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APPENDIX

Crude Assay

1) Arabian Light crude

Gravity (avg. API) 33.1

Light hydrogencarbons	*%wt on crude*
Ethane	0.022
Propane	0.03
Isobutane	0.09
Normal butane	0.67
Isopentane	0.59
Normal pentane	1.21
Sum	2.612

True boiling point (TBP; C) at
Accumulated % volumne of distilled crude

%vol	TBP (C)	%vol	TBP (C)	%vol	TBP (C)
0.05	-17.8	8.4	85	55.1	343
0.10	-12.2	10.4	100	57.0	355
0.15	-6.7	13.5	120	59.4	370
0.29	-1.1	16.2	135	61.8	385
0.52	4.4	19.0	150	64.1	400
0.75	10.0	20.9	160	66.4	415
0.98	15.6	23.8	175	68.6	430
1.23	21.1	26.7	190	70.7	445
1.60	26.7	29.5	205	72.1	455
1.97	32.2	32.3	220	74.7	475
2.63	37.8	35.1	235	76.5	490
3.29	43.3	37.9	250	78.9	510
3.96	48.9	40.7	265	80.0	520
4.64	54.4	43.5	290	81.6	535
5.31	60.0	46.3	295	83.2	550
5.99	65.7	49.1	310	84.7	565
6.53	70.0	51.8	325	100.0	816

Gravity (API) at
Middle point of accumulated %vol. of distilled crude

% vol	API	% vol	API	% vol	API
0.01	246.8	33.7	44.1	75.6	20.4
0.03	147.1	36.5	42.0	77.7	19.4
0.11	119.8	39.3	39.2	79.5	18.5
0.67	110.8	42.1	36.8	80.8	17.7
1.56	94.9	44.9	35.4	82.4	4.2
2.79	92.7	47.7	34.8	84.0	16.5
5.07	79.0	50.5	33.3		
7.46	72.0	53.5	30.5		
9.40	67.5	56.1	28.8		
11.95	63.0	58.2	28.0		
14.85	59.0	60.6	26.7		
17.60	55.3	63.0	25.5		
19.95	52.7	65.3	24.6		
22.35	50.5	67.5	23.7		
25.25	48.6	69.7	22.8		
28.10	47.1	71.4	21.9		
30.90	46.3	73.4	21.2		

2) Oman crude

Gravity (avg. API) 35.3

Light hydrogencarbons	*%weight on crude*
Ethane	0.02
Propane	0.28
Isobutane	0.33
Normal butane	0.87
Isopentane	0.81
Normal pentane	1.18
Sum	3.49

True boiling point (TBP; C) at
Accumulated % volumne of distilled crude

%vol	TBP (C)	%vol	TBP (C)
3.86	50	40.26	300
5.45	70	43.75	320
7.27	90	47.39	340
8.36	100	50.86	360
10.94	120	54.16	380
13.90	140	57.45	400
17.04	160	60.73	420
20.09	180	66.44	460
23.00	200	69.29	480
26.15	220	71.93	500
29.52	240	74.56	520
33.05	260	78.45	550
36.70	280		

3) Phet crude

Specific gravity	0.828

Light hydrogencarbons	*%weight on crude*
Ethane	0.05
Propane	0.48
Isobutane	0.68
Normal butane	0.94
Isopentane	1.54
Normal pentane	1.21
Sum	4.90

ASTM D86 (C) 760mmHg at
Accumulated % volumne of distilled crude

%vol	TBP (C)
6.00	93
13.50	150
25.50	235
37.00	300
49.50	370
89.00	500
95.00	510

4) Qatar crude

Gravity (avg. API)	42.1

Light hydrogencarbons	*%weight on crude*
Ethane	0.08
Propane	0.84
Isobutane	0.44
Normal butane	1.82
Isopentane	1.19
Normal pentane	2.00
Sum	6.37

True boiling point (TBP; C) at
Accumulated % volumne of distilled crude

%vol	TBP (C)	%vol	TBP (C)
0.00	32.0	50.0	263
10.00	92.0	60.0	315
20.00	133.0	70.0	365
30.00	170.0	80.0	460
40.00	211.0	89.0	540

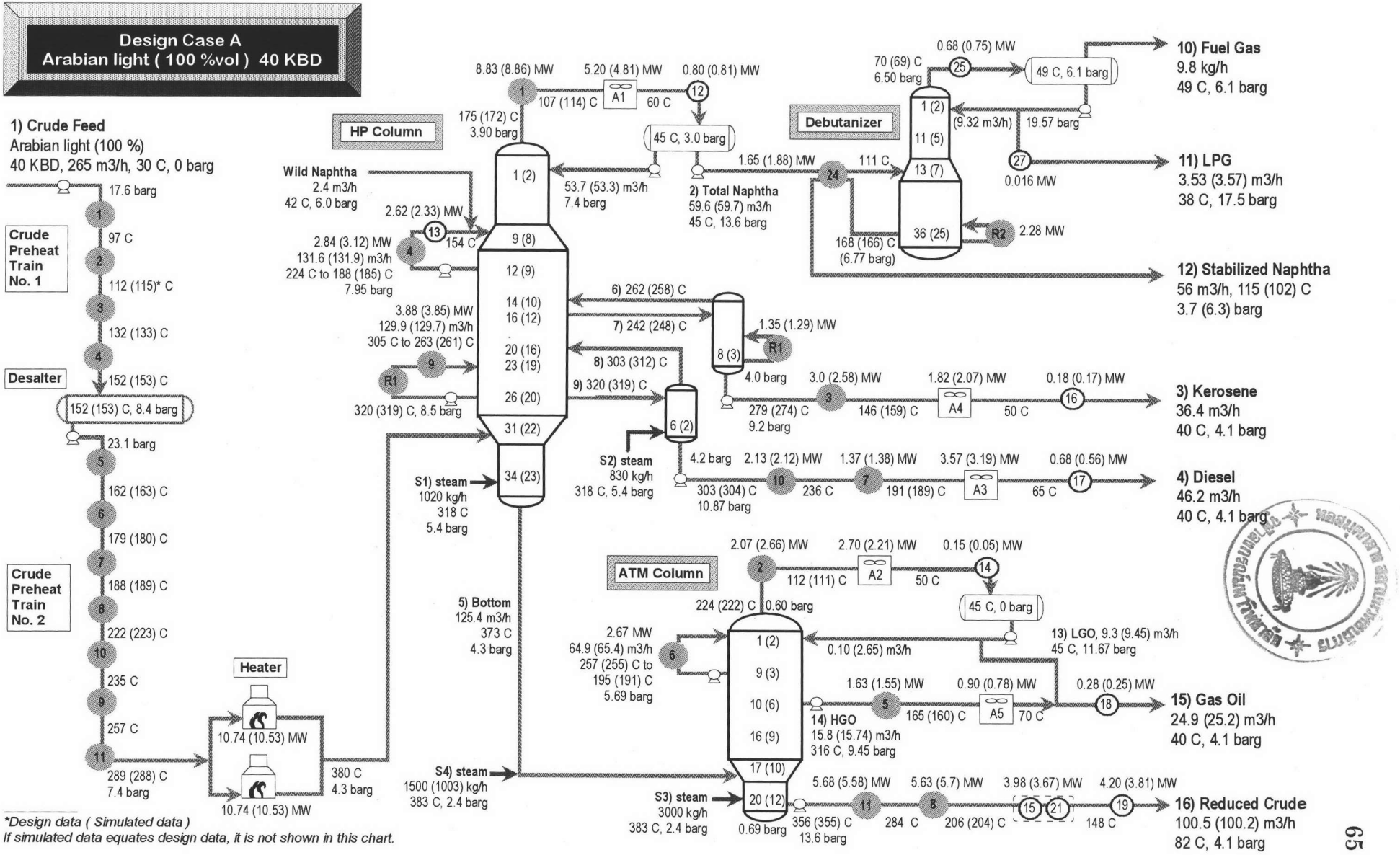
5) Tapis crude

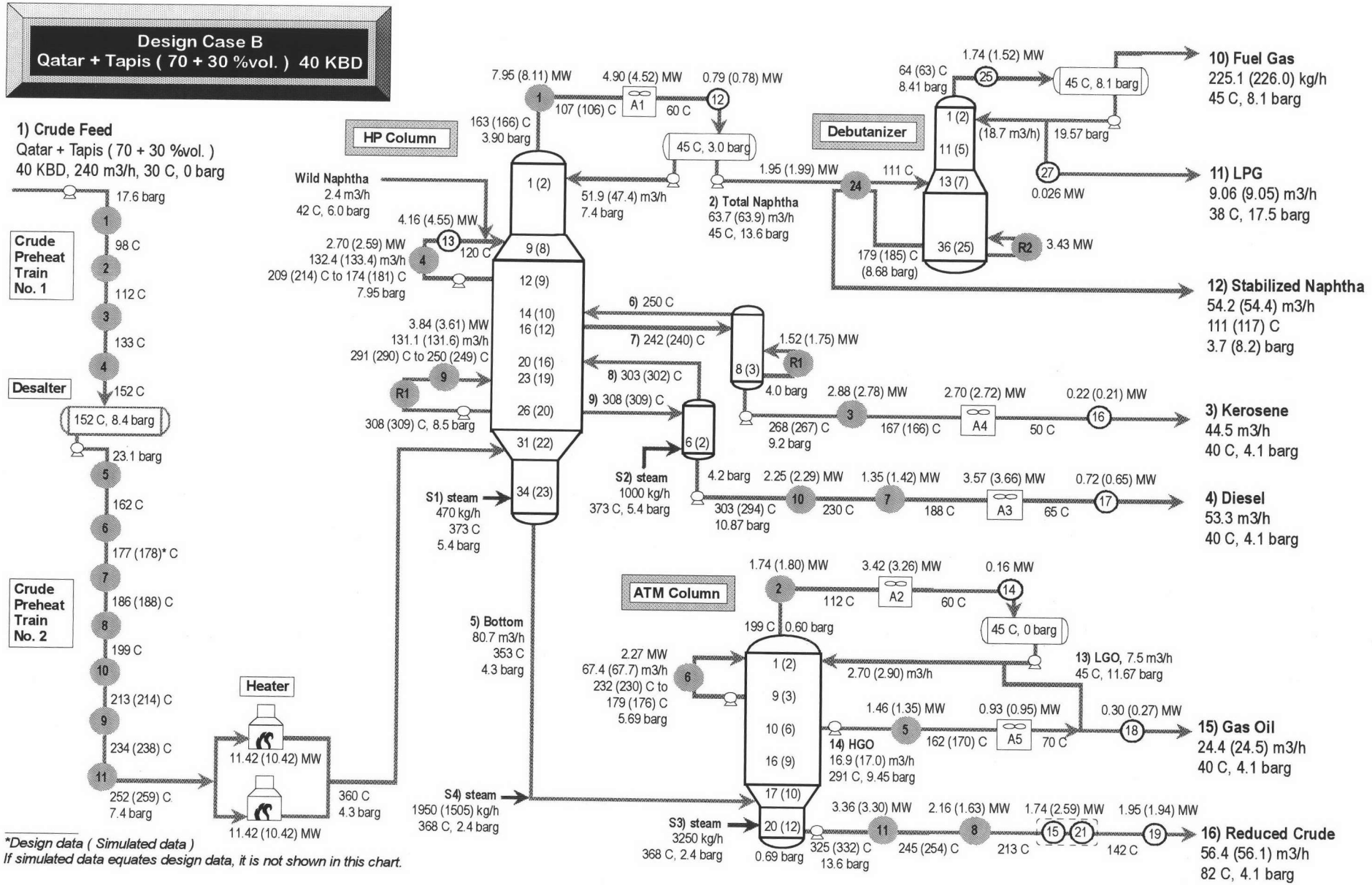
Gravity (avg. API)	43.2

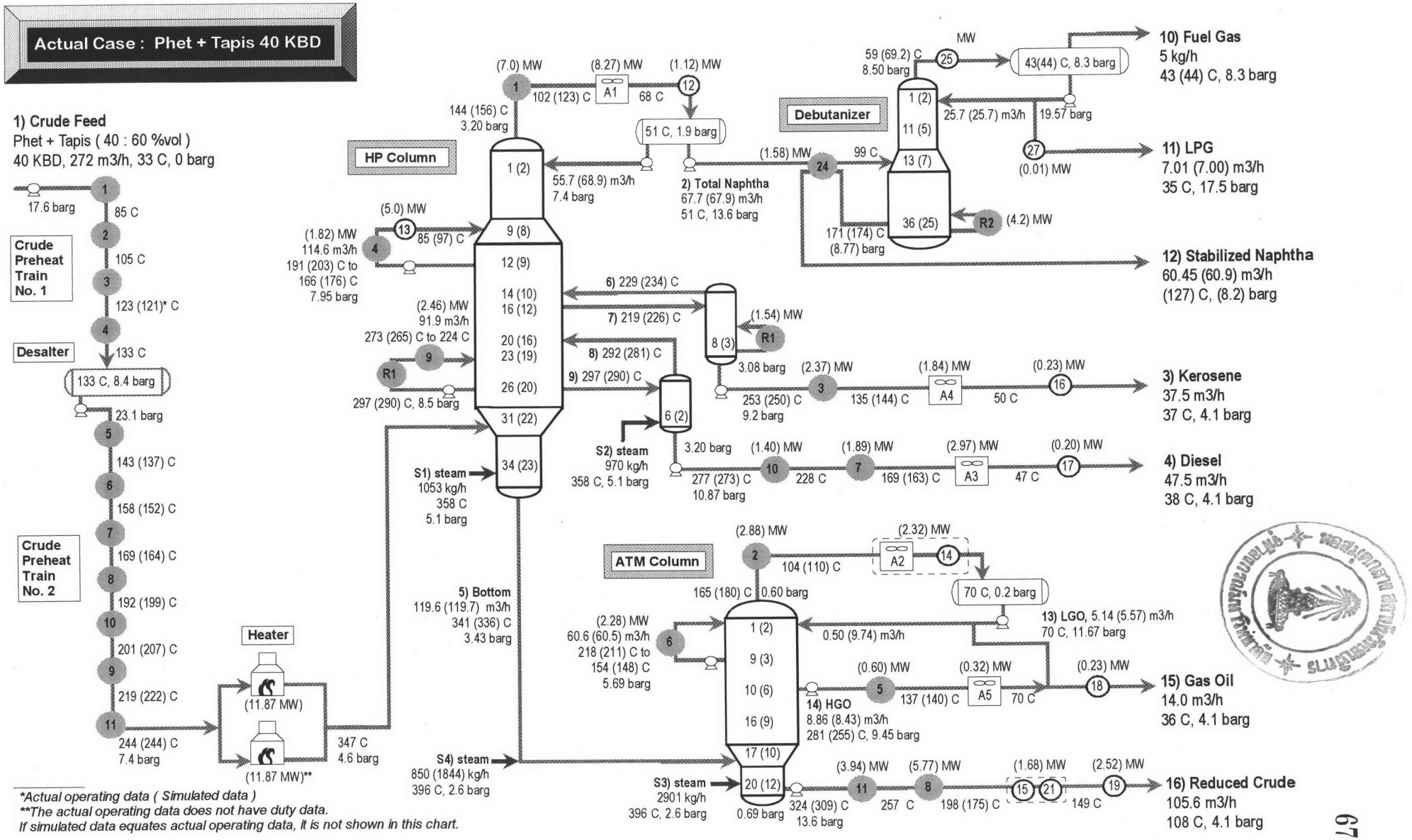
Light hydrogencarbons	*%volume on crude*
Ethane	0.01
Propane	0.11
Isobutane	0.13
Normal butane	0.21
Isopentane	0.36
Normal pentane	0.28
Sum	1.10

