PPI / NARGAN	**DEHDASHT PETROCHEMICAL INDUSTRY COMPANY** **DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT**	شرکت صنایع پتروشیمی خلیج فارس Persian Gulf Petrochemical Industries Co PGPIC شرکت صنایع پتروشیمی دهدشت (سهامی عام)
Contract No.: DPIC/98-12	**DOCUMENT TITLE: Thermal Calculation for Heat Exchangers**	**POI: IFA** / **Rev.: D0**
	DOCUMENT No: DPIC9812-000-VD-1002-ME-CLN-0032	**Sheet 1 of 21**

Exchangers shall be designed and rated by HTRI ver.07

Thermal Calculation for Heat Exchangers

PURCHASER'S COMMENT/APPROVAL STATUS		Purchaser: NARGAN
1	AP: Approved (Released for Manufacturing)	
2	AN: Approved With Minor Comments (Fabrication may Proceed)	Requisition No.: DPIC98-12-001-000-ME-MR-4150-0001-D1
X	NF: Approved With Comments (Fabrication not Proceed)	
4	RJ: Rejected	Item No. (Tag No.): PK-6101
5	NR: Not be Returned	
Date: 20.11.2021	Signature: A.AB	Vendor Doc. No.: DPIC9812-000-VD-1002-ME-CLN-0032-D0

REV.	DATE ISSUE	Purpose of Issue	PREPARED	CHECKED	APPROVED
D0	30-Oct-21	IFA	R.GOUDARZI	DR.A.NEJATI	DR.A.NEJATI

KASRAVAND Engineering & Construction

TABULATION OF REVISED PAGES

Page	Rev-D0	Rev-D1	Rev-D2	Rev-D3	Rev-D4
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2	x				
3	x				
4	x				
5	x				
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PURPOSE:

The purpose of this document is to calculate Heat exchangers.

Thermal calculation is done by “ASPEN EXCHANGER DESIGN AND RATING V11”.

ATTACHMENTS:

Thermal calculation sheets for heat exchangers as below:

1- E-6101 (Hexane Cooler)

2- E-PK6101-1A/B (Oil Cooler)

3- E-PK6101-2 (Propylene Condenser)

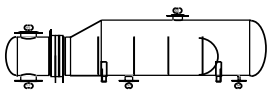
4- E-PK6101-3 (Economizer)

TEMA Sheet

Heat Exchanger Specific

1	Company: DEHDASHT PETROCHEMICAL INDUSTRY COMPANY						
2	For : PK-6101						
3	Service of Unit: HEXANE CHILLER Our Reference:						
4	Item No.: E-6101 Your Reference:						
5	Date: Rev No.: 00 Job No: PK-6101						
6	Size: 1150 /1676 BKU Horizontal				parallel 1 series		
7	Surf/unit(eff.) Shells/unit 1				f.) 434.4 m²		
8	**PERFORMANCE C**						
9	Fluid allocation				Tube Side		
10	Fluid name		RROPYLENE		HEXANE		
11	Fluid quantity, Total	kg/h		21196		911350	
12	Vapor (In/Out)	kg/h	4239	21188	0	0	
13	Liquid	kg/h	16957	8	911350	911350	
14	Noncondensable	kg/h	0	0	0		
15							
16	Temperature (In/Out)	°C	-23.98	-24.89	-16		
17	Bubble / Dew point	°C	/	/	/		
18	Density Vapor/Liquid	kg/m³	5.81 / 580	5.6 / 580.2	/ 703.		
19	Viscosity	cp	0.0073 / 0.1422	0.0073 / 0.1425	/ 0.48		
20	Molecular wt, Vap		42.08	42.08			
21	Molecular wt, NC						
22	Specific heat	kJ/(kg-K)	1.402 / 2.207	1.4 / 2.206	/ 1.90		
23	Thermal conductivity	W/(m-K)	0.0126 / 0.1281	0.0126 / 0.1282	/ 0.13		
24	Latent heat	kJ/k		411			
25	Pressure (abs)	ba		57278	6.914	6.56446	
26	Velocity (Mean/Max)	m			2.55 / 2.55		
27	Pressure drop, allow./	ba		08722	0.26	0.34954	
28	Fouling resistance (m	m²-K/			9E-05	0.00011 Ao based	
29	Heat exchanged W				MTD (corrected) 6.23		°C
30	Transfer rate, Service		Dirty 759.3		Clean 964.7		W/(m²-K)

31	**CONSTRUCTION OF ONE SHELL**						**Sketch**	
32			Shell Side		Tube Side			
33	Design/Vacuum/test pressure	bar	22 /	/	22 /	/		
34	Design temperature / MDMT	°C	120 /	-45	120 /	-45		
35	Number passes per shell		1		2			
36	Corrosion allowance	mm	3		3			
37	Connections In	in	1 8	/ 300 ANSI	1 18	/ 300 ANSI		
38	Size/Rating Out		1 2	/ 300 ANSI	1 18	/ 300 ANSI		
39	Nominal Out - Vapor		1 10	/ 300 ANSI		/ 300 ANS		



40	Tube #: 816 U's OD: 19.05 Tks. Average 2.11 mm Length: 4200 mm P					attern:90
41	Tube type: Plain Insert:None Fin#: #/					06
42	Shell SA-516 70 K02700 ID 1150 OD 1174 mm			Shell cover	SA-516 70 K02700	
43	Channel or bonnet SA-516 70 K02700			Channel cover	-	
44	Tubesheet-stationary Carbon Steel -			Tubesheet-floating	-	
45	Floating head cover -			Impingement protection	None	
46	Baffle-cross Carbon Steel Type Unbaffled Cut(%d)			Spacing: c/c		mm
47	Baffle-long - Seal Type			Inlet		mm
48	Supports-tube U-bend 0			Type		
49	Bypass seal	Tube-tubesheet joint	Expanded & strength welded(App.A 'e')			
50	Expansion joint -	Type None				
51	RhoV2-Inlet nozzle 1197	ntrance 104	Bundle exit 484			kg/(m-s²)
52	Gaskets - Shell side Flat Metal Jacket Fibe	Tube side	Flat Metal Jacket Fibe			
53	Floating head -					
54	Code requirements ASME Code Sec VIII Div 1	TEMA class	R - refinery service			
55	Weight/Shell 15166.8 Filled with water 27816.9	Bundle	7840.1	kg		
56	Remarks 10% OVER DESIGN HAS BEEN CONSIDERED IN FLOW					
57						
58						

based on HTRI checking file, duty is unbalance and it seems propylene flowrate shall be slightly decreased.

according to DPIC98-12-001-0-ME-DS-4150-6101

based on data sheet Hexane fllowrate is 74800x1.1 kg/hr. Please clarify.

Refrigerant shall be fully vaporized in kettle.

revise this item

Calculated pressure drop shall be less than allowable one. Based on data sheet allowable pressure drop is 50kpa.

Design temperature of both sides shall be saturate temperature corresponding to design pressure which is equal to 125C. Please recheck.

Please specify these item accordance with Datasheet

Please check the UC566 and PWHT attention to MDMT

Please specify according to MDS

Overall Summary

Please specify shell thickness.

