Runtime Messages

Released to the following HTRI Member Company:
WCE
RLZ

Xist 8.2 2022/9/28 18:17 SN: 01096-111007767 **US_AP Units**

Corn Oil Jet Mode - EOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Unit ID 100 - WARNING MESSAGES (CALCULATIONS CONTINUE)

The design has parallel-cut baffles and the reported height under the nozzle lowers the bundle below the baffle cut. Unrestricted longitudinal flow can bypass the bundle. This bypass region can be reduced by decreasing the height under the nozzle, changing the baffle cut, or adding sealing arrangements.

The physical properties of the hot fluid have been extrapolated beyond the valid temperature range. Check the calculated values. The thermal analysis requires properties at bulk and skin/wall temperatures.

The longest unsupported span of the bundle is in the U-bend region and thus prone to excessive vibration, even with a full support plate. The longest unsupported span should be in the straight portion of the U-tube.

ASME Section VIII Div. 1 Code was used to ESTIMATE all pressure vessel dimensions and weights. The dimensions in this report cannot be used to fabricate the vessel.

HEAT EXCHANGER SPECIFICATION SHEET

Released to the following HTRI Member Company:
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US_AP Units

Customer			Job No.	
Address			Reference No.	
Plant Location			Proposal No.	
Service of Unit	Jet Side-Cut Stripper Reboiler		Date	2022/9/28 Rev 03
Size	36 x 78 inch Type AEU Horizontal		Item No.	18-X-353
Surf/Unit (Gross/Eff)	1110.4 / 1049.5 ft2 Shell/Unit 1		Connected In	1 Parallel 1 Series
			Surf/Shell (Gross/Eff)	1110.4 / 1049.5 ft2

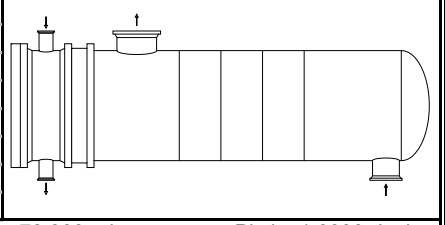
PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		Jet Side-Cut Reboiler Feed		Diesel Product	
Fluid Quantity, Total	lb/hr	93037		56742	
Vapor (In/Out)			30309		
Liquid		93037	62728	56742	56742
Steam					
Water					
Noncondensables					
Temperature (In/Out)	F	439.13	469.95	598.00	478.00
Specific Gravity		0.5689	0.5609	0.5316	0.5965
Viscosity	cP	0.1685	0.0083 V/L 0.1608	0.1390	0.2220
Molecular Weight					
Molecular Weight, Noncondensables					
Specific Heat	Btu/lb-F	0.7147	0.6250 V/L 0.7298	0.7850	0.7140
Thermal Conductivity	Btu/hr-ft-F	0.0539	0.0155 V/L 0.0532	0.0500	0.0550
Latent Heat	Btu/lb	101.59	98.590		
Inlet Pressure	psig	25.770		120.00	
Velocity	ft/sec	5.17		3.72	
Pressure Drop, Allow/Calc	psi	2.000	0.764	10.000	4.382
Fouling Resistance (min)	ft2-hr-F/Btu	0.00200		0.00200	

Heat Exchanged 5.0874 MM Btu/hr MTD (Corrected) 63.3 F
Transfer Rate, Service 76.83 Btu/ft2-hr-F Clean 123.92 Btu/ft2-hr-F Actual 78.66 Btu/ft2-hr-F

CONSTRUCTION OF ONE SHELL

Sketch (Bundle/Nozzle Orientation)



			Shell Side	Tube Side
Design/Test Pressure		psig	250.00 /	325.00 /
Design Temperature		F	550.00	700.00
No Passes per Shell			1	12
Corrosion Allowance		inch	0.1250	0.1250
Connections Size & Rating	In	inch	1 @ 7.4370	1 @ 3.6240
	Out	inch	1 @ 11.492	1 @ 3.6240
	Intermediate		@	@

Tube No. 378U OD 0.7500 inch Thk(Avg) 0.0913 inch Length 78.000 in Pitch 1.0000 inch
Tube Type Plain Material SA-179 Tube (S) K01200 Tube pattern 90
Shell SA-516 70 Pl. K02700 ID 36.000 OD 37.732 inch Shell Cover SA-516 70 Pl. K02700 (Integ.)
Channel or Bonnet SA-516 70 Pl. K02700 Channel Cover SA-516 70 Pl. K02700
Tubesheet-Stationary SA-105 Forgings K03504 Tubesheet-Floating
Floating Head Cover Impingement Plate None
Baffles-Cross Carbon steel Type Single-Seg. %Cut (Diam) 26.04 Spacing(c/c) 13.386 Inlet 31.196 inch
Baffles-Long Seal Type None
Supports-Tube U-Bend Type None
Bypass Seal Arrangement 4 pairs seal strips Tube-Tubesheet Joint Strength welded
Expansion Joint Type None
Rho-V2-Inlet Nozzle 206.74 lb/ft-sec2 Bundle Entrance 11.19 Bundle Exit 220.56 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 12895 lb Filled with Water 17832 lb Bundle 6221.1 lb
Remarks:

Final Results

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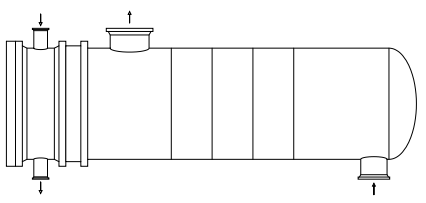
Corn Oil Jet Mode - EOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Process Data		Cold Shellside		Hot Tubeside	
Fluid name		Jet Side-Cut Reboiler Feed		Diesel Product	
Fluid condition		Boil. Liquid		Sens. Liquid	
Total flow rate	(lb/hr)	93037		56742	
Weight fraction vapor, In/Out	(--)	0.0000	0.3258	0.0000	0.0000
Temperature, In/Out	(Deg F)	439.13	469.95	598.00	478.00
Skin temperature, Min/Max	(Deg F)	456.85	510.85	469.90	558.66
Wall temperature, Min/Max	(Deg F)	462.17	528.64	463.08	532.07
Pressure, In/Average	(psig)	25.770	25.388	120.00	117.81
Pressure drop, Total/Allowed	(psi)	0.764	2.000	4.382	10.000
Velocity, Mid/Max allow	(ft/sec)	5.17		3.72	
Boiling range	(Deg F)		78.3		
Average film coef.	(Btu/ft2-hr-F)		271.26		326.92
Heat transfer safety factor	(--)		1.0000		1.0000
Fouling resistance	(ft2-hr-F/Btu)		0.00200		0.00200

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(Btu/ft2-hr-F)	76.83 /	123.92 /	78.66
Heat duty, Calculated/Specified	(MM Btu/hr)	5.0874 /	5.1010	
Effective overall temperature difference	(Deg F)	63.3		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg F)	63.8 *	0.9911 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside (ft3)	56.528
Approximate tubeside (ft3)	22.596

Shell Construction Information

TEMA shell type	AEU		Shell ID	(inch)	36.000
Shells Series	1 Parallel	1	Total area	(ft2)	1110.4
Passes Shell	1 Tube	12	Eff. area	(ft2/shell)	1049.5
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	4		Passlane seal rods (inch)	0.3150	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle	17832 /	12895 /	6221.1	(lb/shell)	

Baffle Information

Type	Parallel	Single-Seg.	Baffle cut (% dia)	26.04	
Crosspasses/shellpass		5	No.	(Pct Area)	(inch) to C.L
Central spacing	(inch)	13.386	1	20.28	8.6250
Inlet spacing	(inch)	31.196	2	0.00	0.0000
Outlet spacing	(inch)	29.720			
Baffle thickness	(inch)	0.3940			
Use deresonating baffles		No			

Tube Information

Tube type		Plain	Tubecount per shell		756
Length to tangent	(in)	78.000	Pct tubes removed (both)		10.98
Effective length	(in)	84.844	Outside diameter	(inch)	0.7500
Total tubesheet	(inch)	4.9210	Wall thickness	(inch)	0.0913
Area ratio	(out/in)	1.3218	Pitch (inch) 1.0000	Ratio	1.3333
Tube metal	SA-179 Tube (S) K01200		Tube pattern (deg)		90

Shellside Performance

Nom vel, X-flow/window 6.64 / 6.11

Flow fractions for vapor phase
A=0.1945 B=0.4257 C=0.0267 E=0.1059 F=0.2473

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.981	0.920	1.066	0.857	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
36.48	12.42	29.81	Inlet	2.92	3.95
MOMENTUM		11.66	Outlet	6.71	2.24

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F
PP/TBR	Flow	Flow	Flow	

H. T. Parameters		Shell	Tube
Overall wall correction			0.997
Midpoint	Prandtl no.		6.36
Midpoint	Reynolds no.	15343	49247
Bundle inlet	Reynolds no.	7081	74835
Bundle outlet	Reynolds no.	10181	47484
Fouling layer	(inch)		

Thermal Resistance, %

Shell	Tube	Fouling	Metal	Over Des
29.00	31.80	36.52	2.68	2.37

Total fouling resistance (ft2-hr-F/Btu) 0.0046
Differential resistance (ft2-hr-F/Btu) 3.02e-4

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-No		1	1	0
Diameter	(inch)	7.4370	11.492	
Velocity	(ft/sec)	2.41	18.15	
Pressure drop	(psi)	0.022	0.051	
Height under nozzle	(inch)	36.000	3.8850	
Nozzle R-V-SQ	(lb/ft-sec2)	206.74	651.05	
Shell ent.	(lb/ft-sec2)	0.54	314.70	