True boiling point (TBP; C) at
Accumulated % volumne of distilled crude

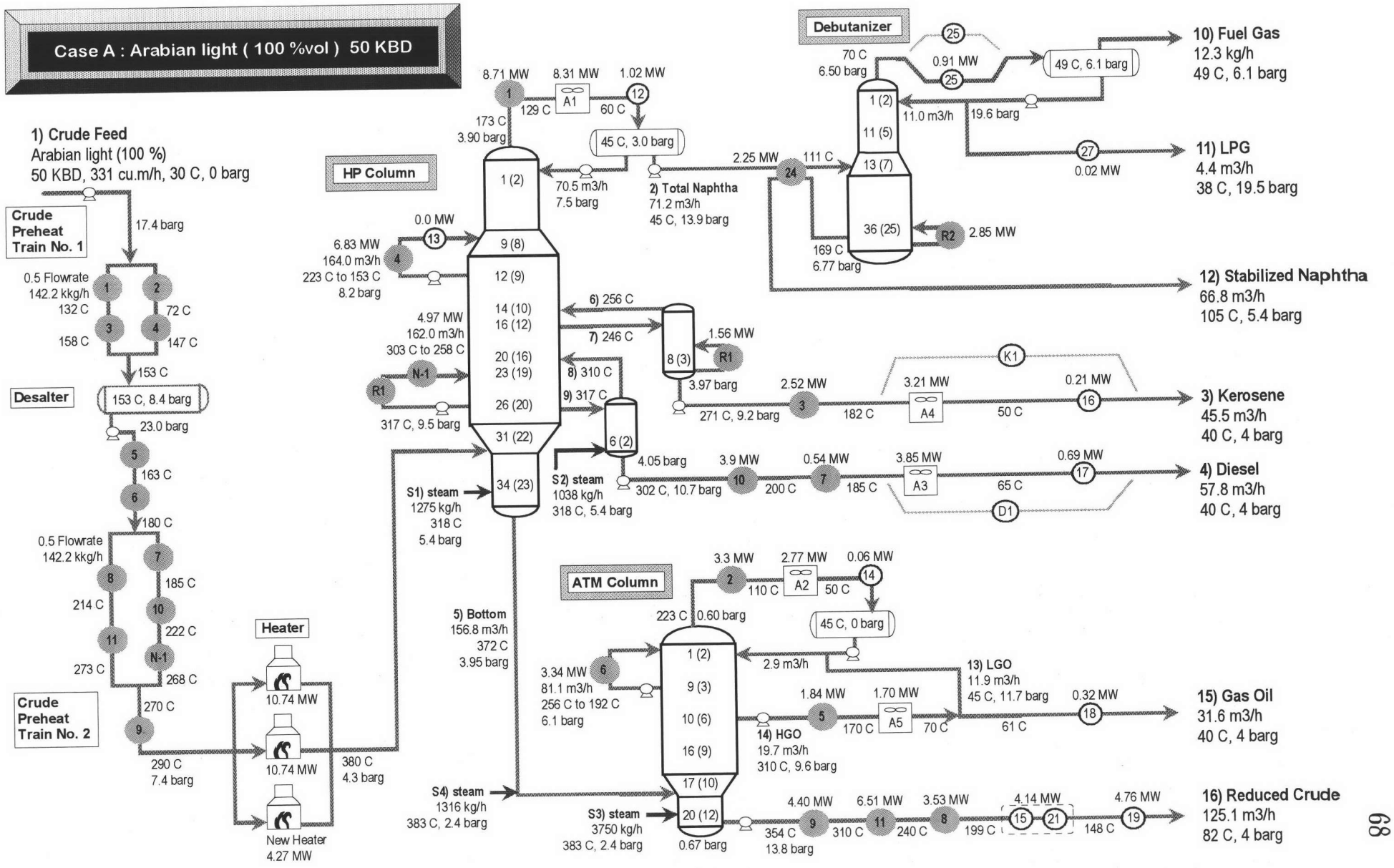
%vol	TBP (C)	%vol	TBP (C)
2.97	70.0	49.0	250
4.70	85.0	55.4	265
7.10	100.0	61.2	280
10.80	120.0	66.6	295
14.40	135.0	71.2	310
18.30	150.0	75.3	325
20.90	160.0	79.7	343
25.10	175.0	82.0	355
29.30	190.0	84.9	370
33.50	205.0	87.4	285
38.30	220.0	89.5	400
43.20	235.0	100.0	816

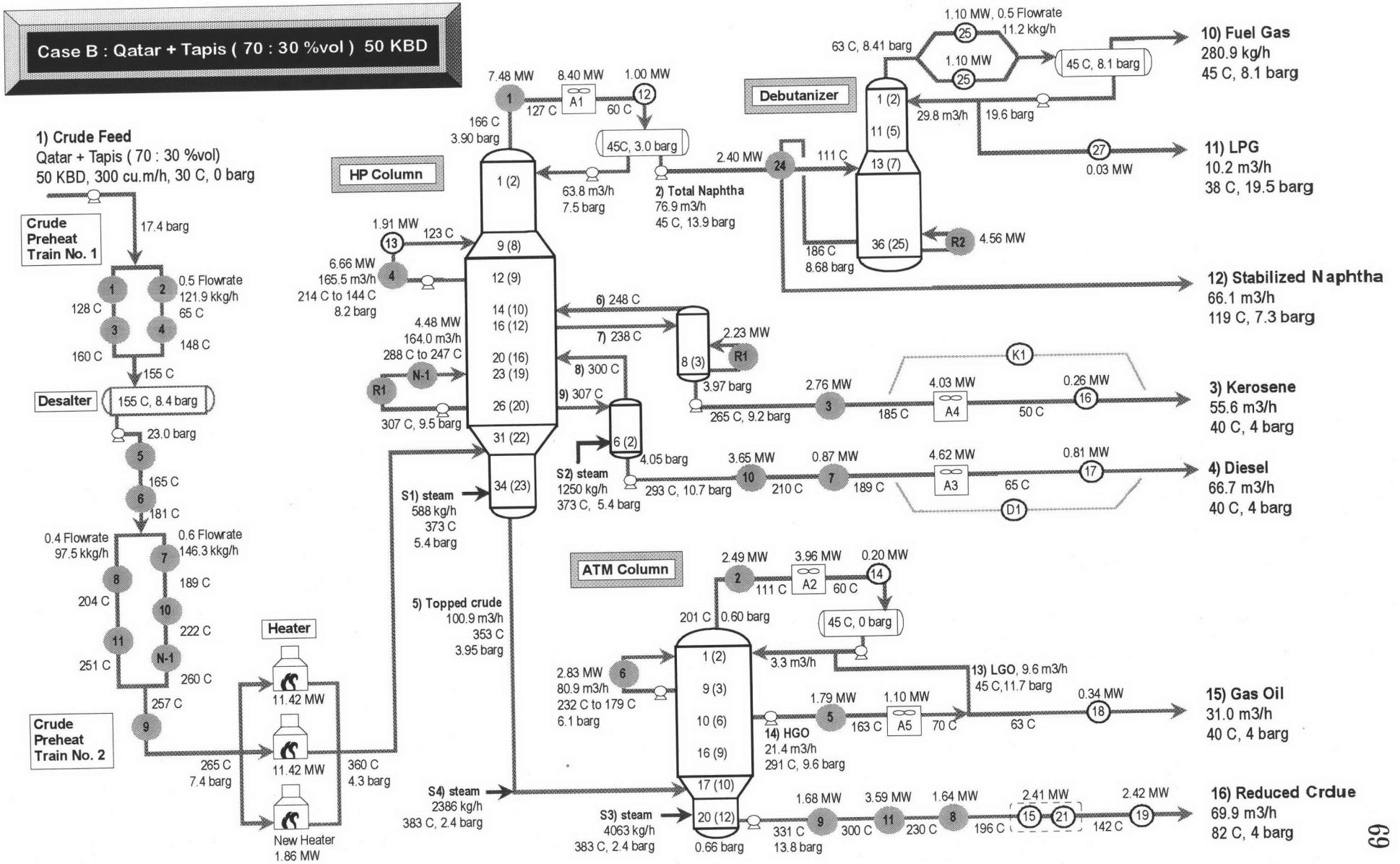

Design Case A
Arabian light (100 %vol) 40 KBD
1) Crude Feed
Arabian light (100 %)
40 KBD, 265 m3/h, 30 C, 0 barg
Crude Preheat Train No. 1
Crude Preheat Train No. 2
Desalter
152 (153) C, 8.4 barg
Heater
10.74 (10.53) MW
HP Column
Debutanizer
ATM Column
A1
A2
A3
A4
A5
R1
R2
Wild Naphtha
2.4 m3/h
42 C, 6.0 barg
2.62 (2.33) MW
154 C
2.84 (3.12) MW
131.6 (131.9) m3/h
224 C to 188 (185) C
7.95 barg
3.88 (3.85) MW
129.9 (129.7) m3/h
305 C to 263 (261) C
320 (319) C, 8.5 barg
S1) steam
1020 kg/h
318 C
5.4 barg
S2) steam
830 kg/h
318 C, 5.4 barg
S3) steam
3000 kg/h
383 C, 2.4 barg
S4) steam
1500 (1003) kg/h
383 C, 2.4 barg
5) Bottom
125.4 m3/h
373 C
4.3 barg
2) Total Naphtha
59.6 (59.7) m3/h
45 C, 13.6 barg
53.7 (53.3) m3/h
7.4 barg
45 C, 3.0 barg
1.65 (1.88) MW
111 C
168 (166) C
(6.77 barg)
2.28 MW
0.68 (0.75) MW
70 (69) C
6.50 barg
49 C, 6.1 barg
(9.32 m3/h)
19.57 barg
0.016 MW
10) Fuel Gas
9.8 kg/h
49 C, 6.1 barg
11) LPG
3.53 (3.57) m3/h
38 C, 17.5 barg
12) Stabilized Naphtha
56 m3/h, 115 (102) C
3.7 (6.3) barg
6) 262 (258) C
7) 242 (248) C
8) 303 (312) C
9) 320 (319) C
1.35 (1.29) MW
4.0 barg
279 (274) C
9.2 barg
3.0 (2.58) MW
146 (159) C
1.82 (2.07) MW
50 C
0.18 (0.17) MW
3) Kerosene
36.4 m3/h
40 C, 4.1 barg
4.2 barg
303 (304) C
10.87 barg
2.13 (2.12) MW
236 C
1.37 (1.38) MW
191 (189) C
3.57 (3.19) MW
65 C
0.68 (0.56) MW
4) Diesel
46.2 m3/h
40 C, 4.1 barg
2.07 (2.66) MW
112 (111) C
2.70 (2.21) MW
50 C
0.15 (0.05) MW
224 (222) C
0.60 barg
45 C, 0 barg
13) LGO, 9.3 (9.45) m3/h
45 C, 11.67 barg
0.10 (2.65) m3/h
2.67 MW
64.9 (65.4) m3/h
257 (255) C to
195 (191) C
5.69 barg
1.63 (1.55) MW
165 (160) C
0.90 (0.78) MW
70 C
0.28 (0.25) MW
14) HGO
15.8 (15.74) m3/h
316 C, 9.45 barg
15) Gas Oil
24.9 (25.2) m3/h
40 C, 4.1 barg
5.68 (5.58) MW
356 (355) C
13.6 barg
5.63 (5.7) MW
284 C
3.98 (3.67) MW
206 (204) C
4.20 (3.81) MW
148 C
0.69 barg
16) Reduced Crude
100.5 (100.2) m3/h
82 C, 4.1 barg
*Design data (Simulated data)
If simulated data equates design data, it is not shown in this chart.

