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.: E0351-3AE101-P-02	Rev: 0	Date Rec'd 2013/09/04
Doc. Title: L53.51, L53.53 - THERMAL DESIGN CALCULATION - Tag:3A-E-101A/B			
Client Code:	Project: MEG Phase 3A EPC		
Reviewed by: SS Date: 11-Sept-2013	Document No P-5310-01-0031		Submittal 02

SEWON CELLONTECH	DOCUMENT FOR EQUIPMENT	SWC JOB NO	E-0351
		ITEM NO.	3A-E-101A/B
		SWC DOC. NO.	E0351-3AE101-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-101A/B	PRODUCED GAS / BFW EXCHANGER

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

- Total Sheet :20 Sheet (Including This Cover)

1	M.K. Park 8/16/2013	T.W.Kim 8/16/13	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	Produced Gas / BFW Exchanger
ITEM NO.	3A-E-101A/B (Max Duty and UA Case)

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

Total 2 Shells, Connected in 2 Parallel 1 Series Shells | Install ■ Hor. □ Vert. | Size 1,100.0 ID - 12,192.0 L

Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type AEL | TEMA Class R | Effective Area 929.53 (Note 1) m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			BFW		Produced Gas	
Total Fluid	kg/hr		669128		103332	
Vapor	kg/hr	MW			103332	18598.3
Liquid	kg/hr	MW	669128	669128		84734.1
Steam	kg/hr					
Water	kg/hr		669128	669128		
Noncondendable	kg/hr	MW				
Operating Temperature	℃		98.30	164.00	174.00	136.30
Operating Pressure	kPag		2850.04		984.014	
Density	kg/m3	L / V	960.84	904.81	5.1072 / 913.79	5.7960
Viscosity	cP	L / V	0.2876	0.1663	0.0120 / 0.2115	0.0141
Thermal Conductivity	W/m·℃	L / V	0.6787	0.6824	0.0344 / 0.6665	0.0413
Specific Heat	kJ/kg·℃	L / V	4.2084	4.3421	2.0745 / 4.4661	2.1882
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPag / ℃		/	/	/	/
Velocity	m/sec		0.61		5.45	
Pressure Drop	kPa.		Allow. 105.002	Calc. 48.264	Allow. 15.000	Calc. 3.982
Fouling Resistance	m2·℃/kW		0.18		0.35	
Film Coefficient	W/m2·K		8,691.24		5,771.16	
Overall Coefficient	W/m2·K		Clean 2739.43	Calc. 1036.50	Design 1016.73	
Heat Duty	KW		52,093.00		LMTD ℃	MTD 27.5 ℃

CONSTRUCTION

Design Pressure / Design Temperature	4340.0 / FV kPag	-29 / 210 ℃	1500.0 / FV kPag	-29 / 210 ℃
No. of Passes	1		1	

Tubes No. 968 / Shell, Size 25.40 mm , Thickness 2.11 (Min.) mm (BWG : 14) Length 12,192.0 mm

Shell 1100 mm ID | Tube Pitch 31.75 mm , Layout angle 30 ° , Leffective - mm

Baffles Cross Baffle 20 ea / Shell , Type Single Seg. (Hori.) , Cut (25.0 % Dia. , Spacing c/c 530.0 mm , End - mm

ρv² Inlet Nozzle 1,916.26 , Entrance 2,481.69 , Outlet Nozzle 2,034.92 kg/m·sec2 | Impingement plate Rectangular Plate

Material				
Tube	SA 179 Seamless	Shell & Cover	SA 516 GR. 70N	Channel & Cover	SA 516 GR. 70N (Note 7)
Tube Sheet	SA 266 GR.2 (Note 7 & 15)	Baffle	Carbon Steel	Expansion Joint	Required (Note 3)

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, ℃ Shell	Tube	Pressure, kPag Shell	Tube
Normal Operating	-	-	-	-
Startup	-	-	-	-

NOZZLE	SHELL SIDE Tag	No	NPS	Remarks	TUBE SIDE Tag	No	NPS	Remarks
Inlet	S1	1	12		T1	1	16	
Outlet	S2	1	12		T2	1	12	
Vent				(Note 11)				(Note 11 & 12)
Drain				(Note 11)				(Note 11 & 12)
Thermowell								
Util. Con.								
RATING	RFWN 600#				RFWN 300#			

Remarks

1) Seller shall verify and guarantee thermal rating of the unit.

2) Refer to heat curve.

3) Expansion joint design shall be based on design conditions noted on page 3 & 5.
Expansion joint shall be flanged and flued type per TEMA RCB 8. Expansion joint shall include vent and drain connections.

4) Exchangers shall be designed for future field hydrotest in the fully corroded condition.

5) 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.

6) Seller shall supply and install 64mm mineral fiber insulation.

7) Tube side is in sour service. Materials and fabrication shall be in accordance with NACE MR0175-2002. PWHT is required for tube side welds.

8) All tube side category D welds shall be 100% UT examinated after PWHT.

9) All Tube Side butt-welds (including all flange to nozzle welds) shall be 100% RT examined after PWHT.

10) Exchanger shall body shall be 1% sloped to the tube side outlet to facilitate tube side condensing. All flange faces shall be horizontal.

11) Each process nozzle shall be provided with 1-1" 300# RFLWN (complete with blind flange, gasket, bolts & nots).

12) Tube side shall be provided with a NPS 2 (300#, RFLWN) vent and drain. Vent and drain shall come complate with blind flange, gasket, bolts & nuts.

