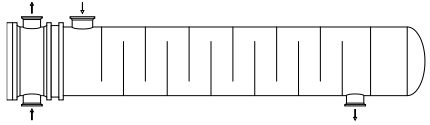


HTRI HEAT EXCHANGER SPECIFICATION SHEET Released to the following HTRI Member Company: WCE RLZ		Page 2
		US_AP Units
Customer	Job No.	
Address	Reference No.	
Plant Location	Proposal No.	
Service of Unit	Lean/Rich Amine Exchanger	Date 2022/5/30 Rev 1
Size	44 x 198 inch Type AEU Horizontal	Item No. 18-X-262
Surf/Unit (Gross/Eff)	4276.5 / 4142.1 ft2	Surf/Shell (Gross/Eff) 4276.5 / 4142.1 ft2
PERFORMANCE OF ONE UNIT		
Fluid Allocation	Shell Side	Tube Side
Fluid Name	Lean Amine	Rich Amine
Fluid Quantity, Total lb/hr	568020	589608
Vapor (In/Out)		
Liquid	568020	589608
Steam		
Water		
Noncondensables		
Temperature (In/Out) F	270.50	210.00
Specific Gravity	0.9599	0.9479
Viscosity cP	0.6570	1.2381
Molecular Weight		
Molecular Weight, Noncondensables		
Specific Heat Btu/lb-F	0.8400	0.7920
Thermal Conductivity Btu/hr-ft-F	0.1760	0.2390
Latent Heat Btu/lb		
Inlet Pressure psig	23.400	60.000
Velocity ft/sec	1.62	3.83
Pressure Drop, Allow/Calc psi	6.000	5.846
Fouling Resistance (min) ft2-hr-F/Btu	0.00200	0.00200
Heat Exchanged	23.115 MM Btu/hr	MTD (Corrected) 53.2 F
Transfer Rate, Service	104.40 Btu/ft2-hr-F	Clean 193.98 Btu/ft2-hr-F Actual 104.44 Btu/ft2-hr-F
CONSTRUCTION OF ONE SHELL		Sketch (Bundle/Nozzle Orientation)
	Shell Side	Tube Side
Design/Test Pressure psig	150.00 /	195.00 /
Design Temperature F	330.00	300.00
No Passes per Shell	1	4
Corrosion Allowance inch	0.0000	0.0000
Connections In inch	1 @ 11.145	1 @ 9.1660
Size & Out inch	1 @ 9.1660	1 @ 9.1660
Rating Intermediate	@	@
		
Tube No. 660U	OD 0.7500 inch	Thk(Avg) 0.0650 inch
Tube Type Plain	Material SA-213 TP316L	Tube (S) S31603
Shell SA-516 70 Pl. K02700	ID 44.000	OD 45.000 inch
Channel or Bonnet SA-240 316L Pl. S31603	Shell Cover SA-516 70 Pl. K02700	(Integ.)
Tubesheet-Stationary SA-182 F316L Forgings S31600	Channel Cover SA-240 316L Pl. S31603	
Floating Head Cover	Tubesheet-Floating	
Baffles-Cross 316 Stainless steel (17 Cr, Type Single-Seg.	%Cut (Diam) 21.09	Spacing(c/c) 13.563
Baffles-Long	Seal Type None	Inlet 26.496 inch
Supports-Tube	U-Bend	Type Full support
Bypass Seal Arrangement pairs seal strips	Tube-Tubesheet Joint Expanded (2 grooves)	
Expansion Joint	Type None	
Rho-V2-Inlet Nozzle 905.56 lb/ft-sec2	Bundle Entrance 371.33	Bundle Exit 983.48 lb/ft-sec2
Gaskets-Shell Side Mach. Mtl. (Kammprofile\Flex. Face)	Tube Side Mach. Mtl. (Kammprofile\Flex. Face)	
- Floating Head		
Code Requirements	TEMA Class R	
Weight/Shell 24565 lb	Filled with Water 37601 lb	Bundle 15780 lb
Remarks:		
Shell lining material - SA-240 316L Pl. S31603		
Channel lining material - SA-240 316L Pl. S31603		
Reprinted with Permission		