1	Size	1150	X	4200	mm	Type	BKU	Hor		Connected in	1	parallel	1	series
2	Surf/Unit (gross/eff/finned)			447.3	/	434.4	/		m²	Shells/unit	1			
3	Surf/Shell (gross/eff/finned)			447.3	/	434.4	/		m²					
4	Rating / Checking									**PERFORMANCE OF ONE UNIT**				
5						**Shell Side**		**Tube Side**		**Heat Transfer Parameters**				
6	**Process Data**					**In**	**Out**	**In**	**Out**	Total heat load		kW	1924.5	
7	Total flow			kg/h		21196		911350		Eff. MTD/ 1 pass MTD		°C	6.23 /	6.31
8	Vapor			kg/h		4239	21188	0	0	Actual/Reqd area ratio - fouled/clean			1.07 /	1.36
9	Liquid			kg/h		16957	8	911350	911350					
10	Noncondensable			kg/h		0		0		**Coef./Resist.**	W/(m²-K)	m²-K/W		%
11	Cond./Evap.			kg/h		16949		0		Overall fouled	759.3	0.00132		
12	Temperature			°C		-23.98	-24.89	-16	-19.99	Overall clean	964.7	0.00104		
13	Bubble Point			°C						Tube side film	2144.8	0.00047		35.4
14	Dew Point			°C						Tube side fouling	9052.1	0.00011		8.39
15	Vapor mass fraction					0.2	1	0	0	Tube wall	25469	4E-05		2.98
16	Pressure (abs)			bar		2.66	2.57278	6.914	6.56446	Outside fouling	5882.4	0.00017		12.91
17	DeltaP allow/cal			bar		0.5	0.08722	0.26	0.34954	Outside film	1882.9	0.00053		40.32
18	Velocity			m/s		0.57	2.01	2.55	2.54					
19	**Liquid Properties**									**Shell Side Pressure Drop**		bar		%
20	Density			kg/m³		580	580.2	703.25	706.68	Inlet nozzle		0.01617		41.49
21	Viscosity			cp		0.1422	0.1425	0.4872	0.5128	InletspaceXflow		0		0
22	Specific heat			kJ/(kg-K)		2.207	2.206	1.906	1.89	Baffle Xflow		0.014		35.92
23	Therm. cond.			W/(m-K)		0.1281	0.1282	0.131	0.1324	Baffle window		0		0
24	Surface tension			N/m		0.0116	0.0117	0.0224	0.0229	OutletspaceXflow		0		0
25	Molecular weight					42.08	42.08	85.93	85.93	Outlet nozzle		0.0088		22.58
26	**Vapor Properties**									Intermediate nozzles				
27	Density			kg/m³		5.81	5.6			**Tube Side Pressure Drop**		bar		%
28	Viscosity			cp		0.0073	0.0073			Inlet nozzle		0.0185		5.29
29	Specific heat			kJ/(kg-K)		1.402	1.4			Entering tubes		0.01717		4.91
30	Therm. cond.			W/(m-K)		0.0126	0.0126			Inside tubes		0.29638		84.79
31	Molecular weight					42.08	42.08			Exiting tubes		0.00674		1.93
32	**Two-Phase Properties**									Outlet nozzle		0.01075		3.08
33	Latent heat			kJ/kg		410	411			Intermediate nozzles				
34	**Heat Transfer Parameters**									**Velocity / Rho*V2**		m/s		kg/(m-s²)
35	Reynolds No. vapor					95762.25	478945.6			Shell nozzle inlet		6.56		1197
36	Reynolds No. liquid					19549.12	8.8	54670.3	51943.13	Shell bundle Xflow		0.57	2.01	
37	Prandtl No. vapor					0.81	0.81			Shell baffle window				
38	Prandtl No. liquid					2.45	2.45	7.09	7.32	Shell nozzle outlet		20.75		2401
39	**Heat Load**					kW		kW		Shell nozzle interm				
40	Vapor only					0		0				m/s		kg/(m-s²)
41	2-Phase vapor					0		0		Tube nozzle inlet		2.39		4009
42	Latent heat					1924.5		0		Tubes		2.55	2.54	
43	2-Phase liquid					0		0		Tube nozzle outlet		2.38		3989
44	Liquid only					0		-1924.5		Tube nozzle interm				
45	**Tubes**							**Baffles**				**Nozzles: (No./OD)**		
46	Type					Plain		Type	Unbaffled				**Shell Side**	**Tube Side**
47	ID/OD			mm		14.83 /	19.05	Number	0	Inlet	mm	1 /	219.08	1 / 457.2
48	Length act/eff			cm		420 /	406.7	Cut(%d)		Outlet		1 /	60.32	1 / 457.2
49	Tube passes					2		Cut orientation		Intermediate		1 /	273.05	/
50	Tube No.					1632		Spacing: c/c	mm	Impingement protection			None	
51	Tube pattern					90		Spacing at inlet	mm					
52	Tube pitch			mm		24		Spacing at outlet	mm					
53	Insert						None							
54	Vibration problem (HTFS / TEMA)					Yes /				RhoV2 violation				Yes

Overall Performance

Rating / Checking		Shell Side		Tube Side	
Total mass flow rate	kg/h	21196		911350	
Vapor mass flow rate (In/Out)	kg/h	4239	21188	0	0
Liquid mass flow rate	kg/h	16957	8	911350	911350
Vapor mass fraction		0.2	1	0	0
Temperatures	°C	-23.98	-24.89	-16	-19.99
Bubble / Dew point	°C	/	/	/	/
Operating Pressures	bar	2.66	2.57278	6.914	6.56446
Film coefficient	W/(m²-K)	1882.9		2144.8	
Fouling resistance	m²-K/W	0.00017		0.00011	
Velocity (highest)	m/s	2.01		2.55	
Pressure drop (allow./calc.)	bar	0.5 / 0.08722		0.26 / 0.34954	

Total heat exchanged	kW	1924.5	Unit	BKU	2 pass	1 ser	1 par
Overall clean coeff. (plain/finned)	W/(m²-K)	964.7 /	Shell size	1150 - 4200	mm	Hor	
Overall dirty coeff. (plain/finned)	W/(m²-K)	759.3 /	Tubes	Plain			
Effective area (plain/finned)	m²	434.4 /	Insert	None			
Effective MTD	°C	6.23	No.	1632	OD 19.05	Tks 2.11	mm
Actual/Required area ratio (dirty/clean)		1.07 / 1.36	Pattern	90	Pitch 24	mm	
Vibration problem (HTFS)		Yes	Baffles	Unbaffled	Cut(%d)		
RhoV2 problem		Yes	Total cost	187805	Dollar(US)		

Total M
Errors:
Input: 0
Results
Operati
Notes &
Warning

Heat Transfer Resistance

Shell side / Fouling / Wall / Fouling / Tube side

Shell Side  Tube Side

Resistance Distribution

Overall Coefficient / Resistance Summary			Clean	Dirty	Max Dirty
Area required (tube OD base)		m²	320.4	407.1	434.4
Area ratio: actual/required			1.36	1.07	1
Overall coefficient		W/(m²-K)	964.7	759.3	711.6
Overall resistance		m²-K/W	0.00104	0.00132	0.00141
Shell side fouling		m²-K/W	0	0.00017	0.00022
Tube side fouling			0	0.00011	0.00015
Resistance Distribution	W/(m²-K)	m²-K/W	%	%	%
Shell side film	1882.9	0.00053	51.23	40.32	37.79
Shell side fouling	5882.4	0.00017		12.91	15.9
Tube wall	25469	4E-05	3.79	2.98	2.79
Tube side fouling *	9052.1	0.00011		8.39	10.33
Tube side film *	2144.8	0.00047	44.98	35.4	33.18