13) Tube side girth flanges shall be fabricated from SA 266, Grade 2.

14) For tubeside shell plates, Seller shall specify supplementary requirement S3 of ASTM A20 in the plate purchase order. Simulated PWHT holding time shall be three times that of production PWHT holding time. Plate mill shall guarantee the mechanical properties of the plate after three times production PWHT holding time.

15) Seller shall meet requirement noted in UW-13(f)(1).

SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 3 OF 20

CUSTOMER	MEG Energy Corp.
LOCATION	CANADA
JOB NO.	511036
SERVICE	Produced Gas / BFW Exchanger
ITEM NO.	3A-E-101A/B (Min Case)

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

Total 2 Shells, Connected in 2 Parallel 1 Series Shells | Install ■ Hor. □ Vert. | Size 1,100.0 ID - 12,192.0 L

Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type AEL | TEMA Class R | Effective Area 929.53 (Note 1) m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			BFW		Produced Gas	
Total Fluid	kg/hr		551436		32254.1	
Vapor	kg/hr	MW			32240.8	4292.44
Liquid	kg/hr	MW	551436	551436	13.3537	27961.7
Steam	kg/hr					
Water	kg/hr		551436	551436		
Noncondendable	kg/hr	MW				
Operating Temperature	℃		98.30	125.80	174.30	108.30
Operating Pressure	kPag		2850.04		984.014	
Density	kg/m3	L / v	960.84	939.68	881.03 / 5.2926	932.0 / 6.7969
Viscosity	cP	L / v	0.2876	0.2212	0.155 / 0.0121	0.2917 / 0.0144
Thermal Conductivity	W/m·℃	L / v	0.6787	0.6862	0.6797 / 0.0338	0.6299 / 0.0391
Specific Heat	kJ/kg·℃	L / v	4.2084	4.2500	4.6986 / 2.0369	4.3111 / 1.9324
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPag / ℃		/	/	/	/
Velocity	m/sec		0.48		0.38	
Pressure Drop	kPa.		Allow. 105.002	Calc. 33.175	Allow. 15.000	Calc. 0.254
Fouling Resistance	m2·℃/kW		0.18		0.35	
Film Coefficient	W/m2·K		6,943.65		732.08	
Overall Coefficient	W/m2·K		Clean 548.14	Calc. 412.53	Design 210.95	
Heat Duty	KW		17,779.00		LMTD ℃	MTD 45.3 ℃

CONSTRUCTION

Design Pressure / Design Temperature	/ kPag	/ ℃	/ kPag / ℃
No. of Passes			

Tubes No. / Shell, Size mm , Thickness (Min.) mm (BWG :) Length mm

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

Baffles Cross Baffle ea / Shell , Type , Cut - % Dia. , Spacing c/c mm , End - mm

pv² Inlet Nozzle 1,301.45 , Entrance 1,685.46 , Outlet Nozzle 1,330.76 kg/m·sec2 | Impingement plate

Material			
Tube		Shell & Cover	Channel & Cover
Tube Sheet		Baffle	Expansion Joint

Estimated Weight Empty Weight kg | Bundle Weight kg | Full Water Weight kg

Corrosion Allowance Shell side mm | Tube side mm | Tube Joints :

Insulation Shell side mm | Tube side mm

MEAN METAL TEMPERATURE	Temperature, ℃		Pressure, kPag	
	Shell	Tube	Shell	Tube
Normal Operating	-	-	-	-
Startup	-	-	-	-

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

(6) EHT design shall use voltage of 277 VAC.

MMT Condition

item	condition	shell pressure (kPa(g))	shell temp	tube pressure (kPa(g))	tube temp
E101	Maximum Op Temperature	4340	130.13	1500	136.94
	Maximum Op Pressure	4340	130.13	1500	136.94
	Maximum PG Flow	4340	135.16	1500	144.3
	Steam Out	103.506	10	103.506	83.5
	Shutdown&Depressured	103.506	-39	103.506	-39
	Hydortest-shell side	3315	20	103.506	15
	Hydortest-tube side	103.506	10	2021	20
	Prod. Gas CV Fails Closed	4340	98	1500	99.21
	BFW Pump Emergency S/D	4340	135.27	1500	172.32
	Start-up tube side	103.506	10	1500	92
	Start-up shell side	4340	98	103.506	98

SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 4 OF 20

CUSTOMER	MEG Energy Corp.
LOCATION	CANADA
JOB NO.	511036
SERVICE	Produced Gas / BFW Exchanger
ITEM NO.	3A-E-101A/B (Start-Up Case)

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

Total 2 Shells, Connected in 2 Parallel 1 Series Shells | Install ■ Hor. □ Vert. | Size 1,100.0 ID - 12,192.0 L

Code ASME Sec.VIII Div.1 (STAMP), TEMA, API660 TEMA Type AEL | TEMA Class R | Effective Area 929.53 (Note 1) m² /Shell