Tube Nozzle		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(inch)	3.6240	3.6240	
Velocity	(ft/sec)	6.63	5.91	
Pressure drop	(psi)	0.173	0.098	
Nozzle R-V-SQ	(lb/ft-sec2)	1459.7	1300.8	

Annular Distributor		Inlet	Outlet
Length	(inch)		
Height	(inch)		
Slot area	(in2)		

Diametral Clearances (inch)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
0.1875	0.5618	0.0313

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Externally Enhanced Tube Geometry			**Internally Enhanced Tube Geometry**		
Type		Plain	Type		None
Fin density	(fin/inch)		Thickness	(inch)	
Fin height	(inch)		Pitch	(L/D)	
Fin thickness	(inch)				
Root diameter	(inch)				
Area/length	(ft2/ft)				

Mean Metal Temperatures

Mean shell temperature	455.32	(F)
Tubesheet temperature	700.00	(F)

Mean tube metal temperature in each tubepass, (F)

Tube Pass	Inside	Outside	Radial
1	520.83	517.24	518.87
2	512.19	509.03	510.47
3	502.80	500.15	501.35
4	495.06	492.69	493.76
5	487.92	485.99	486.87
6	484.21	482.61	483.33
7	479.47	478.12	478.74
8	475.92	474.76	475.29
9	473.01	472.00	472.46
10	470.95	470.10	470.48
11	468.95	468.22	468.55
12	466.98	466.34	466.63

Vibration Analysis

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1	Shellside condition		Boil. Liquid	(Level 2.3000)	
2	Axial stress loading	(1000-psi)	0.000	Added mass factor	1.394
3	Beta		2.717		

	Position In The Bundle		U-Bend	Center	Outlet
5	Length for natural frequency	(in)	43.831	26.772	43.106
6	Length/TEMA maximum span	(--)	0.566	0.446	0.718
7	Number of spans	(--)	2	3	3
8	Tube natural frequency	(Hz)	30.3	118.7	64.5 +
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**U-Bend**	**Center**	**Outlet**
11	Window parallel velocity	(ft/sec)	0.61	4.56	10.92
12	Bundle crossflow velocity	(ft/sec)	0.28	4.96	5.19
13	Bundle/shell velocity	(ft/sec)	0.38	2.87	3.00
14	**Fluidelastic Instability Check**		**U-Bend**	**Center**	**Outlet**
15	Log decrement	HTRI	0.053	0.051	0.032
16	Critical velocity	(ft/sec)	6.26	40.04	18.77
17	Baffle tip cross velocity ratio	(--)	0.0441	0.1240	0.2765
18	Average crossflow velocity ratio	(--)	0.0441	0.1240	0.2765
19	**Acoustic Vibration Check**		**U-Bend**	**Center**	**Outlet**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**U-Bend**	**Center**	**Outlet**
24	Vortex shedding ratio	(--)	0.052	0.436	0.455
25	Parallel flow amplitude	(inch)	0.0000	0.0000	0.0000
26	Crossflow amplitude	(inch)	0.0000	0.0003	0.0009
27	Tube gap	(inch)	0.2500	0.2500	0.2500
28	Crossflow amplitude/tube gap	(--)	1.50e-4	0.0011	0.0035
29	Crossflow RHO-V-SQ	(lb/ft-sec2)	2.70	116.70	53.34

	Bundle Entrance/Exit (analysis at first tube row)		Entrance	Exit
32	Fluidelastic instability ratio	(--)	0.000	0.175
33	Vortex shedding ratio	(--)	0.105	0.926
34	Crossflow amplitude	(inch)	0.00016	0.00196
35	Crossflow velocity	(ft/sec)	0.56	10.56
36	Tubesheet to inlet/outlet support	(inch)	None	19.055
37	**Shell Entrance/Exit Parameters**		**Entrance**	**Exit**
38	Impingement device		None	--
39	Flow area	(ft2)	7.069	1.036
40	Velocity	(ft/sec)	0.10	12.62
41	Critical velocity	(ft/sec)	2.94	60.31
42	RHO-V-SQ	(lb/ft-sec2)	0.54	314.70

43	Shell type	AEU	Baffle type	Single-Seg.
44	Tube type	Plain	Baffle layout	Parallel
45	Pitch ratio	1.3333	Tube diameter, (inch)	0.7500
46	Layout angle	90	Tube material	SA-179 Tube (S) K01200
47	Number U-Bend supports	1	Elastic modulus, (1000-psi)	26712
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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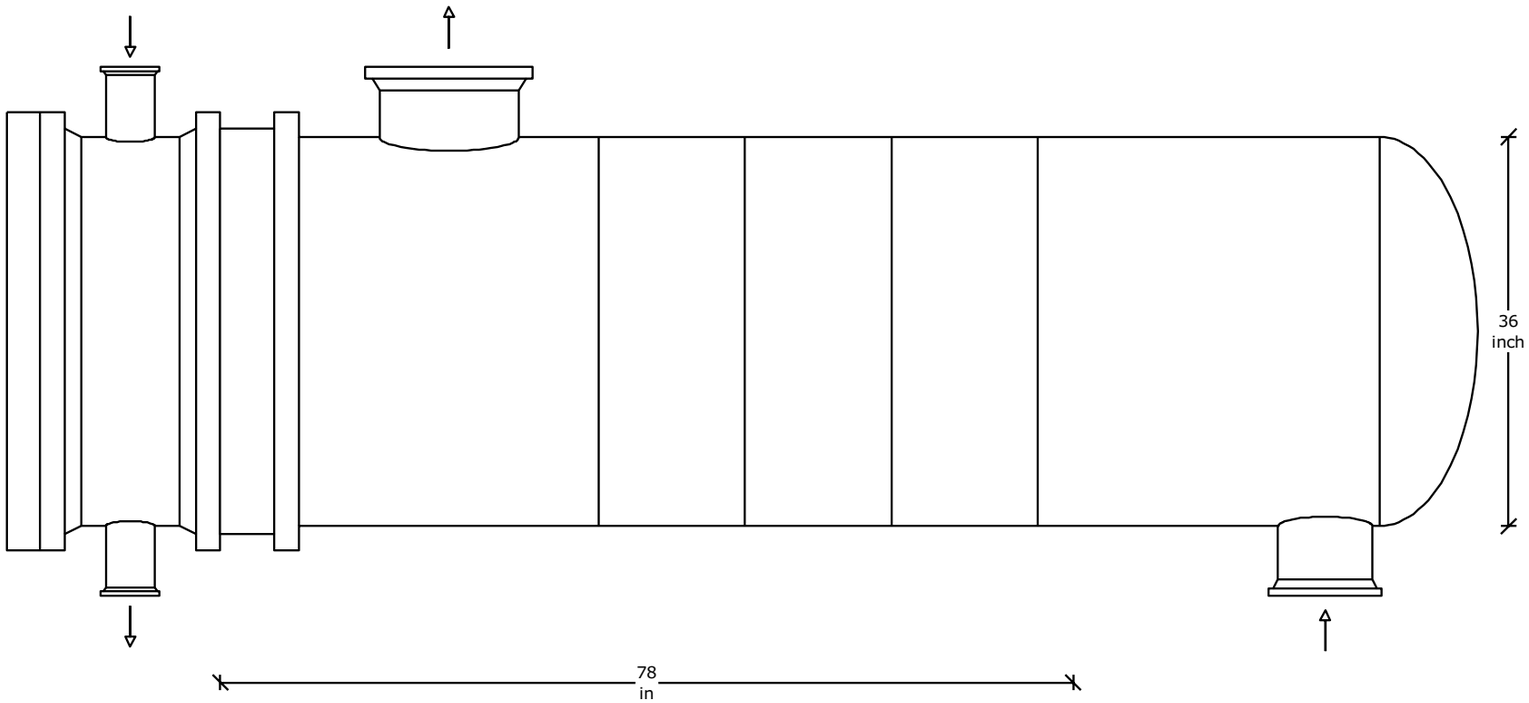

Unit	Shell 1		Total tube inlet nozzles	1	Stream ID	Shellside		Tubeside	
Item number	18-X-353		Total tube outlet nozzles	1	Stream name	Jet Side-Cut Reboiler Feed		Diesel Product	
TEMA type	AEU		Total shell inlet nozzles	1	Flow, lb/hr	93037		56742	
Shell diameter	36	inch	Total shell outlet nozzles	1	Pressure drop, psi	0.764		4.382	
Tube length	78	in			Temperature, F	439.13	469.95	598.00	478.00
Dry weight	12895	lb/shell			Wt. fraction vapor	0.0000	0.3258	0.0000	0.0000
Wet weight	17832	lb/shell			Pressure, psig	25.770	25.006	120.00	115.62
Bundle weight	6221	lb/shell							