* Based on outside surface - Area ratio: Ao/Ai = 1.28

Shell by Shell Conditions

		Shell 1
Shell heat load	**kW**	1924.5
Shell inlet temperature	**C**	-23.98
Shell outlet temperature	**C**	-24.89
Tube inlet temperature	**C**	-16
Tube outlet temperature	**C**	-19.99
Shell inlet vapor fraction		0.2
Shell outlet vapor fraction		1
Tube inlet vapor fraction		0
Tube outlet vapor fraction		0
Shell inlet pressure	**bar**	2.66
Shell outlet pressure	**bar**	2.57278
Tube inlet pressure	**bar**	6.914
Tube outlet pressure	**bar**	6.56446
Shell pressure drop	**bar**	0.08722
Tube pressure drop	**bar**	0.34954
Mean shell metal temperature	**C**	-24.45
Mean tube metal temperature	**C**	-21.07
Minimum tube metal temperature	**C**	-21.98
Maximum tube metal temperature	**C**	-19.96

1- Shell entrance velocity exceeds critical velocity, indicating a probability of fluidelastic instability and flow-induced vibration damage.
2- Shell exit velocity exceeds 80% of critical velocity, indicating that fluidelastic instability and flow-induced vibration damage are possible.
3- he longest unsupported span of the bundle is in the U-bend region and thus prone to excessive vibration.

TEMA Sheet

Heat Exchanger Spe

1	Company: DEHDASHT PETROCHEMICAL INDUSTRY COMPANY					
2	FOR : PK-6101					
3	Service of Un		Our Reference:			
4	Item No.: E-		Your Reference:			
5	Date:		No.:			
6	Size: 330	Type: BEM	Horizonta	: 1 parallel	1 series	
7	Surf/unit(eff.)	Shells/unit 1		Surf/shell(eff.)	30.5	m²
8	**PERFORMANCE OF ONE UNIT**					
9	Fluid allocati	Shell Side		Tube Side		
10	Fluid name	OIL		COOLING WATER		
11	Fluid quantity kg/h	15206		22248		
12	Vapor (In kg/h	0	0	0	0	
13	Liquid kg/h	15206	15206	22248	22248	
14	Noncondensable kg/h	0	0	0	0	
15						
16	Temperatur °C	80.3	50	35	45	
17	Bubble °C	/	/	/	/	
18	Density kg/m³	/ 873.29	/ 886.58	/	/	
19	Viscosity cp	/ 1.6365	/ 2.1994	/	/	
20	Molecular wt, vap					
21	Molecular wt, NC					
22	Specific heat kJ/(kg-K)			/ 4.171	/ 4.172	
23	Thermal conductivity W/(m-K)			/ 0.6232	/ 0.6371	
24	Latent heat kJ/kg					
25	Pressure (abs) bar	21.9	21.7797	6.5	6.4709	
26	Velocity (Mean/Max) m/s	0.27 / 0.28		0.44 / 0.44		
27	Pressure drop, allow./calc bar	0.2	0.1203	0.5	0.0291	
28	Fouling resistance (min) -K/W	0.00017		0.00035	0.0004 Ao based	
29	Heat exchanged			MTD (corrected)	21.31	°C
30	Transfer rate, Service	rty 445.8			597.8	W/(m²-K)
31	C LL				Sketch	

32			Shell Side	Tube Side	
33	Design/Vacuum/test pressure	bar	25 / -1.013 /	20 / -1.013 /	
34	Design temperature / MDMT	°C	120 /	65 /	
35	Number passes per shell		1	2	
36	Corrosion allowance	mm	3	3	
37	Connections In	in	1 3 / -	1 3 / -	
38	Size/Rating Out		1 3 / -	1 3 / -	
39	Nominal Intermediate		/ -	/ -	

40	Tube #: 130	OD: 19.05	Tks. Average 1.2	mm	Length: 4000	mm	Pitch:
41	Tube type: Plain		Insert:None		Fin#:	#/m	Material:SA-179 K01200
42	Shell SA-106 B K03006	ID 336.6	OD 355.6	mm	Shell cover -		
43	Channel or bonnet	SA-106 B K03006			Channel cover -		
44	Tubesheet-stationary	Carbon Steel			Tubes		
45	Floating head cover	-			Impinç		
46	Baffle-cross Carbon Steel		Type Single segmental		Cut(%d) 26.76		mm
47	Baffle-long -		Seal Type				mm
48	Supports-tube	U-bend	0		Type		
49	Bypass seal		Tube-tubesheet joint		Expanded & strength welded(App.A 'e')		
50	Expansion joint	-	Type None				
51	RhoV2-Inlet nozzle 604		Bundle entrance 27		Bundle exit 26		lb/(ft-s²)
52	Gaskets - Shell side	-	Tube side		Flat Metal Jacket Fibe		
53	Floating head	-					
54	Code requirements	ASME Code Sec VIII Div 1		TEMA class	R - refinery service		
55	Weight/Shell	979.3	Filled with water 1326.6		Bundle 382		kg
56	Remarks	20% OVER DESIGN HAS BEEN CONSIDERED IN OIL FLOW RATE					
57							
58							

according to DPIC-12-001/000-4150-ME-PFD-027 there is discrepancy at the shell side.240*60/1000= 12672 kg/h

according to DPIC-12-001/000-4150-ME-PFD-027 there is discrepancy at the shell side.28 m3/hr = 27846 kg/h

Refer to utility and site condition, Jacketed water temperature is 37-47C.

please specify the density for PFD to controlling this value

CW velocity is too low shall be increased up to 1m/s.

6.914 bara based on utility and site condition.

Please specify MDMT according to MD

design temperature of JSW is 190C.

up to 1 bar is accepted.

0.0002 based on utility and site condition.

Please modify according to Datasheet

shell inlet shall be located at bottom.

tube nozzle shall be located at top of channel.