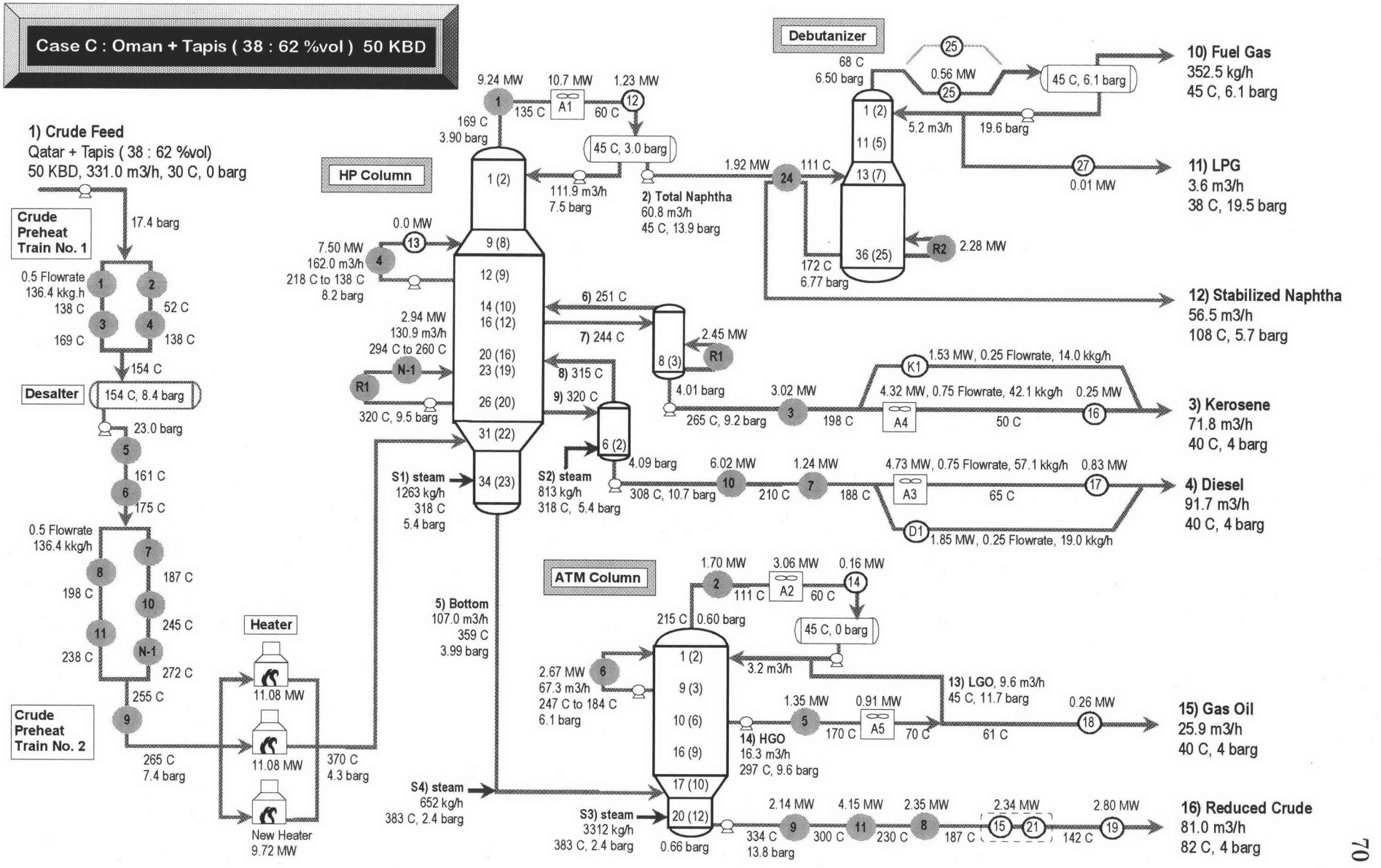

Design Case B
Qatar + Tapis (70 + 30 %vol.) 40 KBD
1) Crude Feed
Qatar + Tapis (70 + 30 %vol.)
40 KBD, 240 m3/h, 30 C, 0 barg
17.6 barg
Crude Preheat Train No. 1
98 C
112 C
133 C
Desalter
152 C
152 C, 8.4 barg
23.1 barg
162 C
177 (178)* C
Crude Preheat Train No. 2
186 (188) C
199 C
213 (214) C
234 (238) C
252 (259) C
7.4 barg
Heater
11.42 (10.42) MW
11.42 (10.42) MW
360 C
4.3 barg
*Design data (Simulated data)
If simulated data equates design data, it is not shown in this chart.
HP Column
7.95 (8.11) MW
4.90 (4.52) MW
0.79 (0.78) MW
A1
107 (106) C
60 C
45 C, 3.0 barg
163 (166) C
3.90 barg
Wild Naphtha
2.4 m3/h
42 C, 6.0 barg
4.16 (4.55) MW
120 C
2.70 (2.59) MW
132.4 (133.4) m3/h
209 (214) C to 174 (181) C
7.95 barg
51.9 (47.4) m3/h
7.4 barg
2) Total Naphtha
63.7 (63.9) m3/h
45 C, 13.6 barg
3.84 (3.61) MW
131.1 (131.6) m3/h
291 (290) C to 250 (249) C
308 (309) C, 8.5 barg
6) 250 C
7) 242 (240) C
8) 303 (302) C
9) 308 (309) C
S1) steam
470 kg/h
373 C
5.4 barg
S2) steam
1000 kg/h
373 C, 5.4 barg
5) Bottom
80.7 m3/h
353 C
4.3 barg
S4) steam
1950 (1505) kg/h
368 C, 2.4 barg
Debutanizer
1.74 (1.52) MW
64 (63) C
8.41 barg
45 C, 8.1 barg
(18.7 m3/h)
19.57 barg
0.026 MW
179 (185) C
(8.68 barg)
1.52 (1.75) MW
R1
3.43 MW
R2
4.0 barg
268 (267) C
9.2 barg
2.88 (2.78) MW
167 (166) C
A4
2.70 (2.72) MW
50 C
0.22 (0.21) MW
4.2 barg
303 (294) C
10.87 barg
2.25 (2.29) MW
230 C
1.35 (1.42) MW
188 C
A3
3.57 (3.66) MW
65 C
0.72 (0.65) MW
ATM Column
1.74 (1.80) MW
112 C
A2
3.42 (3.26) MW
60 C
0.16 MW
199 C
0.60 barg
45 C, 0 barg
2.27 MW
67.4 (67.7) m3/h
232 (230) C to
179 (176) C
5.69 barg
2.70 (2.90) m3/h
13) LGO, 7.5 m3/h
45 C, 11.67 barg
1.46 (1.35) MW
162 (170) C
A5
0.93 (0.95) MW
70 C
0.30 (0.27) MW
14) HGO
16.9 (17.0) m3/h
291 C, 9.45 barg
S3) steam
3250 kg/h
368 C, 2.4 barg
0.69 barg
3.36 (3.30) MW
325 (332) C
13.6 barg
2.16 (1.63) MW
245 (254) C
1.74 (2.59) MW
213 C
1.95 (1.94) MW
142 C
10) Fuel Gas
225.1 (226.0) kg/h
45 C, 8.1 barg
11) LPG
9.06 (9.05) m3/h
38 C, 17.5 barg
12) Stabilized Naphtha
54.2 (54.4) m3/h
111 (117) C
3.7 (8.2) barg
3) Kerosene
44.5 m3/h
40 C, 4.1 barg
4) Diesel
53.3 m3/h
40 C, 4.1 barg
15) Gas Oil
24.4 (24.5) m3/h
40 C, 4.1 barg
16) Reduced Crude
56.4 (56.1) m3/h
82 C, 4.1 barg

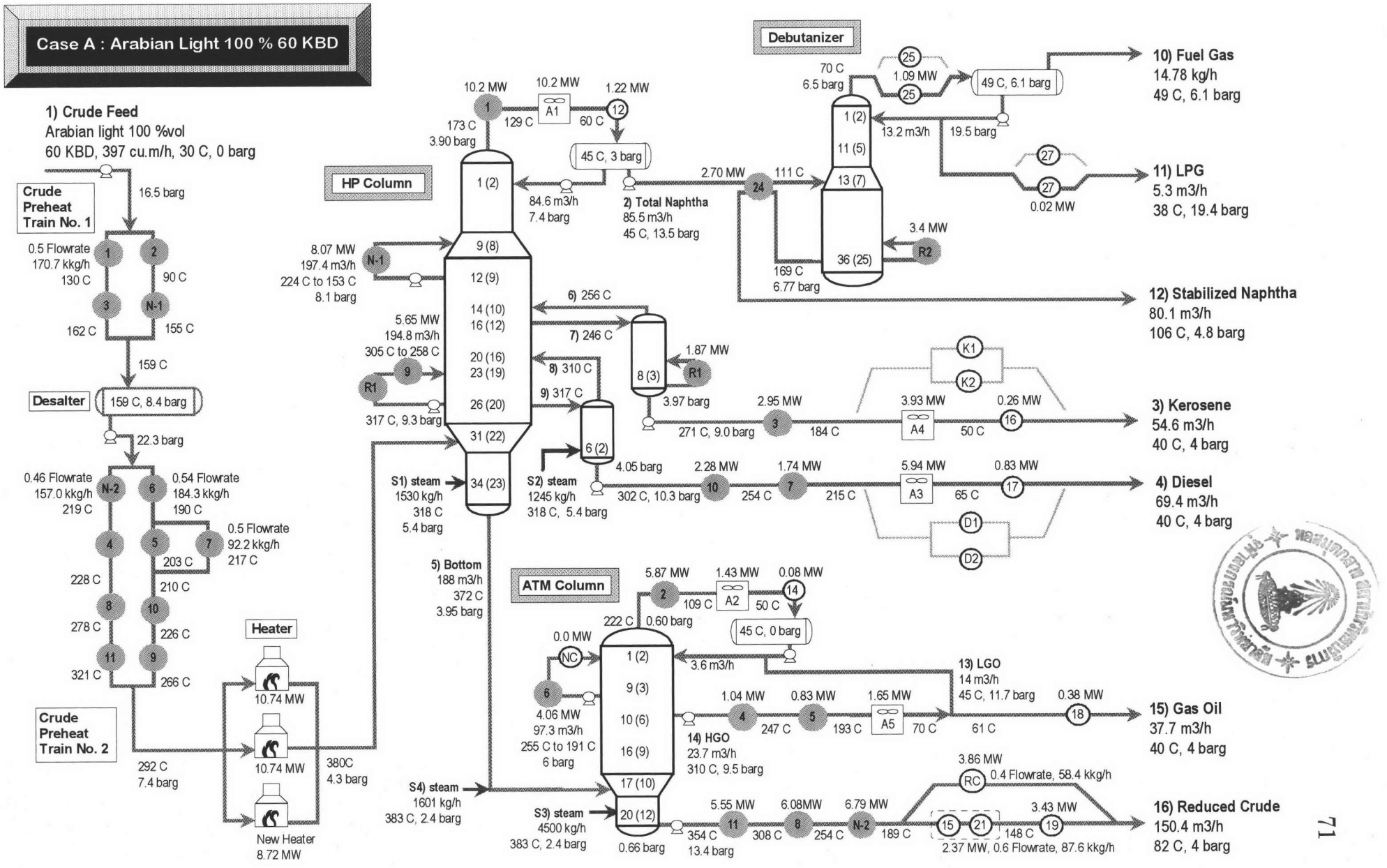


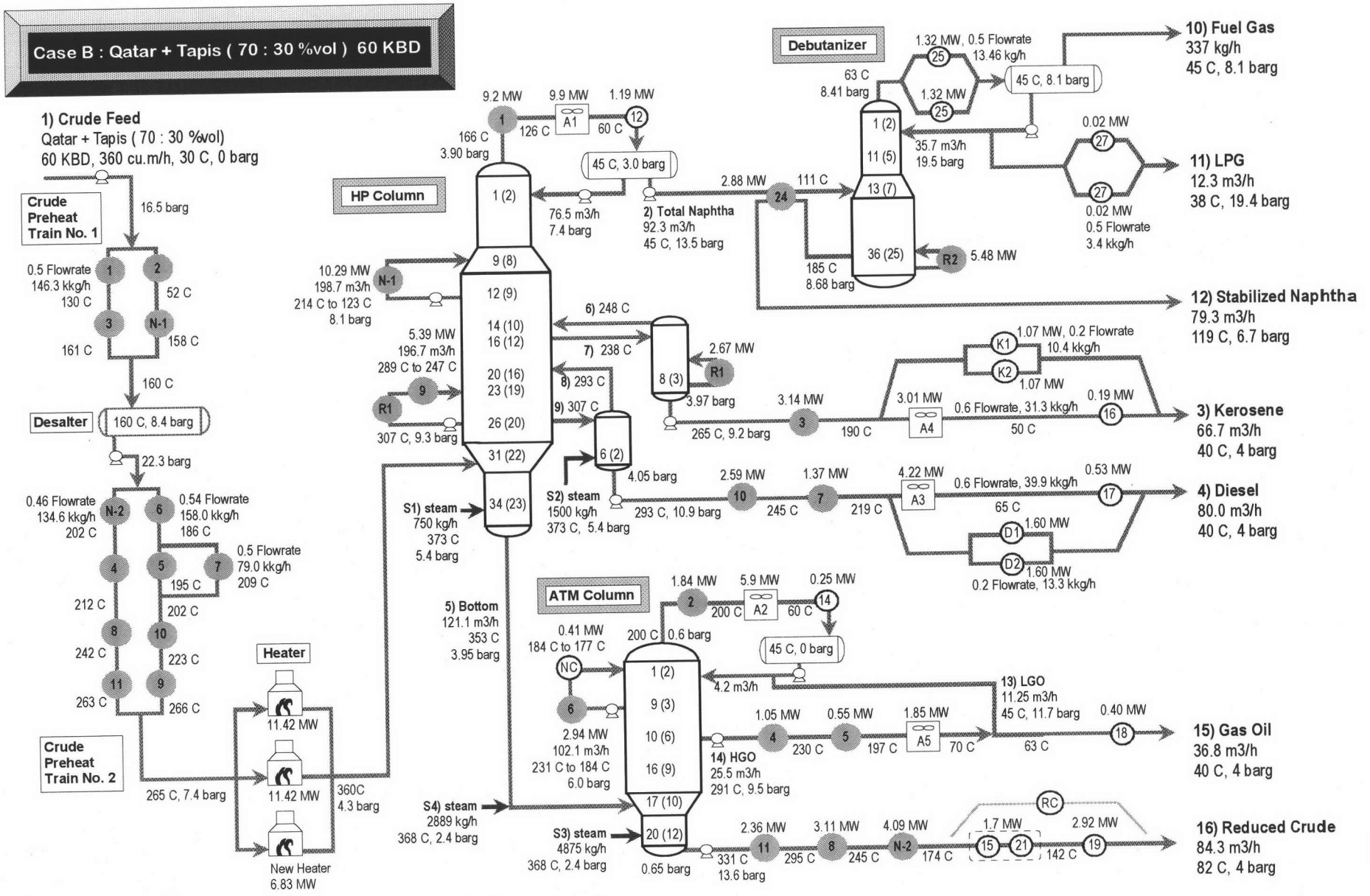
*Actual operating data (Simulated data)
**The actual operating data does not have duty data.
If simulated data equates actual operating data, it is not shown in this chart.