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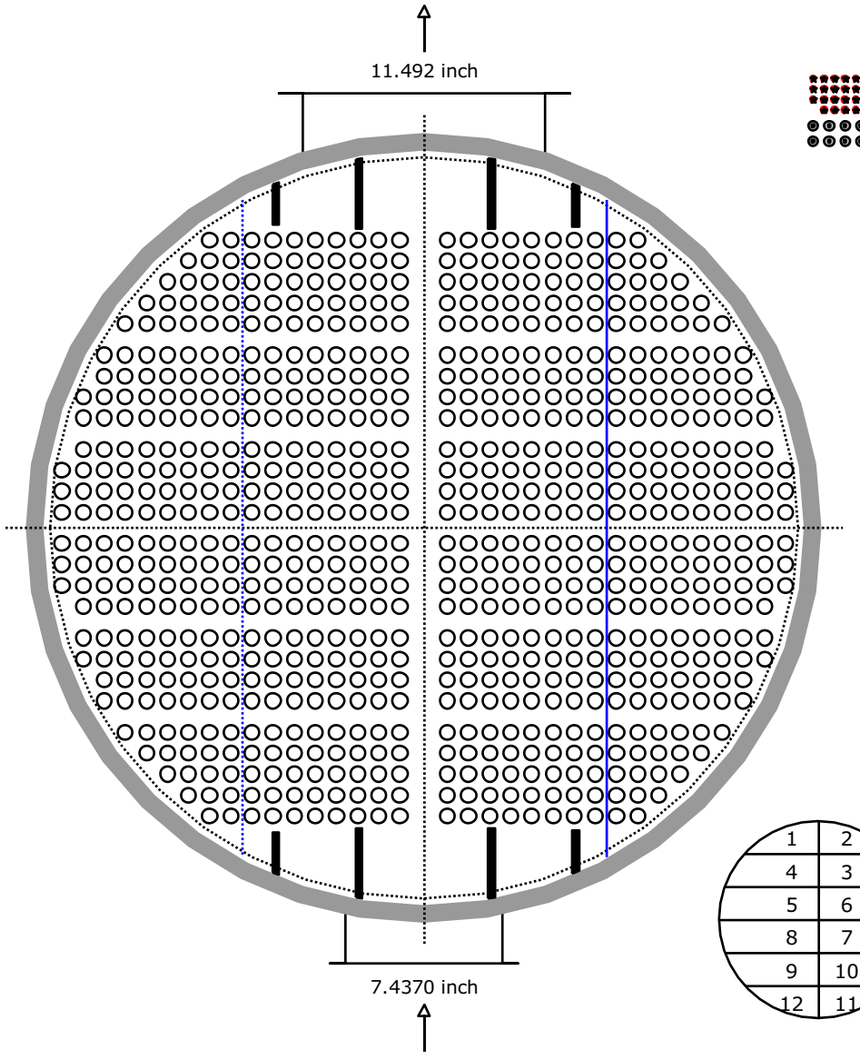

Unit	Shell 1
Item number	18-X-353
TEMA type	AEU
Shell ID	36.000 inch
Actual OTL	35.438 inch
Height under inlet nozzle	36.000 inch
Height under outlet nozzle	3.8850 inch
Tube type	Plain
Tube OD	0.7500 inch
Tube pitch	1.0000 inch
Tube layout angle	90 deg
Tubes	756
Tube positions available	756
Tie rods	8
Seal strip pairs	4
Passlane seal rods	20
Tube Passes	12
Parallel passlane width	0.7460 inch
Perpendicular passlane width	1.5000 inch
Baffle cut % diameter	26.04

TUBEPASS DETAILS

Pass	Rows	Tubes	Pass	Rows	Tubes
1	5	60	7	4	67
2	5	60	8	4	67
3	4	62	9	4	62
4	4	62	10	4	62
5	4	67	11	5	60
6	4	67	12	5	60

SYMBOL LEGEND
- Tube
- Dummy Short Tube
- Dummy Long Tube
- Plugged Tube
- Tie Rod
- Seal Rod
- Impingement Rod

Corn Oil Jet Mode - EOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

1	**Exchanger Data**		
2	Unit identifier	Shell 1	
3	Service type	Once through reboiler	
4	TEMA type	AEU	
5	Run mode	Rating	
6	Hot fluid location	Tubeside	
7	Unit orientation	Horizontal	
8	Number of shells in series	1	
9	Number of shells in parallel	1	
10	Flow in 1st tubepass	Countercurrent	
11	Train flow direction	Countercurrent	
12			
13	**Construction Data**		
14	Shell material	SA-516 70 Pl. K02700	
15	Tube material	SA-179 Tube (S) K01200	
16	Shell cover material	SA-516 70 Pl. K02700	
17	Channel or bonnet material	SA-516 70 Pl. K02700	
18	Channel cover material	SA-516 70 Pl. K02700	
19	Tubesheet-Stationary material	SA-105 Forgings K03504	
20	Baffle-Cross material	Carbon steel	
21	Shellside gasket	Mach. Mtl. (Kammprofile\Flex. Face)	
22	Tubeside gasket	Mach. Mtl. (Kammprofile\Flex. Face)	
23	Shellside design pressure	250.00	psig
24	Tubeside design pressure	325.00	psig
25	Shellside vacuum pressure	Full	
26	Tubeside vacuum pressure	Full	
27	Shellside design temperature	550.00	F
28	Tubeside design temperature	700.00	F
29	Shellside corrosion allowance	0.1250	inch
30	Tubeside corrosion allowance	0.1250	inch
31	Tubesheet design temperature	700.00	F
32	Shellside radiography	Full	
33	Tubeside radiography	Full	
34	TEMA class	R	
35	Small exchanger	No	
36	Shell outside diameter	37.732	inch
37	Shell inside diameter	36.000	inch
38	Shell wall thickness	0.8660	inch
39	Front head outside diameter	37.260	inch
40	Front head inside diameter	36.000	inch
41	Front head thickness	0.6300	inch
42	Rear head outside diameter	37.732	inch
43	Rear head inside diameter	36.000	inch
44	Rear head thickness	0.8660	inch
45	Total tubesheet thickness	4.9210	inch
46	Double tubesheet	No	
47	Shell expansion joint	No	
48	Suppress mechanical calculations	No	
49			
50			

Corn Oil Jet Mode - EOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Reboiler Data			
Reboiler type		Once through reboiler	
Tube Data			
Tube type		Plain	
Tube outside diameter		0.7500	inch
Tube wall thickness		0.0913	inch
Tube pitch		1.0000	inch
Tube pitch ratio		1.3333	
Tubepasses per shell		12	
Tube pattern		90	degrees
Tube count method		Rigorous	
Tube length		78.000	in
Tube material		SA-179 Tube (S) K01200	
Baffle Data			
Baffle type		Single segmental	
Baffle orientation		Parallel	
Baffle cut percent		26.040	% shell ID
Adjust baffle cut		Between rows	
Number of crosspasses		5	
Central baffle spacing		13.386	inch
Outlet baffle spacing		29.720	inch
Variable baffle spacing		No	
Baffle thickness		0.3940	inch
Window cut from baffles		No	
Use deresonating baffles		No	
Supports Data			
Full support at U-Bend		None	
Number of U-bend supports		1	
Include inlet vibration support		No	
Include outlet vibration support		Yes	
Distance from tubesheet to outlet vibration support		19.055	inch

Corn Oil Jet Mode - EOR : Shell 1
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Nozzle Data

Shellside

Nozzle standard		01-ANSI_B36_10.TABLE		
Shell entrance type		No impingement device		
Shell exit type		Remove tubes if TEMA requires		
	Inlet	**Outlet**	**Liq. Outlet**	
Nozzle outside diameter	8.6250	12.750	--	inch
Nozzle schedule	Sch 100	Sch 100	--	
Nozzle inside diameter	7.4370	11.492	--	inch
Number at this position	1	1	--	

Tubeside

Nozzle standard		01-ANSI_B36_10.TABLE		
	Inlet	**Outlet**	**Liq. Outlet**	
Nozzle outside diameter	4.5000	4.5000	--	inch
Nozzle schedule	Sch 120	Sch 120	--	
Nozzle inside diameter	3.6240	3.6240	--	inch
Number at this position	1	1	--	

Nozzle Location Data

Radial position on shell inlet nozzle	Program decides
Longitudinal position on shell of inlet nozzle	At rear head
Radial position on shell outlet nozzle	Program decides
Location of nozzle at U-bend	After U-bend
Tubeside entry type	Radial
Tubeside inlet position	Front head
Tubeside exit type	Same as inlet

Tube Layout Data

Tubepass layout			Quadrant	
First tubepass location			Top left	
Pass partition construction			Program set	
Force symmetric layout			No	
Force continuous cleaning lanes			No	
Force uniform layout			No	
Align across primary passlanes			No	
Fill knock out area with dummy tubes			Program set	
Fill bundle periphery with dummy tubes			Program set	
Fill passlanes with dummy tubes			Program Set	
Square layout tube alignment			Program set	
Use crossed U-bends			No	
Minimum U-bend diameter			2.2500	inch
Use tube layout drawing as input			Yes	
	Inlet	**Outlet**	**Liq. Outlet**	
Tube rows removed under nozzle	3	3	0	

Corn Oil Jet Mode - EOR : Shell 1
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Clearance Data		
Number of seal strip pairs	4	
Block A stream	No	
Block E stream	No	
Block F stream	No	
Parallel/vertical passlane width	0.7460	inch
Perpendicular/horizontal passlane width	1.5000	inch
Number of passlane seal rods	20	
Passlane seal rod diameter	0.3150	inch
Tubes to remove for tie rods	Calculated	
Number of tie rods	8	
Tie rod outside diameter	0.5000	inch
Baffle to shell clearance	0.1875	inch
Baffle clearance type	TEMA	

Process Conditions Data	**Hot Fluid**	**Cold Fluid**	
Phase condition	Sensible liquid	Two phase	
Flow rate	56742	93037	lb/hr
Inlet vapor fraction	0.0000	--	
Outlet vapor fraction	0.0000	0.3300	
Inlet temperature	598.00	439.13	F
Outlet temperature	478.00	469.95	F
Inlet pressure	120.00	25.770	psig
Allowable pressure drop	10.000	2.000	psi
Exchanger duty		5.1010	MM Btu/hr
Duty multiplier		1.0000	

Process Fouling Data	**Hot Fluid**	**Cold Fluid**	
Fouling resistance	0.0020	0.0020	ft2-hr-F/Btu

Hot Fluid Property Data	
Fluid name	Diesel Product
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, 120.00 psig

Temp. F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm
598.00	33.170	0.1390	0.0500	0.7850	6.1000
478.00	37.220	0.2220	0.0550	0.7140	10.200

