



DEHDASHT PETROCHEMICAL INDUSTRY COMPANY
DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT



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	

Thermal Calculation for Heat Exchangers

PURCHASER'S COMMENT/APPROVAL STATUS




Purchaser: NARGAN

1	AP: Approved (Released for Manufacturing)	Requisition No.: DPIC98-12-001-000-ME-MR-4150-0001-D1 Item No. (Tag No.): PK-6101
2	AN: Approved With Minor Comments (Fabrication may Proceed)	
3	NF: Approved With Comments (Fabrication not Proceed)	
4	RJ: Rejected	
5	NR: Not be Returned	

Vendor Doc. No.: DPIC9812-000-VD-1002-ME-CLN-0032-D0





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

 	DEHDASHT PETROCHEMICAL INDUSTRY COMPANY DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT	 شرکت صنایع پتروشیمی خلیج فارس Persian Gulf Petrochemical Industries Co PGPIC شرکت صنایع پتروشیمی دهشت (سهامی عام)	
Contract No.: DPIC/98-12	DOCUMENT TITLE: Thermal Calculation for Heat Exchangers	POI: IFA	Rev.: D0
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3	x				
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5	x				
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	DEHDASHT PETROCHEMICAL INDUSTRY COMPANY DEHDASHT HIGH DENSITY POLYETHYLENE PROJECT		
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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 Specification Sheet

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	-4200	mm	Type: BKU	Horizontal
7	Surf/unit(eff.)	434.4	m ²	Shells/unit	1
8	Surf/shell(eff.) 434.4 m ²				
8	PERFORMANCE OF ONE UNIT				
9	Fluid allocation	Shell Side		Tube Side	
10	Fluid name	PROPYLENE		HEXANE	
11	Fluid quantity, Total	21196		911350	
12	Vapor (In/Out)	kg/h	4239	21188	0
13	Liquid	kg/h	16957	8	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/m ³	5.81 / 580	5.6 / 580.2	/ 703.25
19	Viscosity	cp	0.0073 / 0.1422	0.0073 / 0.1425	/ 0.4872
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	/ 1.906
23	Thermal conductivity	W/(m-K)	0.0126 / 0.1281	0.0126 / 0.1282	/ 0.131
24	Latent heat	kJ/kg	410	411	
25	Pressure (abs)	bar	2.66	2.57278	6.914
26	Velocity (Mean/Max)	m/s	1.29 / 2.01		2.55 / 2.55
27	Pressure drop, allow./calc.	bar	0.5	0.08722	0.26
28	Fouling resistance (min)	m ² -K/W	0.00017		9E-05 0.00011 Ao based
29	Heat exchanged	1924.5	kW		MTD (corrected) 6.23 °C
30	Transfer rate, Service	711.6	Dirty	759.3	Clean 964.7 W/(m ² -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 ANSI	
40	Tube #: 816 U's	OD: 19.05	Tks. Average 2.11	mm	Length: 4200 mm
41	Tube type: Plain	Insert:None	Fin#: #/m	Material:SA-334 6 K03006	Pitch: 24 mm Tube pattern:90
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	Bundle entrance 104	Bundle exit 484	kg/(m-s ²)	
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					

Overall Summary

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	/	m ²	Shells/unit	1			
3	Surf/Shell (gross/eff/finned)	447.3	/	434.4	/	m ²					
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/(m ² -K)	m ² -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/m ³ 580	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	Outlet space Xflow	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/m ³ 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-s ²)			
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-s ²)		
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	0	0			
Liquid mass flow rate	kg/h	16957	8	911350	911350	911350	911350			
Vapor mass fraction		0.2	1	0	0	0	0			
Temperatures	°C	-23.98	-24.89	-16	-19.99	-19.99	-19.99			
Bubble / Dew point	°C	/	/	/	/	/	/			
Operating Pressures	bar	2.66	2.57278	6.914	6.914	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	0.26	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: 1
Input: 0
Results
Operati
Notes &
Warning



