



FABSCO
SHELL & TUBE, LLC



Member HTRI

HEAT EXCHANGER SPECIFICATION SHEET

Page 1
US Units

Customer	AIR PRODUCTS (WORLD ENERGY PARAMOUNT)	Job No.	S-16030-6-18-X-370REV4
Address	ALLENTOWN, PA	P.O. No.	4505600058
Plant Location	PARAMOUNT, CA	Fabsco Job	S21-13258-6 & 7
Service of Unit	PROPANE RECOVERY COMPRESSOR INTERSTAGE COOLER	Date	10/31/2022
Size	21 x 168 inch	Rev. D	
Surf/Unit (Gross/Eff)	571.77 / 558.16 ft2	Item No.	18-X-370
Type	AEU	Connected In	1 Parallel 1 Series
Horizontal		Surf/Shell (Gross/Eff)	571.77 / 558.16 ft2

PERFORMANCE OF ONE UNIT

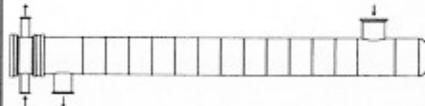
Fluid Allocation	Shell Side	Tube Side
Fluid Name	OFFGASES	COOLING WATER
Fluid Quantity, Total lb/hr	40039	154186
Vapor (In/Out)	40039	39046
Liquid		992.91
Steam		154186
Water		154186
Noncondensables		
Temperature (In/Out) F	219.80	111.70
Specific Gravity		0.6341
Viscosity cP	0.0130	0.0100 V/L 0.2500
Molecular Weight		18.02
Molecular Weight, Noncondensables		
Specific Heat Btu/lb-F	0.5290	0.4709 V/L 0.5830
Thermal Conductivity Btu/hr-ft-F	0.0250	0.0201 V/L 0.0590
Latent Heat Btu/lb	146.85	253.70
Inlet Pressure psia	77.696	64.696
Velocity ft/sec	27.53	6.20
Pressure Drop, Allow/Calc psi	5.000	2.529
Fouling Resistance (min) ft2-hr-F/Btu	0.00200	0.00200

Heat Exchanged	2310000 Btu/hr	MTD (Corrected)	57.7 F
Transfer Rate, Service	71.76 Btu/ft2-hr-F	Clean	105.26 Btu/ft2-hr-F
		Actual	71.84 Btu/ft2-hr-F

CONSTRUCTION OF ONE SHELL

Sketch (Bundle/Nozzle Orientation)

Design/Test Pressure	Shell Side	Tube Side
psig	95/FV / CODE	120 / CODE
Design Temperature F	300 / 300 / 32	150 / 32
No Passes per Shell	1	4
Corrosion Allowance inch	0.1875 ON C'STL.	0.125 ON C'STL.
Connections	In inch	1 @ 10"-300# RF
Size & Rating	Out inch	1 @ 4"-300# RF
	Intermediate	1 @ 8"-300# RF



Tube No.	104 U's	OD	0.7500 inch	Thk(Avg)	0.0650 inch	Length	14.000 ft	Pitch	1.0000 inch			
Tube Type	Plain	Material					SA789-S31803 / S32205 (SEAMLESS)	Tube pattern		45		
Shell	SA-516-70N	ID	21.000	OD	22.000 inch	Shell Cover	SA-516-70N (INTEGRAL)					
Channel or Bonnet	SA-516-70N						Channel Cover	SA-516-70N (REMOVABLE)				
Tubesheet-Stationary	SA-240-S31803 (W/ 0.0625" TOTAL CA)					Tubesheet-Floating						
Floating Head Cover						Impingement Plate	RODS (2 ROWS X 0.75" OD)					
Baffles-Cross	SA-240-316/316L (VERT. CUT Type	DOUBLE SEG.	%Cut (Diam)	26	Spacing(c/c)	10.750	Inlet	15.000 inch				
Baffles-Long						Seal Type						
Supports-Tube	14 Cross Passes						U-Bend	Type FULL SUPPORT				
Bypass Seal Arrangement	2 Pair Seal Strips & 2 Dummy Tubes					Tube-Tubesheet Joint	SEAL WELD, ROLL & EXPAND (2 GROOVES)					
Expansion Joint						Type						
Rho-V2-Inlet Nozzle	1108.8	lb/ft-sec2						Bundle Entrance	638.99	Bundle Exit	452.24	lb/ft-sec2
Gaskets - 0.175" THK. TP304 S/S SPIRAL WOUND GRAPHITE FILLED W/ TP304 S/S INNER & OUTER COMPRESSION RINGS												