Corn Oil Jet Mode - EOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Cold Fluid Property Data

Fluid name	Jet Side-Cut Reboiler Feed
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, 29.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
439.13	-709.6	0.0000	--	--	--	--	35.504	0.1685
453.67	-699.1	0.0000	0.7189	0.0084	0.0154	0.6176	34.973	0.1591
456.08	-694.7	0.0270	0.7218	0.0084	0.0154	0.6188	34.939	0.1586
458.45	-690.2	0.0543	0.7245	0.0084	0.0155	0.6201	34.905	0.1581
460.79	-685.8	0.0820	0.7271	0.0084	0.0155	0.6213	34.873	0.1576
463.12	-681.3	0.1100	0.7297	0.0084	0.0155	0.6225	34.841	0.1572
465.42	-676.9	0.1383	0.7322	0.0084	0.0156	0.6236	34.809	0.1568
467.72	-672.4	0.1668	0.7347	0.0084	0.0156	0.6248	34.778	0.1563
470.00	-668.0	0.1955	0.7371	0.0084	0.0156	0.6260	34.747	0.1559
530.73	-551.2	1.0000	0.8017	0.0085	0.0166	0.6568	33.874	0.1460
536.13	-547.6	1.0000	0.7953	0.0086	0.0167	0.6592	--	--

Pressure Set, 29.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
439.13	0.0539	0.7146	8.0373	267.23	699.29
453.67	0.0533	0.7251	7.4869	267.23	699.29
456.08	0.0533	0.7262	7.4534	266.11	701.30
458.45	0.0532	0.7273	7.4211	264.99	703.29
460.79	0.0532	0.7284	7.3898	263.88	705.28
463.12	0.0531	0.7295	7.3593	262.77	707.27
465.42	0.0531	0.7305	7.3294	261.68	709.26
467.72	0.0530	0.7316	7.3001	260.58	711.25
470.00	0.0530	0.7326	7.2712	259.49	713.24
530.73	0.0516	0.7601	6.5385	231.11	766.14
536.13	--	--	--	--	--

Pressure Set, 27.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
439.13	-709.6	0.0000	--	--	--	--	35.502	0.1685
449.00	-702.5	0.0000	0.6856	0.0084	0.0153	0.6147	35.144	0.1620

Corn Oil Jet Mode - EOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Cold Fluid Physical Property Data

Pressure Set, 27.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
452.11	-696.7	0.0346	0.6891	0.0084	0.0153	0.6164	35.099	0.1614
455.16	-691.0	0.0698	0.6924	0.0084	0.0154	0.6179	35.057	0.1607
458.17	-685.3	0.1056	0.6956	0.0084	0.0154	0.6195	35.016	0.1601
461.15	-679.5	0.1418	0.6987	0.0084	0.0154	0.6210	34.975	0.1596
464.11	-673.8	0.1784	0.7018	0.0084	0.0155	0.6225	34.936	0.1590
467.06	-668.1	0.2153	0.7047	0.0084	0.0155	0.6240	34.896	0.1585
470.00	-662.3	0.2525	0.7077	0.0084	0.0156	0.6255	34.857	0.1580
526.74	-553.5	1.0000	0.7650	0.0085	0.0164	0.6543	34.041	0.1486
532.14	-550.0	1.0000	0.7589	0.0085	0.0166	0.6568	--	--

Pressure Set, 27.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
439.13	0.0539	0.7146	8.0373	267.23	699.29
449.00	0.0535	0.7217	7.6627	267.23	699.29
452.11	0.0534	0.7232	7.6190	265.77	701.89
455.16	0.0534	0.7246	7.5773	264.33	704.47
458.17	0.0533	0.7260	7.5371	262.90	707.05
461.15	0.0533	0.7274	7.4981	261.47	709.63
464.11	0.0532	0.7287	7.4599	260.05	712.20
467.06	0.0531	0.7300	7.4224	258.64	714.78
470.00	0.0531	0.7313	7.3854	257.23	717.36
526.74	0.0518	0.7571	6.6950	230.69	766.91
532.14	--	--	--	--	--

Pressure Set, 25.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
439.13	-709.6	0.0000	--	--	--	--	35.501	0.1685
444.16	-706.0	0.0000	0.6525	0.0083	0.0151	0.6118	35.320	0.1651
448.00	-698.9	0.0424	0.6566	0.0083	0.0152	0.6138	35.265	0.1643
451.75	-691.8	0.0858	0.6604	0.0083	0.0152	0.6157	35.213	0.1635
455.45	-684.8	0.1299	0.6641	0.0083	0.0153	0.6177	35.163	0.1628
459.11	-677.7	0.1746	0.6677	0.0083	0.0154	0.6195	35.114	0.1621
462.75	-670.6	0.2197	0.6712	0.0083	0.0154	0.6214	35.066	0.1615
466.38	-663.6	0.2654	0.6746	0.0083	0.0155	0.6233	35.018	0.1608
470.00	-656.5	0.3114	0.6780	0.0083	0.0155	0.6251	34.970	0.1602
522.59	-556.0	1.0000	0.7284	0.0084	0.0163	0.6519	34.212	0.1514
527.99	-552.5	1.0000	0.7227	0.0085	0.0165	0.6543	--	--

Corn Oil Jet Mode - EOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Cold Fluid Physical Property Data

Pressure Set, 25.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
439.13	0.0539	0.7147	8.0373	267.23	699.29
444.16	0.0537	0.7183	7.8459	267.23	699.29
448.00	0.0536	0.7201	7.7914	265.43	702.50
451.75	0.0535	0.7218	7.7399	263.64	705.70
455.45	0.0535	0.7235	7.6905	261.88	708.89
459.11	0.0534	0.7252	7.6426	260.12	712.08
462.75	0.0533	0.7268	7.5957	258.37	715.28
466.38	0.0532	0.7285	7.5497	256.62	718.48
470.00	0.0532	0.7301	7.5041	254.88	721.68
522.59	0.0520	0.7540	6.8580	230.26	767.72
527.99	--	--	--	--	--

Pressure Set, 23.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
433.73	-713.4	0.0000	--	--	--	--	35.694	0.1721
439.13	-709.6	0.0000	0.6195	0.0082	0.0150	0.6088	35.501	0.1685
443.73	-701.1	0.0504	0.6241	0.0082	0.0151	0.6112	35.436	0.1674
448.21	-692.7	0.1021	0.6285	0.0082	0.0151	0.6135	35.375	0.1665
452.61	-684.2	0.1548	0.6326	0.0082	0.0152	0.6158	35.316	0.1657
456.98	-675.8	0.2083	0.6365	0.0082	0.0152	0.6180	35.258	0.1649
461.32	-667.3	0.2624	0.6405	0.0083	0.0153	0.6202	35.201	0.1641
465.66	-658.9	0.3170	0.6443	0.0083	0.0154	0.6225	35.144	0.1633
470.00	-650.4	0.3722	0.6481	0.0083	0.0154	0.6247	35.087	0.1626
518.28	-558.6	1.0000	0.6920	0.0084	0.0162	0.6493	34.389	0.1544
523.68	-555.1	1.0000	0.6866	0.0084	0.0163	0.6518	--	--

Pressure Set, 23.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
433.73	0.0541	0.7109	8.2435	267.23	699.29
439.13	0.0539	0.7148	8.0371	267.23	699.29
443.73	0.0538	0.7169	7.9712	265.07	703.15
448.21	0.0537	0.7190	7.9095	262.93	706.98
452.61	0.0536	0.7210	7.8505	260.81	710.82
456.98	0.0535	0.7230	7.7934	258.70	714.65
461.32	0.0534	0.7249	7.7374	256.61	718.49
465.66	0.0533	0.7269	7.6823	254.51	722.35
470.00	0.0533	0.7288	7.6277	252.42	726.21

Corn Oil Jet Mode - EOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Cold Fluid Physical Property Data

Pressure Set, 23.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
518.28	0.0522	0.7509	7.0281	229.82	768.55
523.68	--	--	--	--	--

Control Name Data

Case name	Corn Oil Jet Mode - EOR
Item Number	18-X-353
Revision	03
Service	Jet Side-Cut Stripper Reboiler

Control Methods Data

Shellside friction factor method	Commercial	
Tubeside friction factor method	Commercial	
Pure longitudinal flow	No	
Pure component condensation	No	
Condensing correlation	HTRI Proration	
Mole fraction inerts	0.0000	
Momentum exclusion	0.0000	%
Perform shellside subcooling calculations	No	
Pure component boiling	No	
Check film boiling	Yes	
Nucleate boiling method	Physical property/theoretical boiling range	
Component boiling method	Nucleate and convective	
Increments per baffle	Calculated	

Control User-Defined Methods Data

Add non-nucleate boiling	Yes

Runtime Messages

Released to the following HTRI Member Company:
WCE
RLZ

Xist 8.2 2022/9/28 18:18 SN: 01096-111007767 **US_AP Units**

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Unit ID 100 - WARNING MESSAGES (CALCULATIONS CONTINUE)

The design has parallel-cut baffles and the reported height under the nozzle lowers the bundle below the baffle cut. Unrestricted longitudinal flow can bypass the bundle. This bypass region can be reduced by decreasing the height under the nozzle, changing the baffle cut, or adding sealing arrangements.

Stratified flow: 2 baffle spaces are predicted to be under phase separation. Phase separation can lead to poorer than predicted performance because correlations assume a well-mixed flow. Phase separation can also lead to partial tube dryout, which can cause tube damage.

The physical properties of the hot fluid have been extrapolated beyond the valid temperature range. Check the calculated values. The thermal analysis requires properties at bulk and skin/wall temperatures.