Overall Summary

1	Size	336.6	X	4000	mm	Type	BEM	Hor		Connected in	1	parallel	1	series	
2	Surf/Unit (gross/eff/finned)			31.1	/	30.5	/		m²	Shells/unit	1				
3	Surf/Shell (gross/eff/finned)			31.1	/	30.5	/		m²						
4	Rating / Checking									**PERFORMANCE OF ONE UNIT**					
5				**Shell Side**			**Tube Side**			**Heat Transfer Parameters**					
6	**Process Data**			**In**		**Out**	**In**		**Out**	Total heat load		kW		257.6	
7	Total flow		kg/h	15206			22248			Eff. MTD/ 1 pass MTD		°C	21.31	/	23.72
8	Vapor		kg/h	0		0	0		0	Actual/Reqd area ratio - fouled/clean			1.13	/	1.51
9	Liquid		kg/h	15206		15206	22248		22248						
10	Noncondensable		kg/h	0			0			**Coef./Resist.**		W/(m²-K)	m²-K/W		%
11	Cond./Evap.		kg/h	0			0			Overall fouled		445.8	0.00224		
12	Temperature		°C	80.3		50	35		45	Overall clean		597.8	0.00167		
13	Bubble Point		°C							Tube side film		2434.6	0.00041		18.31
14	Dew Point		°C							Tube side fouling		2497.2	0.0004		17.85
15	Vapor mass fraction			0		0	0		0	Tube wall		46758.9	2E-05		0.95
16	Pressure (abs)		bar	21.9		21.7797	6.5		6.4709	Outside fouling		5882.4	0.00017		7.58
17	DeltaP allow/cal		bar	0.2		0.1203	0.5		0.0291	Outside film		806	0.00124		55.31
18	Velocity		m/s	0.28		0.27	0.44		0.44						
19	**Liquid Properties**									**Shell Side Pressure Drop**			bar		%
20	Density		kg/m³	873.29		886.58	994.5		990.61	Inlet nozzle			0.00552		4.59
21	Viscosity		cp	1.6365		2.1994	0.719		0.5964	InletspaceXflow			0.00248		2.06
22	Specific heat		kJ/(kg-K)	2.087		1.853	4.171		4.172	Baffle Xflow			0.0832		69.16
23	Therm. cond.		W/(m-K)	0.15		0.15	0.6232		0.6371	Baffle window			0.02277		18.93
24	Surface tension		dynes/cm							OutletspaceXflow			0.00252		2.1
25	Molecular weight						18.02		18.02	Outlet nozzle			0.00381		3.16
26	**Vapor Properties**									Intermediate nozzles					
27	Density		kg/m³							**Tube Side Pressure Drop**			bar		%
28	Viscosity		cp							Inlet nozzle			0.00857		29.45
29	Specific heat		kJ/(kg-K)							Entering tubes			0.00097		3.32
30	Therm. cond.		W/(m-K)							Inside tubes			0.01412		48.54
31	Molecular weight									Exiting tubes			0.0013		4.48
32	**Two-Phase Properties**									Outlet nozzle			0.00414		14.21
33	Latent heat		kJ/kg							Intermediate nozzles					
34	**Heat Transfer Parameters**									**Velocity / Rho*V2**			m/s		kg/(m-s²)
35	Reynolds No. vapor									Shell nozzle inlet			1.01		898
36	Reynolds No. liquid			2806.98		2088.58	10112.03		12190.78	Shell bundle Xflow		0.28	0.27		
37	Prandtl No. vapor									Shell baffle window		0.15	0.15		
38	Prandtl No. liquid			22.77		27.17	4.81		3.91	Shell nozzle outlet			1		885
39	**Heat Load**				kW			kW		Shell nozzle interm					
40	Vapor only				0			0					m/s		kg/(m-s²)
41	2-Phase vapor				0			0		Tube nozzle inlet			1.3		1688
42	Latent heat				0			0		Tubes		0.44	0.44		
43	2-Phase liquid				0			0		Tube nozzle outlet			1.31		1695
44	Liquid only				257.6			257.6		Tube nozzle interm					
45	**Tubes**						**ffles**			**Nozzles: (No./OD)**					
46	Type				Plain		Type	Single segmental				**Shell Side**		**Tube Side**	
47	ID/OD		mm	16.65	/	19.05	Number		35	Inlet	mm	1	/ 88.9	1	/ 88.9
48	Length act/eff		mm	4000	/	3923.8	Cut(%d)		26.76	Outlet		1	/ 88.9	1	/ 88.9
49	Tube passes			2			Cut orientation		H	Intermediate			/		/
50	Tube No.			130			Spacing: c/c	mm	100	Impingement protection			None		
51	Tube pattern			30			Spacing at inlet	mm	261.9						
52	Tube pitch		mm	24			Spacing at outlet	mm	261.9						
53	Insert					None									
54	Vibration problem (HTFS / TEMA)				No	/				RhoV2 violation					No

Baffle spacing is too tight and baffle number shall be reduced.

Overall Performance

Rating / Checking		Shell Side		Tube Side	
Total mass flow rate	kg/h	15206		22248	
Vapor mass flow rate (In/Out)	kg/h	0	0	0	0
Liquid mass flow rate	kg/h	15206	15206	22248	22248
Vapor mass fraction		0	0	0	0
Temperatures	°C	80.3	50	35	45
Bubble / Dew point	°C	/	/	/	/
Operating Pressures	bar	21.9	21.7797	6.5	6.4709
Film coefficient	W/(m²-K)	806		2434.6	
Fouling resistance	m²-K/W	0.00017		0.0004	
Velocity (highest)	m/s	0.28		0.44	
Pressure drop (allow./calc.)	bar	0.2 / 0.1203		0.5 / 0.0291	

Total heat exchanged	kW	257.6	Unit	BEM	2 pass	1 ser	1 par
Overall clean coeff. (plain/finned)	W/(m²-K)	597.8 /	Shell size	330 - 4000	mm	Hor	
Overall dirty coeff. (plain/finned)	W/(m²-K)	445.8 /	Tubes	Plain			
Effective area (plain/finned)	m²	30.5 /	Insert	None			
Effective MTD	°C	21.31	No.	130	OD 19.05	Tks 1.2	mm
Actual/Required area ratio (dirty/clean)		1.13 / 1.51	Pattern	30	Pitch 24	mm	
Vibration problem (HTFS)		No	Baffles	Single segmental	Cut(%d) 26.76		
RhoV2 problem		No	Total cost	24255	Dollar(US)		

Total M
Errors:
Input: 1
Results
Operati
Notes &
Warning

Heat Transfer Resistance

Shell side / Fouling / Wall / Fouling / Tube side

Resistance Distribution

Overall Coefficient / Resistance Summary			Clean	Dirty	Max Dirty
Area required (tube OD base)		m²	20.2	27.1	30.5
Area ratio: actual/required			1.51	1.13	1
Overall coefficient		W/(m²-K)	597.8	445.8	396
Overall resistance		m²-K/W	0.00167	0.00224	0.00253
Shell side fouling		m²-K/W	0	0.00017	0.00025
Tube side fouling			0	0.0004	0.0006
Resistance Distribution	W/(m²-K)	m²-K/W	%	%	%
Shell side film	806	0.00124	74.17	55.31	49.14
Shell side fouling	5882.4	0.00017		7.58	10.06
Tube wall	46758.9	2E-05	1.28	0.95	0.85
Tube side fouling *	2497.2	0.0004		17.85	23.69
Tube side film *	2434.6	0.00041	24.55	18.31	16.27

* Based on outside surface - Area ratio: Ao/Ai = 1.14

Shell by Shell Conditions

		Shell 1
Shell heat load	**kW**	257.6
Shell inlet temperature	**C**	80.3
Shell outlet temperature	**C**	50
Tube inlet temperature	**C**	35
Tube outlet temperature	**C**	45
Shell inlet vapor fraction		0
Shell outlet vapor fraction		0
Tube inlet vapor fraction		0
Tube outlet vapor fraction		0
Shell inlet pressure	**bar**	21.9
Shell outlet pressure	**bar**	21.7797
Tube inlet pressure	**bar**	6.5
Tube outlet pressure	**bar**	6.4709
Shell pressure drop	**bar**	0.1203
Tube pressure drop	**bar**	0.0291
Mean shell metal temperature	**C**	61.66
Mean tube metal temperature	**C**	48.25
Minimum tube metal temperature	**C**	40.06
Maximum tube metal temperature	**C**	54.74

TEMA Sheet

Please modify the tag number.

according to DPIC-12-001/0 150-ME-PFD-0 there is discrepancy at side: 994.5 3240 kg/h

Refer to utility and site condition, Jacketed water temperature is 37-47C.