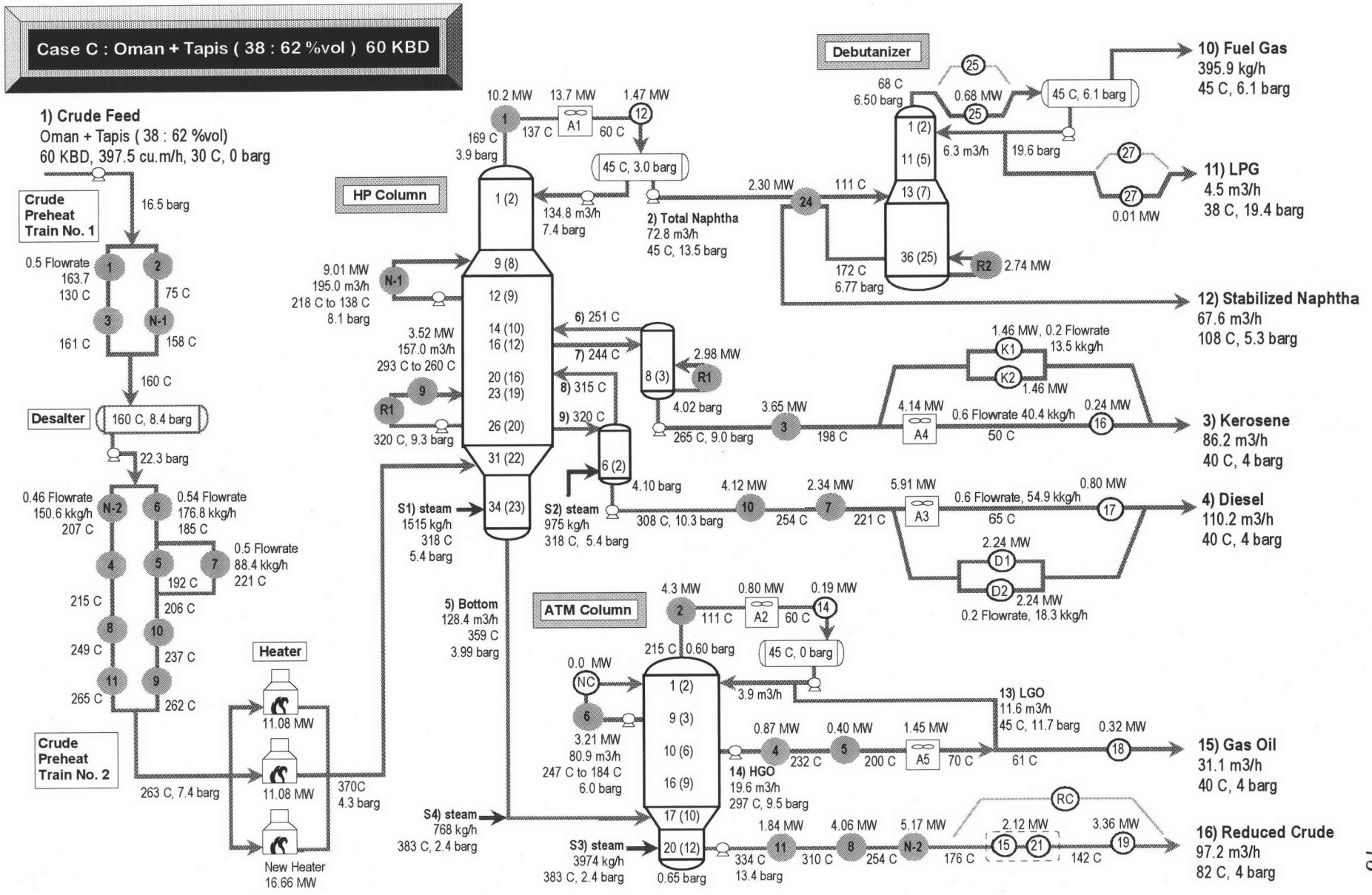

Case A : Arabian light (100 %vol) 50 KBD
1) Crude Feed
Arabian light (100 %)
50 KBD, 331 cu.m/h, 30 C, 0 barg
Crude Preheat Train No. 1
17.4 barg
0.5 Flowrate
142.2 kkg/h
132 C
72 C
158 C
147 C
153 C
Desalter
153 C, 8.4 barg
23.0 barg
163 C
180 C
0.5 Flowrate
142.2 kkg/h
185 C
214 C
222 C
273 C
268 C
Crude Preheat Train No. 2
270 C
290 C
7.4 barg
Heater
10.74 MW
10.74 MW
New Heater
4.27 MW
380 C
4.3 barg
HP Column
8.71 MW
8.31 MW
1.02 MW
129 C
60 C
173 C
3.90 barg
45 C, 3.0 barg
70.5 m3/h
7.5 barg
2) Total Naphtha
71.2 m3/h
45 C, 13.9 barg
0.0 MW
6.83 MW
164.0 m3/h
223 C to 153 C
8.2 barg
4.97 MW
162.0 m3/h
303 C to 258 C
317 C, 9.5 barg
6) 256 C
7) 246 C
8) 310 C
9) 317 C
1.56 MW
3.97 barg
271 C, 9.2 barg
4.05 barg
302 C, 10.7 barg
S1) steam
1275 kg/h
318 C
5.4 barg
S2) steam
1038 kg/h
318 C, 5.4 barg
5) Bottom
156.8 m3/h
372 C
3.95 barg
S4) steam
1316 kg/h
383 C, 2.4 barg
S3) steam
3750 kg/h
383 C, 2.4 barg
0.67 barg
Debutanizer
70 C
6.50 barg
0.91 MW
49 C, 6.1 barg
11.0 m3/h
19.6 barg
0.02 MW
2.25 MW
111 C
169 C
6.77 barg
2.85 MW
ATM Column
3.3 MW
2.77 MW
0.06 MW
110 C
50 C
223 C
0.60 barg
45 C, 0 barg
2.9 m3/h
3.34 MW
81.1 m3/h
256 C to 192 C
6.1 barg
1.84 MW
1.70 MW
170 C
70 C
14) HGO
19.7 m3/h
310 C, 9.6 barg
13) LGO
11.9 m3/h
45 C, 11.7 barg
0.32 MW
61 C
4.40 MW
6.51 MW
3.53 MW
4.14 MW
4.76 MW
354 C
13.8 barg
310 C
240 C
199 C
148 C
2.52 MW
3.21 MW
0.21 MW
182 C
50 C
3.9 MW
0.54 MW
3.85 MW
0.69 MW
200 C
185 C
65 C
10) Fuel Gas
12.3 kg/h
49 C, 6.1 barg
11) LPG
4.4 m3/h
38 C, 19.5 barg
12) Stabilized Naphtha
66.8 m3/h
105 C, 5.4 barg
3) Kerosene
45.5 m3/h
40 C, 4 barg
4) Diesel
57.8 m3/h
40 C, 4 barg
15) Gas Oil
31.6 m3/h
40 C, 4 barg
16) Reduced Crude
125.1 m3/h
82 C, 4 barg


Case B : Qatar + Tapis (70 : 30 %vol) 50 KBD
1) Crude Feed
Qatar + Tapis (70 : 30 %vol)
50 KBD, 300 cu.m/h, 30 C, 0 barg
Crude Preheat Train No. 1
17.4 barg
0.5 Flowrate
121.9 kkg/h
65 C
128 C
148 C
160 C
155 C
Desalter
155 C, 8.4 barg
23.0 barg
165 C
181 C
0.4 Flowrate
97.5 kkg/h
0.6 Flowrate
146.3 kkg/h
189 C
204 C
222 C
251 C
260 C
257 C
Crude Preheat Train No. 2
265 C
7.4 barg
Heater
11.42 MW
11.42 MW
New Heater
1.86 MW
360 C
4.3 barg
HP Column
7.48 MW
8.40 MW
1.00 MW
A1
127 C
60 C
166 C
3.90 barg
45C, 3.0 barg
63.8 m3/h
7.5 barg
2) Total Naphtha
76.9 m3/h
45 C, 13.9 barg
1.91 MW
123 C
6.66 MW
165.5 m3/h
214 C to 144 C
8.2 barg
4.48 MW
164.0 m3/h
288 C to 247 C
307 C, 9.5 barg
6) 248 C
7) 238 C
8) 300 C
9) 307 C
2.23 MW
3.97 barg
265 C, 9.2 barg
S1) steam
588 kg/h
373 C
5.4 barg
5) Topped crude
100.9 m3/h
353 C
3.95 barg
S2) steam
1250 kg/h
373 C, 5.4 barg
4.05 barg
293 C, 10.7 barg
Debutanizer
63 C, 8.41 barg
1.10 MW, 0.5 Flowrate
11.2 kkg/h
1.10 MW
29.8 m3/h
19.6 barg
0.03 MW
2.40 MW
111 C
186 C
8.68 barg
4.56 MW
ATM Column
2.49 MW
3.96 MW
0.20 MW
A2
111 C
60 C
201 C
0.60 barg
45 C, 0 barg
3.3 m3/h
2.83 MW
80.9 m3/h
232 C to 179 C
6.1 barg
13) LGO, 9.6 m3/h
45 C,11.7 barg
1.79 MW
1.10 MW
0.34 MW
A5
163 C
70 C
63 C
14) HGO
21.4 m3/h
291 C, 9.6 barg
S4) steam
2386 kg/h
383 C, 2.4 barg
S3) steam
4063 kg/h
383 C, 2.4 barg
0.66 barg
1.68 MW
3.59 MW
1.64 MW
2.41 MW
2.42 MW
331 C
13.8 barg
300 C
230 C
196 C
142 C
3.65 MW
0.87 MW
4.62 MW
0.81 MW
A3
210 C
189 C
65 C
4.03 MW
0.26 MW
A4
185 C
50 C
10) Fuel Gas
280.9 kg/h
45 C, 8.1 barg
11) LPG
10.2 m3/h
38 C, 19.5 barg
12) Stabilized Naphtha
66.1 m3/h
119 C, 7.3 barg
3) Kerosene
55.6 m3/h
40 C, 4 barg
4) Diesel
66.7 m3/h
40 C, 4 barg
15) Gas Oil
31.0 m3/h
40 C, 4 barg
16) Reduced Crdue
69.9 m3/h
82 C, 4 barg


Case C : Oman + Tapis (38 : 62 %vol) 50 KBD
1) Crude Feed
Qatar + Tapis (38 : 62 %vol)
50 KBD, 331.0 m3/h, 30 C, 0 barg
Crude Preheat Train No. 1
17.4 barg
0.5 Flowrate
136.4 kkg.h
138 C
52 C
169 C
138 C
154 C
Desalter
154 C, 8.4 barg
23.0 barg
161 C
175 C
0.5 Flowrate
136.4 kkg/h
198 C
187 C
245 C
238 C
272 C
255 C
Crude Preheat Train No. 2
265 C
7.4 barg
Heater
11.08 MW
11.08 MW
New Heater
9.72 MW
370 C
4.3 barg
HP Column
9.24 MW
10.7 MW
1.23 MW
135 C
A1
60 C
169 C
3.90 barg
45 C, 3.0 barg
111.9 m3/h
7.5 barg
2) Total Naphtha
60.8 m3/h
45 C, 13.9 barg
1.92 MW
111 C
0.0 MW
7.50 MW
162.0 m3/h
218 C to 138 C
8.2 barg
2.94 MW
130.9 m3/h
294 C to 260 C
320 C, 9.5 barg
6) 251 C
7) 244 C
8) 315 C
9) 320 C
2.45 MW
4.01 barg
265 C, 9.2 barg
3.02 MW
198 C
1.53 MW, 0.25 Flowrate, 14.0 kkg/h
4.32 MW, 0.75 Flowrate, 42.1 kkg/h
0.25 MW
A4
50 C
3) Kerosene
71.8 m3/h
40 C, 4 barg
S1) steam
1263 kg/h
318 C
5.4 barg
S2) steam
813 kg/h
318 C, 5.4 barg
4.09 barg
308 C, 10.7 barg
6.02 MW
210 C
1.24 MW
188 C
4.73 MW, 0.75 Flowrate, 57.1 kkg/h
0.83 MW
A3
65 C
4) Diesel
91.7 m3/h
40 C, 4 barg
1.85 MW, 0.25 Flowrate, 19.0 kkg/h
5) Bottom
107.0 m3/h
359 C
3.99 barg
ATM Column
1.70 MW
3.06 MW
0.16 MW
111 C
A2
60 C
215 C
0.60 barg
45 C, 0 barg
3.2 m3/h
2.67 MW
67.3 m3/h
247 C to 184 C
6.1 barg
13) LGO, 9.6 m3/h
45 C, 11.7 barg
1.35 MW
0.91 MW
170 C
A5
70 C
61 C
0.26 MW
15) Gas Oil
25.9 m3/h
40 C, 4 barg
14) HGO
16.3 m3/h
297 C, 9.6 barg
S4) steam
652 kg/h
383 C, 2.4 barg
S3) steam
3312 kg/h
383 C, 2.4 barg
0.66 barg
2.14 MW
4.15 MW
2.35 MW
2.34 MW
2.80 MW
334 C
13.8 barg
300 C
230 C
187 C
142 C
16) Reduced Crude
81.0 m3/h
82 C, 4 barg
Debutanizer
68 C
6.50 barg
0.56 MW
45 C, 6.1 barg
5.2 m3/h
19.6 barg
10) Fuel Gas
352.5 kg/h
45 C, 6.1 barg
0.01 MW
11) LPG
3.6 m3/h
38 C, 19.5 barg
172 C
6.77 barg
2.28 MW
12) Stabilized Naphtha
56.5 m3/h
108 C, 5.7 barg


Case A : Arabian Light 100 % 60 KBD
1) Crude Feed
Arabian light 100 %vol
60 KBD, 397 cu.m/h, 30 C, 0 barg
Crude Preheat Train No. 1
16.5 barg
0.5 Flowrate
170.7 kkg/h
130 C
90 C
162 C
155 C
159 C
Desalter
159 C, 8.4 barg
22.3 barg
0.46 Flowrate
157.0 kkg/h
219 C
0.54 Flowrate
184.3 kkg/h
190 C
0.5 Flowrate
92.2 kkg/h
217 C
203 C
228 C
210 C
278 C
226 C
321 C
266 C
Crude Preheat Train No. 2
292 C
7.4 barg
Heater
10.74 MW
10.74 MW
New Heater
8.72 MW
380C
4.3 barg
HP Column
10.2 MW
10.2 MW
1.22 MW
A1
173 C
3.90 barg
129 C
60 C
45 C, 3 barg
84.6 m3/h
7.4 barg
2) Total Naphtha
85.5 m3/h
45 C, 13.5 barg
2.70 MW
111 C
8.07 MW
197.4 m3/h
224 C to 153 C
8.1 barg
5.65 MW
194.8 m3/h
305 C to 258 C
317 C, 9.3 barg
6) 256 C
7) 246 C
8) 310 C
9) 317 C
1.87 MW
3.97 barg
271 C, 9.0 barg
2.95 MW
184 C
3.93 MW
A4
50 C
0.26 MW
3) Kerosene
54.6 m3/h
40 C, 4 barg
S1) steam
1530 kg/h
318 C
5.4 barg
S2) steam
1245 kg/h
318 C, 5.4 barg
4.05 barg
302 C, 10.3 barg
2.28 MW
254 C
1.74 MW
215 C
5.94 MW
A3
65 C
0.83 MW
4) Diesel
69.4 m3/h
40 C, 4 barg
5) Bottom
188 m3/h
372 C
3.95 barg
Debutanizer
70 C
6.5 barg
1.09 MW
49 C, 6.1 barg
13.2 m3/h
19.5 barg
0.02 MW
10) Fuel Gas
14.78 kg/h
49 C, 6.1 barg
11) LPG
5.3 m3/h
38 C, 19.4 barg
3.4 MW
169 C
6.77 barg
12) Stabilized Naphtha
80.1 m3/h
106 C, 4.8 barg
K1
K2
D1
D2
ATM Column
5.87 MW
1.43 MW
0.08 MW
A2
109 C
50 C
45 C, 0 barg
222 C
0.60 barg
3.6 m3/h
13) LGO
14 m3/h
45 C, 11.7 barg
0.0 MW
4.06 MW
97.3 m3/h
255 C to 191 C
6 barg
1.04 MW
247 C
0.83 MW
193 C
1.65 MW
A5
70 C
61 C
0.38 MW
15) Gas Oil
37.7 m3/h
40 C, 4 barg
14) HGO
23.7 m3/h
310 C, 9.5 barg
S4) steam
1601 kg/h
383 C, 2.4 barg
S3) steam
4500 kg/h
383 C, 2.4 barg
0.66 barg
5.55 MW
354 C
13.4 barg
6.08MW
308 C
6.79 MW
254 C
189 C
3.86 MW
RC
0.4 Flowrate, 58.4 kkg/h
3.43 MW
148 C
2.37 MW, 0.6 Flowrate, 87.6 kkg/h
16) Reduced Crude
150.4 m3/h
82 C, 4 barg