The longest unsupported span of the bundle is in the U-bend region and thus prone to excessive vibration, even with a full support plate. The longest unsupported span should be in the straight portion of the U-tube.

ASME Section VIII Div. 1 Code was used to ESTIMATE all pressure vessel dimensions and weights. The dimensions in this report cannot be used to fabricate the vessel.

HEAT EXCHANGER SPECIFICATION SHEET

Released to the following HTRI Member Company:
WCE
RLZ

US_AP Units

Customer			Job No.	
Address			Reference No.	
Plant Location			Proposal No.	
Service of Unit	Jet Side-Cut Stripper Reboiler		Date	2022/9/28 Rev 03
Size	36 x 78 inch Type AEU Horizontal		Item No.	18-X-353
Surf/Unit (Gross/Eff)	1110.4 / 1049.5 ft2 Shell/Unit 1		Surf/Shell (Gross/Eff)	1110.4 / 1049.5 ft2

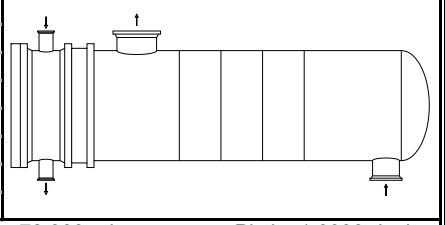
PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		Jet Side-Cut Reboiler Feed		Diesel Product	
Fluid Quantity, Total	lb/hr	46514		27041	
Vapor (In/Out)			15350		
Liquid		46514	31164	27041	27041
Steam					
Water					
Noncondensables					
Temperature (In/Out)	F	437.05	470.19	591.00	465.15
Specific Gravity		0.5701	0.5608	0.5410	0.6101
Viscosity	cP	0.1699	0.0083 V/L 0.1608	0.1490	0.2541
Molecular Weight					
Molecular Weight, Noncondensables					
Specific Heat	Btu/lb-F	0.7132	0.6251 V/L 0.7299	0.7710	0.6990
Thermal Conductivity	Btu/hr-ft-F	0.0540	0.0155 V/L 0.0532	0.0510	0.0540
Latent Heat	Btu/lb	101.73	98.629		
Inlet Pressure	psig	25.420		120.00	
Velocity	ft/sec	2.80		1.72	
Pressure Drop, Allow/Calc	psi	2.000	0.440	10.000	1.132
Fouling Resistance (min)	ft2-hr-F/Btu	0.00200		0.00200	

Heat Exchanged 2.5638 MM Btu/hr MTD (Corrected) 46.0 F
Transfer Rate, Service 51.74 Btu/ft2-hr-F Clean 73.04 Btu/ft2-hr-F Actual 54.54 Btu/ft2-hr-F

CONSTRUCTION OF ONE SHELL

Sketch (Bundle/Nozzle Orientation)



			Shell Side	Tube Side
Design/Test Pressure		psig	250.00 /	325.00 /
Design Temperature		F	550.00	700.00
No Passes per Shell			1	12
Corrosion Allowance		inch	0.1250	0.1250
Connections Size & Rating	In	inch	1 @ 7.4370	1 @ 3.6240
	Out	inch	1 @ 11.492	1 @ 3.6240
	Intermediate		@	@

Tube No. 378U OD 0.7500 inch Thk(Avg) 0.0913 inch Length 78.000 in Pitch 1.0000 inch
Tube Type Plain Material SA-179 Tube (S) K01200 Tube pattern 90
Shell SA-516 70 Pl. K02700 ID 36.000 OD 37.732 inch Shell Cover SA-516 70 Pl. K02700 (Integ.)
Channel or Bonnet SA-516 70 Pl. K02700 Channel Cover SA-516 70 Pl. K02700
Tubesheet-Stationary SA-105 Forgings K03504 Tubesheet-Floating
Floating Head Cover Impingement Plate None
Baffles-Cross Carbon steel Type Single-Seg. %Cut (Diam) 26.04 Spacing(c/c) 13.386 Inlet 31.185 inch
Baffles-Long Seal Type None
Supports-Tube U-Bend Type None
Bypass Seal Arrangement 4 pairs seal strips Tube-Tubesheet Joint Strength welded
Expansion Joint Type None
Rho-V2-Inlet Nozzle 51.57 lb/ft-sec2 Bundle Entrance 2.79 Bundle Exit 55.86 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 12895 lb Filled with Water 17832 lb Bundle 6221.2 lb

Remarks:

Final Results

Released to the following HTRI Member Company:
WCE
RLZ

Xist 8.2 2022/9/28 18:18 SN: 01096-111007767 **US_AP Units**

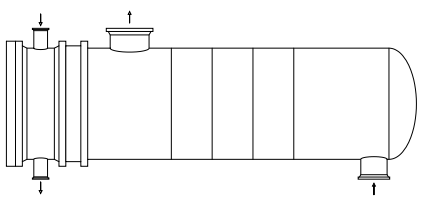
Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Process Data		Cold Shellside		Hot Tubeside	
Fluid name		Jet Side-Cut Reboiler Feed		Diesel Product	
Fluid condition		Boil. Liquid		Sens. Liquid	
Total flow rate	(lb/hr)	46514		27041	
Weight fraction vapor, In/Out	(--)	0.0000	0.3300	0.0000	0.0000
Temperature, In/Out	(Deg F)	437.05	470.19	591.00	465.15
Skin temperature, Min/Max	(Deg F)	452.21	504.90	457.91	539.68
Wall temperature, Min/Max	(Deg F)	454.50	518.86	454.89	521.23
Pressure, In/Average	(psig)	25.420	25.200	120.00	119.43
Pressure drop, Total/Allowed	(psi)	0.440	2.000	1.132	10.000
Velocity, Mid/Max allow	(ft/sec)	2.80		1.72	
Boiling range	(Deg F)		78.5		
Average film coef.	(Btu/ft2-hr-F)		178.04		170.88
Heat transfer safety factor	(--)		1.0000		1.0000
Fouling resistance	(ft2-hr-F/Btu)		0.00200		0.00200

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(Btu/ft2-hr-F)	51.74 /	73.04 /	54.54	
Heat duty, Calculated/Specified	(MM Btu/hr)	2.5638 /	2.5008		
Effective overall temperature difference	(Deg F)	46.0			
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg F)	47.2 *	0.9763 *	1.0000	

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside (ft3)	56.528
Approximate tubeside (ft3)	22.596

Shell Construction Information

TEMA shell type	AEU		Shell ID	(inch)	36.000
Shells Series	1 Parallel	1	Total area	(ft2)	1110.4
Passes Shell	1 Tube	12	Eff. area	(ft2/shell)	1049.5
Shell orientation angle (deg)	0.00				
Impingement present	No				
Pairs seal strips	4		Passlane seal rods (inch)	0.3150	No. 20
Shell expansion joint	No		Full support at U-Bend	No	
Weight estimation Wet/Dry/Bundle		17832 /	12895 /	6221.2	(lb/shell)

Baffle Information

Type	Parallel	Single-Seg.	Baffle cut (% dia)	26.04	
Crosspasses/shellpass		5	No.	(Pct Area)	(inch) to C.L
Central spacing	(inch)	13.386	1	20.28	8.6250
Inlet spacing	(inch)	31.185	2	0.00	0.0000
Outlet spacing	(inch)	29.720			
Baffle thickness	(inch)	0.3940			
Use deresonating baffles		No			

Tube Information

Tube type		Plain	Tubecount per shell		756
Length to tangent	(in)	78.000	Pct tubes removed (both)		10.98
Effective length	(in)	84.844	Outside diameter	(inch)	0.7500
Total tubesheet	(inch)	4.9210	Wall thickness	(inch)	0.0913
Area ratio	(out/in)	1.3218	Pitch (inch) 1.0000	Ratio	1.3333
Tube metal	SA-179 Tube (S) K01200		Tube pattern (deg)		90

Shellside Performance

Nom vel, X-flow/window 3.45 / 3.17

Flow fractions for vapor phase
A=0.1997 B=0.4193 C=0.0258 E=0.1104 F=0.2449

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.981	0.920	1.066	0.857	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
32.78	18.24	39.46	Inlet	1.26	3.41
MOMENTUM		5.26	Outlet	2.99	1.93

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F
PP/TBR	Flow	Flow	Flow	

H. T. Parameters		Shell	Tube
Overall wall correction			1.000
Midpoint	Prandtl no.		7.26
Midpoint	Reynolds no.	7594	20035
Bundle inlet	Reynolds no.	3607	33074
Bundle outlet	Reynolds no.	5244	19748
Fouling layer	(inch)		

Thermal Resistance, %

Shell	Tube	Fouling	Metal	Over Des
30.63	42.19	25.33	1.85	5.40

Total fouling resistance (ft2-hr-F/Btu) 0.0046
Differential resistance (ft2-hr-F/Btu) 9.91e-4

Shell Nozzles		Inlet	Outlet	Liquid Outlet
Inlet at channel end-No				
Number at each position		1	1	0
Diameter	(inch)	7.4370	11.492	
Velocity	(ft/sec)	1.20	9.17	
Pressure drop	(psi)	5.57e-3	0.013	
Height under nozzle	(inch)	36.000	3.8850	
Nozzle R-V-SQ	(lb/ft-sec2)	51.57	164.53	
Shell ent.	(lb/ft-sec2)	0.13	79.53	

Tube Nozzle		Inlet RADIAL	Outlet RADIAL	Liquid Outlet
Diameter	(inch)	3.6240	3.6240	
Velocity	(ft/sec)	3.11	2.75	
Pressure drop	(psi)	0.039	0.022	
Nozzle R-V-SQ	(lb/ft-sec2)	325.71	288.82	

