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PROJECT

Ingeniería Básica Proyecto Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

1	11/04/2024	Aprobado para Construcción - Actualización donde se indique	Robert Pérez (RPM)	David Cepeda (DCJ)	Jaime Viloria (JVA)
0	15/12/2023	Aprobado para Construcción	Robert Pérez (RPM)	Omar Villarreal (OVM)	Jorge Huertas (JHR)
A	14/12/2023	Emitido para comentarios del cliente	Robert Pérez (RPM)	Omar Villarreal (OVM)	Jorge Huertas (JHR)
REV	DATE	DESCRIPTION	Author	Checked by	Approved by
STATUS	FOR INFORMATION		FOR PURCHASING		
	FOR APPROVAL/COMMENTS		FOR CONSTRUCTION		
	FOR DESIGN		AS BUILT		
DOCUMENT EC		DOCUMENT TITLE			
107-DS-ME01-0308		Hoja de Datos Modificaciones Intercambiador de Calor E-201 A/B			
DOCUMENT ECP					
GRC-107-MEE-HD-000007					

Company: ECOPETROL SA

Rev: 1 Date: 11/04/24 Pag: 1 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

HTRI		HEAT EXCHANGER SPECIFICATION SHEET				Page 4	
		Released to the following company:				US Units	
		INTERCOL EPC					
		LEONARDO MOSQUERA					
Customer		Job No.					
Address		Reference No.					
Plant Location		Proposal No.					
Service of Unit		Date 05-10-2023				Rev 0	
Size 35 x 216 inch		Type BEU		Horizontal		Item No.	
Surf/Unit (Gross/Eff) 5891,3 / 5758,4 ft2		Shell/Unit 2		Connected In 1		Parallel 2 Series	
				Surf/Shell (Gross/Eff) 2945,6 / 2879,2 ft2			
PERFORMANCE OF ONE UNIT							
Fluid Allocation		Shell Side		Tube Side			
Fluid Name		CDHDS FEED		CDHDS OVER HEAD			
Fluid Quantity, Total lb/hr		174807		214924			
Vapor (In/Out)		6319,9		59570		214924	
Liquid		168487		115237		64267	
Steam						150657	
Water							
Noncondensables							
Temperature (In/Out) F		321,00		491,00		523,00	
Specific Gravity		0,6715		0,5661		0,5853	
Viscosity cP		0,0160 V/L 0,1792		0,0150 V/L 0,0948		0,0140	
Molecular Weight						0,0140 V/L 0,1086	
Molecular Weight, Noncondensables							
Specific Heat Btu/lb-F		0,7728 V/L 0,5738		0,6025 V/L 0,6902		0,6199	
Thermal Conductivity Btu/hr-ft-F		0,0510 V/L 0,0540		0,0342 V/L 0,0401		0,0290	
Latent Heat Btu/lb		118,80		84,509		81,659	
Inlet Pressure psia		330,70		269,70			
Velocity ft/sec		4,72		22,21			
Pressure Drop, Allow/Calc		21,000		6,451		15,000	
Fouling Resistance (min) ft2-hr-F/Btu		0,00196		0,00098		12,612	
Heat Exchanged 23832210 Btu/hr		MTD (Corrected) 52,1 F					
Transfer Rate, Service 79,49 Btu/ft2-hr-F		Clean 151,44 Btu/ft2-hr-F		Actual 101,55 Btu/ft2-hr-F			
CONSTRUCTION OF ONE SHELL							
Design/Test Pressure psig		Shell Side 550,00 /		Tube Side 425,00 / 15,000			
Design Temperature F		550,00		650,00			
No Passes per Shell		1		2			
Corrosion Allowance inch		0,1250		0,0000			
Connections In inch		1 @ 9,5620		1 @ 12,812			
Size & Rating Out inch		1 @ 9,5620		1 @ 12,812			
Intermediate		@		@			
Tube No. 396U		OD 0,7500 inch		Thk(Avg) 0,0830 inch		Length 18,000 ft	
Tube Type Plain		Material SA-179 Tube (S) K01200		Tube pattern 90			
Shell SA-516 70 PI. K02700		ID 35,000 OD 36,750 inch		Shell Cover SA-516 70 PI. K02700 (Integ.)			
Channel or Bonnet SA-516 70 PI. K02700		Channel Cover					
Tubesheet-Stationary Carbon steel		Tubesheet-Floating					
Floating Head Cover		Impingement Plate None					
Baffles-Cross Carbon steel		Type		%Cut (Diam) 22,5		Spacing(c/c) 12,500	
Baffles-Long		Seal Type		Inlet inch			
Supports-Tube		U-Bend Carbon steel		Type None			
Bypass Seal Arrangement 4		pairs seal strips		Tube-Tubesheet Joint			
Expansion Joint		Type					
Rho-V2-Inlet Nozzle lb/ft-sec2		Bundle Entrance		Bundle Exit		lb/ft-sec2	
Gaskets-Shell Side Mtl. Jkt. Flat/Grafoil (SS)		Tube Side Mtl. Jkt. Flat/Grafoil (SS)					
- Floating Head							
Code Requirements ASME		TEMA Class					
Weight/Shell lb		Filled with Water lb		Bundle lb			
Remarks:							
1. TUBE-SHEET SA-266 GR 2-N							
2. HEAD CHANNEL SA-516 GR 60 + WELD OVER LAY							
Reprinted with Permission							

Company: ECOPETROL SA

Rev: 1 Date: 11/04/24 Pag: 2 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre



Output Summary

Page 1

Released to the following company:

INTERCOL EPC

LEONARDO MOSQUERA

Xist 9 (32 bit) 05/10/2023 19:22 SN: 46639-

US Units

Summary Unit

Rating - Horizontal

No Data Check Messages.

No Runtime Messages.

Process Conditions		Cold Shellside		Hot Tubeside	
Fluid name		CDHDS FEED		CDHDS OVER HEAD	
Total flow rate	(1000-lb/hr)		174,81		214,92
Inlet/Outlet Y	(Wt. frac vap.)	0,0362	0,3408	1,0000	0,2990
Inlet/Outlet T	(Deg F)	321,00	491,00	523,00	443,00
Inlet P/Avg	(psia)	330,70		269,70	263,39
dP/Allow.	(psi)	6,451	21,000	12,612	15,000
Fouling	(ft2-hr-F/Btu)		0,00196		0,00098

Exchanger Performance					
Shell h	(Btu/ft2-hr-F)	276,63	Actual U	(Btu/ft2-hr-F)	101,55
Tube h	(Btu/ft2-hr-F)	472,38	Required U	(Btu/ft2-hr-F)	79,49
Hot regime	(--)		Total duty	(MM Btu/hr)	23,832
Cold regime	(--)	Mixed No Phase Change	Eff. area	(ft2)	5758,4
EMTD	(Deg F)	52,1	Overdesign	(%)	27,76

Shell Geometry			Baffle Geometry		
TEMA type	(--)	BEU	Baffle type		
Shell ID	(inch)	35,000	Baffle cut	(Pct Dia.)	22,5
Series	(--)	2	Baffle orientation	(--)	
Parallel	(--)	1	Central spacing	(inch)	12,500
Orientation	(deg)	0,00	Crosspasses	(--)	

Tube Geometry			Nozzles		
Tube type	(--)	Plain	Shell inlet	(inch)	9,5620
Tube OD	(inch)	0,7500	Shell outlet	(inch)	9,5620
Length	(ft)	18,000	Inlet height	(inch)	
Pitch ratio	(--)	1,3333	Outlet height	(inch)	
Layout	(deg)	90	Tube inlet	(inch)	12,812
Tubecount	(--)	792	Tube outlet	(inch)	12,812
Tube Pass	(--)	2			

Thermal Resistance; %		Velocities; ft/sec			Flow Fractions	
Shell	36,73		Min	Max	A	0,248
Tube	27,78	Tubeside	15,40	28,74	B	0,475
Fouling	32,51	Crossflow	2,11	8,23	C	0,047
Metal	2,98	Longitudinal	1,40	3,46	E	0,115
					F	0,116

Company: ECO PETROL SA

Rev: 1 Date: 11/04/24 Pag: 3 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

**Series Summary**

Page 2

Released to the following company:

 INTERCOL EPC
 LEONARDO MOSQUERA

Xist 9 (32 bit) 05/10/2023 19:22 SN: 46639-

US Units

Summary Unit

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

Shell #	1	2
Unit	Shell 1	Shell 2
Performance		
Overdesign (%)	27,48	28,08
Overall U (Btu/ft ² -hr-F)	108,99	94,11
Required U (Btu/ft ² -hr-F)	85,49	73,48
Unit Duty (MM Btu/hr)	8,9345	14,898
Shellside h (Btu/ft ² -hr-F)	298,78	254,76
Tubeside h (Btu/ft ² -hr-F)	555,16	402,82
Shellside delta P (psi)	4,047	2,404
Tubeside delta P (psi)	6,945	5,666
EMTD (F)	36,3	70,4
Process Conditions		
Inlet T, Shell (F)	438,16	321,00
Outlet T, Shell (F)	491,00	438,16
Inlet T, Tube (F)	523,00	496,52
Outlet T, Tube (F)	496,52	443,00
Inlet Y, Shell (Wt. fraction)	0,1580	0,0362
Outlet Y, Shell (Wt. fraction)	0,3408	0,1580
Inlet Y, Tube (Wt. fraction)	1,0000	0,6909
Outlet Y, Tube (Wt. fraction)	0,6909	0,2990
Geometry		
Shell type (--)	E	E
Parallel (--)	1	1
Effective area (ft ²)	2879,2	2879,2
Shell orientation (--)	Horizontal	Horizontal
Shell ID (inch)	35,000	35,000
Shellside fluid (--)	Cold	Cold
Baffle type (--)	Single-Seg.	Single-Seg.
Baffle cut (Pct Dia.)	22,5	22,5
Baffle orientation (--)	Parallel	Parallel
Central spacing (inch)	12,500	12,500
Crosspasses (--)	17	16
Tube type (--)	Plain	Plain
Tube Pass (--)	2	2
Tubecount (--)	792	792
Tube length (ft)	18,000	18,000
Tube OD (inch)	0,7500	0,7500
Tube layout angle (--)	90	90
Pitch ratio (--)	1,3333	1,3333

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2 Pag: 4 de 28

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Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

VAPORIZATION CURVE SHELL SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
321.3	330.7	2.136	24.192	0.000	26.328	214.00	1060	242.2	445.5
342.5	330.7	2.742	25.977	0.000	28.719	252.00	1061	253.8	444.9
362.9	330.7	3.509	27.600	0.000	31.110	294.60	1061	266.6	444.2
382.5	330.7	4.480	29.020	0.000	33.500	341.10	1062	280.3	443.6
401.1	330.7	5.702	30.189	0.000	35.891	390.70	1064	294.5	442.8
418.9	330.7	7.230	31.052	0.000	38.282	442.30	1065	309.0	442.1
435.8	330.7	9.124	31.549	0.000	40.673	494.40	1068	323.2	441.2
451.6	330.7	11.447	31.616	0.000	43.063	545.90	1070	336.7	440.2
466.6	330.7	14.259	31.195	0.000	45.454	595.40	1073	349.2	439.1
480.6	330.7	17.611	30.234	0.000	47.845	642.10	1077	360.5	437.9
493.7	330.7	21.541	28.695	0.000	50.236	685.20	1081	370.4	436.7

