	0.00	1135.17

41	Shell type	BEU	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	45	Tube material	Carbon steel
45	Number U-Bend supports	1	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

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:01 SN: 1500213869 — MEG Energy Units

Min.Duty Case : Shell 1

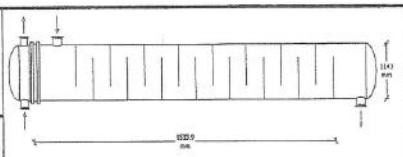
Rating - Horizontal Multipass Flow TEMA BEU Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition		Sens. Liquid		Sens. Liquid	
Total flow rate	(kg/hr)	404707		478370	
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	131.10	108.03	62.40	75.00
Temperature, Average/Skin	(Deg C)	119.57	87.61	68.70	76.99
Wall temperature, Min/Max	(Deg C)	73.88	87.61	73.54	86.99
Pressure, In/Average	(kPa)	984.014	973.692	882.096	865.122
Pressure drop, Total/Allowed	(kPa)	20.644	250.000	33.948	275.000
Velocity, Mid/Max allow	(m/s)	0.30		0.90	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		388.83		1809.68
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	100.83 /	305.31 /	243.47
Heat duty, Calculated/Specified	(kW)	4176. /		
Effective overall temperature difference	(Deg C)	49.6		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	49.87 *	0.9953 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle	26893.6 /	17360.4 /	10093.9 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.45	291.465
Inlet spacing	(mm)	1088.00	2	0.00	0.000
Outlet spacing	(mm)	932.000			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		4.42
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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 0.38 / 0.49

Flow fractions for heat transfer 0.675

A=0.0042 B=0.6193 C=0.0424 E=0.1821 F=0.1520

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.918	0.918	1.000	0.954	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
60.22	19.56	5.88	Inlet	12.35	7.76
MOMENTUM		0.00	Outlet	1.98	4.99

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.843	1.019
Midpoint	Prandtl no.	188.92	23.59
Midpoint	Reynolds no.	726	8482
Bundle inlet	Reynolds no.	441	7410
Bundle outlet	Reynolds no.	288	9615
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
62.62	16.13	20.25	1.00	141.48
Total fouling resistance				8.313e-4
Differential resistance				0.00581

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.37	1.35	
Pressure drop	(kPa)	2.549	0.409	
Height under nozzle	(mm)	61.187	1143.00	
Nozzle R-V-SQ	(kg/m-s2)	1665.51	1637.60	
Shell ent.	(kg/m-s2)	2057.22	0.00	

Tube Nozzle		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.12	2.14	
Pressure drop	(kPa)	2.636	1.692	
Nozzle R-V-SQ	(kg/m-s2)	4792.02	4834.66	

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	21.7000	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:01 SN: 1500213869 — MEG Energy Units

Min.Duty Case : Shell 2

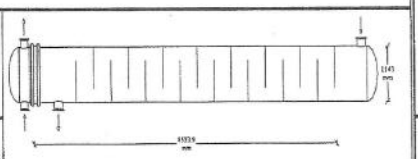
Rating - Horizontal Multipass Flow TEMA BEU Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition			Sens. Liquid		Sens. Liquid
Total flow rate	(kg/hr)		404707		478370
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	108.03	89.90	52.86	62.40
Temperature, Average/Skin	(Deg C)	98.97	73.11	57.63	65.22
Wall temperature, Min/Max	(Deg C)	60.54	71.86	60.28	71.40
Pressure, In/Average	(kPa)	963.384	951.943	917.556	899.822
Pressure drop, Total/Allowed	(kPa)	22.882	250.000	35.468	275.000
Velocity, Mid/Max allow	(m/s)	0.29		0.89	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		356.01		1458.12
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	92.60 /	272.36 /	222.05
Heat duty, Calculated/Specified	(kW)	3122. /		
Effective overall temperature difference	(Deg C)	40.4		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	40.60 *	0.9952 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle			26902.6 / 17369.4 / 10102.8 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.35	291.465
Inlet spacing	(mm)	932.000	2	0.00	0.000
Outlet spacing	(mm)	1088.00			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		3.91
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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 0.37 / 0.49