Final Results

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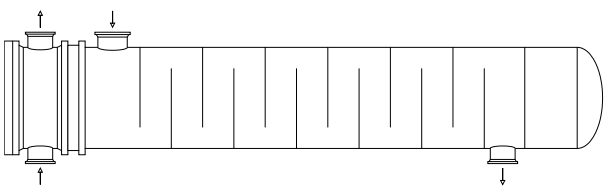
Page 3

Xist 8.2 2022/6/14 14:34 SN: 01096-1681353279

US_AP Units

Shell 1

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

Process Data				Hot Shellside		Cold Tubeside		Shellside Performance						
Fluid name				Lean Amine		Rich Amine		Nom vel, X-flow/window						
Fluid condition				Sens. Liquid		Sens. Liquid		2.36 / 2.36						
Total flow rate (lb/hr)				568020		589608		Flow fractions for heat transfer 0.612						
Weight fraction vapor, In/Out (--)				0.0000	0.0000	0.0000	0.0000	A=0.1183 B=0.5418 C=0.0236 E=0.1993 F=0.1170						
Temperature, In/Out (Deg F)				270.50	221.30	158.60	210.00							
Skin temperature, Min/Max (Deg F)				211.13	257.77	188.35	222.82							
Wall temperature, Min/Max (Deg F)				202.19	244.04	199.17	239.42							
Pressure, In/Average (psig)				23.400	21.691	60.000	57.077							
Pressure drop, Total/Allowed (psi)				3.418	6.000	5.846	6.000							
Velocity, Mid/Max allow (ft/sec)				1.62		3.83								
Mole fraction inert (--)														
Average film coef. (Btu/ft2-hr-F)					539.79		460.24							
Heat transfer safety factor (--)					1.0000		1.0000							
Fouling resistance (ft2-hr-F/Btu)					0.00200		0.00200							
Overall Performance Data														
Overall coef., Req'd/Clean/Actual (Btu/ft2-hr-F)				104.40	/	193.98	/	104.44						
Heat duty, Calculated/Specified (MM Btu/hr)				23.115	/	23.000								
Effective overall temperature difference (Deg F)				53.2										
EMTD = (MTD) * (DELTA) * (F/G/H) (Deg F)				54.2	*	0.9822	*	1.0000						
See Runtime Messages Report for warnings.														
Exchanger Fluid Volumes														
Approximate shellside (ft3)		135.10												
Approximate tubeside (ft3)		73.813												
Shell Construction Information														
TEMA shell type		AEU	Shell ID		(inch)	44.000								
Shells Series		1 Parallel	1	Total area		(ft2)	4276.5							
Passes Shell		1 Tube	4	Eff. area		(ft2/shell)	4142.1							
Shell orientation angle (deg)		0.00												
Impingement present		Rods	Impingement rod rows			2								
Pairs seal strips		0	Passlane seal rods (inch)		1.0240	No. 7								
Shell expansion joint		No	UBend tangent to Support Dist. (inch)		1.5000									
Weight estimation Wet/Dry/Bundle			37601	/	24565	/	15780	(lb/shell)						
Baffle Information														
Type		Perpend. Single-Seg.	Baffle cut (% dia)		21.09									
Crosspasses/shellpass		13	No. (Pct Area)		(inch) to C.L									