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
321.3	330.7	6350.0	17.12	0.04	168400.0	112.3	0.0	11.95	121.83
342.5	330.7	8160.0	20.97	0.05	166600.0	112.4	0.0	10.88	116.94
362.9	330.7	10430.0	25.32	0.06	164300.0	112.6	0.0	9.88	112.21
382.5	330.7	13260.0	30.11	0.08	161500.0	112.9	0.0	8.95	107.64
401.1	330.7	16780.0	35.28	0.10	158000.0	113.2	0.0	8.10	103.27
418.9	330.7	21120.0	40.70	0.12	153600.0	113.6	0.0	7.32	99.11
435.8	330.7	26430.0	46.25	0.15	148300.0	114.1	0.0	6.62	95.21
451.6	330.7	32840.0	51.81	0.19	141900.0	114.7	0.0	6.00	91.57
466.6	330.7	40500.0	57.24	0.23	134300.0	115.4	0.0	5.45	88.23
480.6	330.7	49510.0	62.45	0.28	125200.0	116.1	0.0	4.96	85.19
493.7	330.7	59940.0	67.35	0.34	114800.0	117.0	0.0	4.54	82.45

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
321.3	330.7	0.67	41.89	0.772	0.574	0.051	0.054	0.016	0.179
342.5	330.7	0.81	41.09	0.717	0.586	0.049	0.052	0.017	0.164
362.9	330.7	0.96	40.30	0.677	0.598	0.047	0.050	0.017	0.152
382.5	330.7	1.12	39.52	0.649	0.611	0.045	0.048	0.017	0.141
401.1	330.7	1.30	38.77	0.630	0.623	0.044	0.047	0.016	0.131
418.9	330.7	1.49	38.05	0.617	0.635	0.042	0.045	0.016	0.123
435.8	330.7	1.69	37.37	0.608	0.647	0.041	0.044	0.016	0.115
451.6	330.7	1.89	36.74	0.604	0.659	0.039	0.043	0.016	0.108
466.6	330.7	2.09	36.16	0.602	0.671	0.037	0.042	0.016	0.102
480.6	330.7	2.29	35.64	0.602	0.682	0.036	0.041	0.015	0.097
493.7	330.7	2.48	35.18	0.604	0.693	0.034	0.040	0.015	0.093

Company: ECOPETROL SA

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Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

VAPORIZATION CURVE SHELL SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
321.1	320.2	2.195	24.133	0.000	26.328	218.20	1061	243.5	445.6
342.2	320.2	2.822	25.897	0.000	28.719	257.10	1062	255.4	445.0
362.6	320.2	3.618	27.492	0.000	31.110	300.50	1062	268.4	444.3
382.0	320.2	4.624	28.876	0.000	33.500	347.70	1064	282.3	443.7
400.6	320.2	5.891	30.000	0.000	35.891	397.90	1065	296.7	442.9
418.2	320.2	7.473	30.808	0.000	38.282	449.90	1067	311.2	442.1
434.9	320.2	9.432	31.241	0.000	40.673	502.20	1069	325.4	441.2
450.6	320.2	11.827	31.236	0.000	43.063	553.50	1072	338.9	440.2
465.4	320.2	14.717	30.737	0.000	45.454	602.70	1075	351.2	439.1
479.2	320.2	18.147	29.697	0.000	47.845	648.80	1079	362.3	437.8
492.2	320.2	22.152	28.084	0.000	50.236	691.30	1083	371.9	436.5

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
321.1	320.2	6570.0	17.53	0.04	168200.0	112.4	0.0	11.99	121.67
342.2	320.2	8440.0	21.47	0.05	166300.0	112.5	0.0	10.93	116.87
362.6	320.2	10800.0	25.90	0.06	164000.0	112.7	0.0	9.94	112.22
382.0	320.2	13750.0	30.78	0.08	161000.0	113.0	0.0	9.02	107.75
400.6	320.2	17410.0	36.01	0.10	157400.0	113.4	0.0	8.18	103.47
418.2	320.2	21910.0	41.47	0.13	152800.0	113.8	0.0	7.41	99.41
434.9	320.2	27410.0	47.05	0.16	147400.0	114.3	0.0	6.72	95.61
450.6	320.2	34040.0	52.61	0.19	140700.0	114.9	0.0	6.11	92.09
465.4	320.2	41930.0	58.01	0.24	132800.0	115.6	0.0	5.57	88.86
479.2	320.2	51170.0	63.18	0.29	123600.0	116.4	0.0	5.10	85.94
492.2	320.2	61810.0	68.02	0.35	112900.0	117.3	0.0	4.69	83.31

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
321.1	320.2	0.67	41.90	0.763	0.574	0.051	0.054	0.016	0.180
342.2	320.2	0.80	41.11	0.710	0.586	0.049	0.052	0.017	0.164
362.6	320.2	0.95	40.32	0.671	0.598	0.047	0.050	0.017	0.152
382.0	320.2	1.11	39.56	0.644	0.610	0.045	0.048	0.017	0.142
400.6	320.2	1.29	38.82	0.626	0.622	0.043	0.047	0.016	0.132
418.2	320.2	1.47	38.11	0.613	0.635	0.042	0.045	0.016	0.124
434.9	320.2	1.67	37.45	0.606	0.646	0.040	0.044	0.016	0.116
450.6	320.2	1.86	36.83	0.601	0.658	0.038	0.043	0.016	0.109
465.4	320.2	2.06	36.27	0.600	0.669	0.037	0.042	0.015	0.104
479.2	320.2	2.25	35.76	0.600	0.680	0.035	0.041	0.015	0.099
492.2	320.2	2.43	35.32	0.602	0.691	0.034	0.040	0.015	0.095

Company: ECOPEPETROL SA

Rev: 1

Date: 11/04/2 Pag: 6 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

VAPORIZATION CURVE SHELL SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
320.9	309.7	2.257	24.071	0.000	26.328	222.60	1062	245.0	445.7
342.0	309.7	2.907	25.812	0.000	28.719	262.40	1063	257.1	445.1
362.2	309.7	3.733	27.377	0.000	31.110	306.60	1064	270.4	444.4
381.5	309.7	4.778	28.723	0.000	33.500	354.60	1065	284.4	443.7
400.0	309.7	6.092	29.799	0.000	35.891	405.40	1066	299.0	443.0
417.4	309.7	7.731	30.550	0.000	38.282	457.70	1068	313.5	442.1
434.0	309.7	9.757	30.916	0.000	40.673	510.10	1071	327.7	441.2
449.5	309.7	12.227	30.836	0.000	43.063	561.30	1073	341.1	440.1
464.1	309.7	15.196	30.258	0.000	45.454	610.20	1077	353.3	439.0
477.7	309.7	18.705	29.140	0.000	47.845	655.70	1081	364.1	437.7
490.5	309.7	22.783	27.453	0.000	50.236	697.50	1085	373.5	436.3

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
320.9	309.7	6790.0	17.97	0.04	168000.0	112.5	0.0	12.03	121.54
342.0	309.7	8750.0	22.00	0.05	166000.0	112.7	0.0	10.98	116.82
362.2	309.7	11200.0	26.52	0.06	163600.0	112.9	0.0	10.00	112.26
381.5	309.7	14270.0	31.47	0.08	160500.0	113.2	0.0	9.09	107.87
400.0	309.7	18080.0	36.77	0.10	156700.0	113.6	0.0	8.25	103.69
417.4	309.7	22760.0	42.28	0.13	152000.0	114.0	0.0	7.50	99.74
434.0	309.7	28450.0	47.88	0.16	146300.0	114.6	0.0	6.82	96.05
449.5	309.7	35310.0	53.43	0.20	139500.0	115.2	0.0	6.22	92.64
464.1	309.7	43430.0	58.80	0.25	131300.0	115.9	0.0	5.69	89.52
477.7	309.7	52910.0	63.92	0.30	121900.0	116.8	0.0	5.23	86.71
490.5	309.7	63760.0	68.70	0.36	111000.0	117.7	0.0	4.83	84.20

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
320.9	309.7	0.66	41.92	0.754	0.574	0.050	0.054	0.016	0.181
342.0	309.7	0.80	41.13	0.702	0.586	0.048	0.052	0.017	0.165
362.2	309.7	0.94	40.36	0.665	0.598	0.046	0.050	0.017	0.153
381.5	309.7	1.10	39.60	0.640	0.610	0.044	0.048	0.016	0.142
400.0	309.7	1.27	38.87	0.622	0.622	0.043	0.047	0.016	0.133
417.4	309.7	1.46	38.18	0.610	0.634	0.041	0.045	0.016	0.125
434.0	309.7	1.64	37.53	0.603	0.646	0.040	0.044	0.016	0.117
449.5	309.7	1.83	36.93	0.599	0.657	0.038	0.043	0.016	0.111
464.1	309.7	2.02	36.38	0.597	0.668	0.036	0.042	0.015	0.105
477.7	309.7	2.20	35.89	0.598	0.679	0.035	0.041	0.015	0.100
490.5	309.7	2.38	35.46	0.599	0.689	0.034	0.040	0.015	0.096

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2. Pag: 7 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

CONDENSATION CURVE TUBE SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
523.2	269.7	80.064	0.000	0.000	80.064	876.40		407.6	
521.8	269.7	79.883	0.000	0.000	79.883	876.40		407.6	
516.4	269.7	72.734	4.939	0.000	77.674	861.70	1091	406.0	430.6
510.2	269.7	65.358	9.925	0.000	75.283	844.40	1088	404.0	431.8
503.7	269.7	58.370	14.522	0.000	72.892	825.40	1085	401.4	433.0
496.8	269.7	51.787	18.714	0.000	70.501	804.50	1082	398.3	434.2
489.6	269.7	45.627	22.484	0.000	68.111	781.60	1078	394.6	435.4
481.9	269.7	39.906	25.814	0.000	65.720	756.30	1075	390.2	436.5
473.8	269.7	34.638	28.691	0.000	63.329	728.50	1073	385.0	437.6
465.1	269.7	29.834	31.104	0.000	60.938	698.10	1070	378.9	438.7
455.8	269.7	25.500	33.048	0.000	58.548	665.00	1067	372.0	439.8
445.9	269.7	21.633	34.524	0.000	56.157	629.30	1064	364.08	440.76

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
523.2	269.7	214920.0	88.72	1.00	0.0	0.0	0.0	0.00	
521.8	269.7	214920.0	88.72	1.00	0.0	0.0	0.0	0.00	80.66
516.4	269.7	196690.0	86.76	0.92	18200.0	117.4	0.0	3.96	81.48
510.2	269.7	177750.0	84.49	0.83	37100.0	116.6	0.0	4.10	82.47
503.7	269.7	159690.0	82.08	0.74	55200.0	115.8	0.0	4.25	83.57
496.8	269.7	142550.0	79.48	0.66	72300.0	115.1	0.0	4.42	84.77
489.6	269.7	126410.0	76.69	0.59	88500.0	114.3	0.0	4.61	86.10
481.9	269.7	111300.0	73.69	0.52	103600.0	113.6	0.0	4.83	87.57
473.8	269.7	97280.0	70.46	0.45	117600.0	112.9	0.0	5.07	89.18
465.1	269.7	84400.0	66.99	0.39	130500.0	112.3	0.0	5.35	90.95
455.8	269.7	72680.0	63.29	0.34	142200.0	111.6	0.0	5.65	92.89
445.9	269.7	62130.0	59.36	0.29	152700.0	111.1	0.0	6.00	95.01

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
523.2	269.7	2.82		0.620	0.000	0.029		0.014	
521.8	269.7	2.83		0.619	0.000	0.029		0.014	
516.4	269.7	2.76	34.12	0.617	0.737	0.029	0.039	0.014	0.086
510.2	269.7	2.67	34.27	0.615	0.732	0.029	0.039	0.014	0.088
503.7	269.7	2.59	34.44	0.613	0.727	0.029	0.039	0.014	0.089
496.8	269.7	2.49	34.62	0.611	0.721	0.029	0.040	0.014	0.091
489.6	269.7	2.40	34.84	0.608	0.715	0.030	0.040	0.014	0.092
481.9	269.7	2.29	35.07	0.606	0.709	0.030	0.041	0.014	0.095
473.8	269.7	2.18	35.34	0.605	0.702	0.030	0.041	0.014	0.097
465.1	269.7	2.07	35.64	0.603	0.695	0.031	0.042	0.014	0.100
455.8	269.7	1.94	35.97	0.602	0.688	0.032	0.042	0.014	0.103
445.9	269.7	1.82	36.33	0.602	0.680	0.033	0.043	0.015	0.106