PERFORMANCE OF ONE BATTERY

			SHELL SIDE		TUBE SIDE	
			INLET	OUTLET	INLET	OUTLET
Fluid Circulated			BFW		Produced Gas	
Total Fluid	kg/hr		669128		139760	
Vapor	kg/hr	MW			139760	78968.7
Liquid	kg/hr	MW	669128	669128		60790.8
Steam	kg/hr					
Water	kg/hr		669128	669128		
Noncondendable	kg/hr	MW				
Operating Temperature	℃		98.30	146.00	166.00	151.20
Operating Pressure	kPag		2850.04		984.014	
Density	kg/m3	L / V	960.84	922.04	4.9464 / 899.83	4.9422
Viscosity	cP	L / V	0.2876	0.1884	0.0125 / 0.1758	0.0131
Thermal Conductivity	W/m·℃	L / V	0.6787	0.6862	0.0373 / 0.6791	0.0402
Specific Heat	kJ/kg·℃	L / V	4.2084	4.2928	2.1575 / 4.5883	2.2325
Latent Heat	kJ/kg					
Bubble / Dew Point	℃		/	/	/	/
Critical Press. / Temp.	kPag / ℃		/	/	/	/
Velocity	m/sec		0.60		9.43	
Pressure Drop	kPa.		Allow. 105.002	Calc. 48.042	Allow. 15.000	Calc. 11.738
Fouling Resistance	m2·℃/kW		0.18		0.35	
Film Coefficient	W/m2·K		8,396.34		7,264.35	
Overall Coefficient	W/m2·K		Clean 3066.42	Calc. 1080.08	Design 581.08	
Heat Duty	KW		38,155.00		LMTD ℃	MTD 34.8 ℃

CONSTRUCTION

Design Pressure / Design Temperature	/ kPag	/ ℃	/ kPag / ℃
No. of Passes			

Tubes No. / Shell, Size mm , Thickness (Min.) mm (BWG :) Length mm

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

Baffles Cross Baffle ea / Shell , Type , Cut - % Dia. , Spacing c/c mm , End - mm

ρv²	Inlet Nozzle	1,916.26 , Entrance 2,481.69 , Outlet Nozzle 1,996.90 kg/m·sec2			Impingement plate
Material	Tube		Shell & Cover		Channel & Cover
	Tube Sheet		Baffle		Expansion Joint
Estimated Weight	Empty Weight kg		Bundle Weight kg		Full Water Weight kg
Corrosion Allowance	Shell side mm		Tube side mm		Tube Joints :
Insulation	Shell side mm		Tube side mm		

MEAN METAL TEMPERATURE	Temperature, ℃		Pressure, kPag	
	Shell	Tube	Shell	Tube
Normal Operating	-	-	-	-
Startup	-	-	-	-

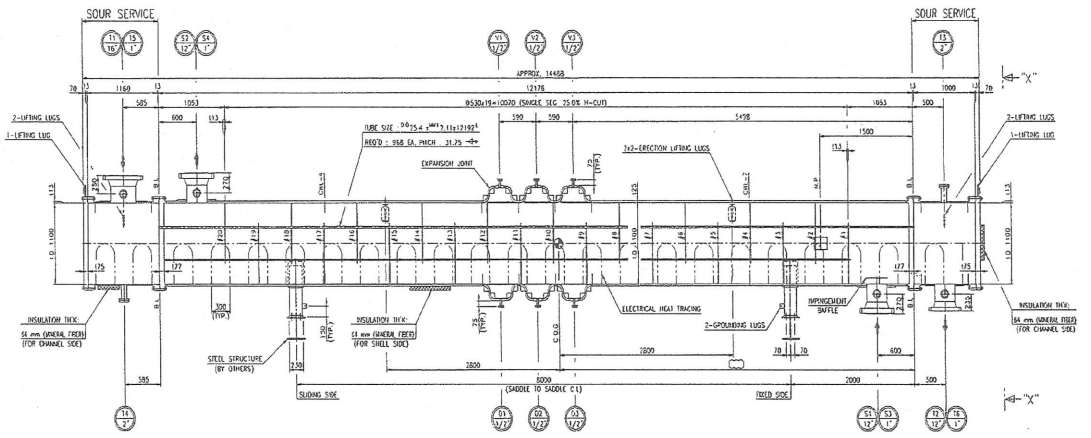
NOZZLE	SHELL SIDE				TUBE SIDE			
	Tag	No	NPS	Remarks	Tag	No	NPS	Remarks
Inlet								
Outlet								
Vent								
Drain								
Liquid Outlet								
Thermowell								
Util. Con.								
RATING								

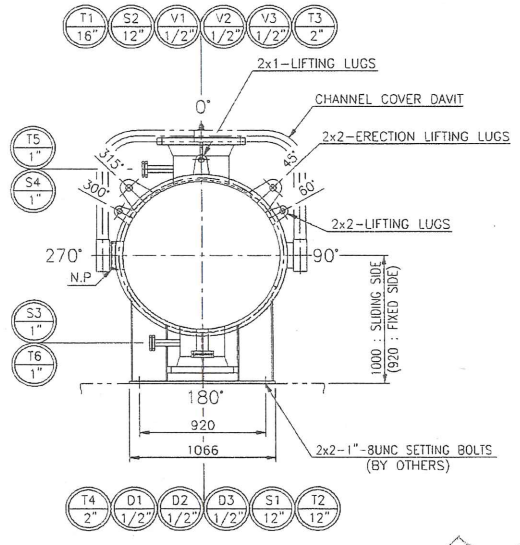
SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 6 OF 20

		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	Produced Gas / BFW Exchanger					
ITEM NO.	3A-E-101A/B					