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

TEMA Sheet

Heat Exchanger Specification Sheet

1	Company: DEHDASHT PETROCHEMICAL INDUSTRY COMPANY				
2	FOR : PK-6101				
3	Service of Unit: OIL COOLER		Our Reference:		
4	Item No.: E-PK6101-1A/B		Your Reference:		
5	Date:	Rev No.: 00	Job No.:		
6	Size: 330 - 4000	mm	Type: BEM	Horizontal	Connected in: 1 parallel 1 series
7	Surf/unit(eff.)	30.5	m ²	Shells/unit 1	Surf/shell(eff.) 30.5 m ²
8	PERFORMANCE OF ONE UNIT				
9	Fluid allocation	Shell Side		Tube Side	
10	Fluid name	OIL		COOLING WATER	
11	Fluid quantity, Total	kg/h	15206		22248
12	Vapor (In/Out)	kg/h	0	0	0 0
13	Liquid	kg/h	15206	15206	22248 22248
14	Noncondensable	kg/h	0	0	0 0
15					
16	Temperature (In/Out)	°C	80.3	50	35 45
17	Bubble / Dew point	°C	/	/	/ /
18	Density Vapor/Liquid	kg/m ³	/ 873.29	/ 886.58	/ 994.5 / 990.61
19	Viscosity	cp	/ 1.6365	/ 2.1994	/ 0.719 / 0.5964
20	Molecular wt, Vap				
21	Molecular wt, NC				
22	Specific heat	kJ/(kg-K)	/ 2.087	/ 1.853	/ 4.171 / 4.172
23	Thermal conductivity	W/(m-K)	/ 0.15	/ 0.15	/ 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)	m ² -K/W	0.00017		0.00035 0.0004 Ao based
29	Heat exchanged	257.6	kW		MTD (corrected) 21.31 °C
30	Transfer rate, Service	396	Dirty	445.8	Clean 597.8 W/(m ² -K)
31	CONSTRUCTION OF ONE SHELL				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: 24 mm Tube pattern:30
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				Tubesheet-floating -
45	Floating head cover -				Impingement protection None
46	Baffle-cross Carbon Steel	Type	Single segmental	Cut(%d) 26.76	HorizSpacing: c/c 100 mm
47	Baffle-long -	Seal Type			Inlet 261.9 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-s ²)
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					



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	/	m ²	Shells/unit	1			
3	Surf/Shell (gross/eff/finned)	31.1	/	30.5	/	m ²					
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	0	0	Coef./Resist.	W/(m ² -K)	m ² -K/W	%	
11	Cond./Evap.	kg/h	0	0	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/m ³	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					Outlet space Xflow	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/m ³					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-s ²)		
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-s ²)		
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						Baffles			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	mm	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	

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/(m ² -K)	806		2434.6	
Fouling resistance	m ² -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/(m ² -K)	597.8	/	Shell size	330 - 4000 mm Hor
Overall dirty coeff. (plain/finned)	W/(m ² -K)	445.8	/	Tubes	Plain
Effective area (plain/finned)	m ²	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: 1
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)	m ²		20.2	27.1	30.5
Area ratio: actual/required			1.51	1.13	1
Overall coefficient	W/(m ² -K)		597.8	445.8	396
Overall resistance	m ² -K/W		0.00167	0.00224	0.00253
Shell side fouling	m ² -K/W		0	0.00017	0.00025
Tube side fouling			0	0.0004	0.0006
Resistance Distribution	W/(m ² -K)	m ² -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

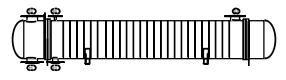
Shell by Shell Conditions

		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

Heat Exchanger Specification Sheet

1	Company: DEHDASHT PETROCHEMICAL INDUSTRY COMPANY				
2	For : PK-6101				
3	Service of Unit: CONDENSER	Our Reference:			
4	Item No.: E-PK1601-2	Your Reference:			
5	Date:	Rev No.:	Job No.:		
6	Size: 1180 - 6000	mm	Type: BEM	Horizontal	Connected in: 1 parallel 1 series
7	Surf/unit(eff.)	656.2	m ²	Shells/unit 1	Surf/shell(eff.) 656.2 m ²
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)	kg/h	30385	0	0
13	Liquid	kg/h	0	30385	254002
14	Noncondensable	kg/h	0	0	0
15					
16	Temperature (In/Out)	°C	80.3	48.33	35 45
17	Bubble / Dew point	°C	48.56 / 48.56	48.47 / 48.47	/ /
18	Density Vapor/Liquid	kg/m ³	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 /	/ 3.321	/ 4.171 / 4.172
23	Thermal conductivity	W/(m-K)	0.0237 /	/ 0.0898	/ 0.6231 / 0.6371
24	Latent heat	kJ/kg	282.4	282.7	
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)	m ² -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	Clean 966.9 W/(m ² -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	Length: 6000 mm Pitch: 24 mm Tube pattern:60
41	Tube type: Plain	Insert:None	Fin#:	#/m	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 VertiSpacing: 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-s ²)
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					