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2. Pag: 8 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

CONDENSATION CURVE TUBE SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
522.3	262.2	80.064	0.000	0.000	80.064	876.40		407.6	
518.9	262.2	79.605	0.000	0.000	79.605	876.40		407.6	
514.1	262.2	73.414	4.259	0.000	77.673	863.70	1092	406.3	430.3
508.0	262.2	66.076	9.207	0.000	75.283	846.70	1089	404.3	431.5
501.6	262.2	59.110	13.782	0.000	72.892	828.00	1086	401.8	432.7
494.9	262.2	52.536	17.966	0.000	70.501	807.50	1083	398.8	433.9
487.7	262.2	46.369	21.741	0.000	68.111	785.00	1080	395.3	435.1
480.2	262.2	40.628	25.092	0.000	65.720	760.20	1077	391.0	436.3
472.1	262.2	35.327	28.002	0.000	63.329	732.90	1074	385.9	437.4
463.5	262.2	30.479	30.459	0.000	60.938	703.00	1071	380.0	438.5
454.4	262.2	26.092	32.456	0.000	58.548	670.40	1068	373.3	439.6
444.6	262.2	22.165	33.992	0.000	56.157	635.10	1066	365.54	440.63

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
522.3	262.2	214920.0	88.72	1.00	0.0	0.0	0.0	0.00	
518.9	262.2	214920.0	88.72	1.00	0.0	0.0	0.0	0.00	81.82
514.1	262.2	199090.0	87.02	0.93	15800.0	117.7	0.0	4.11	82.51
508.0	262.2	180210.0	84.78	0.84	34700.0	116.9	0.0	4.24	83.47
501.6	262.2	162170.0	82.40	0.75	52700.0	116.1	0.0	4.39	84.53
494.9	262.2	145020.0	79.84	0.67	69900.0	115.3	0.0	4.56	85.69
487.7	262.2	128820.0	77.09	0.60	86100.0	114.6	0.0	4.75	86.97
480.2	262.2	113620.0	74.13	0.53	101300.0	113.9	0.0	4.96	88.39
472.1	262.2	99490.0	70.94	0.46	115400.0	113.2	0.0	5.20	89.94
463.5	262.2	86460.0	67.52	0.40	128400.0	112.5	0.0	5.46	91.65
454.4	262.2	74570.0	63.86	0.35	140300.0	111.9	0.0	5.77	93.53
444.6	262.2	63830.0	59.97	0.30	151000.0	111.3	0.0	6.11	95.59

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
522.3	262.2	2.72		0.617	0.000	0.029		0.014	
518.9	262.2	2.74		0.617	0.000	0.028		0.014	
514.1	262.2	2.68	34.28	0.615	0.733	0.029	0.039	0.014	0.088
508.0	262.2	2.61	34.43	0.613	0.729	0.029	0.039	0.014	0.089
501.6	262.2	2.52	34.59	0.611	0.724	0.029	0.039	0.014	0.090
494.9	262.2	2.44	34.77	0.609	0.718	0.029	0.040	0.014	0.092
487.7	262.2	2.34	34.98	0.606	0.713	0.029	0.040	0.014	0.094
480.2	262.2	2.24	35.21	0.605	0.707	0.030	0.041	0.014	0.096
472.1	262.2	2.14	35.47	0.603	0.700	0.030	0.041	0.014	0.098
463.5	262.2	2.03	35.75	0.601	0.693	0.031	0.042	0.014	0.101
454.4	262.2	1.91	36.07	0.600	0.686	0.032	0.043	0.014	0.104
444.6	262.2	1.79	36.43	0.600	0.679	0.033	0.043	0.014	0.107

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2. Pag: 9 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

CONDENSATION CURVE TUBE SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
521.5	254.7	80.064	0.000	0.000	80.064	876.40		407.6	
515.8	254.7	79.317	0.000	0.000	79.317	876.40		407.6	
511.8	254.7	74.098	3.575	0.000	77.674	865.80	1094	406.5	430.0
505.8	254.7	66.798	8.485	0.000	75.283	849.00	1091	404.6	431.2
499.5	254.7	59.857	13.035	0.000	72.892	830.70	1087	402.2	432.4
492.8	254.7	53.292	17.209	0.000	70.501	810.60	1084	399.4	433.6
485.8	254.7	47.122	20.989	0.000	68.111	788.40	1081	395.9	434.9
478.3	254.7	41.362	24.357	0.000	65.720	764.10	1078	391.8	436.0
470.4	254.7	36.031	27.298	0.000	63.329	737.30	1075	386.9	437.2
461.9	254.7	31.140	29.798	0.000	60.938	707.90	1072	381.2	438.3
452.9	254.7	26.701	31.847	0.000	58.548	675.70	1069	374.6	439.4
443.3	254.7	22.715	33.442	0.000	56.157	640.90	1067	367.00	440.48

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
521.5	254.7	214920.0	88.72	1.00	0.0	0.0	0.0	0.00	
515.8	254.7	214920.0	88.72	1.00	0.0	0.0	0.0	0.00	82.98
511.8	254.7	201540.0	87.28	0.94	13300.0	118.0	0.0	4.26	83.55
505.8	254.7	182710.0	85.08	0.85	32200.0	117.2	0.0	4.39	84.48
499.5	254.7	164690.0	82.72	0.77	50200.0	116.4	0.0	4.54	85.50
492.8	254.7	147530.0	80.20	0.69	67400.0	115.6	0.0	4.70	86.62
485.8	254.7	131280.0	77.48	0.61	83600.0	114.9	0.0	4.88	87.86
478.3	254.7	116000.0	74.57	0.54	98900.0	114.1	0.0	5.09	89.22
470.4	254.7	101750.0	71.43	0.47	113100.0	113.4	0.0	5.32	90.72
461.9	254.7	88580.0	68.05	0.41	126300.0	112.7	0.0	5.58	92.38
452.9	254.7	76520.0	64.43	0.36	138400.0	112.1	0.0	5.88	94.19
443.3	254.7	65600.0	60.58	0.31	149300.0	111.5	0.0	6.22	96.19

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
521.5	254.7	2.63		0.615	0.000	0.029		0.014	
515.8	254.7	2.66		0.614	0.000	0.028		0.014	
511.8	254.7	2.61	34.45	0.612	0.729	0.028	0.039	0.014	0.089
505.8	254.7	2.54	34.59	0.610	0.725	0.028	0.039	0.014	0.091
499.5	254.7	2.46	34.75	0.608	0.720	0.029	0.040	0.014	0.092
492.8	254.7	2.38	34.93	0.606	0.715	0.029	0.040	0.014	0.094
485.8	254.7	2.29	35.12	0.604	0.710	0.029	0.040	0.014	0.095
478.3	254.7	2.19	35.35	0.603	0.704	0.029	0.041	0.014	0.097
470.4	254.7	2.09	35.59	0.601	0.698	0.030	0.041	0.014	0.100
461.9	254.7	1.99	35.87	0.600	0.691	0.030	0.042	0.014	0.102
452.9	254.7	1.87	36.18	0.599	0.684	0.031	0.043	0.014	0.105
443.3	254.7	1.76	36.53	0.598	0.677	0.032	0.043	0.014	0.109

Company: ECOPETROL SA

Rev: 1 Date: 11/04/24 Pag: 10 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C2

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

HTRI		HEAT EXCHANGER SPECIFICATION SHEET				Page 4	
		Released to the following company:				US Units	
		INTERCOL EPC					
		LEONARDO MOSQUERA					
Customer		Job No.					
Address		Reference No.					
Plant Location		Proposal No.					
Service of Unit		Date 05-10-2023				Rev 0	
Size 35 x 216 inch		Type BEU		Horizontal			
Surf/Unit (Gross/Eff) 5598,3 / 5154,5 ft2		Shell/Unit 2		Connected In 1		Parallel 2 Series	
				Surf/Shell (Gross/Eff) 2799,2 / 2577,2 ft2			
PERFORMANCE OF ONE UNIT							
Fluid Allocation		Shell Side		Tube Side			
Fluid Name		CDHDS FEED		CDHDS OVER HEAD			
Fluid Quantity, Total lb/hr		139259		177476			
Vapor (In/Out)		4546.6		24151		177476	
Liquid		134712		115108		97551	
Steam						79925	
Water							
Noncondensables							
Temperature (In/Out) F		367,00		457,00		472,00	
Specific Gravity		0,6089		0,5440		0,5612	
Viscosity cP		0,0160 V/L 0,1278		0,0140 V/L 0,0877		0,0130	
Molecular Weight						0,0130 V/L 0,0981	
Molecular Weight, Noncondensables							
Specific Heat Btu/lb-F		0,6177 V/L 0,6312		0,5909 V/L 0,7169		0,5970	
Thermal Conductivity Btu/hr-ft-F		0,0400 V/L 0,0480		0,0288 V/L 0,0410		0,0260	
Latent Heat Btu/lb		98,303		82,906		86,331	
Inlet Pressure psia		300,70		239,70		23,15	
Velocity ft/sec		2,31		3,019		15,000	
Pressure Drop, Allow/Calc psi		21,000		3,019		10,547	
Fouling Resistance (min) ft2-hr-F/Btu		0,00196		0,00098			
Heat Exchanged 10439516 Btu/hr		MTD (Corrected) 28,3 F					
Transfer Rate, Service 71,60 Btu/ft2-hr-F		Clean 139,58 Btu/ft2-hr-F		Actual 96,27 Btu/ft2-hr-F			
CONSTRUCTION OF ONE SHELL				Sketch (Bundle/Nozzle Orientation)			
Design/Test Pressure psig		Shell Side 550,00 /		Tube Side 425,00 / 15,000			
Design Temperature F		550,00		650,00			
No Passes per Shell		1		2			
Corrosion Allowance inch		0,1250		0,0000			
Connections In inch		1 @ 9,5620		1 @ 12,812			
Size & Rating Out inch		1 @ 9,5620		1 @ 12,812			
Rating Intermediate		@		@			
Tube No. 396U		OD 0,7500 inch		Thk(Avg) 0,0830 inch		Length 18,000 ft	
Tube Type Plain		Material SA-179 Tube (S) K01200		Tube pattern 90			
Shell SA-516 70 Pl. K02700		ID 35,000 OD 36,750 inch		Shell Cover SA-516 70 Pl. K02700 (Integ.)			
Channel or Bonnet SA-516 70 Pl. K02700		Channel Cover					
Tubesheet-Stationary Carbon steel		Tubesheet-Floating					
Floating Head Cover		Impingement Plate None					
Baffles-Cross Carbon steel		Type		%Cut (Diam) 22,5		Spacing(c/c) 12,500	
Baffles-Long		Seal Type		Inlet 23,730 inch			
Supports-Tube		U-Bend Carbon steel		Type Full support			
Bypass Seal Arrangement 4 pairs seal strips		Tube-Tubesheet Joint					
Expansion Joint		Type					
Rho-V2-Inlet Nozzle lb/ft-sec2		Bundle Entrance		Bundle Exit		lb/ft-sec2	
Gaskets-Shell Side Mtl. Jkt. Flat/Grafoil (SS)		Tube Side Mtl. Jkt. Flat/Grafoil (SS)					
- Floating Head							
Code Requirements ASME		TEMA Class					
Weight/Shell lb		Filled with Water lb		Bundle lb			
Remarks:							
1. TUBE-SHEET SA-266 GR 2-N							
2. HEAD CHANNEL SA-516 GR 60 + WELD OVER LAY							
Reprinted with Permission							

Company: ECO PETROL SA

Rev: 1 Date: 11/04/24 Pag: 11 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C2

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre



Output Summary

Page 1

Released to the following company:

INTERCOL EPC

LEONARDO MOSQUERA

Xist 9 (32 bit) 05/10/2023 19:11 SN: 46639-

US Units

Summary Unit

Rating - Horizontal

No Data Check Messages.