Gaskets - 0.175" THK, TP304 S/S SPIRAL WOUND GRAPHITE FILLED W/ TP304 S/S INNER & OUTER COMPRESSION RINGS

Code Requirements	ASME SECTION VIII, DIV. 1		NATIONAL BOARD		TEMA Class R	API 660		
Weight/Shell	5,800.	lb	Filled with Water	8,300.	lb	Bundle	2,150.	lb

1. CORN OIL JET MODE - EOR. UNIT IS THERMALLY & MECHANICALLY GUARANTEED. 2. FLOWS & DUTY INCREASED BY 10%.
3. (2)TWO IDENTICAL EXCHANGERS ARE REQUIRED, EACH TO PERFORM SHOWN DUTY.
4. PROVIDE PARTIAL TUBE SUPPORT IN SHELL INLET, UNDER THE NOZZLE. SUPPORTING (4)FOUR TUBE ROWS.
5. PROVIDE (1)2"-300# RFLWN W/ BLIND IN EACH PROCESS NOZZLE. 6. PROVIDE (2)2"-300# RFLWN W/ BLIND IN CHANNEL FOR VENT & DRAIN. 7. TUBES ARE TO BE SOLUTION ANNEALED.

Output Summary

Page 1

Released to the following HTRI Member Company:

ST

Al Nader

Xist 9 (64 bit) 10/31/2022 9:41 SN: 13528-113450684

US Units

Shell 1

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

No Data Check Messages.

See Runtime Message Report for Warning Messages.

Process Conditions		Hot Shellside		Cold Tubeside	
Fluid name		OFFGASES		COOLING WATER	
Total flow rate	(1000-lb/hr)		40.039 *		154.19 *
Inlet/Outlet Y	(Wt. frac vap.)	1.0000	0.9752	0.0000	0.0000
Inlet/Outlet T	(Deg F)	219.80	111.70	80.00	95.00
Inlet P/Avg	(psia)	77.696	76.431	64.696	59.825
dP/Allow.	(psi)	2.529	5.000	9.742	10.000
Fouling	(ft2-hr-F/Btu)		0.00200		0.00200
Exchanger Performance					
Shell h	(Btu/ft2-hr-F)	124.87	Actual U	(Btu/ft2-hr-F)	71.84
Tube h	(Btu/ft2-hr-F)	1466.8	Required U	(Btu/ft2-hr-F)	71.76
Hot regime	(--)	Sens Gas	Total duty	(MM Btu/hr)	2.3100
Cold regime	(--)	Sens. Liquid	Eff. area	(ft2)	558.16
EMTD	(Deg F)	57.7	Overdesign	(%)	0.11
Shell Geometry			Baffle Geometry		
TEMA type	(--)	AEU	Baffle type	Double-Seg.	
Shell ID	(inch)	21.000	Baffle cut	(Pct Dia.)	26
Series	(--)	1	Baffle orientation	(--)	Parallel
Parallel	(--)	1	Central spacing	(inch)	10.750
Orientation	(deg)	0.00	Crosspasses	(--)	14
Tube Geometry			Nozzles		
Tube type	(--)	Plain	Shell inlet	(inch)	9.7500
Tube OD	(inch)	0.7500	Shell outlet	(inch)	7.6250
Length	(ft)	14.000	Inlet height	(inch)	2.4995
Pitch ratio	(--)	1.3333	Outlet height	(inch)	3.1360
Layout	(deg)	45	Tube inlet	(inch)	4.0260
Tubecount	(--)	208	Tube outlet	(inch)	4.0260
Tube Pass	(--)	4			
Thermal Resistance, %		Velocities, ft/sec		Flow Fractions	
Shell	57.53	Min	Max	A	0.031
Tube	5.92	Tubeside	6.19 6.45	B	0.705
Fouling	31.75	Crossflow	16.32 28.21	C	0.052
Metal	4.80	Longitudinal	15.41 37.61	E	0.119
				F	0.093

Runtime Messages

Page 2

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US Units

Shell 1

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

Unit ID 100 - WARNING MESSAGES (CALCULATIONS CONTINUE)

Geometry, Mechanical Design, and Vibration

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. (MN 3505)

The areas in the window for multi-segmental baffles are not equal. Check the specified baffle cut and overlap. The program uses the average window area for calculating shellside pressure drop and heat transfer. (MN 3031)