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	/	m ² Shells/unit	1				
3	Surf/Shell (gross/eff/finned)	673.6	/	656.2	/	m ²					
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	Actual/Reqd area ratio - fouled/clean	1.08		/ 1.83		
9	Liquid	kg/h	0	30385	254002	Coef./Resist.	W/(m ² -K)	m ² -K/W	%		
10	Noncondensable	kg/h	0	0		Overall fouled	572.1	0.00175			
11	Cond./Evap.	kg/h	30385	0		Overall clean	966.9	0.00103			
12	Temperature	°C	80.3	48.33	35	45	Tube side film	3840.4	0.00026	14.9	
13	Bubble Point	°C	48.56	48.47			Tube side fouling	1946.2	0.00051	29.39	
14	Dew Point	°C	48.56	48.47			Tube wall	15249.4	7E-05	3.75	
15	Vapor mass fraction		1	0	0	0	Outside fouling	5000	0.0002	11.44	
16	Pressure (abs)	bar	19.937	19.90218	5.5	5.3094	Outside film	1412	0.00071	40.52	
17	DeltaP allow/cal	bar	0.1	0.03482	0.5	0.1906					
18	Velocity	m/s	0.98	0.08	0.87	0.88					
19	Liquid Properties						Shell Side Pressure Drop		bar	%	
20	Density	kg/m ³	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					Outlet spaceXflow	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/m ³	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-s ²)	
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				Tube nozzle inlet	m/s	kg/(m-s ²)		
41	2-Phase vapor	-0.6	0				Tubes	0.87	0.88		
42	Latent heat	-2384.5	0				Tube nozzle outlet	0.98	944		
43	2-Phase liquid	-0.9	0				Tube nozzle interm				
44	Liquid only	-4.1	2941.9								
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	0	0	0	0
Liquid mass flow rate	kg/h	0	30385	254002	254002	254002	254002	254002	254002
Vapor mass fraction		1	0	0	0	0	0	0	0
Temperatures	°C	80.3	48.33	35	35	45	45	45	45
Bubble / Dew point	°C	48.56 / 48.56	48.47 / 48.47	/	/	/	/	/	/
Operating Pressures	bar	19.937	19.90218	5.5	5.5	5.3094	5.3094	5.3094	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	0.1906	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)		

Total M
Errors: 1
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		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	m²-K/W		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		Connected in: 1 parallel 1 series	
7	Surf/unit(eff.)		117.3		m ²		Shells/unit 1		Surf/shell(eff.) 117.3 m ²	
8	PERFORMANCE OF ONE UNIT									
9	Fluid allocation				Shell Side			Tube Side		
10	Fluid name				PROPYLENE			PROPYLENE		
11	Fluid quantity, Total				21450			8174		
12	Vapor (In/Out)		kg/h		0		0		2370 8174	
13	Liquid		kg/h		21450		21450		5804 0	
14	Noncondensable		kg/h		0		0		0 0	
15										
16	Temperature (In/Out)				°C		48.55 14		12.37 15	
17	Bubble / Dew point				°C		48.56 / 48.56 48.36 / 48.36		12.37 / 12.37 12.37 / 12.37	
18	Density Vapor/Liquid		kg/m ³		/ 461.41		/ 524.12		17.36 / 526.76 17.02 /	
19	Viscosity				mPa-s		/ 0.0598		/ 0.0915 0.0087 / 0.0933 0.0087 /	
20	Molecular wt, Vap									
21	Molecular wt, NC									
22	Specific heat		kJ/(kg-K)		/ 3.332		/ 2.558		1.65 / 2.578 1.655 /	
23	Thermal conductivity		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)				m ² -K/W		0.00017		0.00017 0.00021 Ao based	
29	Heat exchanged		590.2		kW		MTD (corrected)		11.81 °C	
30	Transfer rate, Service		425.9		Dirty		512.7		Clean 638.3 W/(m ² -K)	
31	CONSTRUCTION OF ONE SHELL							Sketch		
32					Shell Side		Tube Side			
33	Design/Vacuum/test pressure		bar		23 / 0 / 29.9		23 / 0 / 29.9			
34	Design temperature / MDMT		°C		120 / -45		120 / -45			
35	Number passes per shell				1		3			
36	Corrosion allowance				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 Pitch: 32 mm Tube pattern:30	
41	Tube type: Plain		Insert:None		Fin#:		#/m		Material:SA-334 6 K03006	
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		Tubesheet-floating -					
45	Floating head cover		-		Impingement protection None					
46	Baffle-cross SA-285 C K02801		Type		Single segmental		Cut(%d) 15.4		HorizSpacing: 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 ² -s ²)	
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										