No Runtime Messages.

Process Conditions		Cold Shellside		Hot Tubeside	
Fluid name		CDHDS FEED		CDHDS OVER HEAD	
Total flow rate	(1000-lb/hr)		139,26		177,48
Inlet/Outlet Y	(Wt. frac vap.)	0,0326	0,1734	1,0000	0,5497
Inlet/Outlet T	(Deg F)	367,00	457,00	472,00	438,00
Inlet P/Avg	(psia)	300,70		239,70	234,42
dP/Allow.	(psi)	3,019	21,000	10,547	15,000
Fouling	(ft2-hr-F/Btu)		0,00196		0,00098

Exchanger Performance					
Shell h	(Btu/ft2-hr-F)	228,25	Actual U	(Btu/ft2-hr-F)	96,27
Tube h	(Btu/ft2-hr-F)	514,18	Required U	(Btu/ft2-hr-F)	71,60
Hot regime	(--)		Total duty	(MM Btu/hr)	10,440
Cold regime	(--)	Mixed No Phase Change	Eff. area	(ft2)	5154,5
EMTD	(Deg F)	28,3	Overdesign	(%)	34,45

Shell Geometry			Baffle Geometry		
TEMA type	(--)	BEU	Baffle type		
Shell ID	(inch)	35,000	Baffle cut	(Pct Dia.)	22,5
Series	(--)	2	Baffle orientation	(--)	Parallel
Parallel	(--)	1	Central spacing	(inch)	12,500
Orientation	(deg)	0,00	Crosspasses	(--)	15

Tube Geometry			Nozzles		
Tube type	(--)	Plain	Shell inlet	(inch)	9,5620
Tube OD	(inch)	0,7500	Shell outlet	(inch)	9,5620
Length	(ft)	18,000	Inlet height	(inch)	3,1172
Pitch ratio	(--)	1,3333	Outlet height	(inch)	3,1172
Layout	(deg)	90	Tube inlet	(inch)	12,812
Tubecount	(--)	792	Tube outlet	(inch)	12,812
Tube Pass	(--)	2			

Thermal Resistance; %		Velocities; ft/sec			Flow Fractions	
Shell	42,18		Min	Max	A	0,246
Tube	24,08	Tubeside	18,85	26,35	B	0,469
Fouling	30,95	Crossflow	1,30	3,75	C	0,046
Metal	2,79	Longitudinal	0,74	1,55	E	0,114
					F	0,125

Company: ECOPETROL SA

Rev: 1 Date: 11/04/24 Pag: 12 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C2

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

**Series Summary**

Page 2

Released to the following company:

INTERCOL EPC

LEONARDO MOSQUERA

Xist 9 (32 bit) 05/10/2023 19:11 SN: 46639-

US Units

Summary Unit

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

Shell #	1	2
Unit	Shell 1	Shell 2
Performance		
Overdesign (%)	33,80	35,14
Overall U (Btu/ft ² -hr-F)	99,38	93,15
Required U (Btu/ft ² -hr-F)	74,28	68,93
Unit Duty (MM Btu/hr)	3,4075	7,0321
Shellside h (Btu/ft ² -hr-F)	236,49	220,07
Tubeside h (Btu/ft ² -hr-F)	552,56	478,71
Shellside delta P (psi)	1,640	1,379
Tubeside delta P (psi)	5,137	5,410
EMTD (F)	17,8	39,6
Process Conditions		
Inlet T, Shell (F)	431,86	367,00
Outlet T, Shell (F)	457,00	431,86
Inlet T, Tube (F)	472,00	460,69
Outlet T, Tube (F)	460,69	438,00
Inlet Y, Shell (Wt. fraction)	0,0992	0,0326
Outlet Y, Shell (Wt. fraction)	0,1734	0,0992
Inlet Y, Tube (Wt. fraction)	1,0000	0,8478
Outlet Y, Tube (Wt. fraction)	0,8478	0,5497
Geometry		
Shell type (—)	E	E
Parallel (—)	1	1
Effective area (ft ²)	2577,2	2577,2
Shell orientation (—)	Horizontal	Horizontal
Shell ID (inch)	35,000	35,000
Shellside fluid (—)	Cold	Cold
Baffle type (—)	Single-Seg.	Single-Seg.
Baffle cut (Pct Dia.)	22,5	22,5
Baffle orientation (—)	Parallel	Parallel
Central spacing (inch)	12,500	12,500
Crosspasses (—)	15	15
Tube type (—)	Plain	Plain
Tube Pass (—)	2	2
Tubecount (—)	792	792
Tube length (ft)	18,000	18,000
Tube OD (inch)	0,7500	0,7500
Tube layout angle (—)	90	90
Pitch ratio (—)	1,3333	1,3333

Company: ECOPEPETROL SA

Rev: 1

Date: 11/04/2012 Pag: 13 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C2

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

VAPORIZATION CURVE SHELL SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
366.7	300.7	1.450	23.602	0.000	25.052	390.30	1024	296.6	454.8
377.7	300.7	1.717	24.387	0.000	26.104	426.60	1024	307.7	454.6
388.3	300.7	2.038	25.119	0.000	27.157	464.10	1025	319.0	454.5
398.7	300.7	2.426	25.783	0.000	28.209	502.60	1025	330.5	454.4
408.7	300.7	2.895	26.366	0.000	29.261	541.60	1026	342.0	454.2
418.4	300.7	3.463	26.850	0.000	30.314	580.60	1027	353.4	454.1
427.7	300.7	4.151	27.215	0.000	31.366	619.00	1028	364.4	453.9
436.5	300.7	4.981	27.437	0.000	32.418	656.30	1029	375.0	453.6
444.9	300.7	5.977	27.493	0.000	33.470	692.00	1031	385.0	453.3
452.9	300.7	7.163	27.360	0.000	34.523	725.60	1032	394.1	453.0
460.3	300.7	8.560	27.015	0.000	35.575	756.70	1034	402.3	452.6

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
366.7	300.7	4530.0	34.67	0.03	134700.0	104.2	0.0	8.10	106.70
377.7	300.7	5340.0	38.33	0.04	133900.0	104.3	0.0	7.57	103.46
388.3	300.7	6300.0	42.14	0.05	132900.0	104.4	0.0	7.08	100.38
398.7	300.7	7470.0	46.07	0.05	131700.0	104.5	0.0	6.60	97.47
408.7	300.7	8860.0	50.06	0.06	130400.0	104.6	0.0	6.16	94.72
418.4	300.7	10550.0	54.07	0.08	128700.0	104.8	0.0	5.74	92.14
427.7	300.7	12570.0	58.05	0.09	126600.0	105.0	0.0	5.36	89.73
436.5	300.7	14990.0	61.94	0.11	124200.0	105.2	0.0	5.00	87.47
444.9	300.7	17880.0	65.68	0.13	121300.0	105.4	0.0	4.68	85.38
452.9	300.7	21310.0	69.24	0.15	117900.0	105.7	0.0	4.38	83.46
460.3	300.7	25310.0	72.57	0.18	113900.0	106.0	0.0	4.12	81.69

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
366.7	300.7	1.21	38.01	0.618	0.631	0.040	0.048	0.016	0.128
377.7	300.7	1.34	37.53	0.608	0.639	0.039	0.047	0.016	0.122
388.3	300.7	1.47	37.05	0.600	0.648	0.038	0.046	0.016	0.117
398.7	300.7	1.60	36.57	0.594	0.657	0.037	0.045	0.015	0.112
408.7	300.7	1.74	36.11	0.590	0.666	0.035	0.045	0.015	0.107
418.4	300.7	1.89	35.67	0.588	0.676	0.034	0.044	0.015	0.103
427.7	300.7	2.04	35.24	0.587	0.685	0.033	0.043	0.015	0.099
436.5	300.7	2.19	34.84	0.587	0.694	0.031	0.042	0.014	0.095
444.9	300.7	2.35	34.46	0.588	0.703	0.030	0.042	0.014	0.092
452.9	300.7	2.50	34.11	0.590	0.712	0.029	0.041	0.014	0.089
460.3	300.7	2.64	33.79	0.593	0.721	0.029	0.041	0.014	0.086

Company: ECOPETROL SA

Rev: 1

Date: 11/04/24 Page: 14 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C2

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

VAPORIZATION CURVE SHELL SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
366.4	290.2	1.530	23.522	0.000	25.052	400.00	1025	299.7	454.9
377.3	290.2	1.815	24.289	0.000	26.104	436.90	1025	310.9	454.8
387.9	290.2	2.159	24.997	0.000	27.157	475.10	1026	322.4	454.7
398.2	290.2	2.575	25.634	0.000	28.209	514.00	1027	334.0	454.5
408.1	290.2	3.079	26.183	0.000	29.261	553.40	1027	345.6	454.4
417.6	290.2	3.688	26.625	0.000	30.314	592.50	1028	357.0	454.2
426.8	290.2	4.425	26.940	0.000	31.366	630.80	1029	368.0	453.9
435.5	290.2	5.313	27.106	0.000	32.418	667.90	1031	378.5	453.7
443.7	290.2	6.374	27.097	0.000	33.470	703.00	1032	388.2	453.4
451.4	290.2	7.631	26.892	0.000	34.523	735.90	1034	397.1	453.0
458.7	290.2	9.102	26.473	0.000	35.575	766.20	1035	405.1	452.5

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
366.4	290.2	4800.0	35.63	0.03	134400.0	104.3	0.0	8.15	106.67
377.3	290.2	5660.0	39.36	0.04	133500.0	104.4	0.0	7.63	103.55
387.9	290.2	6710.0	43.24	0.05	132500.0	104.5	0.0	7.14	100.59
398.2	290.2	7960.0	47.21	0.06	131300.0	104.6	0.0	6.67	97.80
408.1	290.2	9460.0	51.24	0.07	129800.0	104.8	0.0	6.24	95.16
417.6	290.2	11270.0	55.27	0.08	127900.0	104.9	0.0	5.83	92.69
426.8	290.2	13440.0	59.24	0.10	125800.0	105.1	0.0	5.45	90.39
435.5	290.2	16040.0	63.11	0.12	123200.0	105.4	0.0	5.10	88.24
443.7	290.2	19130.0	66.81	0.14	120100.0	105.6	0.0	4.79	86.26
451.4	290.2	22770.0	70.30	0.16	116400.0	105.9	0.0	4.50	84.43
458.7	290.2	27000.0	73.55	0.19	112200.0	106.3	0.0	4.25	82.77

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
366.4	290.2	1.21	38.04	0.613	0.631	0.040	0.048	0.016	0.128
377.3	290.2	1.33	37.56	0.603	0.639	0.039	0.047	0.016	0.123
387.9	290.2	1.46	37.08	0.596	0.648	0.037	0.046	0.015	0.117
398.2	290.2	1.59	36.62	0.591	0.657	0.036	0.046	0.015	0.112
408.1	290.2	1.73	36.17	0.587	0.666	0.035	0.045	0.015	0.108
417.6	290.2	1.87	35.73	0.585	0.675	0.033	0.044	0.015	0.104
426.8	290.2	2.02	35.32	0.584	0.684	0.032	0.043	0.015	0.100
435.5	290.2	2.17	34.93	0.585	0.693	0.031	0.042	0.014	0.096
443.7	290.2	2.31	34.56	0.586	0.702	0.030	0.042	0.014	0.093
451.4	290.2	2.45	34.22	0.588	0.710	0.029	0.041	0.014	0.090
458.7	290.2	2.59	33.92	0.590	0.719	0.028	0.041	0.014	0.088