Flow fractions for heat transfer 0.663

A=0.0029 B=0.6040 C=0.0404 E=0.1894 F=0.1632

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.919	0.919	1.000	0.952	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
66.37	17.44	5.91	Inlet	3.58	7.38
MOMENTUM		0.00	Outlet	6.71	4.73

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters

		Shell	Tube
Overall wall correction		0.852	1.012
Midpoint	Prandtl no.	304.37	30.02
Midpoint	Reynolds no.	421	6643
Bundle inlet	Reynolds no.	283	5945
Bundle outlet	Reynolds no.	140	7357
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
62.37	18.26	18.47	0.89	139.79

Total fouling resistance 8.313e-4

Differential resistance 0.0063

Shell Nozzles

Inlet at channel end-No		Inlet	Outlet	Liquid Outlet
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.35	1.33	
Pressure drop	(kPa)	0.819	1.535	
Height under nozzle	(mm)	1143.00	61.187	
Nozzle R-V-SQ	(kg/m-s2)	1637.60	1616.44	
Shell ent.	(kg/m-s2)	0.00	1155.68	

Tube Nozzle

		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.11	2.12	
Pressure drop	(kPa)	2.618	1.677	
Nozzle R-V-SQ	(kg/m-s2)	4760.25	4792.02	

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	21.7000	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:01 SN: 1500213869 — MEG Energy Units

Min.Duty Case : Shell 3

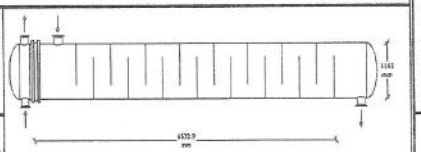
Rating - Horizontal Multipass Flow TEMA BEU Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition		Sens. Liquid		Sens. Liquid	
Total flow rate	(kg/hr)		404707		478370
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	89.90	75.83	45.61	52.87
Temperature, Average/Skin	(Deg C)	82.87	62.09	49.24	56.15
Wall temperature, Min/Max	(Deg C)	53.76	62.29	53.57	61.97
Pressure, In/Average	(kPa)	940.516	926.016	954.978	936.266
Pressure drop, Total/Allowed	(kPa)	29.000	250.000	37.424	275.000
Velocity, Mid/Max allow	(m/s)	0.29		0.89	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		333.44		1200.68
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	85.60 /	247.67 /	205.36
Heat duty, Calculated/Specified	(kW)	2353. /		
Effective overall temperature difference	(Deg C)	33.0		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	33.12 *	0.9950 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle	26909.5 /	17376.4 /	10109.8 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	486.000	1	20.45	291.465
Inlet spacing	(mm)	1088.00	2	0.00	0.000
Outlet spacing	(mm)	932.000			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		4.42
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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 0.37 / 0.48

Flow fractions for heat transfer 0.659

A=0.0022 B=0.6014 C=0.0392 E=0.1987 F=0.1585

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.919	0.919	1.000	0.954	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
66.71	16.10	5.88	Inlet	9.93	6.96
MOMENTUM		0.00	Outlet	1.38	4.45

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		Shell	Tube
Overall wall correction		0.869	1.019
Midpoint	Prandtl no.	509.01	36.52
Midpoint	Reynolds no.	238	5446
Bundle inlet	Reynolds no.	139	4995
Bundle outlet	Reynolds no.	97	5913
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
61.59	20.51	17.08	0.82	139.91
Total fouling resistance				8.313e-4
Differential resistance				0.00681

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-Yes				
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.33	1.32	
Pressure drop	(kPa)	2.880	0.400	
Height under nozzle	(mm)	61.187	1143.00	
Nozzle R-V-SQ	(kg/m-s2)	1616.44	1600.28	
Shell ent.	(kg/m-s2)	1996.60	0.00	

Tube Nozzle		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.10	2.11	
Pressure drop	(kPa)	2.605	1.666	
Nozzle R-V-SQ	(kg/m-s2)	4736.37	4760.26	