CW velocity is low shall be increased up to 1m/s.

Heat Exchanger Specific

1	Company: DEHDASHT PETROCHEMICAL INDUSTRY COMPANY							
2	For : PK-6101							
3	Service of Unit: CONDENSER	Our Reference:						
4	Item No.: E-PK1601-2	Your R						
5	Date: Rev No.: Job No.:							
6	Size: 1180 - 6000 mm Type:					parallel	1 series	
7	Surf/unit(eff.) 656.2 m²					ff.)	656.2 m²	
8	**PERFORMANCE OF ONE UNIT**							
9	Fluid allocation	Shell Side			Tube Side			
10	Fluid name	PROPYLENE			COOLING WATER			
11	Fluid quantity, Total kg/h	30385			254002			
12	Vapor (In/Out)	30385	0		0	0		
13	Liquid	0	30385		254002	254002		
14	Noncondensable	0	0		0			
15								
16	Temperature (In/Out) °C	80.3	48.33		35			
17	Bubble / Dew point °C	48.56 / 48.56	48.47 / 48.47		/	/		
18	Density Vapor/Liquid kg/m³	35.84 /	/ 462.02		/ 994.45	/ 990.56		
19	Viscosity cp	0.0111 /	/ 0.06		/ 0.719	/ 0.5964		
20	Molecular wt, Vap	42.08						
21	Molecular wt, NC							
22	Specific heat kJ/(kg-K)	2.025			/ 4.171	/ 4.172		
23	Thermal conductivity /(m-K)	0.0237			/ 0.6231	/ 0.6371		
24	Latent heat kJ/kg							
25	Pressure (abs) bar	19.937	19.90218		5.5	5.3094		
26	Velocity (Mean/Max) m/s	0.66 / 1.46			0.88 / 0.88			
27	Pressure drop, allow./calc. bar	0.1	0.03482		0.5	0.1906		
28	Fouling resistance (min) m²-K/W	0.0002			0.0004	0.00051 Ao based		
29	Heat exchanged 2941.9 kW			MTD (corrected)	8.49 °C			
30	Transfer rate, Service 527.7	Dirty 572.1			966.9 W/(m²-K)			
31	**CONSTRUCTION OF ONE SHELL**					**Sketch**		
32		Shell Side		Tube Side				
33	Design/Vacuum/test pressure bar	23 / -1.013 /		23 / -1.013 /				
34	Design temperature / MDMT °C	120 / -45		80 / -45				
35	Number passes per shell	1		4				
36	Corrosion allowance mm	3		3				
37	Connections In in	1 10 / -		1 12 /				
38	Size/Rating Out	1 6 / -		1 12 /				
39	Nominal Out - Vapor	1 2 / -						
40	Tube #: 1876 OD: 19.05 Tks. Average 2.11 mm Le							0
41	Tube type: Plain Insert:None					Material:SA-334 8 K81340		
42	Shell SA-516 70 K02700 ID 1180 OD 1210 mm					Shell cover -		
43	Channel or bonnet SA-516 70 K02700					Channel cover -		
44	Tubesheet-stationary Carbon Steel -					Tubesheet-floating -		
45	Floating head cover -					Impingement protection Square plate		
46	Baffle-cross Carbon Steel Type Single segmental Cut(%d) 39.83					Verti Spacing: c/c 210 mm		
47	Baffle-long - Seal Type					Inlet 402.48 mm		
48	Supports-tube U-bend 0					Type		
49	Bypass seal			Tube-tubesheet joint		Expanded & strength welded(App.A 'e')		
50	Expansion joint -			Type None				
51	RhoV2-Inlet nozzle 768	Bundle entrance 753			Bundle exit 37 kg/(m-s²)			
52	Gaskets - Shell side Flat Metal Jacket Fibe	Tube side			Flat Metal Jacket Fibe			
53	Floating head -							
54	Code requirements ASME Code Sec VIII Div 1			TEMA class R - refinery service				
55	Weight/Shell 16540.6 Filled with water 23326.3			Bundle 11477.6		kg		
56	Remarks 10% OVER DESIGN HAS BEEN CONSIDERED IN FLOW							
57								
58								

Please give your technical explain about 10% oversizing

According to PFD inlet temp. is 37 C.

6.914 bara based on utility and site condition.

Please clarify case on Full vacuum.

up to 1 bar is accepted.

Please specify right angle at the sketch of DS.

0.0002 based on utility and site condition.

design temperature of JSW is 190C.