The inlet baffle spacing is less than the calculated minimum inlet spacing 17.625 in. (447 mm) using estimated nozzle clearance requirements. This could result in the first baffle being placed beneath or before the inlet nozzle. This geometry is not recommended. (MN 3036)

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. (MN 0042)

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. (MN 10170)

Fluid Properties

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. (MN 5033)

Final Results

Page 3

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US Units

Shell 1

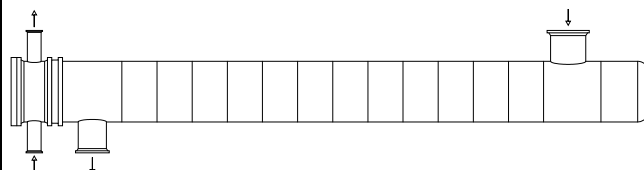
Rating - Horizontal Multipass Flow TEMA AEU Shell With Double-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		OFFGASES		COOLING WATER	
Fluid condition		Cond. Vapor		Sens. Liquid	
Total flow rate	(1000-lb/hr)		40.039 *		154.19 *
Weight fraction vapor, In/Out	(--)	1.0000	0.9752	0.0000	0.0000
Temperature, In/Out	(Deg F)	219.80	111.70	80.00	95.00
Skin temperature, Min/Max	(Deg F)	93.90	147.97	82.14	99.54
Wall temperature, Min/Max	(Deg F)	89.28	128.93	87.74	122.58
Pressure, In/Average	(psia)	77.696	76.431	64.696	59.825
Pressure drop, Total/Allowed	(psi)	2.529	5.000	9.742	10.000
Velocity, Mid/Max allow	(ft/sec)	27.53		6.20	
Mole fraction inert	(--)		0.0000		
Average film coef.	(Btu/ft2-hr-F)		124.87		1466.8
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)	71.76 /	105.26 /	71.84
Heat duty, Calculated/Specified	(MM Btu/hr)	2.3100 /	2.1000	
Effective overall temperature difference	(Deg F)	57.7		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg F)	58.3 *	0.9893 *	1.0000

See Runtime Messages Report for warnings.

**Exchanger Fluid Volumes**

Approximate shellside (ft3)	29.772
Approximate tubeside (ft3)	9.133

Shell Construction Information

TEMA shell type	AEU	Shell ID	(inch)	21.000
Shells Series	1 Parallel	1	Total area	(ft2) 571.77
Passes Shell	1 Tube	4	Eff. area	(ft2/shell) 558.16
Shell orientation angle (deg)	0.00			
Impingement present	Rods		Impingement rod rows	2
Pairs seal strips	2		Passlane seal rods (inch)	0.5000 No. 2
Shell expansion joint	No		UBend tangent to Support Dist. (inch)	2.0000
Weight estimation Wet/Dry/Bundle		7171 /	4740.7 /	2016.1 (lb/shell)

Baffle Information

Type	Parallel	Double-Seg.	Baffle cut (% dia)	26
Crosspasses/shellpass		14	No. (Pct Area)	(inch) to C.L
Central spacing	(inch)	10.750	1	40.49 5.0400
Inlet spacing	(inch)	15.000	2	35.76 2.9190
Outlet spacing	(inch)	19.500	Baffle overlap	(inch) 2.1210
Baffle thickness	(inch)	0.1875		
Use deresonating baffles	No			

Tube Information

Tube type	Plain	Tubecount per shell	208
Length to tangent	(ft) 14.000	Pct tubes removed (both)	21.21
Effective length	(ft) 13.667	Outside diameter	(inch) 0.7500
Total tubesheet	(inch) 2.0000	Wall thickness	(inch) 0.0650
Area ratio	(out/in) 1.2097	Pitch (inch)	1.0000 Ratio 1.3333
Tube metal	Alloy 2205 (S31803)	Tube pattern (deg)	45

Final Results

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US Units

Shell 1

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

Shellside Performance

Nom vel, X-flow/window 24.10 / 38.39

Flow fractions for vapor phase

A=0.0312 B=0.7052 C=0.0519 E=0.1190 F=0.0927

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.981	0.920	1.066	0.922	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
23.48	45.96	8.73	Inlet	6.92	4.60
MOMENTUM		-0.01	Outlet	14.92	2.93

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F
RPM	Sens Gas	Sens Gas	Shear	0.3350

H. T. Parameters

Shell

Tube

Overall wall correction		1.001
Midpoint Prandtl no.		5.29
Midpoint Reynolds no.	107189	37986
Bundle inlet Reynolds no.	68409	34613
Bundle outlet Reynolds no.	25970	42726
Fouling layer (inch)		