Company: ECOPETROL SA

Rev: 1

Date: 11/04/24 Pag: 15 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C2

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

VAPORIZATION CURVE SHELL SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
366.1	279.7	1.617	23.435	0.000	25.052	410.30	1026	303.0	455.1
376.9	279.7	1.923	24.182	0.000	26.104	447.90	1026	314.4	455.0
387.4	279.7	2.292	24.865	0.000	27.157	486.60	1027	326.1	454.8
397.6	279.7	2.738	25.471	0.000	28.209	526.00	1028	337.8	454.7
407.4	279.7	3.279	25.982	0.000	29.261	565.60	1029	349.4	454.5
416.8	279.7	3.934	26.380	0.000	30.314	604.80	1030	360.8	454.3
425.8	279.7	4.724	26.642	0.000	31.366	643.00	1031	371.7	454.0
434.3	279.7	5.672	26.746	0.000	32.418	679.60	1032	382.0	453.7
442.4	279.7	6.801	26.669	0.000	33.470	714.20	1034	391.5	453.3
449.9	279.7	8.132	26.391	0.000	34.523	746.30	1035	400.2	452.9
456.9	279.7	9.679	25.896	0.000	35.575	775.60	1037	407.8	452.4

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
366.1	279.7	5090.0	36.65	0.04	134100.0	104.4	0.0	8.21	106.71
376.9	279.7	6030.0	40.45	0.04	133200.0	104.5	0.0	7.69	103.71
387.4	279.7	7150.0	44.39	0.05	132100.0	104.6	0.0	7.21	100.86
397.6	279.7	8490.0	48.41	0.06	130700.0	104.8	0.0	6.75	98.18
407.4	279.7	10110.0	52.47	0.07	129100.0	104.9	0.0	6.32	95.66
416.8	279.7	12060.0	56.51	0.09	127200.0	105.1	0.0	5.92	93.30
425.8	279.7	14400.0	60.47	0.10	124800.0	105.3	0.0	5.55	91.09
434.3	279.7	17180.0	64.30	0.12	122000.0	105.6	0.0	5.21	89.05
442.4	279.7	20480.0	67.94	0.15	118700.0	105.8	0.0	4.90	87.17
449.9	279.7	24340.0	71.36	0.17	114900.0	106.2	0.0	4.63	85.45
456.9	279.7	28810.0	74.52	0.21	110400.0	106.5	0.0	4.39	83.89

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
366.1	279.7	1.20	38.07	0.608	0.630	0.039	0.048	0.016	0.129
376.9	279.7	1.32	37.59	0.599	0.639	0.038	0.047	0.015	0.123
387.4	279.7	1.44	37.12	0.592	0.648	0.037	0.047	0.015	0.118
397.6	279.7	1.58	36.67	0.587	0.657	0.035	0.046	0.015	0.113
407.4	279.7	1.71	36.22	0.584	0.665	0.034	0.045	0.015	0.109
416.8	279.7	1.85	35.80	0.582	0.674	0.033	0.044	0.015	0.104
425.8	279.7	1.99	35.40	0.582	0.683	0.031	0.043	0.014	0.101
434.3	279.7	2.13	35.02	0.582	0.692	0.030	0.043	0.014	0.097
442.4	279.7	2.27	34.67	0.584	0.700	0.029	0.042	0.014	0.094
449.9	279.7	2.41	34.35	0.585	0.708	0.028	0.041	0.014	0.091
456.9	279.7	2.54	34.05	0.588	0.716	0.028	0.041	0.014	0.089

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2. Pag: 16 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C2

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

CONDENSATION CURVE TUBE SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
472.2	239.7	61.213	0.000	0.000	61.213	868.90		419.3	
470.7	239.7	61.049	0.000	0.000	61.049	868.90		419.3	
468.6	239.7	58.270	1.890	0.000	60.160	862.40	1050	418.5	444.2
466.1	239.7	55.047	4.061	0.000	59.108	854.40	1049	417.3	444.8
463.5	239.7	51.899	6.157	0.000	58.056	845.80	1047	416.0	445.5
460.8	239.7	48.829	8.175	0.000	57.003	836.80	1046	414.5	446.1
458.0	239.7	45.841	10.110	0.000	55.951	827.10	1045	412.9	446.8
455.1	239.7	42.939	11.960	0.000	54.899	816.90	1044	411.0	447.4
452.0	239.7	40.125	13.722	0.000	53.847	806.00	1043	409.0	448.0
448.9	239.7	37.403	15.391	0.000	52.794	794.30	1041	406.7	448.6
445.6	239.7	34.778	16.964	0.000	51.742	782.00	1040	404.2	449.2
442.1	239.7	32.252	18.437	0.000	50.690	768.80	1039	401.44	449.82

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
472.2	239.7	177480.0	85.43	1.00	0.0	0.0	0.0	0.00	
470.7	239.7	177480.0	85.43	1.00	0.0	0.0	0.0	0.00	86.39
468.6	239.7	169760.0	84.63	0.96	7700.0	108.0	0.0	4.38	86.75
466.1	239.7	160780.0	83.64	0.91	16700.0	107.7	0.0	4.44	87.22
463.5	239.7	151980.0	82.60	0.86	25400.0	107.4	0.0	4.51	87.71
460.8	239.7	143380.0	81.51	0.81	34100.0	107.1	0.0	4.58	88.22
458.0	239.7	134980.0	80.37	0.76	42500.0	106.8	0.0	4.66	88.77
455.1	239.7	126790.0	79.17	0.71	50600.0	106.5	0.0	4.74	89.34
452.0	239.7	118830.0	77.90	0.67	58600.0	106.2	0.0	4.83	89.94
448.9	239.7	111100.0	76.57	0.63	66300.0	106.0	0.0	4.93	90.58
445.6	239.7	103630.0	75.17	0.58	73800.0	105.7	0.0	5.03	91.26
442.1	239.7	96410.0	73.69	0.54	81000.0	105.4	0.0	5.14	91.97

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
472.2	239.7	2.54		0.597	0.000	0.026		0.013	
470.7	239.7	2.55		0.597	0.000	0.026		0.013	
468.6	239.7	2.52	33.92	0.596	0.736	0.026	0.040	0.013	0.089
466.1	239.7	2.48	33.99	0.595	0.733	0.026	0.041	0.013	0.089
463.5	239.7	2.45	34.07	0.594	0.731	0.026	0.041	0.013	0.090
460.8	239.7	2.41	34.15	0.592	0.728	0.026	0.041	0.013	0.091
458.0	239.7	2.37	34.24	0.591	0.726	0.026	0.041	0.013	0.091
455.1	239.7	2.33	34.34	0.590	0.723	0.026	0.041	0.013	0.092
452.0	239.7	2.28	34.44	0.589	0.720	0.026	0.042	0.013	0.093
448.9	239.7	2.24	34.54	0.588	0.717	0.027	0.042	0.013	0.094
445.6	239.7	2.19	34.66	0.586	0.714	0.027	0.042	0.013	0.095
442.1	239.7	2.14	34.78	0.585	0.711	0.027	0.042	0.013	0.096

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2. Pag: 17 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C2

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

CONDENSATION CURVE TUBE SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
471.3	232.2	61.213	0.000	0.000	61.213	868.90		419.3	
467.4	232.2	60.796	0.000	0.000	60.796	868.90		419.3	
465.9	232.2	58.830	1.331	0.000	60.160	864.30	1051	418.7	443.8
463.4	232.2	55.631	3.477	0.000	59.108	856.40	1050	417.6	444.5
460.8	232.2	52.504	5.552	0.000	58.056	848.10	1048	416.4	445.2
458.2	232.2	49.451	7.552	0.000	57.003	839.20	1047	414.9	445.8
455.4	232.2	46.477	9.474	0.000	55.951	829.80	1046	413.4	446.5
452.6	232.2	43.584	11.315	0.000	54.899	819.80	1045	411.6	447.1
449.6	232.2	40.776	13.071	0.000	53.847	809.10	1044	409.6	447.7
446.5	232.2	38.056	14.738	0.000	52.794	797.80	1043	407.5	448.4
443.3	232.2	35.428	16.314	0.000	51.742	785.70	1041	405.1	449.0
439.9	232.2	32.895	17.794	0.000	50.690	772.80	1040	402.39	449.60

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
471.3	232.2	177480.0	85.43	1.00	0.0	0.0	0.0	0.00	
467.4	232.2	177480.0	85.43	1.00	0.0	0.0	0.0	0.00	87.63
465.9	232.2	171990.0	84.86	0.97	5400.0	108.2	0.0	4.53	87.88
463.4	232.2	163060.0	83.89	0.92	14400.0	107.9	0.0	4.60	88.33
460.8	232.2	154290.0	82.87	0.87	23100.0	107.6	0.0	4.66	88.81
458.2	232.2	145710.0	81.80	0.82	31700.0	107.3	0.0	4.74	89.30
455.4	232.2	137330.0	80.68	0.77	40100.0	107.0	0.0	4.81	89.83
452.6	232.2	129140.0	79.50	0.73	48300.0	106.7	0.0	4.89	90.38
449.6	232.2	121170.0	78.26	0.68	56300.0	106.4	0.0	4.98	90.96
446.5	232.2	113430.0	76.95	0.64	64000.0	106.2	0.0	5.07	91.57
443.3	232.2	105920.0	75.58	0.60	71500.0	105.9	0.0	5.17	92.22
439.9	232.2	98660.0	74.12	0.56	78800.0	105.6	0.0	5.28	92.91

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
471.3	232.2	2.44		0.595	0.000	0.026		0.013	
467.4	232.2	2.46		0.594	0.000	0.025		0.013	
465.9	232.2	2.44	34.09	0.593	0.732	0.026	0.041	0.013	0.090
463.4	232.2	2.41	34.16	0.592	0.729	0.026	0.041	0.013	0.091
460.8	232.2	2.38	34.24	0.591	0.727	0.026	0.041	0.013	0.091
458.2	232.2	2.34	34.32	0.590	0.725	0.026	0.041	0.013	0.092
455.4	232.2	2.30	34.40	0.589	0.722	0.026	0.041	0.013	0.093
452.6	232.2	2.26	34.49	0.587	0.720	0.026	0.042	0.013	0.094
449.6	232.2	2.22	34.59	0.586	0.717	0.026	0.042	0.013	0.094
446.5	232.2	2.18	34.70	0.585	0.714	0.026	0.042	0.013	0.095
443.3	232.2	2.14	34.81	0.584	0.711	0.027	0.042	0.013	0.096
439.9	232.2	2.09	34.93	0.583	0.708	0.027	0.042	0.013	0.097

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2. Pag: 18 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S1C2

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

CONDENSATION CURVE TUBE SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
470.4	224.7	61.213	0.000	0.000	61.213	868.90		419.3	
463.9	224.7	60.535	0.000	0.000	60.535	868.90		419.3	
463.1	224.7	59.390	0.771	0.000	60.161	866.20	1052	419.0	443.5
460.6	224.7	56.216	2.892	0.000	59.108	858.50	1051	417.9	444.2
458.1	224.7	53.110	4.945	0.000	58.056	850.40	1049	416.7	444.8
455.5	224.7	50.076	6.927	0.000	57.003	841.70	1048	415.4	445.5
452.8	224.7	47.117	8.834	0.000	55.951	832.50	1047	413.9	446.2
450.0	224.7	44.235	10.664	0.000	54.899	822.70	1046	412.2	446.8
447.1	224.7	41.433	12.413	0.000	53.847	812.30	1045	410.3	447.5
444.1	224.7	38.716	14.078	0.000	52.794	801.20	1044	408.2	448.1
440.9	224.7	36.087	15.655	0.000	51.742	789.40	1042	405.9	448.7
437.6	224.7	33.549	17.140	0.000	50.690	776.80	1041	403.33	449.35