Please give your technical explain

Overall Summary

1	Size	1180	X	6000	mm	Type	BEM	Hor		Connected in	1 parallel	1 series	
2	Surf/Unit (gross/eff/finned)			673.6	/	656.2	/		m²	Shells/unit	1		
3	Surf/Shell (gross/eff/finned)			673.6	/	656.2	/		m²				
4	Rating / Checking									**PERFORMANCE OF ONE UNIT**			
5					**Shell Side**		**Tube Side**			**Heat Transfer Parameters**			
6	**Process Data**				**In**	**Out**	**In**	**Out**		Total heat load	kW	2941.9	
7	Total flow	kg/h			30385		254002			Eff. MTD/ 1 pass MTD	°C	8.49 /	9.64
8	Vapor	kg/h			30385	0	0	0		Actual/Reqd area ratio - fouled/clean		1.08 /	1.83
9	Liquid	kg/h			0	30385	254002	254002					
10	Noncondensable	kg/h			0		0			**Coef./Resist.**	W/(m²-K)	m²-K/W	%
11	Cond./Evap.	kg/h			30385		0			Overall fouled	572.1	0.00175	
12	Temperature	°C			80.3	48.33	35	45		Overall clean	966.9	0.00103	
13	Bubble Point	°C			48.56	48.47				Tube side film	3840.4	0.00026	14.9
14	Dew Point	°C			48.56	48.47				Tube side fouling	1946.2	0.00051	29.39
15	Vapor mass fraction				1	0	0	0		Tube wall	15249.4	7E-05	3.75
16	Pressure (abs)	bar			19.937	19.90218	5.5	5.3094		Outside fouling	5000	0.0002	11.44
17	DeltaP allow/cal	bar			0.1	0.03482	0.5	0.1906		Outside film	1412	0.00071	40.52
18	Velocity	m/s			0.98	0.08	0.87	0.88					
19	**Liquid Properties**									**Shell Side Pressure Drop**		bar	%
20	Density	kg/m³				462.02	994.45	990.56		Inlet nozzle		0.00637	18.16
21	Viscosity	mPa-s				0.06	0.719	0.5964		InletspaceXflow		0.00295	8.41
22	Specific heat	kJ/(kg-K)				3.321	4.171	4.172		Baffle Xflow		0.02066	58.86
23	Therm. cond.	W/(m-K)				0.0898	0.6231	0.6371		Baffle window		0.00289	8.23
24	Surface tension	N/m								OutletspaceXflow		0.00043	1.22
25	Molecular weight					42.08	18.02	18.02		Outlet nozzle		0.0018	5.12
26	**Vapor Properties**									Intermediate nozzles			
27	Density	kg/m³			35.84					**Tube Side Pressure Drop**		bar	%
28	Viscosity	cp			0.0111					Inlet nozzle		0.00438	2.3
29	Specific heat	kJ/(kg-K)			2.025					Entering tubes		0.00773	4.06
30	Therm. cond.	W/(m-K)			0.0237					Inside tubes		0.16391	86.01
31	Molecular weight				42.08					Exiting tubes		0.01205	6.32
32	**Two-Phase Properties**									Outlet nozzle		0.0025	1.31
33	Latent heat	kJ/kg			282.4	282.7				Intermediate nozzles			
34	**Heat Transfer Parameters**									**Velocity / Rho*V2**		m/s	kg/(m-s²)
35	Reynolds No. vapor				59772.96					Shell nozzle inlet		4.63	768
36	Reynolds No. liquid					11094.23	17849.74	21612.52		Shell bundle Xflow	0.98	0.08	
37	Prandtl No. vapor				0.95					Shell baffle window	0.4	0.03	
38	Prandtl No. liquid					2.22	4.81	3.91		Shell nozzle outlet		0.98	444
39	**Heat Load**					kW		kW		Shell nozzle interm			
40	Vapor only					-551.8		0				m/s	kg/(m-s²)
41	2-Phase vapor					-0.6		0		Tube nozzle inlet		0.97	940
42	Latent heat					-2384.5		0		Tubes	0.87	0.88	
43	2-Phase liquid					-0.9		0		Tube nozzle outlet		0.98	944
44	Liquid only					-4.1		2941.9		Tube nozzle interm			
45	**Tubes**						**Baffles**			**Nozzles: (No./OD)**			
46	Type					Plain	Type	Single segmental			**Shell Side**		**Tube Side**
47	ID/OD	mm		14.83	/	19.05	Number		25	Inlet mm	1	/ 273.05	1 / 323.85
48	Length act/eff	cm		600	/	584.5	Cut(%d)		39.83	Outlet	1	/ 168.28	1 / 323.85
49	Tube passes			4			Cut orientation		V	Intermediate	1	/ 60.32	/
50	Tube No.			1876			Spacing: c/c	mm	210	Impingement protection		Square plate	
51	Tube pattern			60			Spacing at inlet	mm	402.48				
52	Tube pitch	mm		24			Spacing at outlet	mm	402.48				
53	Insert					None							
54	Vibration problem (HTFS / TEMA)				Possible	/				RhoV2 violation			No

Overall Performance

Rating / Checking		Shell Side		Tube Side	
Total mass flow rate	kg/h	30385		254002	
Vapor mass flow rate (In/Out)	kg/h	30385	0	0	0
Liquid mass flow rate	kg/h	0	30385	254002	254002
Vapor mass fraction		1	0	0	0
Temperatures	°C	80.3	48.33	35	45
Bubble / Dew point	°C	48.56 / 48.56	48.47 / 48.47	/	/
Operating Pressures	bar	19.937	19.90218	5.5	5.3094
Film coefficient	W/(m²-K)	1412		3840.4	
Fouling resistance	m²-K/W	0.0002		0.00051	
Velocity (highest)	m/s	1.46		0.88	
Pressure drop (allow./calc.)	bar	0.1 / 0.03482		0.5 / 0.1906	

Total heat exchanged	kW	2941.9	Unit	BEM	4 pass	1 ser	1 par
Overall clean coeff. (plain/finned)	W/(m²-K)	966.9 /	Shell size	1180	- 6000	mm	Hor
Overall dirty coeff. (plain/finned)	W/(m²-K)	572.1 /	Tubes	Plain			
Effective area (plain/finned)	m²	656.2 /	Insert	None			
Effective MTD	°C	8.49	No.	1876	OD 19.05	Tks 2.11	mm
Actual/Required area ratio (dirty/clean)		1.08 / 1.83	Pattern	60	Pitch 24		mm
Vibration problem (HTFS)		Possible	Baffles	Single segmental		Cut(%d)	39.83
RhoV2 problem		No	Total cost		204540	Dollar(US)	

Heat Transfer Resistance

Shell side / Fouling / Wall / Fouling / Tube side

Resistance Distribution

Overall Coefficient / Resistance Summary			Clean	Dirty	Max Dirty
Area required (tube OD base)		m²	358.2	605.4	656.2
Area ratio: actual/required			1.83	1.08	1
Overall coefficient		W/(m²-K)	966.9	572.1	527.7
Overall resistance		m²-K/W	0.00103	0.00175	0.00189
Shell side fouling		m²-K/W	0	0.0002	0.00024
Tube side fouling			0	0.00051	0.00062
Resistance Distribution	W/(m²-K)	m²-K/W	%	%	%
Shell side film	1412	0.00071	68.48	40.52	37.38
Shell side fouling	5000	0.0002		11.44	12.73
Tube wall	15249.4	7E-05	6.34	3.75	3.46
Tube side fouling *	1946.2	0.00051		29.39	32.7
Tube side film *	3840.4	0.00026	25.18	14.9	13.74

* Based on outside surface - Area ratio: Ao/Ai = 1.28

Shell by Shell Conditions

		Shell 1
Shell heat load	**kW**	2941.9
Shell inlet temperature	**C**	80.3
Shell outlet temperature	**C**	48.33
Tube inlet temperature	**C**	35
Tube outlet temperature	**C**	45
Shell inlet vapor fraction		1
Shell outlet vapor fraction		0
Tube inlet vapor fraction		0
Tube outlet vapor fraction		0
Shell inlet pressure	**bar**	19.937
Shell outlet pressure	**bar**	19.90214
Tube inlet pressure	**bar**	5.5
Tube outlet pressure	**bar**	5.30939
Shell pressure drop	**bar**	0.03486
Tube pressure drop	**bar**	0.19061
Mean shell metal temperature	**C**	50.21
Mean tube metal temperature	**C**	44.9
Minimum tube metal temperature	**C**	41.33
Maximum tube metal temperature	**C**	52.41

Hot Stream Composition

		Total	Comp 1	Comp 2
Stream mass fractions		1	0	1
Liquid mass fractions at inlet		0		
Liquid mass fractions at outlet		1	0	1
Vapor mass fractions at inlet		1	0	1
Vapor mass fractions at outlet		0		0
Liquid 2 mass fractions at inlet				
Liquid 2 mass fractions at outlet				
Stream mole fractions		1	0	1
Liquid mole fractions at inlet		0		
Liquid mole fractions at outlet		1		1
Vapor mole fractions at inlet		1		1
Vapor mole fractions at outlet		0		0
Liquid-2 mole fractions at inlet				
Liquid-2 mole fractions at outlet				
Stream mass flow	**kg/h**	30385	0	30385
Liquid mass flow at inlet	**kg/h**	0	0	0
Liquid mass flow at outlet	**kg/h**	30385	0	30385
Vapor mass flow at inlet	**kg/h**	30385	0	30385
Vapor mass flow at outlet	**kg/h**	0	0	0
Liquid 2 mass flow at inlet	**kg/h**			
Liquid 2 mass flow at outlet	**kg/h**			