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	21.7000	0.3969

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/16 10:01 SN: 1500213869 **MEG Energy Units**

Min.Duty Case : Shell 4

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

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		BP Frac Dilbit		TEG/Water (60%/40% wt)	
Fluid condition		Sens. Liquid		Sens. Liquid	
Total flow rate	(kg/hr)	404707		478370	
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	75.84	64.70	40.00	45.61
Temperature, Average/Skin	(Deg C)	70.27	53.66	42.81	49.10
Wall temperature, Min/Max	(Deg C)	46.18	53.26	46.02	53.01
Pressure, In/Average	(kPa)	911.529	894.448	994.015	974.496
Pressure drop, Total/Allowed	(kPa)	34.162	250.000	39.037	275.000
Velocity, Mid/Max allow	(m/s)	0.28		0.89	
Mole fraction inert	(--)				
Average film coef.	(W/m2-K)		320.27		1008.41
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000616		0.000180

Shellside Performance

Nom vel, X-flow/window 0.36 / 0.48

Flow fractions for heat transfer 0.661

A=0.0017 B=0.6056 C=0.0328 E=0.2048 F=0.1551

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.920	0.920	1.000	0.959	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
70.18	16.02	6.64	Inlet	2.34	6.65
MOMENTUM		0.00	Outlet	4.81	4.25

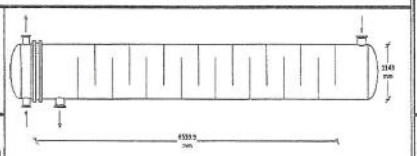
Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	80.55 /	229.83 /	192.94
Heat duty, Calculated/Specified	(kW)	1808. /		
Effective overall temperature difference	(Deg C)	26.9		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	27.03 *	0.9946 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5023.9
Approximate tubeside	(L)	4515.8

H. T. Parameters

		Shell	Tube
Overall wall correction		0.892	1.012
Midpoint	Prandtl no.	778.52	42.67
Midpoint	Reynolds no.	151	4652
Bundle inlet	Reynolds no.	98	4334
Bundle outlet	Reynolds no.	52	4972
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
60.24	22.95	16.05	0.76	139.55

Total fouling resistance 8.313e-4

Differential resistance 0.00723

Shell Construction Information

TEMA shell type	BEU		Shell ID	(mm)	1143.00
Shells Series	1 Parallel	2	Total area	(m2)	1125.71
Passes Shell	1 Tube	4	Eff. area	(m2/shell)	556.411
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	0		Passlane seal rods (mm)	25.400	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle			26914.8 / 17381.7 / 10115.1	(kg/shell)	

Shell Nozzles

Inlet at channel end-No		Inlet	Outlet	Liquid Outlet
Number at each position		1	1	0
Diameter	(mm)	242.875	242.875	
Velocity	(m/s)	1.32	1.31	
Pressure drop	(kPa)	0.800	1.645	
Height under nozzle	(mm)	1143.00	61.187	
Nozzle R-V-SQ	(kg/m-s2)	1600.28	1587.74	
Shell ent.	(kg/m-s2)	0.00	1135.17	

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	24.50	
Crosspasses/shellpass		17	No. (Pct Area)	(mm)	to C.L
Central spacing	(mm)	486.000	1 20.35	291.465	
Inlet spacing	(mm)	932.000	2 0.00	0.000	
Outlet spacing	(mm)	1088.00			
Baffle thickness	(mm)	12.700			

Tube Nozzle		Inlet	Outlet	Liquid Outlet
		RADIAL	RADIAL	
Diameter	(mm)	193.675	193.675	
Velocity	(m/s)	2.09	2.10	
Pressure drop	(kPa)	2.595	1.658	
Nozzle R-V-SQ	(kg/m-s2)	4718.06	4736.37	

Tube Information

Tube type		Plain	Tubecount per shell		792
Length to tangent	(mm)	8534.	Pct tubes removed (both)		3.91
Effective length	(mm)	8804.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	102.000	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

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	21.7000	0.3969