Thermal Resistance, %

Shell	Tube	Fouling	Metal	Over Des
57.53	5.92	31.75	4.80	0.11
Total fouling resistance	(ft2-hr-F/Btu)			0.0044
Differential resistance	(ft2-hr-F/Btu)			1.6e-5

Shell Nozzles

Inlet at channel end	No			
Nozzle location at U-bend	Before U-bend			
	Inlet	Outlet	Liquid Outlet	
Number at each position	1	1	0	
Diameter (inch)	9.7500	7.6250		
Velocity (ft/sec)	51.69	78.89		
Pressure drop (psi)	0.175	0.377		
Height under nozzle (inch)	2.4995	3.1360		
Nozzle R-V-SQ (lb/ft-sec2)	1108.8	2766.9		
Shell ent. (lb/ft-sec2)	639.05	843.86		

Tube Nozzle

	Inlet	Outlet	Liquid Outlet
	RADIAL	RADIAL	
Diameter (inch)	4.0260	4.0260	
Velocity (ft/sec)	7.79	7.81	
Pressure drop (psi)	0.448	0.286	
Nozzle R-V-SQ (lb/ft-sec2)	3771.9	3781.7	

Annular Distributor

Inlet

Outlet

Length (inch)	
Height (inch)	
Slot area (in2)	

Diametral Clearances (inch)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
0.1875	0.5363	0.0313

Supplementary Results

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Released to the following HTRI Member Company:

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Xist 9 (64 bit) 10/31/2022 9:41 SN: 13528-113450684

US Units

Shell 1

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

Externally Enhanced Tube Geometry

Type	Plain
Fin density	(fin/inch)
Fin height	(inch)
Fin thickness	(inch)
Root diameter	(inch)
Area/length	(ft ² /ft)

Internally Enhanced Tube Geometry

Type	None
Thickness	(inch)
Pitch	(L/D)

Mean Metal Temperatures

Mean shell temperature 145.78 (F)

Tubesheet temperature 300.00 (F)

Mean tube metal temperature in each tubepass, (F)

<u>Tube Pass</u>	<u>Inside</u>	<u>Outside</u>	<u>Radial</u>
1	96.54	99.59	98.16
2	100.45	103.27	101.95
3	102.61	105.36	104.07
4	106.11	108.66	107.47

Vibration Analysis

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Xist 9 (64 bit) 10/31/2022 9:41 SN: 13528-113450684

US Units

Shell 1

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

Shellside condition		Cond. Vapor		
Axial stress loading	(1000-psi)	0.000	Added mass factor	1.394
Beta		4.217		
Position In The Bundle		Inlet	Center	Outlet
Length for natural frequency	(ft)	2.146	1.792	2.521
Length/TEMA maximum span	(--)	0.429	0.358	0.504
Number of spans	(--)	7	8	7
Tube natural frequency	(Hz)	149.7	146.8	124.9 +
Shell acoustic frequency	(Hz)	262.3 +		
Flow Velocities		Inlet	Center	Outlet
Window parallel velocity	(ft/sec)	38.54	37.16	35.97
Bundle crossflow velocity	(ft/sec)	15.13	20.71	10.86
Bundle/shell velocity	(ft/sec)	17.69	17.05	8.94
Fluidelastic Instability Check		Inlet	Center	Outlet
Log decrement	HTRI	0.025	0.026	0.025
Critical velocity	(ft/sec)	139.18	199.24	97.44
Baffle tip cross velocity ratio	(--)	0.1306	0.1249	0.1339
Average crossflow velocity ratio	(--)	0.1443	0.1380	0.1480
Acoustic Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	0.671		
Chen number	(--)	12729		
Turbulent buffeting ratio	(--)	0.657		
Tube Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	1.157	1.584	0.831
Parallel flow amplitude	(inch)	0.0001	0.0001	0.0001
Crossflow amplitude	(inch)	0.0020	0.0010	0.0007
Tube gap	(inch)	0.2500	0.2500	0.2500
Crossflow amplitude/tube gap	(--)	0.0078	0.0038	0.0026
Crossflow RHO-V-SQ	(lb/ft-sec2)	167.46	325.62	92.49
Bundle Entrance/Exit (analysis at first tube row)			Entrance	Exit
Fluidelastic instability ratio	(--)		0.138	0.083
Vortex shedding ratio	(--)		3.002	2.440
Crossflow amplitude	(inch)		0.00047	0.00026
Crossflow velocity	(ft/sec)		39.24	31.89
Tubesheet to inlet/outlet support	(inch)		7.7500	15.250
Shell Entrance/Exit Parameters			Entrance	Exit
Impingement device			Rods	--
Flow area	(ft2)		0.683	0.574
Velocity	(ft/sec)		39.24	43.57
Critical velocity	(ft/sec)		284.83	383.42
RHO-V-SQ	(lb/ft-sec2)		639.05	843.86
Shell type	AEU	Baffle type	Double-Seg.	
Tube type	Plain	Baffle layout	Parallel	
Pitch ratio	1.3333	Tube diameter, (inch)	0.7500	
Layout angle	45	Tube material	Alloy 2205 (S31803)	
Number U-Bend supports		Elastic modulus, (1000-psi)	27448	
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.