Central spacing (inch)		13.563	1	16.87	12.719									
Inlet spacing (inch)		26.496	2	0.00	0.0000									
Outlet spacing (inch)		16.087												
Baffle thickness (inch)		0.3100												
Use deresonating baffles		No												
Tube Information														
Tube type		Plain	Tubecount per shell			1320								
Length to tangent (in)		198.00	Pct tubes removed (both)			5								
Effective length (in)		191.78	Outside diameter		(inch)	0.7500								
Total tubesheet (inch)		4.7240	Wall thickness		(inch)	0.0650								
Area ratio (out/in)		1.2097	Pitch (inch)		1.0000	Ratio	1.3333							
Tube metal		SA-213 TP316L Tube (S) S316C	Tube pattern (deg)			90								
Shellside Heat Transfer Corrections														
		Total	Beta	Gamma	End	Fin								
		0.970	0.906	1.071	0.934	1.000								
Pressure Drops (Percent of Total)														
		Cross	Window	Ends	Nozzle	Shell	Tube							
		61.61	12.85	9.62	Inlet	6.91	3.97							
		MOMENTUM		0.00	Outlet	9.01	2.79							
Two-Phase Parameters														
		Method	Inlet	Center	Outlet	Mix F								
H. T. Parameters										Shell	Tube			
		Overall wall correction			0.973	1.027								
		Midpoint	Prandtl no.	10.45	16.25									
		Midpoint	Reynolds no.	10517	9846									
		Bundle inlet	Reynolds no.	7960	5690									
		Bundle outlet	Reynolds no.	7535	14429									
		Fouling layer	(inch)											
Thermal Resistance, %														
		Shell	Tube	Fouling	Metal	Over Des								
		19.35	27.45	46.16	7.04	0.04								
		Total fouling resistance (ft2-hr-F/Btu)				0.0044								
		Differential resistance (ft2-hr-F/Btu)				4.26e-6								
Shell Nozzles										Inlet	Outlet	Liquid Outlet		
		Inlet at channel end-Yes												
		Number at each position			1	1	0							
		Diameter	(inch)	11.145	9.1660									
		Velocity	(ft/sec)	3.89	5.61									
		Pressure drop	(psi)	0.236	0.308									
		Height under nozzle	(inch)	1.3242	2.9062									
		Nozzle R-V-SQ	(lb/ft-sec2)	905.56	1932.2									
		Shell ent.	(lb/ft-sec2)	1360.0	967.84									
Tube Nozzle										Inlet	Outlet	Liquid Outlet		
		Diameter	(inch)	9.1660	9.1660									
		Velocity	(ft/sec)	5.46	6.04									
		Pressure drop	(psi)	0.232	0.163									
		Nozzle R-V-SQ	(lb/ft-sec2)	1952.4	2159.7									
Annular Distributor										Inlet	Outlet			
		Length	(inch)											
		Height	(inch)											
		Slot area	(in2)											
Diametral Clearances (inch)														
		Baffle-to-shell		Bundle-to-shell		Tube-to-baffle								
		0.2500		0.5870		0.0157								