Cold Stream Composition

		Total	Comp 1	Comp 2
Stream mass fractions		1	1	0
Liquid mass fractions at inlet		1	1	0
Liquid mass fractions at outlet		1	1	0
Vapor mass fractions at inlet		0		
Vapor mass fractions at outlet		0	0	
Liquid 2 mass fractions at inlet				
Liquid 2 mass fractions at outlet				
Stream mole fractions		1	1	0
Liquid mole fractions at inlet		1	1	
Liquid mole fractions at outlet		1	1	
Vapor mole fractions at inlet		0		
Vapor mole fractions at outlet		0	0	
Liquid-2 mole fractions at inlet				
Liquid-2 mole fractions at outlet				
Stream mass flow	**kg/h**	254002	254002	0
Liquid mass flow at inlet	**kg/h**	254002	254002	0
Liquid mass flow at outlet	**kg/h**	254002	254002	0
Vapor mass flow at inlet	**kg/h**	0	0	0
Vapor mass flow at outlet	**kg/h**	0	0	0
Liquid 2 mass flow at inlet	**kg/h**			
Liquid 2 mass flow at outlet	**kg/h**			

TEMA Sheet

Heat Exchanger Specification Sheet

1	Company:						
2	Location:						
3	Service of Unit: ECONOMIZER	Our Reference:					
4	Item No.: E-PK6101-3	Your Reference:					
5	Date:	Rev No.: 00	Job No.:				
6	Size: 591 - 6000 mm	Type: BEM	Horizontal		el 1 series		
7	Surf/unit(eff.) 117.3 m²	Shells/unit 1			117.3 m²		
8	**PERFORMANCE OF ONE**						
9	Fluid allocation		Shell		Tube Side		
10	Fluid name		PROP		PROPYLENE		
11	Fluid quantity, Total	kg/h	21450		8174		
12		kg/h	0	0	2370	8174	
13		kg/h	21450	21450	5804	0	
14		kg/h	0	0	0	0	
15							
16		°C	48.55	14	12.37	15	
17		°C	48.56 / 48.56	48.36 / 48.36	12.37 / 12.37	12.37 / 12.37	
18		kg/m³	/ 461.41	/ 524.12	17.36 / 526.76	17.02 /	
19		mPa-s	/ 0.0598	/ 0.0915	0.0087 / 0.0933	0.0087 /	
20					42.08	42.08	
21							
22		kJ/(kg-K)	/ 3.332	/ 2.558	1.65 / 2.578	1.655 /	
23		W/(m-K)	/ 0.0897	/ 0.1072	0.0162 / 0.1081	0.0165 /	
24	Latent heat	kJ/kg			360	360	
25	Pressure (abs)	bar	19.94	19.85263	8.3	8.25237	
26	Velocity (Mean/Max)	m/s	0.33 / 0.39		2.36 / 5.14		
27	Pressure drop, allow./calc.	bar	0.25	0.08738	0.2	0.04763	
28	Fouling resistance (min)	m²-K/W	0.00017		0.00017	0.00021 Ao based	
29	He[illegible]	kW			MTD (corrected)	11.81	°C
30			Dirty 512.7		Clean 638.3		W/(m²-K)
31	**ONSTRUCTION OF ONE SHELL**					**Sketch**	
32			Shell Side		Tube Side		
33		bar	23 / 0 / 29.9		23 / 0 / 29.9		
34		°C	120 / -45		120 / -45		
35			1		3		
36		mm	3		3		
37	Connections In	in	1 6 / 300 ANSI		1 4 / 300 ANSI		
38	Size/Rating Out		1 6 / 300 ANSI		1 6 / 300 ANSI		
39	Nominal Intermediate		/ 300 ANSI		/ 300 ANSI		
40	Tube #: 249	OD: 25.4	Tks. Average 2.6	mm	Length: 6000	mm	Pit n:30
41	Tube type: Plain		Insert:None		Fin#:	#/m	
42	Shell SA-516 70 K02700	ID 590.6	OD 609.6	mm	Shell cover		
43	Channel or bonnet	SA-516 70 K02700			Channel cover	-	
44	Tubesheet-stationary	SA-516 70 K02700	-		eet-floating	-	
45	Floating head cover	-			ement protection	None	
46	Baffle-cross SA-285 C K02801	Type	Single seg		Horiz. Spacing: c/c	115	mm
47	Baffle-long -	Seal Type			Inlet	307	mm
48	Supports-tube	U-bend	0		Type		
49	Bypass seal		Tube-tubesheet joint		Expanded only (2 grooves)(App.A 'i')		
50	Expansion joint	-	Type	None			
51	RhoV2-Inlet nozzle 272	Bundle entrance 119		Bundle exit 105		kg/(m-s²)	
52	Gaskets - Shell side	Flat Metal Jacket Fibe	Tube side	Flat Metal Jacket Fibe			
53	Floating head	-					
54	Code requirements	ASME Code Sec VIII Div 1		TEMA class	R - refinery service		
55	Weight/Shell	4009.6	Filled with water 5509.4		Bundle 2659.5	kg	
56	Remarks						
57							
58							

according to DPIC-12-001/000-4 150-ME-PFD-027 Type of this unit is kettle type. please shall be revise this unit.

according to DPIC-12-001/000 4150-ME-PFD-02 there is discrepancy at th shell side. It's consider that erro to arrangement o shell and tube sid

Design temperature of both sides shall be saturate temperature corresponding to design pressure which is equal to 125C. Please recheck.

Please clarify why design pressure of economizer and water cooler is higher than chiller.

Please check the UC566 and PWHT attention to MDMT

According to MDS, material of baffle-cross shall be modified.

Overall Summary

1	Size	590.6	X	6000	mm	Type	BEM	Hor		Connected in	1	parallel	1	series
2	Surf/Unit (gross/eff/finned)			119.2	/	117.3	/	m²		Shells/unit	1			
3	Surf/Shell (gross/eff/finned)			119.2	/	117.3	/	m²						
4	Rating / Checking						**PERFORMANCE OF ONE UNIT**							

			Shell Side		Tube Side	
5						
6	**Process Data**		**In**	**Out**	**In**	**Out**
7	Total flow	kg/h	21450		8174	
8	Vapor	kg/h	0	0	2370	8174
9	Liquid	kg/h	21450	21450	5804	0
10	Noncondensable	kg/h	0		0	
11	Cond./Evap.	kg/h	0		5804	
12	Temperature	°C	48.55	14	12.37	15
13	Bubble Point	°C	48.56	48.36	12.37	12.37
14	Dew Point	°C	48.56	48.36	12.37	12.37
15	Vapor mass fraction		0	0	0.29	1
16	Pressure (abs)	bar	19.94	19.85263	8.3	8.25237
17	DeltaP allow/cal	bar	0.25	0.08738	0.2	0.04763
18	Velocity	m/s	0.31	0.28	1.58	5.14

19	**Liquid Properties**					
20	Density	kg/m³	461.41	524.12	526.76	
21	Viscosity	cp	0.0598	0.0915	0.0933	
22	Specific heat	kJ/(kg-K)	3.332	2.558	2.578	
23	Therm. cond.	W/(m-K)	0.0897	0.1072	0.1081	
24	Surface tension	N/m			0.0072	
25	Molecular weight		42.08	42.08	42.08	
26	**Vapor Properties**					
27	Density	kg/m³			17.36	17.02
28	Viscosity	mPa-s			0.0087	0.0087
29	Specific heat	kJ/(kg-K)			1.65	1.655
30	Therm. cond.	W/(m-K)			0.0162	0.0165
31	Molecular weight				42.08	42.08
32	**Two-Phase Properties**					
33	Latent heat	kJ/kg			360	360