Annular Distributor		Inlet	Outlet
Length	(inch)		
Height	(inch)		
Slot area	(in2)		

Diametral Clearances (inch)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
0.1875	0.5618	0.0313

Xist 8.2 2022/9/28 18:18 SN: 01096-111007767 **US_AP Units**

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Externally Enhanced Tube Geometry			**Internally Enhanced Tube Geometry**		
Type		Plain	Type		None
Fin density	(fin/inch)		Thickness	(inch)	
Fin height	(inch)		Pitch	(L/D)	
Fin thickness	(inch)				
Root diameter	(inch)				
Area/length	(ft2/ft)				

Mean Metal Temperatures

Mean shell temperature	454.91	(F)
Tubesheet temperature	700.00	(F)

Mean tube metal temperature in each tubepass, (F)

Tube Pass	Inside	Outside	Radial
1	506.35	503.85	504.99
2	499.39	497.44	498.33
3	488.89	487.39	488.07
4	481.75	480.51	481.07
5	475.88	474.97	475.38
6	472.57	471.86	472.18
7	468.76	468.20	468.45
8	465.77	465.31	465.52
9	463.89	463.51	463.68
10	462.27	461.97	462.11
11	460.91	460.65	460.77
12	459.64	459.43	459.53

Vibration Analysis

Released to the following HTRI Member Company:
WCE
RLZ

Xist 8.2 2022/9/28 18:18 SN: 01096-111007767 **US_AP Units**

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

1	Shellside condition		Boil. Liquid	(Level 2.3000)	
2	Axial stress loading	(1000-psi)	0.000	Added mass factor	1.394
3	Beta		2.717		

	Position In The Bundle		U-Bend	Center	Outlet
5	Length for natural frequency	(in)	43.831	26.772	43.106
6	Length/TEMA maximum span	(--)	0.566	0.446	0.718
7	Number of spans	(--)	2	3	3
8	Tube natural frequency	(Hz)	30.3	118.7	64.5 +
9	Shell acoustic frequency	(Hz)			
10	**Flow Velocities**		**U-Bend**	**Center**	**Outlet**
11	Window parallel velocity	(ft/sec)	0.30	2.34	5.49
12	Bundle crossflow velocity	(ft/sec)	0.14	2.52	2.59
13	Bundle/shell velocity	(ft/sec)	0.18	1.43	1.47
14	**Fluidelastic Instability Check**		**U-Bend**	**Center**	**Outlet**
15	Log decrement	HTRI	0.053	0.051	0.032
16	Critical velocity	(ft/sec)	6.26	40.49	18.83
17	Baffle tip cross velocity ratio	(--)	0.0217	0.0622	0.1374
18	Average crossflow velocity ratio	(--)	0.0217	0.0622	0.1374
19	**Acoustic Vibration Check**		**U-Bend**	**Center**	**Outlet**
20	Vortex shedding ratio	(--)			
21	Chen number	(--)			
22	Turbulent buffeting ratio	(--)			
23	**Tube Vibration Check**		**U-Bend**	**Center**	**Outlet**
24	Vortex shedding ratio	(--)	0.025	0.221	0.227
25	Parallel flow amplitude	(inch)	0.0000	0.0000	0.0000
26	Crossflow amplitude	(inch)	0.0000	0.0001	0.0002
27	Tube gap	(inch)	0.2500	0.2500	0.2500
28	Crossflow amplitude/tube gap	(--)	3.64e-5	2.38e-4	7.18e-4
29	Crossflow RHO-V-SQ	(lb/ft-sec2)	0.65	29.17	13.09

	Bundle Entrance/Exit			
31	**(analysis at first tube row)**		**Entrance**	**Exit**
32	Fluidelastic instability ratio	(--)	0.000	0.088
33	Vortex shedding ratio	(--)	0.052	0.469
34	Crossflow amplitude	(inch)	0.00004	0.00009
35	Crossflow velocity	(ft/sec)	0.28	5.34
36	Tubesheet to inlet/outlet support	(inch)	None	19.055
37	**Shell Entrance/Exit Parameters**		**Entrance**	**Exit**
38	Impingement device		None	--
39	Flow area	(ft2)	7.069	1.036
40	Velocity	(ft/sec)	5.14e-2	6.38
41	Critical velocity	(ft/sec)	2.94	60.50
42	RHO-V-SQ	(lb/ft-sec2)	0.13	79.53

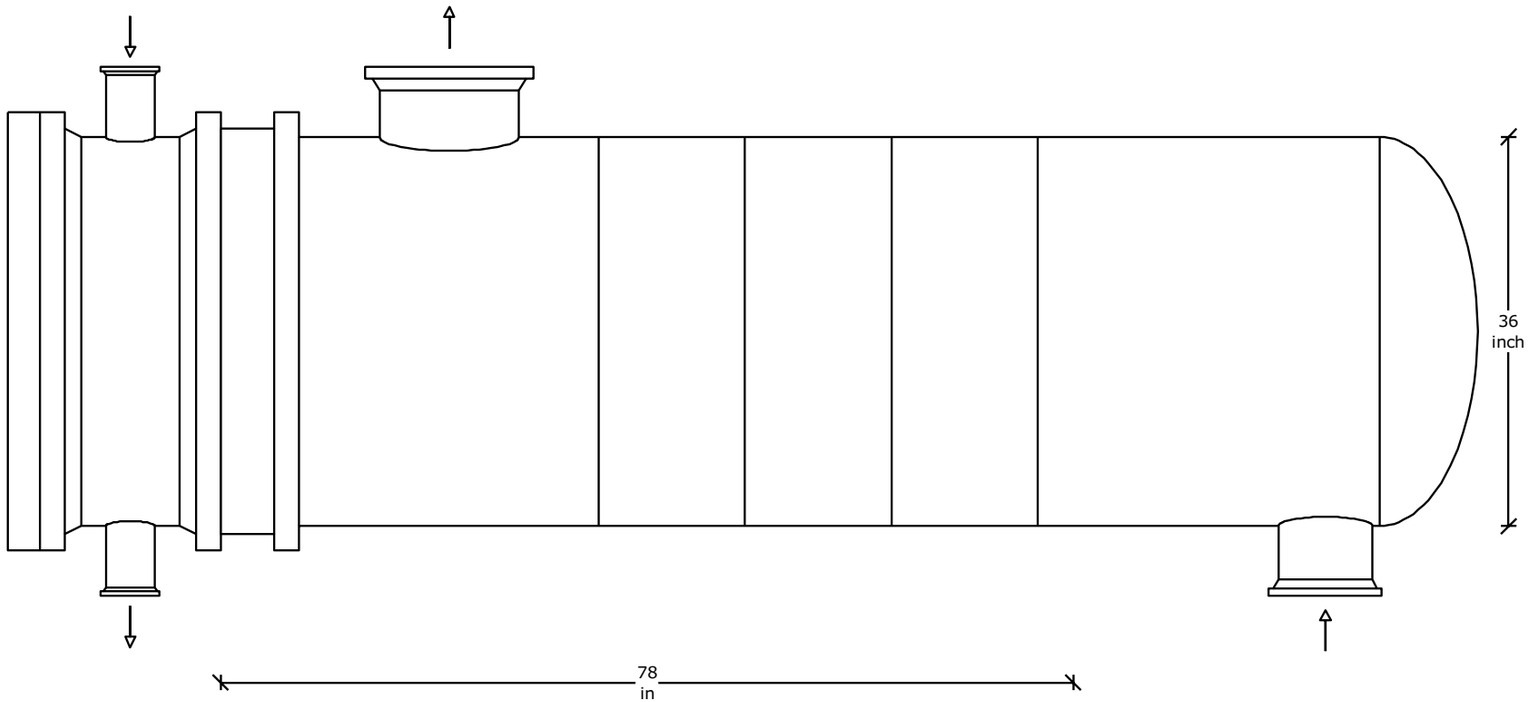
43	Shell type	AEU	Baffle type	Single-Seg.
44	Tube type	Plain	Baffle layout	Parallel
45	Pitch ratio	1.3333	Tube diameter, (inch)	0.7500
46	Layout angle	90	Tube material	SA-179 Tube (S) K01200
47	Number U-Bend supports	1	Elastic modulus, (1000-psi)	26754
48	Use deresonating baffles	No	Supports/baffle space	

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.