Supplementary Results

Page 4

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US_AP Units

Shell 1

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

1	Externally Enhanced Tube Geometry		Internally Enhanced Tube Geometry	
2	Type	Plain	Type	None
3	Fin density	(fin/inch)	Thickness	(inch)
4	Fin height	(inch)	Pitch	(L/D)
5	Fin thickness	(inch)		
6	Root diameter	(inch)		
7	Area/length	(ft ² /ft)		
8				
9	Mean Metal Temperatures			
10	Mean shell temperature	242.38 (F)		
11	Tubesheet temperature	330.00 (F)		
12	Mean tube metal temperature in each tubepass, (F)			
13	<u>Tube Pass</u>	<u>Inside</u>	<u>Outside</u>	<u>Radial</u>
14	1	209.91	214.70	212.46
15	2	213.81	218.02	216.05
16	3	219.93	223.33	221.74
17	4	223.63	226.48	225.14
18				



Vibration Analysis

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US_AP Units

Shell 1

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

1	Shellside condition	Sens. Liquid	(Level 2.3000)	
2	Axial stress loading	(1000-psi)	0.000	Added mass factor 1.394
3	Beta		2.717	
4	Position In The Bundle			
5	Length for natural frequency	(in)	Inlet 40.059	Center 27.126 Outlet 29.650
6	Length/TEMA maximum span	(--)	0.668	0.452 0.494
7	Number of spans	(--)	7	7 7
8	Tube natural frequency	(Hz)	59.7 +	78.2 78.1
9	Shell acoustic frequency	(Hz)		
10	Flow Velocities			
11	Window parallel velocity	(ft/sec)	Inlet 2.12	Center 2.08 Outlet 2.06
12	Bundle crossflow velocity	(ft/sec)	0.82	1.62 1.32
13	Bundle/shell velocity	(ft/sec)	1.15	1.13 0.93
14	Fluidelastic Instability Check			
15	Log decrement	HTRI	Inlet 0.074	Center 0.070 Outlet 0.070
16	Critical velocity	(ft/sec)	5.31	11.25 9.33
17	Baffle tip cross velocity ratio	(--)	0.1775	0.1648 0.1623
18	Average crossflow velocity ratio	(--)	0.1547	0.1437 0.1414
19	Acoustic Vibration Check			
20	Vortex shedding ratio	(--)	Inlet	Center Outlet
21	Chen number	(--)		
22	Turbulent buffeting ratio	(--)		
23	Tube Vibration Check			
24	Vortex shedding ratio	(--)	Inlet 0.078	Center 0.153 Outlet 0.125
25	Parallel flow amplitude	(inch)	0.0000	0.0001 0.0001
26	Crossflow amplitude	(inch)	0.0005	0.0004 0.0004
27	Tube gap	(inch)	0.2500	0.2500 0.2500
28	Crossflow amplitude/tube gap	(--)	0.0020	0.0016 0.0016
29	Crossflow RHO-V-SQ	(lb/ft-sec2)	40.39	158.94 106.96
30	Bundle Entrance/Exit			
31	(analysis at first tube row)		Entrance	Exit
32	Fluidelastic instability ratio	(--)	0.205	0.126
33	Vortex shedding ratio	(--)	0.236	0.380
34	Crossflow amplitude	(inch)	0.00091	0.00036
35	Crossflow velocity	(ft/sec)	2.49	4.00
36	Tubesheet to inlet/outlet support	(inch)	None	None
37	Shell Entrance/Exit Parameters			
38	Impingement device		Entrance Rods	Exit --
39	Flow area	(ft2)	0.553	0.647
40	Velocity	(ft/sec)	4.76	3.97
41	Critical velocity	(ft/sec)	12.13	31.71
42	RHO-V-SQ	(lb/ft-sec2)	1360.0	967.84
43	Shell type	AEU	Baffle type	Single-Seg.
44	Tube type	Plain	Baffle layout	Perpend.
45	Pitch ratio	1.3333	Tube diameter, (inch)	0.7500
46	Layout angle	90	Tube material	SA-213 TP316L Tube (S) S31603
47	Number U-Bend supports	1	Elastic modulus, (1000-psi)	27177
48	Use deresonating baffles	No	Supports/baffle space	

Program Messages

+ Natural or acoustic frequency used in vibration analysis.

See help for additional information.

* Items with asterisk exceed a conservative lower limit for vibration-free design.

Review your case using the procedure described in Online Help;