HEAT EXCHANGER RATING DATA SHEET										Page 7		
Released to the following HTRI Member Company:										US Units		
ST												
Al Nader												
Service of Unit PROPANE RECOVERY COMPRESSOR INTERSTAC Item No. 18-X-370 (Corn Oil Jet Mode - EOR)												
Type	AEU		Orientation	Horizontal		Connected In	1 Parallel		1 Series			
Surf/Unit (Gross/Eff)	571.77 / 558.16 ft2		Shell/Unit	1		Surf/Shell (Gross/Eff)	571.77 / 558.16 ft2					
PERFORMANCE OF ONE UNIT												
Fluid Allocation			Shell Side				Tube Side					
Fluid Name			OFFGASES				COOLING WATER					
Fluid Quantity, Total			40.039				154.19					
Vapor (In/Out)			wt%		100.00	97.52		0.00		0.00		
Liquid			wt%		0.00	2.48		100.00		100.00		
Temperature (In/Out)			F		219.80	111.70		80.00		95.00		
Density			lb/ft3		0.4150	0.4337 V/L 39.570		62.226		62.065		
Viscosity			cP		0.0130	0.0100 V/L 0.2500		0.8572		0.7193		
Specific Heat			Btu/lb-F		0.5290	0.4709 V/L 0.5830		0.9991		0.9986		
Thermal Conductivity			Btu/hr-ft-F		0.0250	0.0201 V/L 0.0590		0.3526		0.3595		
Critical Pressure			psia									
Inlet Pressure			psia		77.696				64.696			
Velocity			ft/sec						27.53			
Pressure Drop, Allow/Calc			psi		5.000				2.529			
Average Film Coefficient			Btu/ft2-hr-F		124.87				1466.8			
Fouling Resistance (min)			ft2-hr-F/Btu		0.00200				0.00200			
Heat Exchanged			2.3100 MM Btu/hr		MTD (Corrected)		57.7 F		Overdesign 0.11 %			
Transfer Rate, Service			71.76 Btu/ft2-hr-F		Calculated		71.84 Btu/ft2-hr-F		Clean 105.26 Btu/ft2-hr-F			
CONSTRUCTION OF ONE SHELL												
			Shell Side		Tube Side							
Design Pressure			psig		95.000						120.00	
Design Temperature			F		300.00						150.00	
No Passes per Shell					1						4	
Flow Direction					Downward						Upward	
Connections			In inch		1 @ 9.7500						1 @ 4.0260	
Size &			Out inch		1 @ 7.6250		1 @ 4.0260					
Rating			Liq. Out inch		@		1 @					
Tube No. 208.00			OD 0.7500 inch		Thk(Avg) 0.0650 inch		Length 14.000 ft		Pitch 1.0000 inch Tube pattern 45			
Tube Type Plain					Material Alloy 2205 (S31803)				Pairs seal strips 2			
Shell ID 21.000 inch					Kettle ID inch				Passlane Seal Rod No. 2			
Cross Baffle Type Parallel Double-Seg.					%Cut (Diam) 26				Impingement Plate Rods			
Spacing(c/c) 10.750 inch					Inlet 15.000 inch				No. of Crosspasses 14			
Rho-V2-Inlet Nozzle 1108.8 lb/ft-sec2					Shell Entrance 639.05 lb/ft-sec2				Shell Exit 843.86 lb/ft-sec2			
					Bundle Entrance 638.99 lb/ft-sec2				Bundle Exit 452.24 lb/ft-sec2			
Weight/Shell 4483.0 lb					Filled with Water 6910.7 lb				Bundle 1955.3 lb			
Notes:					Thermal Resistance, %		Velocities, ft/sec		Flow Fractions			
					Shell 57.53		Shellside 27.53		A 0.031			
					Tube 5.92		Tubeside 6.20		B 0.705			
					Fouling 31.75		Crossflow 24.10		C 0.052			
Reported duty and flow rates include a user-specified multiplier of 1.10.					Metal 4.80		Window 38.39		E 0.119			
									F 0.093			

HEAT EXCHANGER SPECIFICATION SHEET

Page 8

Released to the following HTRI Member Company:

US Units

ST

Al Nader

Job No.