Xist 8.2 2022/9/28 18:18 SN: 01096-111007767 **US_AP Units**

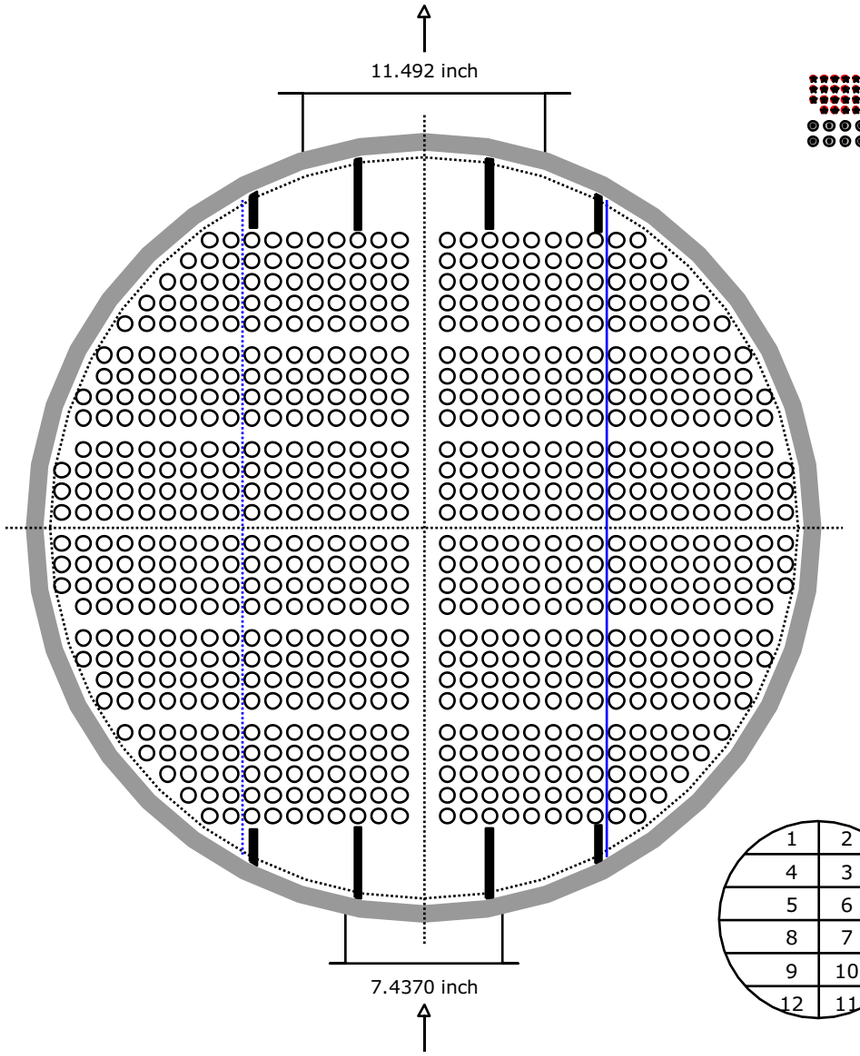
Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles



Unit	Shell 1		Total tube inlet nozzles	1	Stream ID	Shellside		Tubeside	
Item number	18-X-353		Total tube outlet nozzles	1	Stream name	Jet Side-Cut Reboiler Feed		Diesel Product	
TEMA type	AEU		Total shell inlet nozzles	1	Flow, lb/hr	46514		27041	
Shell diameter	36	inch	Total shell outlet nozzles	1	Pressure drop, psi	0.440		1.132	
Tube length	78	in			Temperature, F	437.05	470.19	591.00	465.15
Dry weight	12895	lb/shell			Wt. fraction vapor	0.0000	0.3300	0.0000	0.0000
Wet weight	17832	lb/shell			Pressure, psig	25.420	24.980	120.00	118.87
Bundle weight	6221	lb/shell							

Tallow Diesel Mode - SOR : Shell 1

Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles



Unit	Shell 1
Item number	18-X-353
TEMA type	AEU
Shell ID	36.000 inch
Actual OTL	35.438 inch
Height under inlet nozzle	36.000 inch
Height under outlet nozzle	3.8850 inch
Tube type	Plain
Tube OD	0.7500 inch
Tube pitch	1.0000 inch
Tube layout angle	90 deg
Tubes	756
Tube positions available	756
Tie rods	8
Seal strip pairs	4
Passlane seal rods	20
Tube Passes	12
Parallel passlane width	0.7460 inch
Perpendicular passlane width	1.5000 inch
Baffle cut % diameter	26.04

TUBEPASS DETAILS

Pass	Rows	Tubes	Pass	Rows	Tubes
1	5	60	7	4	67
2	5	60	8	4	67
3	4	62	9	4	62
4	4	62	10	4	62
5	4	67	11	5	60
6	4	67	12	5	60

SYMBOL LEGEND

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

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

1	**Exchanger Data**		
2	Unit identifier	Shell 1	
3	Service type	Once through reboiler	
4	TEMA type	AEU	
5	Run mode	Rating	
6	Hot fluid location	Tubeside	
7	Unit orientation	Horizontal	
8	Number of shells in series	1	
9	Number of shells in parallel	1	
10	Flow in 1st tubepass	Countercurrent	
11	Train flow direction	Countercurrent	
12			
13	**Construction Data**		
14	Shell material	SA-516 70 Pl. K02700	
15	Tube material	SA-179 Tube (S) K01200	
16	Shell cover material	SA-516 70 Pl. K02700	
17	Channel or bonnet material	SA-516 70 Pl. K02700	
18	Channel cover material	SA-516 70 Pl. K02700	
19	Tubesheet-Stationary material	SA-105 Forgings K03504	
20	Baffle-Cross material	Carbon steel	
21	Shellside gasket	Mach. Mtl. (Kammprofile\Flex. Face)	
22	Tubeside gasket	Mach. Mtl. (Kammprofile\Flex. Face)	
23	Shellside design pressure	250.00	psig
24	Tubeside design pressure	325.00	psig
25	Shellside vacuum pressure	Full	
26	Tubeside vacuum pressure	Full	
27	Shellside design temperature	550.00	F
28	Tubeside design temperature	700.00	F
29	Shellside corrosion allowance	0.1250	inch
30	Tubeside corrosion allowance	0.1250	inch
31	Tubesheet design temperature	700.00	F
32	Shellside radiography	Full	
33	Tubeside radiography	Full	
34	TEMA class	R	
35	Small exchanger	No	
36	Shell outside diameter	37.732	inch
37	Shell inside diameter	36.000	inch
38	Shell wall thickness	0.8660	inch
39	Front head outside diameter	37.260	inch
40	Front head inside diameter	36.000	inch
41	Front head thickness	0.6300	inch
42	Rear head outside diameter	36.875	inch
43	Rear head inside diameter	36.000	inch
44	Rear head thickness	0.5510	inch
45	Total tubesheet thickness	4.9210	inch
46	Double tubesheet	No	
47	Shell expansion joint	No	
48	Suppress mechanical calculations	No	
49			
50			

Xist 8.2 2022/9/28 18:18 SN: 01096-111007767 **US_AP Units**

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Reboiler Data			
Reboiler type		Once through reboiler	
Tube Data			
Tube type		Plain	
Tube outside diameter		0.7500	inch
Tube wall thickness		0.0913	inch
Tube pitch		1.0000	inch
Tube pitch ratio		1.3333	
Tubepasses per shell		12	
Tube pattern		90	degrees
Tube count method		Rigorous	
Tube length		78.000	in
Tube material		SA-179 Tube (S) K01200	
Baffle Data			
Baffle type		Single segmental	
Baffle orientation		Parallel	
Baffle cut percent		26.040	% shell ID
Adjust baffle cut		Between rows	
Number of crosspasses		5	
Central baffle spacing		13.386	inch
Outlet baffle spacing		29.720	inch
Variable baffle spacing		No	
Baffle thickness		0.3940	inch
Window cut from baffles		No	
Use deresonating baffles		No	
Supports Data			
Full support at U-Bend		None	
Number of U-bend supports		1	
Include inlet vibration support		No	
Include outlet vibration support		Yes	
Distance from tubesheet to outlet vibration support		19.055	inch

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Nozzle Data

Shellside

Nozzle standard		01-ANSI_B36_10.TABLE		
Shell entrance type		No impingement device		
Shell exit type		Remove tubes if TEMA requires		
	Inlet	**Outlet**	**Liq. Outlet**	
Nozzle outside diameter	8.6250	12.750	--	inch
Nozzle schedule	Sch 100	Sch 100	--	
Nozzle inside diameter	7.4370	11.492	--	inch
Number at this position	1	1	--	

Tubeside

Nozzle standard		01-ANSI_B36_10.TABLE		
	Inlet	**Outlet**	**Liq. Outlet**	
Nozzle outside diameter	4.5000	4.5000	--	inch
Nozzle schedule	Sch 120	Sch 120	--	
Nozzle inside diameter	3.6240	3.6240	--	inch
Number at this position	1	1	--	

Nozzle Location Data

Radial position on shell inlet nozzle	Program decides
Longitudinal position on shell of inlet nozzle	At rear head
Radial position on shell outlet nozzle	Program decides
Location of nozzle at U-bend	After U-bend
Tubeside entry type	Radial
Tubeside inlet position	Front head
Tubeside exit type	Same as inlet

Tube Layout Data

Tubepass layout			Quadrant	
First tubepass location			Top left	
Pass partition construction			Program set	
Force symmetric layout			No	
Force continuous cleaning lanes			No	
Force uniform layout			No	
Align across primary passlanes			No	
Fill knock out area with dummy tubes			Program set	
Fill bundle periphery with dummy tubes			Program set	
Fill passlanes with dummy tubes			Program Set	
Square layout tube alignment			Program set	
Use crossed U-bends			No	
Minimum U-bend diameter			2.2500	inch
Use tube layout drawing as input			Yes	
	Inlet	**Outlet**	**Liq. Outlet**	
Tube rows removed under nozzle	3	3	0	

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Clearance Data

Number of seal strip pairs	4	
Block A stream	No	
Block E stream	No	
Block F stream	No	
Parallel/vertical passlane width	0.7460	inch
Perpendicular/horizontal passlane width	1.5000	inch
Number of passlane seal rods	20	
Passlane seal rod diameter	0.3150	inch
Tubes to remove for tie rods	Calculated	
Number of tie rods	8	
Tie rod outside diameter	0.5000	inch
Baffle to shell clearance	0.1875	inch
Baffle clearance type	TEMA	

Process Conditions Data	**Hot Fluid**	**Cold Fluid**	
Phase condition	Sensible liquid	Two phase	
Flow rate	27041	46514	lb/hr
Inlet vapor fraction	0.0000	--	
Outlet vapor fraction	0.0000	0.3300	
Inlet temperature	591.00	437.05	F
Outlet temperature	465.15	--	F
Inlet pressure	120.00	25.420	psig
Allowable pressure drop	10.000	2.000	psi
Exchanger duty		2.5008	MM Btu/hr
Duty multiplier		1.0000	