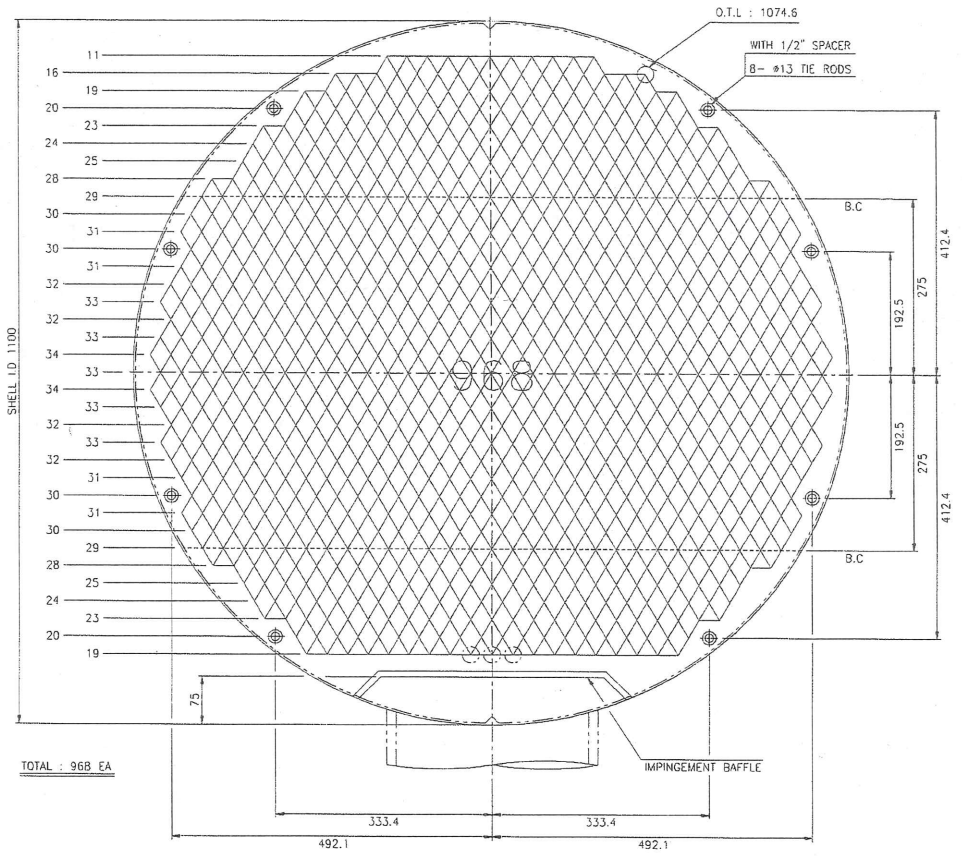


SEWON CELLONTECH

TUBULAR HEAT EXCHANGER

SHEET 7 OF 20

		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	Produced Gas / BFW Exchanger					
ITEM NO.	3A-E-101A/B					



3A-E-101

1/5

I.D.-SHELL	1,100.0 ID	(AEL)
ALLOWABLE O.T.L	1074.6	mm
ACTUAL O.T.L	1074.6	mm
SEAL STRIP	N/A	Pairs
SEAL Rod	N/A	ea

TOTAL 968 HOLES FOR 25.4 OD TUBES ON 31.75 TRIANGULAR PITCH.
1 PASSES. BAFFLE CUT SINGLE SEGM. 25% DIA.

Remarks

Thermal/Hydraulic/ Vibration Verification Report

(Rev.1)

3A-E-101A/B

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

3A-E-101A/B (Max Duty and 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 :		1.94	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	48.264	<	105.000 kPa	----------	O.K
	tube-side	3.982	<	15.000 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-101A/B (Max Duty and UA Case)

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

VALUE TO BE CHECKED	Inlet	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1511.	1060.	1511.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.804	0.564	0.804	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.1500	0.1434	0.1565	< 0.8	O.K
Ave. crossflow velocity ratio	0.1385	0.1324	0.1445	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.059	0.115	0.062	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.200	0.202	< 0.8	O.K
Vortex shedding ratio		0.201	0.207	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.61	2.34	< If velocity is exceed 2.23 / 2.27	O.K.
pv2 (kg/m-s2)		2481.69	4952.99	< 5953 by TEMA	O.K.

11/20

Vibration Analysis

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 14:06 SN: 1500213869 — MEG Energy Units

Max. Duty and UA Case

Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles

Shellside condition		Sens. Liquid	(Level 2.3)	
Axial stress loading	(MPa)	0.000	Added mass factor	1.761
Beta		4.000		

Position In The Bundle		Inlet	Center	Outlet
Length for natural frequency	(mm)	1511.	1060.	1511.
Length/TEMA maximum span	(--)	0.804 *	0.564	0.804 *
Number of spans	(--)	11	11	11
Tube natural frequency	(Hz)	38.0 +	45.2	38.5
Shell acoustic frequency	(Hz)			

Flow Velocities		Inlet	Center	Outlet
Window parallel velocity	(m/s)	0.84	0.87	0.89
Bundle crossflow velocity	(m/s)	0.31	0.61	0.33
Bundle/shell velocity	(m/s)	0.32	0.62	0.34

Fluidelastic Instability Check		Inlet	Center	Outlet
Log decrement	HTRI	0.100	0.100	0.100
Critical velocity	(m/s)	2.23	4.57	2.27
Baffle tip cross velocity ratio	(--)	0.1500	0.1434	0.1565
Average crossflow velocity ratio	(--)	0.1385	0.1324	0.1445

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

Tube Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	0.059	0.115	0.062
Parallel flow amplitude	(mm)	0.002	0.003	0.002
Crossflow amplitude	(mm)	0.039	0.035	0.041
Tube gap	(mm)	6.350	6.350	6.350
Crossflow RHO-V-SQ	(kg/m-s2)	91.49	340.24	97.15

Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
Fluidelastic instability ratio	(--)	0.200	0.202
Vortex shedding ratio	(--)	0.201	0.207
Crossflow amplitude	(mm)	0.08360	0.08364
Crossflow velocity	(m/s)	1.06	1.09
Tubesheet to inlet/outlet support	(mm)	None	None

Shell Entrance/Exit Parameters		Entrance	Exit
Impingement plate		Yes	
Flow area	(m2)	0.060	0.044
Velocity	(m/s)	1.61	2.34
RHO-V-SQ	(kg/m-s2)	2481.69	4952.99

Shell type	AEL	Baffle type	Single-Seg.
Tube type	Plain	Baffle layout	Perpend.
Pitch ratio	1.2500	Tube diameter, (mm)	25.400
Layout angle	30	Tube material	Carbon steel
		Supports/baffle space	

Program Messages

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

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

Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 14:06 SN: 1500213869 — MEG Energy Units

Max. Duty and UA Case

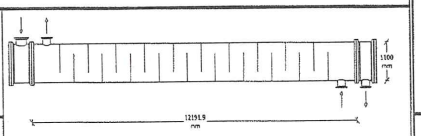
Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles

Process Data		Cold Shellside		Hot Tubeside	
Fluid name		BFW		Produced Gas	
Fluid condition			Sens. Liquid		Cond. Vapor
Total flow rate	(kg/hr)		669128		103332
Weight fraction vapor, In/Out	(--)	0.000	0.000	1.000	0.180
Temperature, In/Out	(Deg C)	98.30	164.00	174.00	136.30
Temperature, Average/Skin	(Deg C)	131.15	139.01	155.15	157.94
Wall temperature, Min/Max	(Deg C)	106.57	167.30	107.66	167.82
Pressure, In/Average	(kPa)	2850.04	2825.91	984.014	982.023
Pressure drop, Total/Allowed	(kPa)	48.264	105.000	3.982	15.000
Velocity, Mid/Max allow	(m/s)	0.61		5.45	
Mole fraction inert	(--)				0.0000
Average film coef.	(W/m2-K)		8691.24		5771.16
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000180		0.000350

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	1016.73 /	2739.43 /	1036.50
Heat duty, Calculated/Specified	(kW)	52093. /	52017.	
Effective overall temperature difference	(Deg C)	27.5		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	28.26 *	0.9739 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5464.3
Approximate tubeside	(L)	6224.3

Shell Construction Information

TEMA shell type	AEL		Shell ID	(mm)	1100.00
Shells Series	1 Parallel	2	Total area	(m2)	1883.47
Passes Shell	1 Tube	1	Eff. area	(m2/shell)	929.377
Shell orientation angle (deg)	1.00				
Impingement present	Rectangular plate		Imp. length/width (mm)		400 / 400
Pairs seal strips	0		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Rear head support plate	No	
Weight estimation Wet/Dry/Bundle	46228.1 /	34547.6 /	15724.4 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	25.00	
Crosspasses/shellpass		21	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	530.000	1	21.86	275.000
Inlet spacing	(mm)	980.939	2	0.00	0.000
Outlet spacing	(mm)	980.939			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		968
Overall length	(mm)	12192.	Pct tubes removed (both)		3.72
Effective length	(mm)	12032.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	160.000	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)		30

Shellside Performance

Nom vel, X-flow/window 0.82 / 1.00

Flow fractions for heat transfer 0.663

A=0.1305 B=0.6260 C=0.0820 E=0.1614 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.985	0.919	1.072	0.956	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
54.17	29.30	5.36	Inlet	5.07	43.13
MOMENTUM		0.00	Outlet	6.10	12.33

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F
RPM	Ann-Mist	Transition	Gravity	0.3895

H. T. Parameters

		Shell	Tube
Overall wall correction		1.010	
Midpoint	Prandtl no.	1.23	
Midpoint	Reynolds no.	71555	11456
Bundle inlet	Reynolds no.	28071	72689
Bundle outlet	Reynolds no.	48533	4784
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
11.93	21.54	62.16	4.37	1.94

Total fouling resistance 5.993e-4

Differential resistance 1.876e-5

Shell Nozzles

Inlet at channel end-No		Inlet	Outlet	Liquid Outlet
Number at each position		1	1	0
Diameter	(mm)	295.301	295.301	
Velocity	(m/s)	1.41	1.50	
Pressure drop	(kPa)	2.447	2.944	
Height under nozzle	(mm)	75.000	42.666	
Nozzle R-V-SQ	(kg/m-s2)	1916.26	2034.92	
Shell ent.	(kg/m-s2)	2481.69	4952.99	

Tube Nozzle

		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(mm)	380.400	295.301	
Velocity	(m/s)	24.73	6.70	
Pressure drop	(kPa)	1.718	0.491	
Nozzle R-V-SQ	(kg/m-s2)	3122.34	1402.93	

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	25.4000	0.3969

3A-E-101A/B (Min Case)

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

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

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

1. Thermal and Hydraulic performance

- Thermal performance :		95.56	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	33.175	<	105.000 kPa	----------	O.K
	tube-side	0.254	<	15.000 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-101A/B (Min Case)

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

VALUE TO BE CHECKED	Inlet	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1511.	1060.	1511.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.804	0.564	0.804	< 1.0 TEMA	O.K
Fluidelastic Instability Check					
Baffle tip cross velocity ratio	0.1234	0.1153	0.1253	< 0.8	O.K
Ave. crossflow velocity ratio	0.1139	0.1064	0.1157	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.048	0.092	0.049	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.165	0.162	< 0.8	O.K
Vortex shedding ratio		0.166	0.164	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.32	1.86	< If velocity is exceed 2.23 / 2.24	O.K.
ρv2 (kg/m-s2)		1685.46	3239.12	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 14:07 SN: 1500213869 — MEG Energy Units