Case B : Qatar + Tapis (70 : 30 %vol) 60 KBD
1) Crude Feed
Qatar + Tapis (70 : 30 %vol)
60 KBD, 360 cu.m/h, 30 C, 0 barg
Crude Preheat Train No. 1
16.5 barg
0.5 Flowrate
146.3 kkg/h
130 C
52 C
161 C
158 C
160 C
Desalter
160 C, 8.4 barg
22.3 barg
0.46 Flowrate
134.6 kkg/h
202 C
0.54 Flowrate
158.0 kkg/h
186 C
0.5 Flowrate
79.0 kkg/h
209 C
195 C
212 C
202 C
242 C
223 C
263 C
266 C
Crude Preheat Train No. 2
265 C, 7.4 barg
Heater
11.42 MW
11.42 MW
New Heater
6.83 MW
360C
4.3 barg
HP Column
9.2 MW
9.9 MW
1.19 MW
166 C
3.90 barg
126 C
60 C
45 C, 3.0 barg
76.5 m3/h
7.4 barg
2) Total Naphtha
92.3 m3/h
45 C, 13.5 barg
2.88 MW
111 C
10.29 MW
198.7 m3/h
214 C to 123 C
8.1 barg
5.39 MW
196.7 m3/h
289 C to 247 C
6) 248 C
7) 238 C
8) 293 C
9) 307 C
2.67 MW
3.97 barg
265 C, 9.2 barg
307 C, 9.3 barg
4.05 barg
S1) steam
750 kg/h
373 C
5.4 barg
S2) steam
1500 kg/h
373 C, 5.4 barg
293 C, 10.9 barg
5) Bottom
121.1 m3/h
353 C
3.95 barg
Debutanizer
1.32 MW, 0.5 Flowrate
13.46 kg/h
63 C
8.41 barg
1.32 MW
35.7 m3/h
19.5 barg
45 C, 8.1 barg
0.02 MW
0.02 MW
0.5 Flowrate
3.4 kkg/h
185 C
8.68 barg
5.48 MW
10) Fuel Gas
337 kg/h
45 C, 8.1 barg
11) LPG
12.3 m3/h
38 C, 19.4 barg
12) Stabilized Naphtha
79.3 m3/h
119 C, 6.7 barg
1.07 MW, 0.2 Flowrate
10.4 kkg/h
1.07 MW
3.14 MW
3.01 MW
0.6 Flowrate, 31.3 kkg/h
0.19 MW
190 C
50 C
3) Kerosene
66.7 m3/h
40 C, 4 barg
1.37 MW
2.59 MW
245 C
219 C
4.22 MW
0.6 Flowrate, 39.9 kkg/h
0.53 MW
65 C
1.60 MW
1.60 MW
0.2 Flowrate, 13.3 kkg/h
4) Diesel
80.0 m3/h
40 C, 4 barg
ATM Column
1.84 MW
5.9 MW
0.25 MW
200 C
0.6 barg
200 C
60 C
45 C, 0 barg
0.41 MW
184 C to 177 C
4.2 m3/h
2.94 MW
102.1 m3/h
231 C to 184 C
6.0 barg
13) LGO
11.25 m3/h
45 C, 11.7 barg
1.05 MW
0.55 MW
1.85 MW
0.40 MW
230 C
197 C
70 C
63 C
14) HGO
25.5 m3/h
291 C, 9.5 barg
15) Gas Oil
36.8 m3/h
40 C, 4 barg
S4) steam
2889 kg/h
368 C, 2.4 barg
S3) steam
4875 kg/h
368 C, 2.4 barg
0.65 barg
2.36 MW
3.11 MW
4.09 MW
1.7 MW
2.92 MW
331 C
13.6 barg
295 C
245 C
174 C
142 C
16) Reduced Crude
84.3 m3/h
82 C, 4 barg


Case C : Oman + Tapis (38 : 62 %vol) 60 KBD
1) Crude Feed
Oman + Tapis (38 : 62 %vol)
60 KBD, 397.5 cu.m/h, 30 C, 0 barg
Crude Preheat Train No. 1
16.5 barg
0.5 Flowrate
163.7
130 C
75 C
161 C
158 C
160 C
Desalter
160 C, 8.4 barg
22.3 barg
0.46 Flowrate
150.6 kkg/h
207 C
0.54 Flowrate
176.8 kkg/h
185 C
0.5 Flowrate
88.4 kkg/h
221 C
192 C
206 C
215 C
249 C
237 C
265 C
262 C
Crude Preheat Train No. 2
263 C, 7.4 barg
Heater
11.08 MW
11.08 MW
New Heater
16.66 MW
370C
4.3 barg
HP Column
10.2 MW
13.7 MW
1.47 MW
169 C
3.9 barg
137 C
A1
60 C
45 C, 3.0 barg
134.8 m3/h
7.4 barg
2) Total Naphtha
72.8 m3/h
45 C, 13.5 barg
9.01 MW
195.0 m3/h
218 C to 138 C
8.1 barg
3.52 MW
157.0 m3/h
293 C to 260 C
320 C, 9.3 barg
6) 251 C
7) 244 C
8) 315 C
9) 320 C
2.98 MW
4.02 barg
265 C, 9.0 barg
S1) steam
1515 kg/h
318 C
5.4 barg
S2) steam
975 kg/h
318 C, 5.4 barg
4.10 barg
308 C, 10.3 barg
5) Bottom
128.4 m3/h
359 C
3.99 barg
S4) steam
768 kg/h
383 C, 2.4 barg
S3) steam
3974 kg/h
383 C, 2.4 barg
ATM Column
4.3 MW
0.80 MW
0.19 MW
111 C
A2
60 C
215 C
0.60 barg
45 C, 0 barg
0.0 MW
3.21 MW
80.9 m3/h
247 C to 184 C
6.0 barg
3.9 m3/h
14) HGO
19.6 m3/h
297 C, 9.5 barg
0.87 MW
0.40 MW
1.45 MW
232 C
200 C
A5
70 C
61 C
13) LGO
11.6 m3/h
45 C, 11.7 barg
0.32 MW
1.84 MW
4.06 MW
5.17 MW
334 C
13.4 barg
310 C
254 C
176 C
2.12 MW
3.36 MW
142 C
0.65 barg
Debutanizer
68 C
6.50 barg
0.68 MW
45 C, 6.1 barg
6.3 m3/h
19.6 barg
0.01 MW
2.30 MW
111 C
172 C
6.77 barg
2.74 MW
1.46 MW, 0.2 Flowrate
13.5 kkg/h
1.46 MW
4.14 MW
0.6 Flowrate 40.4 kkg/h
50 C
0.24 MW
3.65 MW
198 C
A4
A3
5.91 MW
0.6 Flowrate, 54.9 kkg/h
65 C
0.80 MW
2.24 MW
2.24 MW
0.2 Flowrate, 18.3 kkg/h
4.12 MW
2.34 MW
254 C
221 C
10) Fuel Gas
395.9 kg/h
45 C, 6.1 barg
11) LPG
4.5 m3/h
38 C, 19.4 barg
12) Stabilized Naphtha
67.6 m3/h
108 C, 5.3 barg
3) Kerosene
86.2 m3/h
40 C, 4 barg
4) Diesel
110.2 m3/h
40 C, 4 barg
15) Gas Oil
31.1 m3/h
40 C, 4 barg
16) Reduced Crude
97.2 m3/h
82 C, 4 barg

Heat Exchanger Configuration and Pump Rating

1) HEN Configurations

			Existing Units at 40 KBD													50 KBD	60 KBD	
HX-code	2E1XX	Unit	1	2	3	4	5	6	7	8	9	10	11	120	124	N1	N1	N2
Name			HPC	ATMC	KERO	HPTP	GO	ATMP	DIE2	RC2	HPBP	DIE1	RC1	KRE	DBPH	New Unit	New Units	
Type			AJS	AJS	BES	BES	BES	BES	BES	BES	BES	BES	BES	BES	BES	BES	AJS	AJS
Area (m2)			668	582	96.5	96.5	260	338	212.2	862	331.5	190	538	166	75.2	538	434	1159
Tube	Feed		Crude	Crude	Crude	Crude	Crude	Crude			Crude					Crude	Crude	Crude
	Length	mm	7,320	7,320	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	7,320	7,320
	OD	mm	25.4	25.4	19.0	19.0	25.4	19.0	19.0	25.4	19.0	19.0	25.4	19.0	19.0	25.4	31.8	31.8
	Thickness	mm	2.77	2.77	2.11	2.11	2.77	2.11	2.11	2.77	2.11	2.11	2.77	2.11	2.11	2.77	2.77	2.77
	Number		1,180	1,026	284	284	558	980	632	936	956	542	580	475	219	580	304	544
	Pass		8	8	2	2	4	4	6	10	4	8	6	1	4	6	6	6
	Pattern	deg	90	90	90	90	90	90	90	90	90	90	90	90	45	90	90	90
	Pitch	mm	31.8	31.8	25.0	25.0	31.8	25.4	25.4	31.8	25.4	25.4	31.8	25.4	25.4	31.8	39.7	39.7
	Tnozzle	in	8,8	8,8	8,8	8,8	8,8	8,8	4,4	8,8	10,10	4,4	6,6	8,10	6,6	6,6	8,8	8,8
	Δ P (allow.)	bar	1.50	1.00	1.15	0.84	0.60	0.70	0.90	0.70	1.00	0.66	1.00		0.85	1.00	1.50	1.50
	(calcul.)		1.34	1.15	1.15	0.84	0.46	0.62	0.32	0.51	0.90	0.66	0.79		0.85	0.79	0.96	0.33
Shell	Feed								Crude	Crude		Crude	Crude					
	ID	mm	1,400	1,300	550	550	950	1,000	850	1,250	1,000	800	1,000	700	550	1,000	889	1,143
	Series		1	1	1	1	1	1 0	1	1	1	1	1	1	1	1	2	3
	Seal		4	4	0	0	3	4	3	3	4	2	2	3	2	2	4	4
	Δ P (allow.)	bar	0.1	0.1	0.1	0.5	0.1	0.1	0.7	0.6	0.1	0.4	0.6	0.8	0.5	0.6	0.1	0.1
	(calcul.)		0.08	0.03	0 02	0.21	0.03	0.05	0.14	0.22	0.09	0.27	0.43	0.7	0.4	0.43	0.06	0.04
Baffle	Segment		single	single	single	single	single	single	single	single	single	single	single	single	single	single	single	single
	Cut		0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.246	0.250	0.3	0.257	0.257
	Spacing	mm	287	311	300	300	289	245	555	383	300	400	408	150	130	408	287	287
Snozzles	ID	in	20,14*2	14,10*2	8,8	8,8	3,3	6,6	10,10	10,10	8,8	10,10	10,10	6,6	4,4	10,10	20,14	20,14

Note : Debottlenecking at

1) 50 KBD : Heat exchanger No. 4 and 11 must be added 1 shell in series of the existing unit.

2) 60 KBD : Heat exchanger No. 5 and 9 must be added 1 shell in series of the existing unit.

2) Cooler Configurations

			Existing Units at 40 KBD								50 KBD	60KBD
HX-code	2E1XX	Unit	12	13	14	16	17	18	19	25	27	K1, D1	K1, K2 , D1, D2
Name			HP-OV	TPA	ATM-OV	KERO	DIE	L&HGO	RC	DEB-OV	LPG		
Type			BES	BES	BES	BES	BES	BES	BES	BES	BES	BES	BES
Area (m2)			243	257.7	69	97.9	235	148	279.1	334	13.8	279.1	279.1
Tube	Feed		*CW	CW	CW	CW	CW	CW	CW	CW	CW	CW	CW
	Length	mm	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6000
	OD	mm	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19
	Thickness	mm	2.77	2.11	2.11	1.65	2.11	1.65	1.65	1.65	1.65	1.65	1.65
	Number		690	732	194	286	670	422	800	955	40	800	800
	Pass		2	2	6	6	4	6	2	6	4	2	2
	Pattern	deg	90	90	45	45	45	45	45	45	45	45	45
	Pitch	mm	25.0	25.0	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
	Tnozzle	in	8,10	12,12	3,3	4,4	6,6	6,6	8,8	6,6	3,3	8,8	8,8
	Δ P (allow.)	bar	0.10	0.25	0.50	0.90	0.50	0.50	0.40	0.50	0.70	0.40	0.4
	(calcul.)		0.02	0.29	0.24	0.52	0.43	0.43	0.31	0.40	0.39	0.31	0.31
Shell	Feed		HP-OV	TPA	ATM-OV	KERO	DIE	L&HGO	RC	DEB-OV	LPG		
	ID	mm	1,000	800	550	650	838	700	900	1,000	300	900	900
	Series		1	1	1	1	1	1.0	1	1	1	1	1
	Seal		-	-	2	2	4	3	4	4	1	4	4
	Δ P (allow.)	bar	1	0.2	0.1	0.15	0.15	0.3	1.5	0.3	0.5	1.5	1.5
	(calcul.)		0.2	0.13	0.02	0.06	0.11	0.04	0.51	0.05	0.04	0.51	0.51
Baffle	Segment		Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
	Cut		25.0	25.0	23.3	25.0	17.9	23.0	24.0	25.6	25.0	24.0	24
	Spacing	mm	600	300	181	150	168	157	189	288	100	189	189
Snozzles	ID	in	12,10	8,8	8,6	8,8	6,6	4,4	6,6	8,4	2,2	6,6	6,6

Note : Debottlenecking at

1) 50 KBD : Heat exchanger No. 25 must be added 1 shell in series of the existing unit.

2) 60 KBD : Heat exchanger No. 25 and 27 must be added 1 shell in series of the existing unit.

**CW = cooling water*

3) Pump Performace at 50 KBD

1 m. = 3.28 ft
1 bar. = 14.5 psi.
head (ft) = (psi)(2.31)/spgr.

■ Bottleneck pump is 2P103 because the new flowrate is more than the existing capacity about two times.
▨ Debottleneck by adding new pump in parallel connecting (103C).