Process Fouling Data	**Hot Fluid**	**Cold Fluid**	
Fouling resistance	0.0020	0.0020	ft2-hr-F/Btu

Hot Fluid Property Data

Fluid name	Diesel Product
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, 120.00 psig

Temp. F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm
591.00	33.760	0.1490	0.0510	0.7710	6.6000
465.20	38.070	0.2540	0.0540	0.6990	10.700

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Cold Fluid Property Data

Fluid name	Jet Side-Cut Reboiler Feed
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, 29.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
439.13	-709.6	0.0000	--	--	--	--	35.504	0.1685
453.67	-699.1	0.0000	0.7189	0.0084	0.0154	0.6176	34.973	0.1591
456.08	-694.7	0.0270	0.7218	0.0084	0.0154	0.6188	34.939	0.1586
458.45	-690.2	0.0543	0.7245	0.0084	0.0155	0.6201	34.905	0.1581
460.79	-685.8	0.0820	0.7271	0.0084	0.0155	0.6213	34.873	0.1576
463.12	-681.3	0.1100	0.7297	0.0084	0.0155	0.6225	34.841	0.1572
465.42	-676.9	0.1383	0.7322	0.0084	0.0156	0.6236	34.809	0.1568
467.72	-672.4	0.1668	0.7347	0.0084	0.0156	0.6248	34.778	0.1563
470.00	-668.0	0.1955	0.7371	0.0084	0.0156	0.6260	34.747	0.1559
530.73	-551.2	1.0000	0.8017	0.0085	0.0166	0.6568	33.874	0.1460
536.13	-547.6	1.0000	0.7953	0.0086	0.0167	0.6592	--	--

Pressure Set, 29.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
439.13	0.0539	0.7146	8.0373	267.23	699.29
453.67	0.0533	0.7251	7.4869	267.23	699.29
456.08	0.0533	0.7262	7.4534	266.11	701.30
458.45	0.0532	0.7273	7.4211	264.99	703.29
460.79	0.0532	0.7284	7.3898	263.88	705.28
463.12	0.0531	0.7295	7.3593	262.77	707.27
465.42	0.0531	0.7305	7.3294	261.68	709.26
467.72	0.0530	0.7316	7.3001	260.58	711.25
470.00	0.0530	0.7326	7.2712	259.49	713.24
530.73	0.0516	0.7601	6.5385	231.11	766.14
536.13	--	--	--	--	--

Pressure Set, 27.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
439.13	-709.6	0.0000	--	--	--	--	35.502	0.1685
449.00	-702.5	0.0000	0.6856	0.0084	0.0153	0.6147	35.144	0.1620

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Cold Fluid Physical Property Data

Pressure Set, 27.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
452.11	-696.7	0.0346	0.6891	0.0084	0.0153	0.6164	35.099	0.1614
455.16	-691.0	0.0698	0.6924	0.0084	0.0154	0.6179	35.057	0.1607
458.17	-685.3	0.1056	0.6956	0.0084	0.0154	0.6195	35.016	0.1601
461.15	-679.5	0.1418	0.6987	0.0084	0.0154	0.6210	34.975	0.1596
464.11	-673.8	0.1784	0.7018	0.0084	0.0155	0.6225	34.936	0.1590
467.06	-668.1	0.2153	0.7047	0.0084	0.0155	0.6240	34.896	0.1585
470.00	-662.3	0.2525	0.7077	0.0084	0.0156	0.6255	34.857	0.1580
526.74	-553.5	1.0000	0.7650	0.0085	0.0164	0.6543	34.041	0.1486
532.14	-550.0	1.0000	0.7589	0.0085	0.0166	0.6568	--	--

Pressure Set, 27.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
439.13	0.0539	0.7146	8.0373	267.23	699.29
449.00	0.0535	0.7217	7.6627	267.23	699.29
452.11	0.0534	0.7232	7.6190	265.77	701.89
455.16	0.0534	0.7246	7.5773	264.33	704.47
458.17	0.0533	0.7260	7.5371	262.90	707.05
461.15	0.0533	0.7274	7.4981	261.47	709.63
464.11	0.0532	0.7287	7.4599	260.05	712.20
467.06	0.0531	0.7300	7.4224	258.64	714.78
470.00	0.0531	0.7313	7.3854	257.23	717.36
526.74	0.0518	0.7571	6.6950	230.69	766.91
532.14	--	--	--	--	--

Pressure Set, 25.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
439.13	-709.6	0.0000	--	--	--	--	35.501	0.1685
444.16	-706.0	0.0000	0.6525	0.0083	0.0151	0.6118	35.320	0.1651
448.00	-698.9	0.0424	0.6566	0.0083	0.0152	0.6138	35.265	0.1643
451.75	-691.8	0.0858	0.6604	0.0083	0.0152	0.6157	35.213	0.1635
455.45	-684.8	0.1299	0.6641	0.0083	0.0153	0.6177	35.163	0.1628
459.11	-677.7	0.1746	0.6677	0.0083	0.0154	0.6195	35.114	0.1621
462.75	-670.6	0.2197	0.6712	0.0083	0.0154	0.6214	35.066	0.1615
466.38	-663.6	0.2654	0.6746	0.0083	0.0155	0.6233	35.018	0.1608
470.00	-656.5	0.3114	0.6780	0.0083	0.0155	0.6251	34.970	0.1602
522.59	-556.0	1.0000	0.7284	0.0084	0.0163	0.6519	34.212	0.1514
527.99	-552.5	1.0000	0.7227	0.0085	0.0165	0.6543	--	--

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Cold Fluid Physical Property Data

Pressure Set, 25.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
439.13	0.0539	0.7147	8.0373	267.23	699.29
444.16	0.0537	0.7183	7.8459	267.23	699.29
448.00	0.0536	0.7201	7.7914	265.43	702.50
451.75	0.0535	0.7218	7.7399	263.64	705.70
455.45	0.0535	0.7235	7.6905	261.88	708.89
459.11	0.0534	0.7252	7.6426	260.12	712.08
462.75	0.0533	0.7268	7.5957	258.37	715.28
466.38	0.0532	0.7285	7.5497	256.62	718.48
470.00	0.0532	0.7301	7.5041	254.88	721.68
522.59	0.0520	0.7540	6.8580	230.26	767.72
527.99	--	--	--	--	--

Pressure Set, 23.500 psig

Temp. F	Enthalpy Btu/lb	Vapor Mass Fraction	Vapor Density lb/ft3	Vapor Dynamic Viscosity cP	Vapor Thermal Cond. Btu/hr-ft-F	Vapor Heat Capacity Btu/lb-F	Liquid Density lb/ft3	Liquid Dynamic Viscosity cP
433.73	-713.4	0.0000	--	--	--	--	35.694	0.1721
439.13	-709.6	0.0000	0.6195	0.0082	0.0150	0.6088	35.501	0.1685
443.73	-701.1	0.0504	0.6241	0.0082	0.0151	0.6112	35.436	0.1674
448.21	-692.7	0.1021	0.6285	0.0082	0.0151	0.6135	35.375	0.1665
452.61	-684.2	0.1548	0.6326	0.0082	0.0152	0.6158	35.316	0.1657
456.98	-675.8	0.2083	0.6365	0.0082	0.0152	0.6180	35.258	0.1649
461.32	-667.3	0.2624	0.6405	0.0083	0.0153	0.6202	35.201	0.1641
465.66	-658.9	0.3170	0.6443	0.0083	0.0154	0.6225	35.144	0.1633
470.00	-650.4	0.3722	0.6481	0.0083	0.0154	0.6247	35.087	0.1626
518.28	-558.6	1.0000	0.6920	0.0084	0.0162	0.6493	34.389	0.1544
523.68	-555.1	1.0000	0.6866	0.0084	0.0163	0.6518	--	--

Pressure Set, 23.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
433.73	0.0541	0.7109	8.2435	267.23	699.29
439.13	0.0539	0.7148	8.0371	267.23	699.29
443.73	0.0538	0.7169	7.9712	265.07	703.15
448.21	0.0537	0.7190	7.9095	262.93	706.98
452.61	0.0536	0.7210	7.8505	260.81	710.82
456.98	0.0535	0.7230	7.7934	258.70	714.65
461.32	0.0534	0.7249	7.7374	256.61	718.49
465.66	0.0533	0.7269	7.6823	254.51	722.35
470.00	0.0533	0.7288	7.6277	252.42	726.21

Tallow Diesel Mode - SOR : Shell 1
Rating - Horizontal Once Through Reboiler TEMA AEU Shell With Single-Segmental Baffles

Cold Fluid Physical Property Data

Pressure Set, 23.500 psig

Temp. F	Liquid Thermal Cond. Btu/hr-ft-F	Liquid Heat Capacity Btu/lb-F	Liquid Surface Tension dyne/cm	Liquid Critical Pressure psig	Liquid Critical Temp. F
518.28	0.0522	0.7509	7.0281	229.82	768.55
523.68	--	--	--	--	--

Control Name Data

Case name	Tallow Diesel Mode - SOR	
Item Number	18-X-353	
Revision	03	
Service	Jet Side-Cut Stripper Reboiler	

Control Methods Data

Shellside friction factor method	Commercial	
Tubeside friction factor method	Commercial	
Pure longitudinal flow	No	
Pure component condensation	No	
Condensing correlation	HTRI Proration	
Mole fraction inerts	0.0000	
Momentum exclusion	0.0000	%
Perform shellside subcooling calculations	No	
Pure component boiling	No	
Check film boiling	Yes	
Nucleate boiling method	Physical property/theoretical boiling range	
Component boiling method	Nucleate and convective	
Increments per baffle	Calculated	

Control User-Defined Methods Data

Add non-nucleate boiling	Yes	