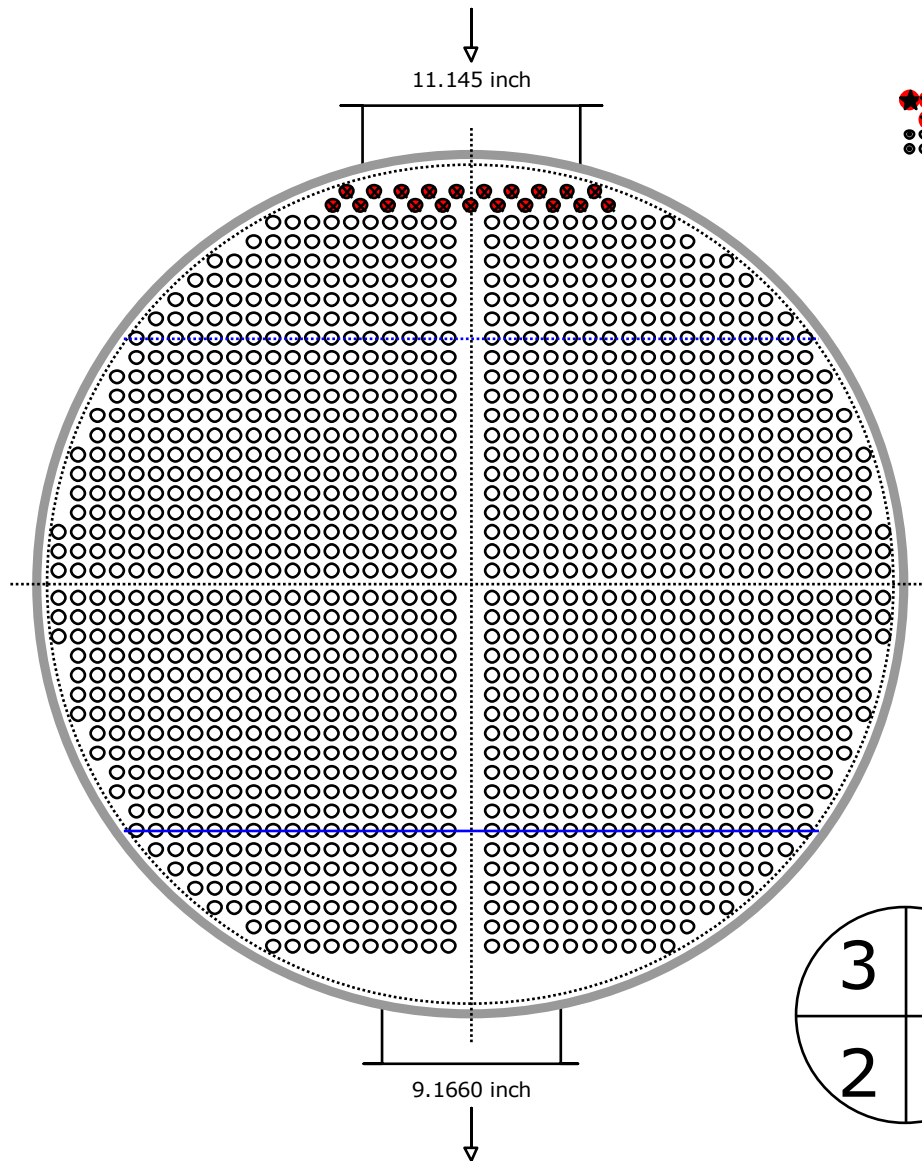
You may find that a vibration problem is unlikely.

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US_AP Units

Shell 1

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



Unit	Shell 1
Item number	18-X-262
TEMA type	AEU
Shell ID	44.000 inch
Actual OTL	43.413 inch
Height under inlet nozzle	1.3242 inch
Rows of impingement rods	2
Impingement rod OD	0.7500 inch
Height under outlet nozzle	2.9062 inch
Tube type	Plain
Tube OD	0.7500 inch
Tube pitch	1.0000 inch
Tube layout angle	90 deg
Tubes	1320
Tube positions available	1320
Tie rods	8
Seal strip pairs	0
Passlane seal rods	7
Tube Passes	4
Parallel passlane width	1.5000 inch
Perpendicular passlane width	0.6875 inch
Baffle cut % diameter	21.09

TUBEPASS DETAILS

Pass	Rows	Tubes
1	19	330
2	19	330
3	19	330
4	19	330

SYMBOL LEGEND

- Tube
- ▲ Dummy Short Tube
- ▲ Dummy Long Tube
- Plugged Tube
- ⊙ Tie Rod
- ⊙ Seal Rod
- ⊙ Impingement Rod



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US_AP Units

Shell 1

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

1 Exchanger Data

2	Unit identifier	Shell 1
3	Service type	Generic shell and tube
4	TEMA type	AEU
5	Run mode	Rating
6	Hot fluid location	Shellside
7	Unit orientation	Horizontal
8	Number of shells in series	1
9	Number of shells in parallel	1
10	Flow in 1st tubepass	Cocurrent
11	Train flow direction	Countercurrent