Code 2PXXX	Service	40 KBD					Debottlenecking at 50 KBD					New	Diff. Head		Pressure
		Flow	Head (1)	Sp.Gr.	Pressure (barg)		Required Flow Rate (m3/h)				Flow per	Head (2)*	= (1) - (2)		out
		m3/h	m		In	Out	A	B	C	Max.	Pump	m.	m.	bar.	barg.
101AB(N)	Crude feed	**310**	**211**	0.85	0.00	17.60	331	300	331	**331**	**331**	**208**	3	0.2	17.4
101C(N)	Crude feed	**133**	**211**	0.85	0.00	17.60									
102AB(N)	Crude booster	**330**	**198**	0.76	8.40	23.10	331	300	331	**331**	**331**	**197**	1	0.1	23.0
103AB(N)	HP reflux	**67**	**60**	0.68	3.40	7.40	71	64	112	**112**	**56**	**62**	-2	-0.1	7.5
103C(add new)	***HP reflux***			0.68							**56**	**62**	-2	-0.1	7.5
104AB(N)	Naptha to debut.	**89**	**144**	0.69	3.84	13.60	71	77	61	**77**	**77**	**148**	-4	-0.3	13.9
105AB	HP PA(top)	**227**	**51**	0.58	5.03	7.95	165	166	162	**166**	**166**	**55**	-4	-0.2	8.2
106	Kerosene	**68**	**89**	0.57	4.27	9.20	46	56	72	**72**	**72**	**88**	1	0.0	9.2
107AB	Diesel	**79**	**107**	0.63	4.35	10.87	58	67	92	**92**	**92**	**104**	3	0.2	10.7
108AB	HP PA(bottom)	**333**	**60**	0.61	4.91	8.50	162	164	131	**164**	**164**	**76**	-16	-1.0	9.5
109AB	ATM reflux	**12**	**145**	0.79	0.49	11.67	17	13	13	**17**	**17**	**145**	0	0.0	11.7
110AB	ATM PA	**144**	**57**	0.68	1.89	5.69	81	86	67	**86**	**86**	**63**	-6	-0.4	6.1
111AB	Heavy gas oil	**26**	**116**	0.68	1.75	9.45	20	21	16	**21**	**21**	**118**	-2	-0.1	9.6
112AB	Reduced crude	**140**	**167**	0.77	1.00	13.60	125	70	81	**125**	**125**	**170**	-3	-0.2	13.8
117AB(N)	Debutanizer reflu	**40**	**224**	0.51	8.35	19.57	16	40	9	**40**	**40**	**224**	0	0.0	19.6

** Read from Centrifugal Pump Performance Curve*

4) Pump Performace at 60 KBD

1 m. = 3.28 ft
1 bar. = 14.5 psi.
head (ft) = (psi)(2.31)/spgr.

■ Bottleneck pump is 2P103 because the new flowrate is more than the existing capacity about two times.
▒ Debottleneck by adding new pump in parallel connecting (103C).

Code 2PXXX	Service	40 KBD					Debottlenecking at 60 KBD					New	Diff. Head = (1) - (2)		Pressure out
		Flow	Head (1)	Sp.Gr.	Pressure (barg)		Required Flow Rate (m3/h)				Flow per	Head (2)*			
		m3/h	m		In	Out	A	B	C	Max.	Pump	m.	m.	bar.	barg.
101AB(N)	Crude feed	**310**	**211**	0.85	0.0	17.6	397	360	397	**397**	**397**	**198**	13	1.1	16.5
101C(N)	Crude feed	**133**	**211**	0.85	0.0	17.6									17.6
102AB(N)	Crude booster	**330**	**198**	0.76	8.4	23.1	397	360	397	**397**	**397**	**188**	10	0.8	22.3
103AB(N)	HP reflux	**67**	**60**	0.68	3.4	7.4	84	76	135	**135**	**68**	**60**	0	0.0	7.4
103C(add new)	***HP reflux***			0.68							**68**	**60**	0	0.0	7.4
104AB(N)	Naptha to debut.	**89**	**144**	0.69	3.8	13.6	85	92	73	**92**	**92**	**143**	1	0.1	13.5
105AB	HP PA(top)	**227**	**51**	0.58	5.0	8.0	197	199	195	**199**	**199**	**53**	-2	-0.1	8.1
106	Kerosene	**68**	**89**	0.57	4.3	9.2	55	67	86	**86**	**86**	**85**	4	0.2	9.0
107AB	Diesel	**79**	**107**	0.63	4.4	10.9	69	80	110	**110**	**110**	**97**	10	0.6	10.3
108AB	HP PA(bottom)	**333**	**60**	0.61	4.9	8.5	195	197	157	**197**	**197**	**74**	-14	-0.8	9.3
109AB	ATM reflux	**12**	**145**	0.79	0.5	11.7	18	15	16	**18**	**18**	**145**	0	0.0	11.7
110AB	ATM PA	**144**	**57**	0.68	1.9	5.7	97	102	81	**102**	**102**	**62**	-5	-0.3	6.0
111AB	Heavy gas oil	**26**	**116**	0.68	1.8	9.5	24	26	20	**26**	**26**	**116**	0	0.0	9.5
112AB	Reduced crude	**140**	**167**	0.77	1.0	13.6	150	84	97	**150**	**150**	**165**	2	0.2	13.4
117AB(N)	Debutanizer reflu	**40**	**224**	0.51	8.4	19.6	18	48	11	**48**	**48**	**223**	1	0.1	19.5

** Read from Centrifugal Pump Performance Curve*

Economic Evaluation

Procurement cost is estimated from summation of four main parts:

1 Purchased Equipment (PE)
2 Piping 15%PE
3 Instrument and Electrical 15%PE
4 Others 15%PE

Marshall & Swift Equipment Cost Index (CI) [27]	
4th Q' 1994	1048.5
Annual index' 1992	943.1
Index Jan.1979	569
Annual Index ' 1969	280

Purchased Equipment Cost Basis

Heat Exchanger [26]

$$Cost(\$) = (30{,}800 + 750A^{0.81})\left(\frac{CI_{1994}}{CI_{1992}}\right)$$

A = shell/tube exchanger area (sq.m.)
CI = Marshall and Swift Equipment Cost Index
Material = Carbon Steel

Heater [20]

$$Cost(\$) = (5.52 \times 10^{3})Q^{0.85}(2.27)\left(\frac{CI_{1994}}{CI_{1969}}\right)$$

Q = adsorbed duty (MBtu/h) , 20 < Q < 300
1 Watt = 3.412 Btu/h

Column

Expanding-Column Cost = 40 K$/m. (Data'1994 from Bangchak's experience of tower revamping.)

Packing Cost [25] = 47.50 $/cu.ft (1979)
(based on 2 inch Pall Rings = 87.53 $/cu.ft (1994)
(stainless steel)) = 3.09 k$/cu.m (1994) (1 cu.m. = 35.3 cu.ft.)

1) Total Capital Cost at 50 KBD is estimated from the purchased equipment cost.

1.1) Purchased equipment cost at 50 KBD

Heat Exchanger		area/shell	Series	Parallel	Area (sq.m)	Cost (M$)
HEN	E104(N)	96	1	1	96	0.07
	N1	269	2	1	538	0.17
	E111	269	1	1	269	0.11
Cooler	E124(N)	75	1	1	75	0.06
	E125(N)	334	1	1	334	0.13
	E127(N)	279	1	2	558	0.17
Total area (sq.m.)					**1,870**	**0.71** (1)
						381 $/m2

Heater	MW	
Max. required duty	31.9	
Existing duty	22.2	
New heater	9.7	
New heater (80%eff.)	12.1	
Cost (M$)	**1.11** (2)	**92** k$/MW

Column		cost (M$)	
HP-column			
Expanding height	1.6 m.	0.064	**40** k$/m.
Packing volume	96.42 cu.m.	0.30	
ATM-column			
Packing volume	11 cu.m.	0.03	**3.09** k$/cu.m.
Sum column cost		**0.40** (3)	Average Cost/Unit

New Pump

Only one new pump must be added for kerosene stream.

Cost new pump [28] =	**0.004** (4)	
(flowrate = 56 m3/h, head = 62 m)	M$	

Total equipment cost = (1)+(2)+(3)+(4) =	**2.22**	**M$**

1.2) Total Capital Investment at 50 KBD

	Percent*	M$
A) Direct cost (DC)		
- Procurement		
1 Purchased Equipment (PE)		**2.22**
2 Piping	15 % of PE	0.33
3 Instrument & Electrical	15 % of PE	0.33
4 Others	15 % of PE	0.33
Total procurement cost	***50 % of DC***	***3.22***
- Engineering & supervision	20 % of DC	1.29
- Construction expense	30 % of DC	1.93
Total direct cost (A)	***100 % of DC***	***6.45***
B) Indirect cost	20 % of A	1.29
C) Contingency	20 % of (A + B)	1.55
Total Capital Investment (A + B +C)		**9.28**

Pay back period	**2.1 year**
NPV (discount rate =15 %)	**13.4 M$**
%IRR	**47%**

**These percents are recommended from Bangchak Petroleum Company.*

2) Total Capital Cost at 60 KBD is estimated from the purchased equipment cost.

2.1) Purchased equipment cost at 60 KBD

Heat Exchanger		area/shell	Series	Parallel	Area (sq.m)	Cost (M$)
HEN	N1	217	2	1	434	0.28
	N2	386	3	1	1158	0.29
	E105	260	1	1	260	0.11
	E109	332	1	1	332	0.13
Cooler	RCN	279	1	1	279	0.11
	E124(N)	75	1	1	75	0.06
	E125(N)	334	1	1	334	0.13
	E127(N)	13.8	1	1	13.8	0.04
	KERO(N)	279	1	2	558	0.17
	DIE(N)	279	1	2	558	0.17
Total area (sq.m.)					**4,002.0**	**1.50** (1)
						375 $/m2

Heater	MW	
Max. required duty	38.8	
Existing duty	22.2	
New heater	16.6	
New heater (80%eff.)	20.8	
Cost (M$)	**1.75** (2)	**85** k$/MW

Column		cost (M$)	
HP-Column			
Expanding height	7 m.	0.280	**40** k$/m.
Packing volume	142.6 cu.m.	0.44	
ATM-Column			
Packing	19.5 cu.m.	0.06	**3.09** k$/cu.m.
Sum column cost		**0.78** (3)	Average Cost/Unit

New Pump

Only one new pump must be added for kerosene stream.

Cost new pump [28] = **0.004** (4) M$

(flowrate = 67 m3/h, head = 60 m)

Total equipment cost = (1)+(2)+(3)+(4) =	**4.04**	**M$**

2.2) Total Capital Investment at 60 KBD

	Percent*	M$
A) Direct cost (DC)		
- Procurement		
1 Purchased Equipment (PE)		**4.04**
2 Piping	15 % of PE	0.61
3 Instrument & Electrical	15 % of PE	0.61
4 Others	15 % of PE	0.61
Total procurement cost	***50 % of DC***	***5.85***
- Engineering & supervision	20 % of DC	2.34
- Construction expense	30 % of DC	3.51
Total direct cost (A)	***100 % of DC***	***11.71***
B) Indirect cost	20 % of A	2.34
C) Contingency	20 % of (A + B)	2.81
Total Capital Investment (A + B +C)		**16.86**

Pay back period	**1.9 year**
NPV (discount rate =15 %)	**28.7 M$**
%IRR	**52%**

**These percents are recommended from Bangchak Petroleum Company.*

3) Cash Flow at 50 KBD

Basis

Increasing capacity	10 KBD
Project life	15 years
Operating days per year	340 days
Gross Margin (fixed)	2.7 $/BBL*
Marginal Expense (Utilities, etc.)	0.5 $/BBL*
%Income Tax per year	35 %
%Inflation of marginal expense per year	4 %

Cash Flow	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Unit : M$																	
1. Total capital cost		-9.3															
2. Gross margin			9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
3. Marginal expense (Utilities, etc.)			-1.7	-1.8	-1.8	-1.9	-2.0	-2.1	-2.2	-2.2	-2.3	-2.4	-2.5	-2.6	-2.7	-2.8	-2.9
4. Depreciation (straight-line) = (1)/15			-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
5. Income before tax = sum (1,2,3,4)			6.9	6.8	6.7	6.6	6.6	6.5	6.4	6.3	6.2	6.1	6.0	5.9	5.8	5.7	5.6
6. Tax (35%per year) = 0.35(5)			-2.4	-2.4	-2.4	-2.3	-2.3	-2.3	-2.2	-2.2	-2.2	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0
7. Income after tax = (5) + (6)			4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.1	4.1	4.0	3.9	3.9	3.8	3.7	3.7
8. Net Cash flow = (1) + (7)		**-9.3**	**4.5**	**4.4**	**4.4**	**4.3**	**4.3**	**4.2**	**4.2**	**4.1**	**4.1**	**4.0**	**3.9**	**3.9**	**3.8**	**3.7**	**3.7**

Pay back period	**2.1 year**
NPV (discount rate =15 %)	**13.4 M$**
%IRR	**47%**

Sensitivity Analysis	**Total capital investment (M$)**		
	7.9 down = -15%	9.3 0%	10.7 up = +15%
Gross Margin ($/BBL)			
2.3 down = -15%	**2.2** **10** **44%**	**2.6** **9** **37%**	**3.1** **7** **31%**
2.7 0%	**2.2** **15** **56%**	**2.1** **13** **47%**	**2.4** **12** **40%**
3.1 up = +15 %	**2.5** **19** **68%**	**2.3** **18** **57%**	**2.0** **16** **49%**

Pay back (year)
NPV (M$)
%IRR

** These values are used to plan capital budget of* Bangchak Petroleum Company for next 15 years.

4) Cash Flow at 60 KBD

Basis

Increasing capacity	20 KBD
Project life	15 years
Operating days per year	340 days
Gross Margin (fixed)	2.70 $/BBL*
Marginal Expense (Utilities, etc.)	0.5 $/BBL*
%Income Tax per year	35 %
%Inflation of marginal expense per year	4 %

Cash Flow	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Unit : M$																	
1. Total capital cost		-16.9															
2. Gross margin			18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4
3. Marginal expense (Utilities, etc.)			-3.4	-3.5	-3.7	-3.8	-4.0	-4.1	-4.3	-4.5	-4.7	-4.8	-5.0	-5.2	-5.4	-5.7	-5.9
4. Depreciation (straight-line) = (1)/15			-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1
5. Income before tax = sum (1,2,3,4)			13.8	13.7	13.6	13.4	13.3	13.1	12.9	12.8	12.6	12.4	12.2	12.0	11.8	11.6	11.3
6. Tax (35%per year) = 0.35(5)			-4.8	-4.8	-4.7	-4.7	-4.6	-4.6	-4.5	-4.5	-4.4	-4.3	-4.3	-4.2	-4.1	-4.1	-4.0
7. Income after tax = (5) + (6)			9.0	8.9	8.8	8.7	8.6	8.5	8.4	8.3	8.2	8.1	7.9	7.8	7.7	7.5	7.4
8. Net Cash flow = (1) + (7)		**-16.9**	**9.0**	**8.9**	**8.8**	**8.7**	**8.6**	**8.5**	**8.4**	**8.3**	**8.2**	**8.1**	**7.9**	**7.8**	**7.7**	**7.5**	**7.4**

Pay back period	**1.9 year**
NPV (discount rate =15 %)	**28.7 M$**
%IRR	**52%**

Sensitivity Analysis	**Total capital investment (M$)**		
	14.3 down = -15%	16.9 0%	19.4 up = +15%
Gross Margin ($/BBL)			
2.3 down = -15%	**2.0** **22** **50%**	**2.4** **20** **41%**	**2.8** **17** **35%**
2.7 0%	**1.6** **31** **62%**	**1.9** **29** **52%**	**2.2** **26** **45%**
3.1 up = +15 %	**1.3** **41** **75%**	**1.6** **38** **63%**	**1.8** **35** **54%**

Pay back (year)
NPV (M$)
%IRR

** These values are used to plan capital budget of* Bangchak Petroleum Company for next 15 years.

Input and Output Files

Input and output files of this work are compressed in diskette. List of those files are

Input Files	**Descriptions**
1. A40.INP	Case A at 40 KBD
2. B40.INP	Case B at 50 KBD
3. ACTUAL.INP	Actual case at 40 KBD
4. A50.INP	Debottlenecking case A at 50 KBD
5. B50.INP	Debottlenecking case B at 50 KBD
6. C50.INP	Debottlenecking case C at 50 KBD
7. A60.INP	Debottlenecking case A at 60 KBD
8. B60.INP	Debottlenecking case B at 60 KBD
9. C60.INP	Debottlenecking case C at 60 KBD

Output Files	**Descriptions**
1. A40.OUT	Case A at 40 KBD
2. B40.OUT	Case B at 50 KBD
3. ACTUAL.OUT	Actual case at 40 KBD
4. A50.OUT	Debottlenecking case A at 50 KBD
5. B50.OUT	Debottlenecking case B at 50 KBD
6. C50.OUT	Debottlenecking case C at 50 KBD
7. A60.OUT	Debottlenecking case A at 60 KBD
8. B60.OUT	Debottlenecking case B at 60 KBD
9. C60.OUT	Debottlenecking case C at 60 KBD

To expand these files to a hardisk directory (e.g., C), print this command (if insert the diskette in drive B)

C:\ **B:\P2**

and then press **ENTER**.