34	**Heat Transfer Parameters**					
35	Reynolds No. vapor				59183.27	202410.7
36	Reynolds No. liquid		61405.68	40123.33	13442.3	
37	Prandtl No. vapor				0.88	0.88
38	Prandtl No. liquid		2.22	2.18	2.23	
39	**Heat Load**		kW		kW	
40	Vapor only				9	
41	2-Phase vapor					
42	Latent heat			0	360.4	
43	2-Phase liquid		0		0	
44	Liquid only		-590.2		0	

Baffle spacing is low

45	**Tubes**				**Baffles**	
46	Type			Plain	Type	Single segmental
47	ID/OD	mm	20.2	/ 25.4	Number	47
48	Length act/eff	cm	600	/ 590.4	Cut(%d)	15.4
49	Tube passes		3		Cut orientation	H
50	Tube No.		249		Spacing: c/c	mm 115
51	Tube pattern		30		Spacing at inlet	mm 307
52	Tube pitch	mm	32		Spacing at outlet	mm 307
53	Insert				None	
54	Vibration problem (HTFS / TEMA)			No /		

1	**Heat Transfer Parameters**			
2	Total heat load	kW	590.2	
3	Eff. MTD/ 1 pass MTD	°C	11.81	/ 11.75
4	Actual/Reqd area ratio - fouled/clean		1.2	/ 1.5
5				
6	**Coef./Resist.**	W/(m²-K)	m²-K/W	%
7	Overall fouled	512.7	0.00195	
8	Overall clean	638.3	0.00157	
9	Tube side film	1393.5	0.00072	36.8
10	Tube side fouling	4678.1	0.00021	10.96
11	Tube wall	20882	5E-05	2.46
12	Outside fouling	5882.4	0.00017	8.72
13	Outside film	1248.3	0.0008	41.07

14	**Shell Side Pressure Drop**	bar	%
15	Inlet nozzle	0.002	2.29
16	InletspaceXflow	0.00187	2.14
17	Baffle Xflow	0.05507	63.01
18	Baffle window	0.02558	29.27
19	OutletspaceXflow	0.00169	1.93
20	Outlet nozzle	0.00123	1.41
21	Intermediate nozzles		
22	**Tube Side Pressure Drop**	bar	%
23	Inlet nozzle	0.01092	24.75
24	Entering tubes	0.00142	3.23
25	Inside tubes	0.02562	58.04
26	Exiting tubes	0.00348	7.88
27	Outlet nozzle	0.0027	6.11
28	Intermediate nozzles		

29	**Velocity / Rho*V2**		m/s		kg/(m-s²)
30	Shell nozzle inlet		0.77		272
31	Shell bundle Xflow	0.31	0.28		
32	Shell baffle window	0.21	0.18		
33	Shell nozzle outlet		0.68		240
34	Shell nozzle interm				
35			m/s		kg/(m-s²)
36	Tube nozzle inlet		6.16		2101
37	Tubes	1.58	5.14		
38	Tube nozzle outlet		7.93		1071
39	Tube nozzle interm				

40	**Nozzles: (No./OD)**						
41			**Shell Side**			**Tube Side**	
42	Inlet	mm	1	/ 168.28	1	/	114.3
43	Outlet		1	/ 168.28	1	/	168.28
44	Intermediate			/		/	
45	Impingement protection		None				
46							
47							
48							
49							
50							
51							
52							
53							
54	RhoV2 violation						No

Overall Performance

Rating / Checking		Shell Side		Tube Side	
Total mass flow rate	kg/h	21450		8174	
Vapor mass flow rate (In/Out)	kg/h	0	0	2370	8174
Liquid mass flow rate	kg/h	21450	21450	5804	0
Vapor mass fraction		0	0	0.29	1
Temperatures	°C	48.55	14	12.37	15
Bubble / Dew point	°C	48.56 / 48.56	48.36 / 48.36	12.37 / 12.37	12.37 / 12.37
Operating Pressures	bar	19.94	19.85263	8.3	8.25237
Film coefficient	W/(m²-K)	1248.3		1393.5	
Fouling resistance	m²-K/W	0.00017		0.00021	
Velocity (highest)	m/s	0.39		5.14	
Pressure drop (allow./calc.)	bar	0.25 / 0.08738		0.2 / 0.04763	

Total heat exchanged	kW	590.2		Unit	BEM	3 pass	1 ser	1 par
Overall clean coeff. (plain/finned)	W/(m²-K)	638.3 /		Shell size	591 - 6000	mm	Hor	
Overall dirty coeff. (plain/finned)	W/(m²-K)	512.7 /		Tubes	Plain			
Effective area (plain/finned)	m²	117.3 /		Insert	None			
Effective MTD	°C	11.81		No.	249	OD 25.4	Tks 2.6	mm
Actual/Required area ratio (dirty/clean)		1.2 / 1.5		Pattern	30	Pitch 32	mm	
Vibration problem (HTFS)		No		Baffles	Single segmental		Cut(%d) 15.4	
RhoV2 problem		No		Total cost	46284	Dollar(US)		

Heat Transfer Resistance

Shell side / Fouling / Wall / Fouling / Tube side

Resistance Distribution

Overall Coefficient / Resistance Summary			Clean	Dirty	Max Dirty
Area required (tube OD base)		m²	78.3	97.5	117.3
Area ratio: actual/required			1.5	1.2	1
Overall coefficient		W/(m²-K)	638.3	512.7	425.9
Overall resistance		m²-K/W	0.00157	0.00195	0.00235
Shell side fouling		m²-K/W	0	0.00017	0.00035
Tube side fouling			0	0.00021	0.00044
Resistance Distribution	W/(m²-K)	m²-K/W	%	%	%
Shell side film	1248.3	0.0008	51.13	41.07	34.12
Shell side fouling	5882.4	0.00017		8.72	14.74
Tube wall	20882	5E-05	3.06	2.46	2.04
Tube side fouling *	4678.1	0.00021		10.96	18.53
Tube side film *	1393.5	0.00072	45.81	36.8	30.57

* Based on outside surface - Area ratio: Ao/Ai = 1.26

Shell by Shell Conditions

		Shell 1
Shell heat load	**kW**	590.2
Shell inlet temperature	**C**	48.55
Shell outlet temperature	**C**	14
Tube inlet temperature	**C**	12.37
Tube outlet temperature	**C**	15
Shell inlet vapor fraction		0
Shell outlet vapor fraction		0
Tube inlet vapor fraction		0.29
Tube outlet vapor fraction		1
Shell inlet pressure	**bar**	19.94
Shell outlet pressure	**bar**	19.85262
Tube inlet pressure	**bar**	8.3
Tube outlet pressure	**bar**	8.25236
Shell pressure drop	**bar**	0.08738
Tube pressure drop	**bar**	0.04764
Mean shell metal temperature	**C**	24.32
Mean tube metal temperature	**C**	18.44
Minimum tube metal temperature	**C**	13.05
Maximum tube metal temperature	**C**	43.21