S-16030-6-18-X-370REV4

Customer AIR PRODUCTS (WORLD ENERGY PARAMOUNT)

Reference No. P.O.# 4505600058

Address ALLENTOWN, PA

Proposal No. S21-13258-6 & 7

Plant Location PARAMOUNT, CA

Date 10/31/2022

Rev D

Service of Unit PROPANE RECOVERY COMPRESSOR INTERSTAGE COOLEF Item No. 18-X-370 (Corn Oil Jet Mode-EOR)

Size 21 x 168 inch Type AEU Horizontal Connected In 1 Parallel 1 Series

Surf/Unit (Gross/Eff) 571.77 / 558.16 ft2 Shell/Unit 1 Surf/Shell (Gross/Eff) 571.77 / 558.16 ft2

PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		OFFGASES		COOLING WATER	
Fluid Quantity, Total lb/hr		40039		154186	
Vapor (In/Out)		40039	39046		
Liquid			992.91	154186	154186
Steam					
Water				154186	154186
Noncondensables					
Temperature (In/Out) F		219.80	111.70	80.00	95.00
Specific Gravity			0.6341	0.9972	0.9946
Viscosity cP		0.0130	0.0100 V/L 0.2500	0.8572	0.7193
Molecular Weight				18.02	18.02
Molecular Weight, Noncondensables					
Specific Heat Btu/lb-F		0.5290	0.4709 V/L 0.5830	0.9991	0.9986
Thermal Conductivity Btu/hr-ft-F		0.0250	0.0201 V/L 0.0590	0.3526	0.3595
Latent Heat Btu/lb		146.85	253.70		
Inlet Pressure psia			77.696		64.696
Velocity ft/sec			27.53		6.20
Pressure Drop, Allow/Calc psi		5.000	2.529	10.000	9.742
Fouling Resistance (min) ft2-hr-F/Btu			0.00200		0.00200

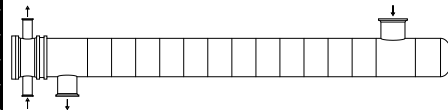
Heat Exchanged 2310000 Btu/hr MTD (Corrected) 57.7 F

Transfer Rate, Service 71.76 Btu/ft2-hr-F Clean 105.26 Btu/ft2-hr-F Actual 71.84 Btu/ft2-hr-F

CONSTRUCTION OF ONE SHELL

Sketch (Bundle/Nozzle Orientation)

		Shell Side		Tube Side	
Design/Test Pressure psig		95.000	/	120.00	/
Design Temperature F		300.00		150.00	
No Passes per Shell		1		4	
Corrosion Allowance inch		0.1875		0.125	
Connections Size & Rating	In inch	1 @ 9.7500		1 @ 4.0260	
	Out inch	1 @ 7.6250		1 @ 4.0260	
	Intermediate	@		@	



Tube No. 104U	OD 0.7500 inch	Thk(Avg) 0.0650 inch	Length 14.000 ft	Pitch 1.0000 inch
Tube Type Plain		Material Alloy 2205 (S31803)		Tube pattern 45
Shell SA-516 70 Pl. K02700	ID 21.000	OD 22.000 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 Alloy 2205 (S31803)			Tubesheet-Floating	
Floating Head Cover			Impingement Plate Rods	
Baffles-Cross 316 Stainless steel (17 Cr, Type Double-Seg.		%Cut (Diam) 26	Spacing(c/c) 10.750	Inlet 15.000 inch
Baffles-Long		Seal Type None		
Supports-Tube		U-Bend		Type Full support
Bypass Seal Arrangement 2 pairs seal strips		Tube-Tubesheet Joint Expanded and Seal Welded (2 grooves)		
Expansion Joint		Type None		
Rho-V2-Inlet Nozzle 1108.8 lb/ft-sec2		Bundle Entrance 638.99	Bundle Exit 452.24	lb/ft-sec2
Gaskets-Shell Side Spiral Wound Metal (SS)		Tube Side Spiral Wound Metal (SS)		
- Floating Head				
Code Requirements			TEMA Class R	
Weight/Shell 4740.7 lb	Filled with Water	7171 lb	Bundle 2016.1 lb	

Remarks:

Note: Reported duty and flow rates include a user-specified multiplier of 1.10.