Input-File Example

Case A : Crude feed is the Arabian light 100% at 40 KBD

```
TITLE PROBLEM=Case:A, PROJECT=Arabia-40KBD, USER=SOMKID
      DIMEN  METRIC,PRES=BARG,TIME=HR,DUTY=WATT,&
             XDEN=SPGR,PBASIS(PSIA)=14.696,STDT(C)=15,STDP(ATM)=1
      OUTDIM SI,REPLACE,TEMP=C,PRES=BARG,VISCOSITY=CP,DUTY=WATT
      PRINT  INPUT=NONE,STREAM=NONE,RATE=WT

COMPONENT DATA
      LIBID  1,H20/2,C2/3,C3/4,IC4/5,NC4/6,IC5/7,NC5

THERMODYNAMIC DATA
      METHODS  KVALUE=SRK,ENTH=LK,ENTR=SRK,DENS(V)=SRK,&
               DENS(L)=API,TRANS=PETRO,FLPT=SIMSCI
      WATER    DECANT=ON,GPSA


STREAM DATA
      PROP STREAM=FEED,TEMP(C)=30,PRES=4.3,PHASE=L,&
           RATE(WT,KG/H)=227820,ASSAY=LV
         TBP   STREAM=FEED,PRES(MMHG)=760,&
               DATA=0.05,-17.78/0.1,-12.22/0.15,-6.67/&
               0.29,-1.11/0.52,4.44/0.75,10/0.98,15.56/&
               1.23,21.11/1.6,26.67/1.97,32.22/2.63,37.78/&
               3.29,43.33/3.96,48.89/4.64,54.44/5.31,60/5.99,65.66/&
               6.53,70/8.40,85/10.4,100/13.5,120/16.2,135/&
               19,150/20.9,160/23.8,175/26.7,190/29.5,205/&
               32.3,220/35.1,235/37.9,250/40.7,265/43.5,290/&
               46.3,295/49.1,310/51.8,325/55.1,343/57,355/&
               59.4,370/61.8,385/64.1,400/66.4,415/68.6,430/&
               70.7,445/72.1,455/74.7,475/76.5,490/78.9,510/&
               80,520/81.6,535/83.2,550/84.7,565/100,816
         API   STREAM=FEED,AVG=33.1,&
               DATA=0,246.8/0.03,147.1/0.11,119.8/&
               0.67,110.8/1.56,94.9/2.79,92.7/&
               5.07,79/7.46,72/9.4,67.5/11.95,63/&
               14.85,59/17.6,55.3/19.95,52.7/22.35,50.5/&
               25.25,48.6/28.1,47.1/30.9,46.3/33.7,44.1/&
               36.5,42/39.3,39.2/42.1,36.8/44.9,35.4/&
               47.7,34.8/50.45,33.3/53.45,30.5/56.05,28.8/&
               58.2,28/60.6,26.7/62.95,25.5/65.25,24.6/&
               67.5,23.7/69.65,22.8/71.4,21.9/73.4,21.2/&
               75.6,20.4/77.7,19.4/79.45,18.5/80.8,17.7/&
               82.4,17/83.95,16.5
         LIGHT STREAM=FEED,PERCENT(WT)=2.59,&
               COMP(WT)=3,0.03/4,0.09/5,0.67/6,0.59/7,1.21
```

```
PROP STREAM=WNAP,TEMP=42,PRES=6,PHASE=L,&
     RATE(WT,KG/H)=1633,ASSAY=WT
   TBP   STREAM=WNAP,PRES(MMHG)=760,&
         DATA=20,1/30,40/70,100/80,200/95,300
   SPGR  STREAM=WNAP,AVG=0.6887
   LIGHT STREAM=WNAP,RATE(WT)=209.7,&
         COMP(WT)=2,45/3,30/4,20/5,114.7

* REFERANCE STREAM PROPERTIES IN HEAT EXCHAGER NETWORK SYSTEM.

PROP STREAM=CF,REFSTREAM=FEED,TEMP=30,PRESS=17.6
PROP STREAM=PC11,REFSTREAM=C11,PRESS=7.4
PROP STREAM=KERO,REFSTREAM=3,PRESS=9.2
PROP STREAM=HGO,REFSTREAM=14,PRESS=11.67
PROP STREAM=DIE1,REFSTREAM=4,PRESS=10.22
PROP STREAM=DIE2,REFSTREAM=4,TEMP=236,PRESS=10.87
PROP STREAM=RC1,REFSTREAM=16,PRESS=12.5
PROP STREAM=RC2,REFSTREAM=16,TEMP=284,PRESS=12
PROP STREAM=TNAP,REFSTREAM=2,PRESS=13.6
PROP STREAM=SNAP,REFSTREAM=12
PROP STREAM=GO,REFSTREAM=15,PRESS=9.5

PROP STREAM=FEED1,TEMP=30,PRES=4.3,PHASE=L,&
     RATE(WT,KG/H)=200,COMP=1,100,NORMALIZE
PROP STREAM=S1,TEMP(C)=318,PRES(BARG)=5.4,PHASE=V,&
     RATE(WT,KG/H)=1020,COMP=1,100,NORMALIZE
PROP STREAM=S2,TEMP(C)=318,PRES(BARG)=5.4,PHASE=V,&
     RATE(WT,KG/H)=830,COMP=1,100,NORMALIZE
PROP STREAM=S3,TEMP(C)=383,PRES(BARG)=2.4,PHASE=V,&
     RATE(WT,KG/H)=3000,COMP=1,100,NORMALIZE
PROP STREAM=S4,TEMP(C)=383,PRES(BARG)=2.4,PHASE=V,&
     RATE(WT,KG/H)=1500,COMP=1,100,NORMALIZE
PROP STREAM=S5,TEMP(C)=173,PRES(BARG)=3.9,PHASE=V,&
     RATE(KGM/H)=107.5,COMP=1,100,NORMALIZE
PROP STREAM=S6,TEMP(C)=225,PRES(BARG)=0.6,PHASE=V,&
     RATE(KGM/H)=223.5,COMP=1,100,NORMALIZE

NAME 1,CRUDE FEED/2,TOTAL NAPHTHA/3,KEROSENE/4,DIESEL/&
     5,TOPPED CRUDE/10,FUEL GAS/11,LPG/12,SATABILIZE NAPHTHA/&
     13,LIGHT GASOIL/14,HEAVY GASOIL/15,GAS OIL/&
     16,REDUCED CRUDE/17,DS+GO

OUTPUT   STREAM=FEED,FEED1,1A,1,FORMAT=FM1
OUTPUT   STREAM=FEED,FEED1,1A,1,2,3,4,5,11,12,13,*
         14,15,16,17,FORMAT=FM2
OUTPUT   STREAM=1,10,FORMAT=FM3
OUTPUT   STREAM=S1,S2,S3,S4,W1,W2,W3,FORMAT=FM4
FORMAT   IDNO=FM1,TOTAL,TEMP,PRESS,RATE(KG/H),&
         SRATE(LV,M3/H),DENSITY(KG/M3),FLASH(C),API,SPGR,&
         VISCOSITY(CP),LFRAC(WT),CRATE(WT,1,7)
FORMAT   IDNO=FM2,LIQUID,TEMP,PRESS,RATE(KG/H),&
         SRATE(LV,M3/H),DENSITY(KG/M3),FLASH(C),API,SPGR,&
         VISCOSITY(CP),LFRAC(WT),CRATE(WT,1,7)
```

```
      FORMAT    IDNO=FM3,VAPOR,TEMP,PRESS,RATE(KG/H),&
                SRATE(LV,M3/H),DENSITY(KG/M3),FLASH(C),API,SPGR,&
                VISCOSITY(CP),LFRAC(WT),CRATE(WT,1,7)
      FORMAT    IDNO=FM4,TOTAL,TEMP,PRESS,RATE(KG/H),CRATE(WT,1,2)

 UNIT OPERATIONS

*** 1) SEPERATION SECTION

   MIXER      UID=MIX1,NAME=FEED MIXER
      FEED    FEED,FEED1
      PROD    L=1A

   HX         UID=HEATER,NAME=CRUDE HEATER
      COLD    FEED=1A,M=1
      OPER    CTEMP=380

   COLUMN     UID=C101,NAME=CRUDE TOWER
      PARAM   TRAY=23,IO=12,DAMP=0.7
      FEED    1,22/6,10/8,16/S1,23/WNAP,8
      PROD    OVHD(KG/H)=2,42276.5,WATER(WT,KG/H)=W1,1,BTMS=5,&
              LDRAW(WT,KG/H)=7,12,38723.3/9,20,50626.7
      COND    TYPE=TFIX,TEMP=45
      DUTY    1,1,-14.836/2,8,-5.462/3,19,-5.231
      PA      FROM=9,TO=8,PHASE=L,RATE(KG/H)=102200
      PA      FROM=20,TO=19,PHASE=L,RATE(KG/H)=109605
      TFLOW   TOTAL(V)=HPOV,2,PA(L)=RK,20,19/TPA,9,8
      PRES    1,3/2,3.9/22,4.2/23,4.3
      ESTI    MODEL=CONV,TTEMP=175,BTEMP=373
      PRINT   PROP=BRIEF
      SPEC    STREAM=3,RATE(M3/H),DRY,VALUE=36.4
      SPEC    STREAM=4,RATE(M3/H),DRY,VALUE=46.2
      SPEC    STREAM=5,RATE(M3/H),DRY,VALUE=125.4
      VARY    DUTY=1,DRAW=9
      TRATE   SECTION(1)=2,7,V1,PASS=2,*
              SPACING(MM)=610,DIAMETER(TRAY,MM)=2740,*
              WEIR(MM)=60,DCC(MM)=40,DCW(MM)=307,266
      TRATE   SECTION(2)=8,V1,PASS=2,*
              SPACING(MM)=760,DIAMETER(TRAY,MM)=3350,*
              WEIR(MM)=100,DCC(MM)=90,DCW(MM)=336,278
      TRATE   SECTION(3)=9,18,V1,PASS=2,*
              SPACING(MM)=500,DIAMETER(TRAY,MM)=3350,*
              WEIR(MM)=70,DCC(MM)=60,DCW(MM)=330,270
      TRATE   SECTION(4)=19,20,V1,PASS=2,*
              SPACING(MM)=660,DIAMETER(TRAY,MM)=3350,*
              WEIR(MM)=70,DCC(MM)=60,DCW(MM)=330,270
      TRATE   SECTION(5)=21,22,V1,PASS=2,*
              SPACING(MM)=450,DIAMETER(TRAY,MM)=3350,*
              WEIR(MM)=70,DCC(MM)=60,DCW(MM)=330,270
      TRATE   SECTION(6)=23,V1,PASS=2,*
              SPACING(MM)=610,DIAMETER(TRAY,MM)=1830,*
              WEIR(MM)=70,DCC(MM)=60,DCW(MM)=325,350
```

```
SIDESTRIPPER UID=C103,NAME=KERO STRIP
   PARAM  TRAY=3
   FEED   7,1
   PROD   OVHD=6,BTMS(WT,KG/H)=3,29068.6
   PRES   1,4.05/3,4.08
   ESTI   MODEL=CONV,TTEMP=262,BTEMP=279
   DUTY   1,3,1.346
   VARY   DUTY=1
   TRATE  SECTION(1)=1,3,V1,PASS=1,*
          SPACING(MM)=600,DIAMETER(TRAY,MM)=1830,*
          WEIR(MM)=70,DCC(MM)=60,DCW(MM)=400

SIDESTRIPPER UID=C104,NAME=DEISEL OIL STRIP
   PARAM  TRAY=2
   FEED   9,1/S2,2
   PROD   OVHD=8,BTMS(WT,KG/H)=4,39432.5
   PRES   1,4.15/2,4.17
   ESTI   MODEL=CONV,TTEMP=314,BTEMP=303
   TRATE  SECTION(1)=1,V1,PASS=1,*
          SPACING(MM)=750,DIAMETER(TRAY,MM)=1070,*
          WEIR(MM)=80,DCC(MM)=70,DCW(MM)=270
   TRATE  SECTION(2)=2,V1,PASS=1,*
          SPACING(MM)=750,DIAMETER(TRAY,MM)=1070,*
          WEIR(MM)=80,DCC(MM)=70,DCW(MM)=325

PUMP      UID=P1,NAME=NAPHTHA PUMP
   FEED   2
   PROD   L=2A
   OPERA  PRESS=8.8

HX        UID=H1,NAME=NAPHTHA HEATER
   COLD   FEED=2A,L=2B
   OPER   CTEMP=111

COLUMN    UID=C105,NAME=DEBUTANIZER
   PARAM  TRAY=25,IO=12,DAMP=0.7
   FEED   2B,7
   PROD   OVHD(KG/H)=10,9.8,WATER=W3,1,&
          BTMS=12,LDRAW(KG/H)=11A,1,2055
   COND   TYPE=MIXED,TESTIMATE=49
   DUTY   1,1,-0.685/2,25,2.28
   PRES   1,6.1/2,6.5/25,6.77
   ESTI   MODEL=SIMP,TTEMP=70,BTEMP=168
   PRINT  PROP=BRIEF
   SPEC   STREAM=10,RATE(KG/H),DRY,VALUE=9.8
   VARY   DUTY=1
   TRATE  SECTION(1)=2,6,V1,PASS=1,*
          SPACING(MM)=610,DIAMETER(TRAY,MM)=1100,*
          WEIR(MM)=50,DCC(MM)=40,DCW(MM)=200
   TRATE  SECTION(2)=7,25,V1,PASS=2,*
          SPACING(MM)=610,DIAMETER(TRAY,MM)=1850,*
          WEIR(MM)=65,DCC(MM)=55,DCW(MM)=226,258
```

```
COLUMN     UID=C102,NAME=ATM FRACTIONATOR
    PARA    TRAY=12,IO=12,DAMP=0.8
    FEED    5,10/S4,10/S3,12
    PROD    OVHD(WT,KG/H)=13,7761.5,WATER=W2,1,&
            BTMS=16,LDRAW(WT,KG/H)=14,6,13836.8
    COND    TYPE=TFIX,TEMP=45
    DUTY    1,1,-4.922/2,2,-2.673
    PA      FROM=3,TO=2,PHASE=L,RATE(WT,KG/H)=55675
    TFLOW   TOTAL(V)=ATMOV,2,PA(L)=ATMPA,3,2
    PRESS   1,0/2,0.6/10,0.67/12,0.69
    PRINT   PROP=BRIEF
    ESTI    MODEL=REFINE,TTEMP=224,BTEMP=356
    SPEC    STREAM=13,RATE(KG/H),DRY,VALUE=7761.5,ATOL=5