Min. Case

Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles

1	Shellside condition		Sens. Liquid	(Level 2.3)	
2	Axial stress loading	(MPa)	0.000	Added mass factor	1.761
3	Beta		4.000		

	Position In The Bundle		Inlet	Center	Outlet
5	Length for natural frequency	(mm)	1511.	1060.	1511.
6	Length/TEMA maximum span	(--)	0.804 *	0.564	0.804 *
7	Number of spans	(--)	11	11	11
8	Tube natural frequency	(Hz)	38.0 +	44.9	38.2
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**Outlet**
11	Window parallel velocity	(m/s)	0.69	0.69	0.70
12	Bundle crossflow velocity	(m/s)	0.25	0.48	0.26
13	Bundle/shell velocity	(m/s)	0.26	0.49	0.26
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**Outlet**
15	Log decrement	HTRI	0.100	0.100	0.100
16	Critical velocity	(m/s)	2.23	4.53	2.24
17	Baffle tip cross velocity ratio	(--)	0.1234	0.1153	0.1253
18	Average crossflow velocity ratio	(--)	0.1139	0.1064	0.1157
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**Outlet**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**Outlet**
24	Vortex shedding ratio	(--)	0.048	0.092	0.049
25	Parallel flow amplitude	(mm)	0.001	0.002	0.001
26	Crossflow amplitude	(mm)	0.026	0.023	0.027
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	61.86	222.84	63.25

	Bundle Entrance/Exit (analysis at first tube row)			Entrance	Exit
31	Fluidelastic instability ratio		(--)	0.165	0.162
32	Vortex shedding ratio		(--)	0.166	0.164
33	Crossflow amplitude		(mm)	0.05603	0.05381
34	Crossflow velocity		(m/s)	0.87	0.86
35	Tubesheet to inlet/outlet support		(mm)	None	None
36	**Shell Entrance/Exit Parameters**			**Entrance**	**Exit**
37	Impingement plate			Yes	
38	Flow area		(m2)	0.060	0.044
39	Velocity		(m/s)	1.32	1.86
40	RHO-V-SQ		(kg/m-s2)	1685.46	3239.12

41	Shell type	AEL	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	30	Tube material	Carbon steel
45			Supports/baffle space	

46 **Program Messages**

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

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

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

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Final Results

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 14:07 SN: 1500213869 **MEG Energy Units**

Min. Case

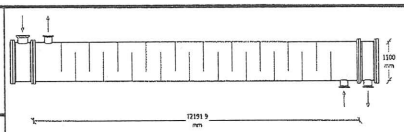
Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles

Process Data		Cold Shellside		Hot Tubeside	
Fluid name		BFW		Produced Gas	
Fluid condition			Sens. Liquid		Cond. Vapor
Total flow rate	(kg/hr)		551436		32254.1
Weight fraction vapor, In/Out	(--)	0.000	0.000	1.000	0.133
Temperature, In/Out	(Deg C)	98.30	125.80	174.30	108.30
Temperature, Average/Skin	(Deg C)	112.05	107.48	141.30	119.50
Wall temperature, Min/Max	(Deg C)	98.84	140.91	98.91	142.93
Pressure, In/Average	(kPa)	2850.04	2833.45	984.014	983.888
Pressure drop, Total/Allowed	(kPa)	33.175	105.000	0.254	15.000
Velocity, Mid/Max allow	(m/s)	0.48		0.38	
Mole fraction inert	(--)				0.0000
Average film coef.	(W/m2-K)		6943.65		732.08
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000180		0.000350

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(W/m2-K)	210.95 /	548.14 /	412.53
Heat duty, Calculated/Specified	(kW)	17779. /	17752.	
Effective overall temperature difference	(Deg C)	45.3		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	45.36 *	0.9982 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(L)	5464.3
Approximate tubeside	(L)	6224.3

Shell Construction Information

TEMA shell type	AEL		Shell ID	(mm)	1100.00
Shells Series	1 Parallel	2	Total area	(m2)	1883.47
Passes Shell	1 Tube	1	Eff. area	(m2/shell)	929.377
Shell orientation angle (deg)	1.00				
Impingement present	Rectangular plate		Imp. length/width (mm)		400 / 400
Pairs seal strips	0		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Rear head support plate	No	
Weight estimation Wet/Dry/Bundle	46227.9 /	34547.4 /	15724.3 (kg/shell)		

Baffle Information

Type	Perpend.	Single-Seg.	Baffle cut (% dia)	25.00	
Crosspasses/shellpass		21	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	530.000	1	21.86	275.000
Inlet spacing	(mm)	980.939	2	0.00	0.000
Outlet spacing	(mm)	980.939			
Baffle thickness	(mm)	12.700			

Tube Information

Tube type		Plain	Tubecount per shell		968
Overall length	(mm)	12192.	Pct tubes removed (both)		3.72
Effective length	(mm)	12032.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	160.000	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)		30

Shellside Performance

Nom vel, X-flow/window 0.66 / 0.79

Flow fractions for heat transfer 0.661

A=0.1307 B=0.6246 C=0.0798 E=0.1649 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.985	0.919	1.072	0.956	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
54.98	28.74	5.36	Inlet	5.04	63.67
MOMENTUM		0.00	Outlet	5.89	12.11

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F
RPM	Gravity	Gravity	Gravity	0.1246