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
470.4	224.7	177480.0	85.43	1.00	0.0	0.0	0.0	0.00	
463.9	224.7	177480.0	85.43	1.00	0.0	0.0	0.0	0.00	88.89
463.1	224.7	174270.0	85.10	0.98	3200.0	108.4	0.0	4.70	89.02
460.6	224.7	165380.0	84.14	0.93	12100.0	108.1	0.0	4.76	89.46
458.1	224.7	156650.0	83.14	0.88	20800.0	107.8	0.0	4.82	89.91
455.5	224.7	148090.0	82.09	0.83	29300.0	107.5	0.0	4.89	90.39
452.8	224.7	139720.0	80.99	0.79	37700.0	107.2	0.0	4.97	90.90
450.0	224.7	131540.0	79.83	0.74	45900.0	106.9	0.0	5.05	91.43
447.1	224.7	123560.0	78.61	0.70	53900.0	106.6	0.0	5.13	91.99
444.1	224.7	115800.0	77.33	0.65	61600.0	106.4	0.0	5.22	92.58
440.9	224.7	108270.0	75.98	0.61	69200.0	106.1	0.0	5.32	93.20
437.6	224.7	100970.0	74.56	0.57	76500.0	105.8	0.0	5.42	93.86

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
470.4	224.7	2.35		0.592	0.000	0.026		0.013	
463.9	224.7	2.38		0.591	0.000	0.025		0.013	
463.1	224.7	2.37	34.27	0.590	0.727	0.025	0.041	0.013	0.092
460.6	224.7	2.34	34.34	0.589	0.725	0.025	0.041	0.013	0.092
458.1	224.7	2.30	34.41	0.588	0.723	0.025	0.041	0.013	0.093
455.5	224.7	2.27	34.49	0.587	0.721	0.026	0.041	0.013	0.094
452.8	224.7	2.24	34.57	0.586	0.718	0.026	0.042	0.013	0.094
450.0	224.7	2.20	34.66	0.585	0.716	0.026	0.042	0.013	0.095
447.1	224.7	2.16	34.75	0.584	0.713	0.026	0.042	0.013	0.096
444.1	224.7	2.12	34.85	0.583	0.711	0.026	0.042	0.013	0.097
440.9	224.7	2.08	34.96	0.582	0.708	0.026	0.042	0.013	0.098
437.6	224.7	2.03	35.07	0.581	0.705	0.026	0.043	0.013	0.099

Company: ECOPETROL SA

Rev: 1 Date: 11/04/24 Pag: 19 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S2C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre



HEAT EXCHANGER SPECIFICATION SHEET

Page 4

Released to the following company:

US Units

INTERCOL EPC
LEONARDO MOSQUERA

Job No.

Customer

Reference No.

Address

Proposal No.

Plant Location

Date 05-10-2023

Rev 0

Service of Unit

Item No.

Size 35 x 216 inch Type BEU Horizontal

Connected In 1 Parallel 2 Series

Surf/Unit (Gross/Eff) 5598,3 / 5154,5 ft2

Shell/Unit 2

Surf/Shell (Gross/Eff) 2799,2 / 2577,2 ft2

PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		CDHDS FEED		CDHDS OVER HEAD	
Fluid Quantity, Total lb/hr		193447		238208	
Vapor (In/Out)		6371,8	65436	238208	73433
Liquid		187075	128011		164775
Steam					
Water					
Noncondensables					
Temperature (In/Out)	F	312,00	483,00	514,00	433,00
Specific Gravity		0,6672	0,5620		0,5845
Viscosity	cP	0,0160 V/L	0,0150 V/L	0,0140	0,0140 V/L
Molecular Weight					
Molecular Weight, Noncondensables					
Specific Heat	Btu/lb-F	0,7487 V/L	0,5993 V/L	0,6180	0,5940 V/L
Thermal Conductivity	Btu/hr-ft-F	0,0480 V/L	0,0321 V/L	0,0280	0,0310 V/L
Latent Heat	Btu/lb	118,99	84,250	81,960	95,541
Inlet Pressure	psia	330,70		269,70	
Velocity	ft/sec	5,01		25,01	
Pressure Drop, Allow/Calc	psi	21,000	7,232	15,000	15,519
Fouling Resistance (min)	ft2-hr-F/Btu	0,00196		0,00098	
Heat Exchanged	26452461 Btu/hr			MTD (Corrected) 49,5 F	
Transfer Rate, Service	103,74 Btu/ft2-hr-F	Clean 163,38 Btu/ft2-hr-F		Actual 106,84 Btu/ft2-hr-F	

CONSTRUCTION OF ONE SHELL

Sketch (Bundle/Nozzle Orientation)

		Shell Side		Tube Side	
Design/Test Pressure	psig	550,00 /		425,00 /	
Design Temperature	F	550,00		650,00	
No Passes per Shell		1		2	
Corrosion Allowance	inch	0,1250		0,0000	
Connections	In inch	1 @	9,5620	1 @	12,812
Size & Rating	Out inch	1 @	9,5620	1 @	12,812
	Intermediate	@		@	
Tube No.	396U	OD	0,7500 inch	Thk(Avg)	0,0830 inch
Tube Type	Plain			Length	18,000 ft
Tube Type	Plain			Pitch	1,0000 inch
Shell	SA-516 70 Pl. K02700	ID	35,000	Material	SA-179 Tube (S) K01200
Channel or Bonnet	SA-516 70 Pl. K02700	OD	36,750 inch	Shell Cover	SA-516 70 Pl. K02700 (Integ.)
Tubesheet-Stationary	Carbon steel			Channel Cover	
Floating Head Cover				Tubesheet-Floating	
Baffles-Cross	Carbon steel	Type		Impingement Plate	None
Baffles-Long				%Cut (Diam)	22,5
Supports-Tube				Spacing(c/c)	12,500
Bypass Seal Arrangement	4 pairs seal strips			Inlet	23,730 inch
Expansion Joint				Seal Type	
Rho-V2-Inlet Nozzle	lb/ft-sec2			U-Bend	Carbon steel
Gaskets-Shell Side	Mtl. Jkt. Flat/Grafoil (SS)			Tube-Tubesheet Joint	Expanded and strength welded
- Floating Head				Type	
Code Requirements	ASME			Bundle Entrance	
Weight/Shell	lb	Filled with Water	lb	Bundle Exit	
				lb/ft-sec2	

Remarks:

1. TUBE-SHEET SA-266 GR 2-N
2. HEAD CHANNEL SA-516 GR 60 + WELD OVER LAY

Reprinted with Permission

Company: ECOPETROL SA

Rev: 1 Date: 11/04/24 Pag: 20 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S2C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre



Output Summary

Page 1

Released to the following company:

INTERCOL EPC

LEONARDO MOSQUERA

Xist 9 (32 bit) 05/10/2023 19:00 SN: 46639-

US Units

Summary Unit

Rating - Horizontal

No Data Check Messages.

No Runtime Messages.

Process Conditions		Cold Shellside		Hot Tubeside	
Fluid name		CDHDS FEED		CDHDS OVER HEAD	
Total flow rate	(1000-lb/hr)		193,45		238,21
Inlet/Outlet Y	(Wt. frac vap.)	0,0329	0,3383	1,0000	0,3083
Inlet/Outlet T	(Deg F)	312,00	483,00	514,00	433,00
Inlet P/Avg	(psia)	330,70		269,70	261,94
dP/Allow.	(psi)	7,232	21,000	15,519	15,000
Fouling	(ft2-hr-F/Btu)		0,00196		0,00098

Exchanger Performance					
Shell h	(Btu/ft2-hr-F)	302,25	Actual U	(Btu/ft2-hr-F)	106,84
Tube h	(Btu/ft2-hr-F)	505,85	Required U	(Btu/ft2-hr-F)	103,74
Hot regime	(--)		Total duty	(MM Btu/hr)	26,453
Cold regime	(--)	Mixed No Phase Change	Eff. area	(ft2)	5154,5
EMTD	(Deg F)	49,5	Overdesign	(%)	2,98

Shell Geometry		Baffle Geometry	
TEMA type	(--)	BEU	
Shell ID	(inch)	35,000	
Series	(--)	2	
Parallel	(--)	1	
Orientation	(deg)	0,00	
Baffle type			
Baffle cut	(Pct Dia.)	22,5	
Baffle orientation	(--)	Parallel	
Central spacing	(inch)	12,500	
Crosspasses	(--)	15	

Tube Geometry		Nozzles	
Tube type	(--)	Plain	
Tube OD	(inch)	0,7500	
Length	(ft)	18,000	
Pitch ratio	(--)	1,3333	
Layout	(deg)	90	
Tubecount	(--)	792	
Tube Pass	(--)	2	
Shell inlet	(inch)	9,5620	
Shell outlet	(inch)	9,5620	
Inlet height	(inch)	3,1172	
Outlet height	(inch)	3,1172	
Tube inlet	(inch)	12,812	
Tube outlet	(inch)	12,812	

Thermal Resistance; %		Velocities; ft/sec		Flow Fractions	
Shell	35,36	Min	Max	A	0,249
Tube	27,27	Tubeside	17,52 32,11	B	0,482
Fouling	34,24	Crossflow	2,42 8,73	C	0,047
Metal	3,13	Longitudinal	1,41 3,73	E	0,115
				F	0,106

Company: ECOPETROL SA

Rev: 1 Date: 11/04/24 Pag: 21 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S2C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

**Series Summary**

Page 2

Released to the following company:

 INTERCOL EPC
 LEONARDO MOSQUERA

Xist 9 (32 bit) 05/10/2023 19:00 SN: 46639-

US Units

Summary Unit

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

Shell #	1	2
Unit	Shell 1	Shell 2
Performance		
Overdesign (%)	2,58	3,45
Overall U (Btu/ft ² -hr-F)	113,76	99,91
Required U (Btu/ft ² -hr-F)	110,90	96,58
Unit Duty (MM Btu/hr)	9,7769	16,676
Shellside h (Btu/ft ² -hr-F)	323,26	281,44
Tubeside h (Btu/ft ² -hr-F)	588,42	436,15
Shellside delta P (psi)	4,319	2,912
Tubeside delta P (psi)	8,524	6,995
EMTD (F)	34,2	67,0
Process Conditions		
Inlet T, Shell (F)	431,05	312,00
Outlet T, Shell (F)	483,00	431,05
Inlet T, Tube (F)	514,00	486,92
Outlet T, Tube (F)	486,92	433,00
Inlet Y, Shell (Wt. fraction)	0,1539	0,0329
Outlet Y, Shell (Wt. fraction)	0,3383	0,1539
Inlet Y, Tube (Wt. fraction)	1,0000	0,7033
Outlet Y, Tube (Wt. fraction)	0,7033	0,3083
Geometry		
Shell type (--)	E	E
Parallel (--)	1	1
Effective area (ft ²)	2577,2	2577,2
Shell orientation (--)	Horizontal	Horizontal
Shell ID (inch)	35,000	35,000
Shellside fluid (--)	Cold	Cold
Baffle type (--)	Single-Seg.	Single-Seg.
Baffle cut (Pct Dia.)	22,5	22,5
Baffle orientation (--)	Parallel	Parallel
Central spacing (inch)	12,500	12,500
Crosspasses (--)	15	15
Tube type (--)	Plain	Plain
Tube Pass (--)	2	2
Tubecount (--)	792	792
Tube length (ft)	18,000	18,000
Tube OD (inch)	0,7500	0,7500
Tube layout angle (--)	90	90
Pitch ratio (--)	1,3333	1,3333

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2 Pag: 22 de 24

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S2C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

VAPORIZATION CURVE SHELL SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
311.9	330.7	2.073	26.035	0.000	28.108	227.90	1045	250.2	453.5
333.5	330.7	2.691	28.082	0.000	30.773	269.40	1046	263.7	453.0
354.2	330.7	3.486	29.952	0.000	33.438	315.60	1046	278.5	452.3
374.1	330.7	4.505	31.599	0.000	36.103	365.70	1048	294.1	451.6
393.0	330.7	5.805	32.963	0.000	38.768	418.60	1049	310.2	450.9
411.0	330.7	7.454	33.980	0.000	41.433	472.90	1051	326.3	450.0
428.0	330.7	9.524	34.574	0.000	44.099	527.00	1054	341.8	449.1
444.0	330.7	12.090	34.673	0.000	46.764	579.50	1057	356.2	448.0
459.1	330.7	15.221	34.208	0.000	49.429	629.00	1061	369.2	446.7
473.1	330.7	18.972	33.122	0.000	52.094	674.70	1065	380.5	445.3
486.2	330.7	23.379	31.380	0.000	54.759	716.20	1069	390.0	443.8