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	/	m ² Shells/unit	1		
3	Surf/Shell (gross/eff/finned)				119.2	/	117.3	/	m ²			
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	590.2	
7	Total flow	kg/h	21450		8174				Eff. MTD/ 1 pass MTD	°C	11.81 / 11.75	
8	Vapor	kg/h	0	0	2370	8174			Actual/Reqd area ratio - fouled/clean	1.2 / 1.5		
9	Liquid	kg/h	21450	21450	5804	0			Coef./Resist.	W/(m ² -K)	m ² -K/W	%
10	Noncondensable	kg/h	0		0				Overall fouled	512.7	0.00195	
11	Cond./Evap.	kg/h	0		5804				Overall clean	638.3	0.00157	
12	Temperature	°C	48.55	14	12.37	15			Tube side film	1393.5	0.00072	36.8
13	Bubble Point	°C	48.56	48.36	12.37	12.37			Tube side fouling	4678.1	0.00021	10.96
14	Dew Point	°C	48.56	48.36	12.37	12.37			Tube wall	20882	5E-05	2.46
15	Vapor mass fraction		0	0	0.29	1			Outside fouling	5882.4	0.00017	8.72
16	Pressure (abs)	bar	19.94	19.85263	8.3	8.25237			Outside film	1248.3	0.0008	41.07
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								Shell Side Pressure Drop	bar	%	
20	Density	kg/m ³	461.41	524.12	526.76				Inlet nozzle	0.002	2.29	
21	Viscosity	cp	0.0598	0.0915	0.0933				InletspaceXflow	0.00187	2.14	
22	Specific heat	kJ/(kg-K)	3.332	2.558	2.578				Baffle Xflow	0.05507	63.01	
23	Therm. cond.	W/(m-K)	0.0897	0.1072	0.1081				Baffle window	0.02558	29.27	
24	Surface tension	N/m			0.0072				OutletspaceXflow	0.00169	1.93	
25	Molecular weight		42.08	42.08	42.08				Outlet nozzle	0.00123	1.41	
26	Vapor Properties								Intermediate nozzles			
27	Density	kg/m ³			17.36	17.02			Tube Side Pressure Drop	bar	%	
28	Viscosity	mPa-s			0.0087	0.0087			Inlet nozzle	0.01092	24.75	
29	Specific heat	kJ/(kg-K)			1.65	1.655			Entering tubes	0.00142	3.23	
30	Therm. cond.	W/(m-K)			0.0162	0.0165			Inside tubes	0.02562	58.04	
31	Molecular weight				42.08	42.08			Exiting tubes	0.00348	7.88	
32	Two-Phase Properties								Outlet nozzle	0.0027	6.11	
33	Latent heat	kJ/kg			360	360			Intermediate nozzles			
34	Heat Transfer Parameters								Velocity / Rho*V2	m/s	kg/(m-s ²)	
35	Reynolds No. vapor				59183.27	202410.7			Shell nozzle inlet	0.77	272	
36	Reynolds No. liquid		61405.68	40123.33	13442.3				Shell bundle Xflow	0.31	0.28	
37	Prandtl No. vapor				0.88	0.88			Shell baffle window	0.21	0.18	
38	Prandtl No. liquid		2.22	2.18	2.23				Shell nozzle outlet	0.68	240	
39	Heat Load								Shell nozzle interm			
40	Vapor only	kW	0		9.9							
41	2-Phase vapor	kW	0		0					m/s	kg/(m-s ²)	
42	Latent heat	kW	0		580.4				Tube nozzle inlet	6.16	2101	
43	2-Phase liquid	kW	0		0				Tubes	1.58	5.14	
44	Liquid only	kW	-590.2		0				Tube nozzle outlet	7.93	1071	
44									Tube nozzle interm			
45	Tubes								Nozzles: (No./OD)			
46	Type			Plain	Type	Single segmental			Shell Side		Tube Side	
47	ID/OD	mm	20.2	/	25.4	Number	47	Inlet	mm	1 / 168.28	1 / 114.3	
48	Length act/eff	cm	600	/	590.4	Cut(%d)	15.4	Outlet	1 / 168.28	1 / 168.28		
49	Tube passes		3			Cut orientation	H	Intermediate	/	/		
50	Tube No.		249			Spacing: c/c	mm	Impingement protection	None			
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	/				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)

Total M
Errors: 0
Input: 0
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		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