    VARY    FEED=S4
    TRATE   SECTION(1)=2,3,V1,PASS=2,*
            SPACING(MM)=750,DIAMETER(TRAY,MM)=2000,*
            WEIR(MM)=60,DCC(MM)=50,DCW(MM)=224,192
    TRATE   SECTION(2)=4,10,V1,PASS=2,*
            SPACING(MM)=750,DIAMETER(TRAY,MM)=2000,*
            WEIR(MM)=55,DCC(MM)=30,DCW(MM)=224,192
    TRATE   SECTION(3)=11,12,V1,PASS=2,*
            SPACING(MM)=610,DIAMETER(TRAY,MM)=1600,*
            WEIR(MM)=60,DCC(MM)=50,DCW(MM)=211,198

HX          UID=H2,NAME=HGO
    HOT     FEED=14,L=14A
    OPER    HTEMP=70

MIXER       UID=MIX2
    FEED    13,14A
    PROD    L=15

MIXER       UID=MIX3
  FEED      15,4
  PROD      L=17

*** 2) HEAT EXCHANGER NETWORK (HEN)

HXRIG       UID=E101, NAME = HP OVHD - CRUDE
    TYPE        TEMA=AJS,AREA(M2)=668
    TUBE        FEED=CF,L=C1,*
                LENGTH(MM)=7320,OD(MM)=25.4,THICKNESS(MM)=2.77,*
                NUMBER=1180,PASS=8,PATTERN=90,PITCH(MM)=31.8
      TNOZZLE   ID(IN)=8,8
    SHELL       FEED=HPOV,M=RHPOV,*
                ID(MM)=1400,SERIES=1,SEALS=4
      BAFFLE    SEGMENT=SINGLE,CUT=.257,SPACING(MM)=287
      SNOZZLE   ID(IN)=20,14
    OPER        TTEMP=97
```

```
HXRIG          UID=E102, NAME = ATM OVHD - CRUDE
   TYPE        TEMA=AJS,AREA(M2)=582
   TUBE        FEED=C1,L=C2,*
               LENGTH(MM)=7320,OD(MM)=25.4,THICKNESS(MM)=2.77,*
               NUMBER=1026,PASS=8,PATTERN=90,PITCH(MM)=31.8
     TNOZZLE   ID(IN)=8,8
   SHELL       FEED=ATMOV,M=RATMOV,*
               ID(MM)=1300,SERIES=1,SEALS=4
     BAFFLE    SEGMENT=SINGLE,CUT=.251,SPACING(MM)=311
     SNOZZLE   ID(IN)=14,10

HXRIG          UID=E103, NAME = KERO - CRUDE
   TYPE        TEMA=BES,AREA(M2)=96.5
   TUBE        FEED=C2,L=C3,*
               LENGTH(MM)=6000,OD(MM)=19,THICKNESS(MM)=2.11,*
               NUMBER=284,PASS=2,PATTERN=90,PITCH(MM)=25
     TNOZZLE   ID(IN)=8,8
   SHELL       FEED=KERO,L=RKERO,*
               ID(MM)=550,SERIES=1,SEALS=0
     BAFFLE    SEGMENT=SINGLE,CUT=.282,SPACING(MM)=300
     SNOZZLE   ID(IN)=8,8

HXRIG          UID=E104, NAME = TOP PA - CRUDE
   TYPE        TEMA=BES,AREA(M2)=96.5
   TUBE        FEED=C3,L=C4,*
               LENGTH(MM)=6000,OD(MM)=19,THICKNESS(MM)=2.11,*
               NUMBER=284,PASS=2,PATTERN=90,PITCH(MM)=25
     TNOZZLE   ID(IN)=8,8
 SHELL         FEED=TPA,M=RTPA,*
               ID(MM)=550,SERIES=1,SEALS=0
    BAFFLE     SEGMENT=SINGLE,CUT=.282,SPACING(MM)=300
     SNOZZLE   ID(IN)=8,8

PUMP           UID=P102,NAME=CRUDE-BOOSTER
   FEED        C4
   PRODUCT     L=CF4
   OPER        PRESS=23.1

HXRIG          UID=E105, NAME = HGO - CRUDE
   TYPE        TEMA=BES,AREA(M2)=260
   TUBE        FEED=CF4,L=C5,*
               LENGTH(MM)=6000,OD(MM)=25.4,THICKNESS(MM)=2.77,*
               NUMBER=558,PASS=4,PATTERN=90,PITCH(MM)=31.8
     TNOZZLE   ID(IN)=8,8
   SHELL       FEED=HGO,L=RHGO,*
               ID(MM)=950,SERIES=1,SEALS=3
     BAFFLE    SEGMENT=SINGLE,CUT=.226,SPACING(MM)=289
     SNOZZLE   ID(IN)=3,3
```

```
HXRIG          UID=E106, NAME = ATM PA - CRUDE
   TYPE        TEMA=BES,AREA(M2)=338
   TUBE        FEED=C5,L=C6,*
               LENGTH(MM)=6000,OD(MM)=19,THICKNESS(MM)=2.11,*
               NUMBER=980,PASS=4,PATTERN=90,PITCH(MM)=25.4
     TNOZZLE   ID(IN)=8,8
   SHELL       ID(MM)=1000,SERIES=1,SEALS=4
     BAFFLE    SEGMENT=SINGLE,CUT=.183,SPACING(MM)=245
     SNOZZLE   ID(IN)=6,6
     ATTACH    COLUMN=C102,TYPE=PA,TRAY=2

HXRIG          UID=E107, NAME = DIESEL 2 - CRUDE
   TYPE        TEMA=BES,AREA(M2)= 212.2
   TUBE        FEED=DIE2,L=RDIE2,*
               LENGTH(MM)=6000,OD(MM)=19,THICKNESS(MM)=2.11,*
               NUMBER=632,PASS=6,PATTERN=90,PITCH(MM)=25.4
     TNOZZLE   ID(IN)=4,4
   SHELL       FEED=C6,L=C7,*
               ID(MM)=850,SERIES=1,SEALS=3
     BAFFLE    SEGMENT=SINGLE,CUT=.25,SPACING(MM)=555
     SNOZZLE   ID(IN)=10,10

HXRIG          UID=E108, NAME = REDUCED CRUDE 2 - CRUDE
   TYPE        TEMA=BES
   TUBE        FEED=RC2,L=RRRC2,*
               LENGTH(MM)=6000,OD(MM)=25.4,THICKNESS(MM)=2.77,*
               NUMBER=936,PASS=10,PATTERN=90,PITCH(MM)=31.8
     TNOZZLE   ID(IN)=8,8
   SHELL       FEED=C7,M=C8,*
               ID(MM)=1250,SERIES=2,PARALLEL=1,SEALS=3
     BAFFLE    SEGMENT=SINGLE,CUT=.25,SPACING(MM)=383
     SNOZZLE   ID(IN)=10,10

HXRIG          UID=E110, NAME = DIESEL 1 - CRUDE
   TYPE        TEMA=BES,AREA(M2)=190
   TUBE        FEED=DIE1,L=RDIE1,*
               LENGTH(MM)=6000,OD(MM)=19,THICKNESS(MM)=2.11,*
               NUMBER=542,PASS=8,PATTERN=90,PITCH(MM)=25.4
     TNOZZLE   ID(IN)=8,8
   SHELL       FEED=C8,M=C9,*
               ID(MM)=800,SERIES=1,SEALS=2
     BAFFLE    SEGMENT=SINGLE,CUT=.25,SPACING(MM)=400
     SNOZZLE   ID(IN)=10,10
   OPER        TTEMP=236

 HXRIG         UID=KRE, NAME = KERO. REBOILER - BOT. PA
   TYPE        TEMA=BES,AREA(M2)=166,ORIENTATION=VERTICAL
   TUBE        LENGTH(MM)=6000,OD(MM)=19,THICKNESS(MM)=2.11,*
               NUMBER=475,PASS=1,PATTERN=90,PITCH(MM)=25.4
     TNOZZLE   ID(IN)=8,10
     ATTACH    COLUMN=C103,TYPE=REBOILER
   SHELL       FEED=RK,M=RRK,*
               ID(MM)=700,SERIES=1,SEALS=3,DPSHELL=0
     BAFFLE    SEGMENT=SINGLE,CUT=.246,SPACING(MM)=150
     SNOZZLE   ID(IN)=6,6
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```
   HXRIG          UID=E109, NAME = BOT. PA - CRUDE
      TYPE        TEMA=BES,AREA(M2)=331.5
      TUBE        FEED=C9,L=C10,*
                  LENGTH(MM)=6000,OD(MM)=19,THICKNESS(MM)=2.11,*
                  NUMBER=956,PASS=4,PATTERN=90,PITCH(MM)=25.4
        TNOZZLE   ID(IN)=10,10
      SHELL       FEED=RRK,M=RRRK,*
                  ID(MM)=1000,SERIES=1,SEALS=4
        BAFFLE    SEGMENT=SINGLE,CUT=.19,SPACING(MM)=300
        SNOZZLE   ID(IN)=8,8
      OPER        TTEMP=257

   HXRIG          UID=E111, NAME = REDUCED CRUDE 1 - CRUDE
      TYPE        TEMA=BES
      TUBE        FEED=RC1,L=RRC1,*
                  LENGTH(MM)=6000,OD(MM)=25.4,THICKNESS(MM)=2.77,*
                  NUMBER=580,PASS=6,PATTERN=90,PITCH(MM)=31.8
        TNOZZLE   ID(IN)=6,6
      SHELL       FEED=C10,M=C11,*
                  ID(MM)=1000,SERIES=2,PARALLEL=1,SEALS=2
        BAFFLE    SEGMENT=SINGLE,CUT=.25,SPACING(MM)=408
        SNOZZLE   ID(IN)=10,10
      OPER        TTEMP=284

   HXRIG          UID=E124, NAME = DEBUTANIZER FEED PREHEATER
      TYPE        TEMA=BES,AREA(M2)=75.2
      TUBE        FEED=SNAP,L=RSNAP,*
                  LENGTH(MM)=6000,OD(MM)=19,THICKNESS(MM)=2.11,*
                  NUMBER=219,PASS=4,PATTERN=45,PITCH(MM)=25.4
        TNOZZLE   ID(IN)=6,6
      SHELL       FEED=TNAP,M=RTNAP,*
                  ID(MM)=550,SERIES=1,SEALS=2
        BAFFLE    SEGMENT=SINGLE,CUT=.25,SPACING(MM)=130
        SNOZZLE   ID(IN)=4,4
      DEFI        DUTY AS HX=H1,DUTY

*** 3) UTILITY SECTION

   HX             UID=F12, NAME = CRUDE HEATER
      COLD        FEED=PC11,M=C12,DP=2.8
      OPER        CTEMP=380

   HX             UID=A101, NAME = HP-OV-AIR
      HOT         FEED=RHPOV,L=HP1
      OPER        HTEMP=60

   HX             UID=E112, NAME = HP-OV-TRAIM
      HOT         FEED=HP1,L=HP2
      OPER        HTEMP=45

   HX             UID=E127, NAME = LPG-COOLER
      HOT          FEED=11A,L=11
      OPER        HTEMP=38
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HX          UID=A104, NAME = KERO-AIR
   HOT      FEED=RKERO,L=KEC1
   OPER     HTEMP=50

HX          UID=E116, NAME = KERO-TRAIM
   HOT      FEED=KEC1,L=KEC2
   OPER     HTEMP=40

HX          UID=A103, NAME = DIE-AIR
   HOT      FEED=RDIE2,L=DIE3
   OPER     HTEMP=65

HX          UID=E117, NAME = DIE-TRAIM
   HOT      FEED=DIE3,L=DIE4
   OPER     HTEMP=40

HX          UID=A102, NAME = ATM-OV-AIR
   HOT      FEED=RATMOV,L=AATM
   OPER     HTEMP=50

HX          UID=E114, NAME = ATM-TRAIM
   HOT      FEED=AATM,L=TATM
   OPER     HTEMP=45

HX          UID=A105, NAME = HGO-AIR
   HOT      FEED=RHGO,L=AHGO
   OPER     HTEMP=70

HX          UID=E118, NAME = GO-TRAIM
   HOT      FEED=GO,L=CGO
   OPER     HTEMP=40

HX          UID=SGEN, NAME = E115-121
   HOT      FEED=RRRC2,L=GEN1
   OPER     HTEMP=148

HX          UID=E119, NAME = RC-TRAIM
   HOT      FEED=GEN1,L=RC-2
   OPER     HTEMP=82

HX          UID=E113, NAME = HP-TPA
   HOT      FEED=RTPA,L=RTPA1
   OPER     HTEMP=154

END
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ABOUT THE AUTHOR

Mr. Somkid Phupaichitkul was born in Trang province on 20th February, 1968. He received his Bachelor of Science(Chemical Technology) from Chulalongkorn University in 1990. After graduation, Mr. Somkid worked at the Bangchak Petroleum Company Limited for one year. In 1992, he read for Master of Chemical Engineering at Chulalongkorn University.