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
311.9	330.7	6360.0	18.05	0.03	187000.0	108.8	0.0	11.82	122.32
333.5	330.7	8230.0	22.14	0.04	185200.0	109.0	0.0	10.73	117.06
354.2	330.7	10620.0	26.74	0.05	182800.0	109.2	0.0	9.71	112.00
374.1	330.7	13650.0	31.78	0.07	179800.0	109.5	0.0	8.77	107.16
393.0	330.7	17460.0	37.16	0.09	175900.0	109.9	0.0	7.91	102.57
411.0	330.7	22210.0	42.75	0.11	171200.0	110.3	0.0	7.13	98.26
428.0	330.7	28100.0	48.41	0.15	165300.0	110.9	0.0	6.43	94.25
444.0	330.7	35300.0	53.99	0.18	158100.0	111.6	0.0	5.82	90.58
459.1	330.7	43960.0	59.35	0.23	149400.0	112.3	0.0	5.28	87.24
473.1	330.7	54190.0	64.41	0.28	139200.0	113.2	0.0	4.82	84.25
486.2	330.7	66040.0	69.11	0.34	127400.0	114.2	0.0	4.42	81.59

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
311.9	330.7	0.72	41.64	0.749	0.573	0.048	0.054	0.016	0.176
333.5	330.7	0.87	40.81	0.697	0.586	0.046	0.052	0.016	0.160
354.2	330.7	1.03	40.00	0.661	0.598	0.044	0.050	0.016	0.148
374.1	330.7	1.20	39.21	0.635	0.611	0.042	0.049	0.016	0.138
393.0	330.7	1.39	38.45	0.618	0.624	0.041	0.047	0.016	0.128
411.0	330.7	1.60	37.72	0.607	0.637	0.039	0.045	0.016	0.120
428.0	330.7	1.80	37.03	0.601	0.649	0.038	0.044	0.016	0.112
444.0	330.7	2.01	36.41	0.598	0.661	0.036	0.043	0.015	0.106
459.1	330.7	2.22	35.84	0.597	0.673	0.035	0.042	0.015	0.100
473.1	330.7	2.42	35.34	0.599	0.685	0.033	0.041	0.015	0.095
486.2	330.7	2.62	34.90	0.601	0.696	0.032	0.040	0.015	0.091

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2 Page: 23 de 24

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S2C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

VAPORIZATION CURVE SHELL SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
311.7	320.2	2.134	25.974	0.000	28.108	232.50	1046	251.8	453.7
333.2	320.2	2.776	27.997	0.000	30.773	274.90	1047	265.6	453.1
353.9	320.2	3.602	29.836	0.000	33.438	322.00	1048	280.6	452.4
373.6	320.2	4.662	31.441	0.000	36.103	372.80	1049	296.5	451.7
392.5	320.2	6.014	32.755	0.000	38.768	426.30	1051	312.7	450.9
410.3	320.2	7.726	33.707	0.000	41.433	480.80	1053	328.8	450.0
427.1	320.2	9.871	34.227	0.000	44.099	535.00	1055	344.2	449.0
443.0	320.2	12.522	34.241	0.000	46.764	587.20	1059	358.5	447.9
457.8	320.2	15.743	33.686	0.000	49.429	636.20	1063	371.3	446.6
471.7	320.2	19.582	32.511	0.000	52.094	681.30	1067	382.3	445.1
484.6	320.2	24.070	30.689	0.000	54.759	721.90	1071	391.6	443.5

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
311.7	320.2	6580.0	18.49	0.03	186800.0	108.9	0.0	11.86	122.15
333.2	320.2	8540.0	22.67	0.04	184900.0	109.1	0.0	10.78	116.99
353.9	320.2	11030.0	27.36	0.06	182400.0	109.3	0.0	9.77	112.03
373.6	320.2	14180.0	32.48	0.07	179200.0	109.7	0.0	8.83	107.29
392.5	320.2	18150.0	37.92	0.09	175200.0	110.1	0.0	7.99	102.81
410.3	320.2	23110.0	43.55	0.12	170300.0	110.5	0.0	7.22	98.62
427.1	320.2	29220.0	49.22	0.15	164200.0	111.1	0.0	6.54	94.73
443.0	320.2	36680.0	54.78	0.19	156700.0	111.8	0.0	5.93	91.17
457.8	320.2	45600.0	60.10	0.24	147800.0	112.6	0.0	5.41	87.96
471.7	320.2	56090.0	65.10	0.29	137300.0	113.5	0.0	4.96	85.09
484.6	320.2	68180.0	69.73	0.35	125200.0	114.5	0.0	4.57	82.54

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
311.7	320.2	0.72	41.65	0.741	0.573	0.048	0.054	0.016	0.176
333.2	320.2	0.86	40.84	0.691	0.586	0.046	0.052	0.016	0.161
353.9	320.2	1.02	40.03	0.655	0.598	0.044	0.050	0.016	0.149
373.6	320.2	1.19	39.25	0.631	0.611	0.042	0.049	0.016	0.138
392.5	320.2	1.38	38.50	0.615	0.623	0.040	0.047	0.016	0.129
410.3	320.2	1.58	37.78	0.604	0.636	0.039	0.045	0.016	0.121
427.1	320.2	1.78	37.12	0.598	0.648	0.037	0.044	0.015	0.113
443.0	320.2	1.98	36.51	0.596	0.660	0.035	0.043	0.015	0.107
457.8	320.2	2.18	35.96	0.595	0.672	0.034	0.042	0.015	0.102
471.7	320.2	2.38	35.47	0.597	0.683	0.033	0.041	0.015	0.097
484.6	320.2	2.56	35.05	0.599	0.694	0.032	0.040	0.015	0.093

Company: ECOPETROL SA

Rev: 1

Date: 11/04/2 Pag: 24 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S2C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

VAPORIZATION CURVE SHELL SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
311.5	309.7	2.199	25.909	0.000	28.108	237.40	1047	253.5	453.8
332.9	309.7	2.867	27.906	0.000	30.773	280.70	1048	267.6	453.2
353.5	309.7	3.726	29.712	0.000	33.438	328.60	1049	282.8	452.5
373.1	309.7	4.829	31.274	0.000	36.103	380.20	1050	298.9	451.8
391.8	309.7	6.236	32.532	0.000	38.768	434.20	1052	315.3	451.0
409.5	309.7	8.015	33.419	0.000	41.433	489.10	1054	331.4	450.0
426.2	309.7	10.238	33.860	0.000	44.099	543.20	1057	346.7	449.0
441.8	309.7	12.976	33.787	0.000	46.764	595.00	1060	360.8	447.8
456.5	309.7	16.288	33.141	0.000	49.429	643.50	1064	373.4	446.4
470.1	309.7	20.216	31.878	0.000	52.094	687.80	1068	384.1	444.9
482.9	309.7	24.783	29.976	0.000	54.759	727.70	1073	393.1	443.2

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
311.5	309.7	6820.0	18.95	0.04	186600.0	109.0	0.0	11.90	122.01
332.9	309.7	8860.0	23.23	0.05	184500.0	109.2	0.0	10.83	116.94
353.5	309.7	11460.0	28.01	0.06	181900.0	109.5	0.0	9.83	112.08
373.1	309.7	14760.0	33.20	0.08	178600.0	109.8	0.0	8.90	107.45
391.8	309.7	18890.0	38.71	0.10	174500.0	110.2	0.0	8.07	103.08
409.5	309.7	24050.0	44.37	0.12	169300.0	110.8	0.0	7.31	99.00
426.2	309.7	30410.0	50.05	0.16	163000.0	111.4	0.0	6.64	95.24
441.8	309.7	38120.0	55.58	0.20	155300.0	112.1	0.0	6.05	91.80
456.5	309.7	47320.0	60.86	0.24	146100.0	112.9	0.0	5.54	88.71
470.1	309.7	58070.0	65.80	0.30	135300.0	113.9	0.0	5.10	85.96
482.9	309.7	70400.0	70.36	0.36	123000.0	114.9	0.0	4.72	83.53

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
311.5	309.7	0.71	41.67	0.733	0.573	0.047	0.054	0.016	0.177
332.9	309.7	0.85	40.86	0.684	0.585	0.045	0.052	0.016	0.162
353.5	309.7	1.01	40.06	0.650	0.598	0.043	0.050	0.016	0.150
373.1	309.7	1.18	39.29	0.626	0.610	0.041	0.049	0.016	0.139
391.8	309.7	1.37	38.55	0.611	0.623	0.040	0.047	0.016	0.130
409.5	309.7	1.56	37.85	0.601	0.635	0.038	0.046	0.016	0.122
426.2	309.7	1.75	37.20	0.596	0.647	0.037	0.044	0.015	0.114
441.8	309.7	1.95	36.61	0.593	0.659	0.035	0.043	0.015	0.108
456.5	309.7	2.14	36.08	0.593	0.670	0.034	0.042	0.015	0.103
470.1	309.7	2.33	35.61	0.594	0.681	0.032	0.041	0.015	0.098
482.9	309.7	2.50	35.21	0.597	0.691	0.031	0.040	0.015	0.095

Company: ECOPETROL SA

Rev: 0

Date: 15/12/2 Pag: 25 de 26

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S2C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

CONDENSATION CURVE TUBE SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
513.8	269.7	87.744	0.000	0.000	87.744	874.10		415.7	
512.5	269.7	87.548	0.000	0.000	87.548	874.10		415.7	
506.9	269.7	79.756	5.323	0.000	85.079	860.00	1083	414.5	434.5
500.6	269.7	71.732	10.681	0.000	82.413	843.40	1079	412.7	435.9
494.0	269.7	64.127	15.621	0.000	79.748	825.30	1076	410.5	437.3
487.0	269.7	56.955	20.128	0.000	77.083	805.40	1073	407.8	438.7
479.7	269.7	50.234	24.184	0.000	74.418	783.50	1069	404.4	440.0
472.0	269.7	43.981	27.772	0.000	71.753	759.40	1066	400.4	441.4
463.7	269.7	38.210	30.877	0.000	69.088	732.90	1063	395.5	442.7
455.0	269.7	32.935	33.488	0.000	66.423	703.80	1060	389.8	444.0
445.7	269.7	28.162	35.595	0.000	63.758	672.00	1057	383.1	445.2
435.8	269.7	23.892	37.200	0.000	61.093	637.60	1054	375.4	446.4

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
513.8	269.7	238210.0	87.19	1.00	0.0	0.0	0.0	0.00	
512.5	269.7	238210.0	87.19	1.00	0.0	0.0	0.0	0.00	81.50
506.9	269.7	218180.0	85.28	0.92	20000.0	115.4	0.0	4.03	82.34
500.6	269.7	197430.0	83.09	0.83	40700.0	114.5	0.0	4.17	83.34
494.0	269.7	177610.0	80.76	0.75	60600.0	113.7	0.0	4.32	84.44
487.0	269.7	158790.0	78.27	0.67	79400.0	112.9	0.0	4.49	85.64
479.7	269.7	141010.0	75.60	0.59	97200.0	112.1	0.0	4.68	86.96
472.0	269.7	124340.0	72.74	0.52	113800.0	111.3	0.0	4.89	88.41
463.7	269.7	108830.0	69.66	0.46	129300.0	110.6	0.0	5.13	89.99
455.0	269.7	94530.0	66.36	0.40	143600.0	109.9	0.0	5.40	91.73
445.7	269.7	81480.0	62.83	0.34	156700.0	109.2	0.0	5.70	93.64
435.8	269.7	69700.0	59.07	0.29	168500.0	108.6	0.0	6.05	95.72