13 Construction Data

14	Shell material	SA-516 70 Pl. K02700
15	Tube material	SA-213 TP316L Tube (S) S31603
16	Shell cover material	SA-516 70 Pl. K02700
17	Channel or bonnet material	SA-240 316L Pl. S31603
18	Channel cover material	SA-240 316L Pl. S31603
19	Tubesheet-Stationary material	SA-182 F316L Forgings S31600
20	Baffle-Cross material	316 Stainless steel (17 Cr, 12 Ni)
21	Shellside gasket	Mach. Mtl. (Kammprofile\Flex. Face)
22	Tubeside gasket	Mach. Mtl. (Kammprofile\Flex. Face)
23	Shellside design pressure	150.00 psig
24	Tubeside design pressure	195.00 psig
25	Shellside vacuum pressure	None
26	Tubeside vacuum pressure	None
27	Shellside design temperature	330.00 F
28	Tubeside design temperature	300.00 F
29	Shellside corrosion allowance	0.0000 inch
30	Tubeside corrosion allowance	0.0000 inch
31	Tubesheet design temperature	330.00 F
32	Shellside radiography	Full
33	Tubeside radiography	Full
34	TEMA class	R
35	Small exchanger	No
36	Shell outside diameter	45.000 inch
37	Shell inside diameter	44.000 inch
38	Shell wall thickness	0.5000 inch
39	Front head outside diameter	44.625 inch
40	Front head inside diameter	44.000 inch
41	Front head thickness	0.3125 inch
42	Rear head outside diameter	45.000 inch
43	Rear head inside diameter	44.000 inch
44	Rear head thickness	0.5000 inch
45	Total tubesheet thickness	4.7240 inch
46	Double tubesheet	No
47	Shell expansion joint	No
48	Suppress mechanical calculations	No



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US_AP Units

Shell 1

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

Lining Materials

Shell lining material	SA-240 316L Pl. S31603
Channel lining material	SA-240 316L Pl. S31603

Tube Data

Tube type	Plain
Tube outside diameter	0.7500 inch
Tube wall thickness	0.0650 inch
Tube pitch	1.0000 inch
Tube pitch ratio	1.3333
Tube passes per shell	4
Tube pattern	90 degrees
Tube count method	Rigorous
Tube length	198.00 in
Tube material	SA-213 TP316L Tube (S) S31603

Baffle Data

Baffle type	Single segmental
Baffle orientation	Program sets
Baffle cut percent	21.000 % shell ID
Adjust baffle cut	On tube c/l
Number of crosspasses	13
Central baffle spacing	13.563 inch
Inlet baffle spacing	26.496 inch
Variable baffle spacing	No
Baffle thickness	0.3100 inch
Window cut from baffles	No
Use deresonating baffles	No

Supports Data

Full support at U-Bend	Full support
Support distance to U-bend tangent	1.5000 inch
Number of U-bend supports	1
Include inlet vibration support	No
Include outlet vibration support	No