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US Units

Shell 1

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

Exchanger Data

Unit identifier	Shell 1
Service type	Generic shell and tube
TEMA type	AEU
Run mode	Rating
Hot fluid location	Shellside
Unit orientation	Horizontal
Number of shells in series	1
Number of shells in parallel	1
Flow in 1st tubepass	Countercurrent
Train flow direction	Countercurrent

Construction Data

Shell material	SA-516 70 Pl. K02700
Tube material	Alloy 2205 (S31803)
Shell cover material	SA-516 70 Pl. K02700
Channel or bonnet material	SA-516 70 Pl. K02700
Channel cover material	SA-516 70 Pl. K02700
Tubesheet-Stationary material	Alloy 2205 (S31803)
Baffle-Cross material	316 Stainless steel (17 Cr, 12 Ni)
Shellside gasket	Spiral Wound Metal (SS)
Tubeside gasket	Spiral Wound Metal (SS)
Shellside design pressure	95.000 psig
Tubeside design pressure	120.00 psig
Shellside vacuum pressure	Full
Tubeside vacuum pressure	None
Shellside design temperature	300.00 F
Tubeside design temperature	150.00 F
Shellside corrosion allowance	0.1875 inch
Tubeside corrosion allowance	0.125 inch
Tubesheet design temperature	300.00 F
Shellside radiography	None
Tubeside radiography	None
TEMA class	R
Small exchanger	No
Shell outside diameter	22.000 inch
Shell inside diameter	21.000 inch
Shell wall thickness	0.5000 inch
Front head outside diameter	22.000 inch
Front head inside diameter	21.000 inch
Front head thickness	0.5000 inch
Rear head outside diameter	22.000 inch
Rear head inside diameter	21.000 inch
Rear head thickness	0.5000 inch
Total tubesheet thickness	2.0000 inch
Double tubesheet	No
Shell expansion joint	No
Suppress mechanical calculations	No

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US Units

Shell 1

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

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
Tubepasses per shell	4
Tube pattern	45 degrees
Tube count method	Rigorous
Tube length	14.000 ft
Tube material	Alloy 2205 (S31803)

Baffle Data

Baffle type	Double segmental
Baffle orientation	Program sets
Baffle cut percent	26.000 % shell ID
Adjust baffle cut	No adjustment
Double segmental overlap	3.0000 Tuberows
Double segmental set center baffle at inlet	Program set
Central baffle spacing	10.750 inch
Inlet baffle spacing	15.000 inch
Outlet baffle spacing	19.500 inch
Variable baffle spacing	No
Baffle thickness	0.1875 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	2.0000 inch
Include inlet vibration support	Yes
Distance from tubesheet to inlet vibration support	7.7500 inch
Include outlet vibration support	Yes
Distance from tubesheet to outlet vibration support	15.250 inch

Nozzle Data**Shellside**

Nozzle standard	01-ANSI_B36_10.TABLE
Shell entrance type	Use impingement device
Shell exit type	Remove tubes if TEMA requires

	Inlet	Outlet	Liq. Outlet
Nozzle outside diameter	10.750	8.6250	-- inch
Nozzle inside diameter	9.7500	7.6250	-- inch
Number at this position	1	1	--

Tubeside

Nozzle standard	01-ANSI_B36_10.TABLE
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	Inlet	Outlet	Liq. Outlet
Nozzle outside diameter	4.5	4.5	-- inch
Nozzle inside diameter	4.0260	4.0260	-- inch
Number at this position	1	1	--

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US Units

Shell 1

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

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	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	0.9375 inch
Impingement rods on centerline	Program set
Impingement rod layout angle	60.00 deg
Rod row width to nozzle diameter	1.0000

Tube Layout Data

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
Shifted staggered layout	Program set
Use crossed U-bends	No
Minimum U-bend diameter	3.0000 inch
Use tube layout drawing as input	Yes
	Inlet Outlet Liq. Outlet
Height under nozzle	2.0000 3.0000 -- inch