H. T. Parameters		Shell	Tube
Overall wall correction		0.994	
Midpoint	Prandtl no.	1.73	
Midpoint	Reynolds no.	41703	1455
Bundle inlet	Reynolds no.	23078	22220
Bundle outlet	Reynolds no.	29999	1048
Fouling layer	(mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
5.94	67.58	24.74	1.74	95.56

Total fouling resistance 5.993e-4

Differential resistance 0.00232

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-No		1	1	0
Number at each position				
Diameter	(mm)	295.301	295.301	
Velocity	(m/s)	1.16	1.19	
Pressure drop	(kPa)	1.672	1.953	
Height under nozzle	(mm)	75.000	42.666	
Nozzle R-V-SQ	(kg/m-s2)	1301.45	1330.76	
Shell ent.	(kg/m-s2)	1685.46	3239.12	

Tube Nozzle		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(mm)	380.400	295.301	
Velocity	(m/s)	7.45	1.34	
Pressure drop	(kPa)	0.161	0.031	
Nozzle R-V-SQ	(kg/m-s2)	293.56	87.75	

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	25.4000	0.3969

3A-E-101A/B (Start-Up 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 (3).

For the design result (the geometry data), please refer to the Equopment DATA SHEET (3) and Fabrication drawing.

1. Thermal and Hydraulic performance

- Thermal performance :		85.88	% Over - Design Case		----------	O.K.
- Pressure drop :						
	Shell-side	48.042	<	105.000 kPa	----------	O.K
	tube-side	11.738	<	15.000 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-101A/B (Min Case)

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

VALUE TO BE CHECKED	Inlet	Center	Outlet	RECOMMEND LIMIT	CONCLUSION
Unsupported span (mm)	1511.	1060.	1511.	1879 (By TEMA)	O.K
Length / TEMA maximum span	0.804	0.564	0.804	< 1.0 TEMA	O.K
Fluidelastic Instability Check.					
Baffle tip cross velocity ratio	0.1498	0.1420	0.1542	< 0.8	O.K
Ave. crossflow velocity ratio	0.1383	0.1311	0.1423	< 0.8	O.K
Acoustic Vibration Check					
Vortex shedding ratio	-	-	-	-	-
Tubulent buffeting ratio	-	-	-	-	-
Tube Vibration Check					
Vortex shedding ratio	0.059	0.114	0.061	< 0.5	O.K
Tubulent buffeting ratio	-	-	-	-	-
Bundle Entance / Exit		Entrance	Exit		
Fluidelastic Instability ratio		0.200	0.199	< 0.8	O.K
Vortex shedding ratio		0.201	0.203	< 0.5	O.K
Shell Entrance / Exit					
Velocity (m/sec)		1.61	2.30	< If velocity is exceed 2.23 / 2.26	O.K.
pv2 (kg/m-s2)		2481.69	4860.53	< 5953 by TEMA	O.K.

Vibration Analysis

Released to the following HTRI Member Company:

sewon
M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 14:08 SN: 1500213869 — **MEG Energy Units**

Start-up Case
Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles

1	Shellside condition		Sens. Liquid	(Level 2.3)	
2	Axial stress loading	(MPa)	0.000	Added mass factor	1.761
3	Beta		4.000		
4	**Position In The Bundle**		**Inlet**	**Center**	**Outlet**
5	Length for natural frequency	(mm)	1511.	1060.	1511.
6	Length/TEMA maximum span	(--)	0.804 *	0.564	0.804 *
7	Number of spans	(--)	11	11	11
8	Tube natural frequency	(Hz)	38.1 +	45.1	38.4
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**Inlet**	**Center**	**Outlet**
11	Window parallel velocity	(m/s)	0.84	0.86	0.87
12	Bundle crossflow velocity	(m/s)	0.31	0.60	0.32
13	Bundle/shell velocity	(m/s)	0.32	0.61	0.33
14	**Fluidelastic Instability Check**		**Inlet**	**Center**	**Outlet**
15	Log decrement	HTRI	0.100	0.100	0.100
16	Critical velocity	(m/s)	2.23	4.56	2.26
17	Baffle tip cross velocity ratio	(--)	0.1498	0.1420	0.1542
18	Average crossflow velocity ratio	(--)	0.1383	0.1311	0.1423
19	**Acoustic Vibration Check**		**Inlet**	**Center**	**Outlet**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**Inlet**	**Center**	**Outlet**
24	Vortex shedding ratio	(--)	0.059	0.114	0.061
25	Parallel flow amplitude	(mm)	0.002	0.003	0.002
26	Crossflow amplitude	(mm)	0.038	0.035	0.040
27	Tube gap	(mm)	6.350	6.350	6.350
28	Crossflow RHO-V-SQ	(kg/m-s2)	91.43	336.20	95.27
29	**Bundle Entrance/Exit**				
30	**(analysis at first tube row)**			**Entrance**	**Exit**
31	Fluidelastic instability ratio		(--)	0.200	0.199
32	Vortex shedding ratio		(--)	0.201	0.203
33	Crossflow amplitude		(mm)	0.08337	0.08172
34	Crossflow velocity		(m/s)	1.06	1.07
35	Tubesheet to inlet/outlet support		(mm)	None	None
36	**Shell Entrance/Exit Parameters**			**Entrance**	**Exit**
37	Impingement plate			Yes	
38	Flow area		(m2)	0.060	0.044
39	Velocity		(m/s)	1.61	2.30
40	RHO-V-SQ		(kg/m-s2)	2481.69	4860.53