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US_AP Units

Shell 1

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

Nozzle Data**Shellside**

Nozzle standard

01-ANSI_B36_10.TABLE

Shell entrance type

Use impingement device

Shell exit type

Remove tubes if TEMA requires

6

Inlet Outlet Liq. Outlet

Nozzle outside diameter

12.750

10.750

-- inch

Nozzle inside diameter

11.145

9.1660

-- inch

Number at this position

1

1

--

Tubeside

Nozzle standard

01-ANSI_B36_10.TABLE

12

Inlet Outlet Liq. Outlet

Nozzle outside diameter

10.750

10.750

-- inch

Nozzle inside diameter

9.1660

9.1660

-- inch

Number at this position

1

1

--

Nozzle Location Data

Radial position on shell inlet nozzle

Top

Longitudinal position on shell of inlet nozzle

At front head

Radial position on shell outlet nozzle

Program decides

Location of nozzle at U-bend

Before U-bend

Tubeside entry type

Radial

Tubeside inlet position

Front head

Tubeside exit type

Same as inlet

Impingement Data

Impingement type

Rods

Use tube positions to place rods

No

Impingement rod rows

2

Impingement rod diameter

0.7500 inch

Impingement rod pitch

1.0000 inch

Impingement rods on centerline

Program set

Impingement rod layout angle

45.00 deg

Rod row width to nozzle diameter

1.2000



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US_AP Units

Shell 1

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

1 Tube Layout Data

2	Pass partition construction		Program set
3	Force symmetric layout		No
4	Force continuous cleaning lanes		No
5	Force uniform layout		No
6	Align across primary passlanes		No
7	Fill knock out area with dummy tubes		Program set
8	Fill bundle periphery with dummy tubes		Program set
9	Fill passlanes with dummy tubes		Program Set
10	Square layout tube alignment		Program set
11	Use crossed U-bends		No
12	Minimum U-bend diameter		2.2500 inch
13	Use tube layout drawing as input		Yes
14		Inlet	Outlet Liq. Outlet
15	Height under nozzle	1.0000	-- -- inch
16	Tube rows removed under nozzle	0	2 0

18 Clearance Data

19	Number of seal strip pairs		None
20	Block A stream		No
21	Block E stream		No
22	Block F stream		No
23	Parallel/vertical passlane width		0.6875 inch
24	Perpendicular/horizontal passlane width		0.6875 inch
25	Number of passlane seal rods		7
26	Passlane seal rod diameter		1.0240 inch
27	Tubes to remove for tie rods		Calculated
28	Number of tie rods		8
29	Tie rod outside diameter		0.5000 inch
30	Tube to baffle clearance		0.0157 inch
31	Baffle to shell clearance		0.2500 inch
32	Baffle clearance type		TEMA

34 Process Conditions Data

		Hot Fluid	Cold Fluid
35	Phase condition	Sensible liquid	Sensible liquid
36	Flow rate	568020	589608 lb/hr
37	Inlet vapor fraction	0.0000	0.0000
38	Outlet vapor fraction	0.0000	0.0000
39	Inlet temperature	270.50	158.60 F
40	Outlet temperature	221.30	210.00 F
41	Inlet pressure	23.400	60.000 psig
42	Allowable pressure drop	6.000	6.000 psi
43	Exchanger duty		23.000 MM Btu/hr
44	Duty multiplier		1.0000

46 Process Fouling Data

		Hot Fluid	Cold Fluid
47	Fouling resistance	0.0020	0.0020 ft ² -hr-F/Btu



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US_AP Units

Shell 1

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

Hot Fluid Property Data

Fluid name	Lean Amine
Physical property method	Property tables
Temperature interpolation option	Program
Flash type	Integral
Quantity units	Moles
Heat release type	Specific enthalpy

Hot Fluid Physical Property Data

Pressure Set - 1				
Temp.	Liquid Density	Liquid Dynamic Viscosity	Liquid Thermal Cond.	Liquid Heat Capacity
F	lb/ft3	cP	Btu/hr-ft-F	Btu/lb-F
270.50	59.900	0.6570	0.1760	0.8400
221.30	61.360	1.1520	0.1760	0.8060

Cold Fluid Property Data

Fluid name	Rich Amine
Physical property method	Property tables
Temperature interpolation option	Program
Flash type	Integral
Quantity units	Moles
Heat release type	Specific enthalpy

Cold Fluid Physical Property Data

Pressure Set - 1				
Temp.	Liquid Density	Liquid Dynamic Viscosity	Liquid Thermal Cond.	Liquid Heat Capacity
F	lb/ft3	cP	Btu/hr-ft-F	Btu/lb-F
158.60	65.430	3.2970	0.1760	0.7410
210.00	59.150	1.2380	0.2390	0.7920

Control Name Data

Item Number	18-X-262
Revision	1
Service	Lean/Rich Amine Exchanger



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US_AP Units

Shell 1

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

Control Methods Data

2	Shellside friction factor method	Commercial
3	Tubeside friction factor method	Commercial
4	Pure longitudinal flow	No
5	Pure component condensation	No
6	Condensing correlation	HTRI Proration
7	Mole fraction inerts	0.0000
8	Momentum exclusion	0.0000 %
9	Perform shellside subcooling calculations	No
10	Pure component boiling	No
11	Check film boiling	Yes
12	Nucleate boiling method	Physical property/theoretical boiling range
13	Component boiling method	Nucleate and convective
14	Increments per baffle	Calculated

Control User-Defined Methods Data

17	Add non-nucleate boiling	Yes
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