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
513.8	269.7	2.80		0.618	0.000	0.028		0.014	
512.5	269.7	2.81		0.618	0.000	0.028		0.014	
506.9	269.7	2.74	34.11	0.615	0.735	0.028	0.039	0.014	0.087
500.6	269.7	2.66	34.26	0.613	0.731	0.028	0.039	0.014	0.088
494.0	269.7	2.58	34.43	0.611	0.725	0.028	0.040	0.014	0.089
487.0	269.7	2.49	34.61	0.608	0.720	0.029	0.040	0.014	0.091
479.7	269.7	2.39	34.82	0.606	0.714	0.029	0.041	0.014	0.093
472.0	269.7	2.29	35.05	0.604	0.708	0.029	0.041	0.014	0.095
463.7	269.7	2.19	35.31	0.602	0.701	0.029	0.042	0.014	0.097
455.0	269.7	2.08	35.59	0.600	0.694	0.030	0.042	0.014	0.100
445.7	269.7	1.96	35.91	0.599	0.687	0.031	0.043	0.014	0.103
435.8	269.7	1.84	36.27	0.598	0.679	0.032	0.044	0.014	0.106

Company: ECOPETROL SA

Rev: 0

Date: 15/12/2 Page: 26 de 26

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S2C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

CONDENSATION CURVE TUBE SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
513.0	262.2	87.744	0.000	0.000	87.744	874.10		415.7	
509.6	262.2	87.247	0.000	0.000	87.247	874.10		415.7	
504.7	262.2	80.468	4.611	0.000	85.078	861.90	1084	414.7	434.1
498.5	262.2	72.487	9.927	0.000	82.413	845.50	1081	413.0	435.5
491.9	262.2	64.908	14.840	0.000	79.748	827.70	1077	410.9	436.9
485.1	262.2	57.748	19.335	0.000	77.083	808.20	1074	408.3	438.3
477.8	262.2	51.023	23.395	0.000	74.418	786.70	1071	405.1	439.7
470.2	262.2	44.752	27.001	0.000	71.753	763.00	1067	401.1	441.1
462.1	262.2	38.950	30.138	0.000	69.088	737.00	1064	396.4	442.5
453.5	262.2	33.631	32.792	0.000	66.423	708.40	1061	390.9	443.8
444.3	262.2	28.804	34.954	0.000	63.758	677.10	1058	384.3	445.0
434.5	262.2	24.473	36.620	0.000	61.093	643.10	1055	376.8	446.2

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
513.0	262.2	238210.0	87.19	1.00	0.0	0.0	0.0	0.00	
509.6	262.2	238210.0	87.19	1.00	0.0	0.0	0.0	0.00	82.65
504.7	262.2	220740.0	85.52	0.93	17400.0	115.7	0.0	4.18	83.37
498.5	262.2	200050.0	83.36	0.84	38100.0	114.8	0.0	4.31	84.35
491.9	262.2	180260.0	81.06	0.76	57900.0	114.0	0.0	4.46	85.41
485.1	262.2	161430.0	78.60	0.68	76700.0	113.2	0.0	4.63	86.57
477.8	262.2	143610.0	75.97	0.60	94600.0	112.4	0.0	4.82	87.85
470.2	262.2	126860.0	73.15	0.53	111300.0	111.6	0.0	5.02	89.25
462.1	262.2	111230.0	70.11	0.47	126900.0	110.8	0.0	5.26	90.78
453.5	262.2	96780.0	66.85	0.41	141400.0	110.1	0.0	5.52	92.47
444.3	262.2	83560.0	63.36	0.35	154600.0	109.4	0.0	5.82	94.31
434.5	262.2	71580.0	59.64	0.30	166600.0	108.8	0.0	6.15	96.34

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
513.0	262.2	2.70		0.615	0.000	0.028		0.014	
509.6	262.2	2.72		0.615	0.000	0.028		0.014	
504.7	262.2	2.67	34.28	0.613	0.731	0.028	0.039	0.014	0.088
498.5	262.2	2.59	34.42	0.611	0.727	0.028	0.039	0.014	0.089
491.9	262.2	2.51	34.58	0.609	0.722	0.028	0.040	0.014	0.091
485.1	262.2	2.43	34.76	0.606	0.717	0.028	0.040	0.014	0.092
477.8	262.2	2.34	34.96	0.604	0.711	0.029	0.041	0.014	0.094
470.2	262.2	2.24	35.18	0.602	0.705	0.029	0.041	0.014	0.096
462.1	262.2	2.14	35.43	0.600	0.699	0.029	0.042	0.014	0.098
453.5	262.2	2.04	35.71	0.598	0.692	0.030	0.042	0.014	0.101
444.3	262.2	1.92	36.02	0.597	0.685	0.030	0.043	0.014	0.104
434.5	262.2	1.81	36.37	0.596	0.678	0.031	0.044	0.014	0.107

Company: ECOPETROL SA

Rev: 0

Date: 15/12/2 Pag: 27 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Case Operation: S2C1

Service of Unit: CDHDS FEED/CDHDS OVERHEAD EXCHANGERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

CONDENSATION CURVE TUBE SIDE

Temp °F	Pressure psia	Enthalpies				Crit Temp - TC		Crit Press - PC	
		Vapor MMBTU/h	Liquid MMBTU/h	Water MMBTU/h	Total MMBTU/h	Vapor R	Liquid R	Vapor psia	Liquid psia
512.1	254.7	87.744	0.000	0.000	87.744	874.10		415.7	
506.6	254.7	86.935	0.000	0.000	86.935	874.10		415.7	
502.5	254.7	81.183	3.895	0.000	85.078	863.70	1086	414.9	433.7
496.3	254.7	73.245	9.168	0.000	82.413	847.70	1082	413.3	435.1
489.8	254.7	65.695	14.054	0.000	79.748	830.20	1079	411.3	436.6
483.0	254.7	58.548	18.535	0.000	77.083	811.00	1075	408.8	438.0
475.9	254.7	51.823	22.595	0.000	74.418	789.90	1072	405.7	439.4
468.3	254.7	45.536	26.217	0.000	71.753	766.60	1069	401.9	440.8
460.3	254.7	39.704	29.384	0.000	69.088	741.10	1066	397.4	442.2
451.8	254.7	34.343	32.080	0.000	66.423	713.00	1062	391.9	443.5
442.8	254.7	29.464	34.294	0.000	63.758	682.20	1059	385.6	444.8
433.1	254.7	25.072	36.021	0.000	61.093	648.60	1056	378.3	446.0

Temp °F	Pressure psia	Vap Flow lb/h	Vapor Mol. Wt	Vapor Wt Frac.	Liq Flow lb/h	Liquid Mol. Wt	Water Flow lb/h	Surf. Ten. dyne/cm	Latent Heat BTU/lb
512.1	254.7	238210.0	87.19	1.00	0.0	0.0	0.0	0.00	
506.6	254.7	238210.0	87.19	1.00	0.0	0.0	0.0	0.00	83.82
502.5	254.7	223350.0	85.77	0.94	14800.0	116.0	0.0	4.33	84.41
496.3	254.7	202730.0	83.64	0.85	35400.0	115.1	0.0	4.46	85.36
489.8	254.7	182970.0	81.36	0.77	55200.0	114.3	0.0	4.61	86.39
483.0	254.7	164130.0	78.94	0.69	74000.0	113.5	0.0	4.77	87.52
475.9	254.7	146270.0	76.34	0.61	91900.0	112.7	0.0	4.95	88.75
468.3	254.7	129430.0	73.55	0.54	108700.0	111.9	0.0	5.16	90.10
460.3	254.7	113700.0	70.56	0.48	124500.0	111.1	0.0	5.39	91.59
451.8	254.7	99100.0	67.34	0.42	139100.0	110.4	0.0	5.64	93.22
442.8	254.7	85700.0	63.90	0.36	152500.0	109.7	0.0	5.94	95.01
433.1	254.7	73530.0	60.21	0.31	164600.0	109.0	0.0	6.26	96.96

Temp °F	Pressure psia	Density		Specific Heat		Thermal Conductivity		Viscosity	
		Vapor lb/ft³	Liquid lb/ft³	Vapor BTU/lb·°F	Liquid BTU/lb·°F	Vapor BTU·ft/hr·ft²·°F	Liquid BTU·ft/hr·ft²·°F	Vapor cP	Liquid cP
512.1	254.7	2.61		0.613	0.000	0.028		0.014	
506.6	254.7	2.64		0.612	0.000	0.028		0.013	
502.5	254.7	2.59	34.45	0.611	0.728	0.028	0.039	0.013	0.090
496.3	254.7	2.52	34.59	0.608	0.723	0.028	0.040	0.014	0.091
489.8	254.7	2.45	34.74	0.606	0.719	0.028	0.040	0.014	0.092
483.0	254.7	2.37	34.92	0.604	0.714	0.028	0.040	0.014	0.094
475.9	254.7	2.28	35.11	0.602	0.708	0.028	0.041	0.014	0.096
468.3	254.7	2.19	35.32	0.600	0.703	0.028	0.041	0.014	0.098
460.3	254.7	2.10	35.57	0.598	0.697	0.029	0.042	0.014	0.100
451.8	254.7	2.00	35.83	0.596	0.690	0.029	0.043	0.014	0.102
442.8	254.7	1.89	36.14	0.595	0.683	0.030	0.043	0.014	0.105
433.1	254.7	1.77	36.47	0.594	0.676	0.031	0.044	0.014	0.109

Company: ECOPETROL SA

Rev: 1 Date: 11/04/24 Pag: 28 de 28

Location: CARTAGENA, COLOMBIA

Equipment: E-201 A/B

Service of Unit: CDHYDRO FEED PREHEATERS

Project: Mejoras en Unidad de Destilación Reactiva U-107 Para Estabilidad y Cumplimiento de 10 PPM Azufre

REMARKS

1. The VENDOR shall perform its own thermal, hydraulic and mechanical design and calculate actual drop pressure and outlet properties for hot stream and cold stream.
2. The corrosion allowance in tube side only applies for front head and tubesheet.
3. Materials thickness and weights shall be verified by VENDOR based in calculations.
4. The VENDOR shall guarantee the exchanger thermally and mechanically, and shall also guarantee against damages caused by flow-induced vibration per the shell-and-tube. The output properties, total duty and drop pressure shall be confirmed by VENDOR, and final values shall update the hydraulic study.
5. PWHT and impact test requirements shall be applied during the manufacturing process as recommended by ASME Section VIII Div 1.
6. Materials indicated in this data sheet are for reference. The VENDOR must verify the materials according to the operating conditions, fluids and client specification 000-SP-ME07-0006 Heat Exchanger Materials Specifications.
7. The VENDOR shall include a update of name plate according typical specification 166000-000-DG-MV09-0072. The name plate material shall be stainless steel.
8. Any specified corrosion allowances shall be added to the minimum calculated thickness. The commercial thicknesses selected by VENDOR must be greater than the calculated thicknesses (including corrosion thickness).
9. The VENDOR shall supply mechanical rating and detailed drawings approved for construction and AS-BUILT, including final loads and reactions according wind and seismic loads for civil studies. All consideration according TEMA, ASME Sec. VIII Div 1 and Client Standard recomendations.
10. The VENDOR shall review and validate all drawings contained in Annex III of the document 107-SP-ME07-0302. Drawings from a preliminary thermal and mechanical study by INTERCOL SA.
11. If the VENDOR considers using clad, it must ensure suitability taking into account typical specification 000-DG-MV09-0062, 000-DG-MV09-0063, 000-DG-MV09-0064 and 000-DG-MV09-0065.
12. Tubesheet, 1/8" 304L SS cladding on Tubesheet, bundle, baffles, impigment plate, tie-rods and all necessary parts shall be replaced to achive new process required duty. Te scope of VENDOR can be seen below. 