41	Shell type	AEL	Baffle type	Single-Seg.
42	Tube type	Plain	Baffle layout	Perpend.
43	Pitch ratio	1.2500	Tube diameter, (mm)	25.400
44	Layout angle	30	Tube material	Carbon steel
45			Supports/baffle space	

46 **Program Messages**

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

Released to the following HTRI Member Company:

sewon

M.K.Park

Xist Ver. 6.00 SP3 2013/08/19 14:08 SN: 1500213869 — MEG Energy Units

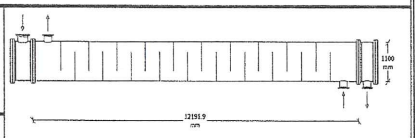
Start-up Case

Rating - Incline Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles

Process Data		Cold Shellside		Hot Tubeside	
Fluid name		BFW		Produced Gas	
Fluid condition			Sens. Liquid		Cond. Vapor
Total flow rate	(kg/hr)		669128		139760
Weight fraction vapor, In/Out	(--)	0.000	0.000	1.000	0.565
Temperature, In/Out	(Deg C)	98.30	146.00	166.00	151.20
Temperature, Average/Skin	(Deg C)	122.15	129.56	158.60	154.10
Wall temperature, Min/Max	(Deg C)	114.43	152.79	116.59	153.76
Pressure, In/Average	(kPa)	2850.04	2826.02	984.014	978.145
Pressure drop, Total/Allowed	(kPa)	48.042	105.000	11.738	15.000
Velocity, Mid/Max allow	(m/s)	0.60		9.43	
Mole fraction inert	(--)				0.0000
Average film coef.	(W/m2-K)		8396.34		7264.35
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-K/W)		0.000180		0.000350

Overall Performance Data						
Overall coef., Reqd/Clean/Actual	(W/m2-K)	581.08	/	3066.42	/	1080.08
Heat duty, Calculated/Specified	(kW)	38155.	/	37608.		
Effective overall temperature difference	(Deg C)	34.8				
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	35.25	*	0.9877	*	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes		
Approximate shellside	(L)	5464.3
Approximate tubeside	(L)	6224.3

Shell Construction Information					
TEMA shell type	AEL		Shell ID	(mm)	1100.00
Shells Series	1 Parallel	2	Total area	(m2)	1883.47
Passes Shell	1 Tube	1	Eff. area	(m2/shell)	929.377
Shell orientation angle (deg)	1.00				
Impingement present	Rectangular plate		Imp. length/width (mm)		400 / 400
Pairs seal strips	0		Passlane seal rods (mm)	0.000	No. 0
Shell expansion joint	No		Rear head support plate	No	
Weight estimation Wet/Dry/Bundle	46233.2	/ 34552.7	/ 15729.5	(kg/shell)	

Baffle Information					
Type	Perpend.	Single-Seg.	Baffle cut (% dia)	25.00	
Crosspasses/shellpass		21	No.	(Pct Area)	(mm) to C.L
Central spacing	(mm)	530.000	1	21.86	275.000
Inlet spacing	(mm)	980.939	2	0.00	0.000
Outlet spacing	(mm)	980.939			
Baffle thickness	(mm)	12.700			

Tube Information					
Tube type		Plain	Tubecount per shell		968
Overall length	(mm)	12192.	Pct tubes removed (both)		3.72
Effective length	(mm)	12032.	Outside diameter	(mm)	25.400
Total tubesheet	(mm)	160.000	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)		30

Shellside Performance	
Nom vel, X-flow/window	0.81 / 0.98

Flow fractions for heat transfer 0.662

A=0.1310 B=0.6258 C=0.0813 E=0.1619 F=0.0000

Shellside Heat Transfer Corrections				
Total	Beta	Gamma	End	Fin
0.985	0.919	1.072	0.956	1.000

Pressure Drops (Percent of Total)					
Cross	Window	Ends	Nozzle	Shell	Tube
54.32	29.20	5.36	Inlet	5.09	27.64
MOMENTUM		0.00	Outlet	6.03	27.49

Two-Phase Parameters				
Method	Inlet	Center	Outlet	Mix F
RPM	Ann-Mist	Shear	Transition	0.3431

H. T. Parameters		Shell	Tube
Overall wall correction		1.010	
Midpoint	Prandtl no.	1.36	
Midpoint	Reynolds no.	64516	20968
Bundle inlet	Reynolds no.	28064	96888
Bundle outlet	Reynolds no.	42824	11618
Fouling layer	(mm)		

Thermal Resistance				
Shell	Tube	Fouling	Metal	Over Des
12.86	17.83	64.78	4.53	85.88
Total fouling resistance				5.993e-4
Differential resistance				7.951e-4

Shell Nozzles				Liquid
Inlet at channel end-No		Inlet	Outlet	Outlet
Number at each position		1	1	0
Diameter	(mm)	295.301	295.301	
Velocity	(m/s)	1.41	1.47	
Pressure drop	(kPa)	2.447	2.899	
Height under nozzle	(mm)	75.000	42.666	
Nozzle R-V-SQ	(kg/m-s2)	1916.26	1996.90	
Shell ent.	(kg/m-s2)	2481.69	4860.53	

Tube Nozzle		Inlet	Outlet	Liquid
		RADIAL	RADIAL	Outlet
Diameter	(mm)	380.400	295.301	
Velocity	(m/s)	34.53	32.53	
Pressure drop	(kPa)	3.244	3.227	
Nozzle R-V-SQ	(kg/m-s2)	5897.35	9219.41	

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	25.4000	0.3969