Clearance Data

Number of seal strip pairs	2
Block A stream	No
Block E stream	No
Block F stream	No
Number of passlane seal rods	2
Passlane seal rod diameter	0.5000 inch
Tubes to remove for tie rods	Calculated
Number of tie rods	8
Tie rod outside diameter	0.5 inch
Baffle to shell clearance	0.1875 inch
Bundle to shell clearance	0.125 inch
Baffle clearance type	TEMA

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US Units

Shell 1

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

Process Conditions Data**Hot Fluid****Cold Fluid**

Phase condition	Two phase	Sensible liquid
Flow rate	36.399	140.17 1000-lb/hr
Inlet vapor fraction	1.0000	0.0000
Outlet vapor fraction	--	0.0000
Inlet temperature	219.80	80.00 F
Outlet temperature	111.70	-- F
Inlet pressure	77.696	64.696 psia
Allowable pressure drop	5.000	10.000 psi
Exchanger duty		2.1000 MM Btu/hr
Duty multiplier		1.1000

Process Fouling Data**Hot Fluid****Cold Fluid**

Fouling resistance	0.0020	0.0020 ft2-hr-F/Btu
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Hot Fluid Property Data

Fluid name	OFFGASES
Physical property method	Combination
Temperature interpolation option	Program
Flash type	Integral
Quantity units	Moles
Heat release type	Total duty from inlet
Heat release flow rate	36.399 1000-lb/hr
Number of components	1
Property package	HTRI (legacy)

Hot Fluid Physical Property Data

Pressure Set, 77.700 psia

Temp. F	Duty MM Btu/hr	Vapor Mass Fraction
219.80	0.0000	1.0000
208.80	-0.210	1.0000
197.80	-0.420	1.0000
186.80	-0.620	1.0000
175.90	-0.830	1.0000
164.90	-1.030	1.0000
153.90	-1.230	1.0000
142.90	-1.420	1.0000
132.00	-1.620	1.0000
121.00	-1.860	0.9910
110.00	-2.290	0.9560

Pressure Set, 72.700 psia

Temp. F	Duty MM Btu/hr	Vapor Mass Fraction
219.30	0.0000	1.0000

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US Units

Shell 1

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

Hot Fluid Physical Property Data

Pressure Set, 72.700 psia

Temp. F	Duty MM Btu/hr	Vapor Mass Fraction
208.40	-0.210	1.0000
197.40	-0.410	1.0000
186.50	-0.620	1.0000
175.60	-0.820	1.0000
164.60	-1.020	1.0000
153.70	-1.220	1.0000
142.80	-1.410	1.0000
131.90	-1.610	1.0000
120.90	-1.820	0.9980
110.00	-2.180	0.9840

Hot Fluid Component Data

Component number	1
Component name	[New User-Defined]
Comp. bank name	<User-Defined>
Component bank	HTRI (legacy)
Component code	-1
Component phase	Mixed
Vapor Properties	
Reference temperature, F	219.80 110.00
Density, lb/ft3	0.4150 0.4340
Viscosity, cP	0.0130 0.0100
Thermal conductivity, Btu/hr-ft-F	0.0250 0.0200
Heat capacity, Btu/lb-F	0.5290 0.4700
Liquid Properties	
Reference temperature, F	-- 110.00
Density, lb/ft3	-- 39.570
Viscosity, cP	-- 0.2500
Thermal conductivity, Btu/hr-ft-F	-- 0.0590
Heat capacity, Btu/lb-F	-- 0.5830
Surface tension, dyne/cm	-- 15.480

Cold Fluid Property Data

Fluid name	COOLING WATER
Physical property method	Composition based
Temperature interpolation option	Program
Flash type	Integral
Quantity units	Moles
Number of components	1
Property package	HTRI (legacy)

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US Units

Shell 1

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

Cold Fluid Component Data

Component number	1
Component name	Water (IAPWS 1997)
Comp. bank name	Water (IAPWS 1997)
Component bank	HTRI (legacy)
Component code	1
Component phase	Liquid
Component quantity	1.0000

Control Name Data

Job Number	S-16030-6-18-X-370REV4
Item Number	18-X-370 Corn Oil Jet Mode - EOR
Reference Number	P.O.# 4505600058
Proposal Number	S21-13258-6 & 7
Revision	D
Service	PROPANE RECOVERY COMPRESSOR INTERSTAGE COOLER
Customer	AIR PRODUCTS (WORLD ENERGY PARAMOUNT)
Address	ALLENTOWN, PA
Plant	PARAMOUNT, CA

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
Reduced pressure calculation method	Program decides
Increments per baffle	Calculated

Control User-Defined Methods Data

Add non-nucleate boiling	Yes
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