

Table 2. Flow rates and normal boiling point ranges for products from processing of 10,000 BPSD of Brent Crude (119,913 lb/h). Design NBP range and flow rates are from CHEMCAD.

Product	Composition	Spec NBP Range, °C	Design NBP Range, °C	Flow Rate, BPSD	Flow Rate, lb/h
LPG	C1 to C4	-162 to -1	-17 to -7	258	2,130
Naphtha	C5 to C12	30 to 200	80 to 130	2,773	29,317
Gas oils	C12 to C20	200 to 371	180 to 370	2,650	33,677
Residuum	C20 to C70	371 to 540	370 to 492	4,234	53,805
Sour Gas	H ₂ S, C1-C3, H ₂ O	---	-72 to 45	53	534
Sour Water ^a	H ₂ O, H ₂ S	---	~100	31	450
Total	---	---	---	9,998	119,912
Note a: Sour water is reported as the difference between the desalter water outlet and 300 BPSD feed.					

Table 3. Sulfur and water content for products from processing of Brent Crude. Design values are from CHEMCAD.

Product	Sulfur, spec	Sulfur, design	H ₂ O, spec	H ₂ O, design
LPG	140 mg/kg [1]	186 mg/kg	10 mg/kg ^a [2] [3]	0.001 mg/kg
Naphtha	80 mg/kg [4]	172 mg/kg	0.005-0.05 vol% [4]	0.016 vol%
Gas oils	15 mg/kg [5]	55 mg/kg	0.01 vol% [5]	0.006 vol %
^a Must pass the Propane Dryness Test (cobalt bromide) or ASTM D 2713-70 (or 2713-91)				

Table 7. Overall energy balance, in units of MMBtu/h.

	Input	Output
Feed Streams	-167.251	
Product Streams		-155.87
Total Heating	23.077	
Total Cooling	-11.999	
Power Added	0.351	
Power Generated	-0.039	
Total	-155.860	-155.870

Table 4. Results of economic analysis of atmospheric crude and light ends units.

Capital Investment (millions of dollars)	
Purchased Equipment Cost	3.59
Working Capital	3.51
Total Indirect Costs	5.68
Total Direct Costs	14.21
Fixed Capital Investment	19.89
Total Capital Investment	22.40
Measures of Profitability	
Return on Investment, %	9.47
Payback Period, years	4.81
Net Present Worth, million \$, at 5% interest	6.02
Net Present Worth, million \$, at 10% interest	-2.53
Discounted Cash Flow Rate of Return, %	8.34
Profitability Benchmarks	
Bond Rate, after taxes, from Table 7-1, %	3.25
Preferred Stock Dividend, from Table 7-1, %	8.00
Common Stock Dividend, from Table 7-1, %	9.00
Minimum Acceptable Return, from Table 8-1, %	12.00
Ref. Payback Period, at MAR, years, eq 8-2c	4.12

Table 5. List of purchased equipment costs from CHEMCAD for atmospheric crude and light ends units.

Equipment Number	Tag Name	Description	Purchased Cost
1	P-101	Crude Pump	\$6,877
2	E-101	Crude / Gas Oil Desalter Preheater	\$117,906
3	E-102	Crude / Naphtha Desalter Preheater	\$79,448
4	V-100	Desalter	\$118,754
5	P-102	Desalter Water Pump	\$5,553
6	E-103	Crude / Gas Oil ACU Preheater	\$65,677
7	E-104	Crude / LPG ACU Preheater	\$11,348
8	E-105	Fired Heater	\$625,399
9	V-200	Atmospheric Crude Unit Main Column	\$428,718
10	E-106	Atmospheric Column Condenser	\$587,350
11	V-201	Atmospheric Column Reflux Drum	\$41,021
12	P-201	Atmospheric Column Reflux Pump	\$5,400
13	P-202	Atmospheric Column Naphtha Pump	\$5,134
14	P-203	Atmospheric Column Gas Oil Pump	\$5,138
15	E-107	Naphtha Heat to Light Ends	\$18,646
16	C-301	Light Ends Unit Feed Compressor	\$341,652
17	E-108	Light Ends Unit Feed Chiller	\$8,922
18	V-300	Light Ends Unit H ₂ S Splitter Column	\$337,479
19	E-109	Light Ends Unit H ₂ S Splitter Condenser	\$15,311
20	V-301	Light Ends Unit H ₂ S Splitter Reflux Drum	\$17,252
21	P-301	Light Ends Unit H ₂ S Splitter Reflux Pump	\$7,815
22	E-110	Light Ends Unit H ₂ S Splitter Reboiler	\$12,567
23	T-302	Light Ends Unit Expander	\$6,172
24	V-302	Light Ends Unit LPG-NAP Splitter Column	\$596,273
25	E-111	Light Ends Unit LPG-NAP Splitter Condenser	\$73,618
26	V-303	Light Ends Unit LPG-NAP Splitter Reflux Drum	\$29,449
27	P-302	Light Ends Unit LPG-NAP Splitter Reflux Pump	\$5,589
28	E-112	Light Ends Unit LPG-NAP Reboiler	\$13,444
Total (carry forward to colorful worksheet)			\$3,587,912

Table 6. Utility usage rates from CHEMCAD for atmospheric crude and light ends units.

Equipment Number	Tag Name	Description	Rate
1	P-101	Crude Pump Power, kW	10.24
5	P-102	Desalter Water Pump Power, kW	0.34
12	P-201	Atm. Column Reflux Pump Power, kW	0.69
13	P-202	Atm. Column Naphtha Pump Power, kW	0.15
14	P-203	Atm. Column Gas Oil Pump Power, kW	0.59
21	P-301	H ₂ S Splitter Reflux Pump Power, kW	0.02
27	P-302	LPG-NAP Splitter Reflux Pump Power, kW	0.08
16	C-301	Light Ends Unit Feed Compressor Power, kW	91.53
23	T-302	Light Ends Unit Expander	-11.44
		Total, kW (Carry Forward to CWS)	92.20
8	E-105	Fired Heater Fuel Usage, SCFH	31,551.66
10	E-106	Atmospheric Column Condenser Water, lb/h	369,008.00
17	E-108	Light Ends Unit Feed Chiller Water, lb/h	16,776.94
19	E-109	H ₂ S Splitter Condenser Water, lb/h	11,695.50
25	E-111	LPG-NAP Splitter Condenser Water, lb/h	183,884.00
		Total, lb/h (Carry Forward to CWS)	581,364.44
22	E-110	H ₂ S Splitter Reboiler Steam, 790 kPa, lb/h	1749.35
28	E-112	LPG-NAP Reboiler Steam, 150 kPa, lb/h	986.59
		(Carry Each Forward to CWS)	

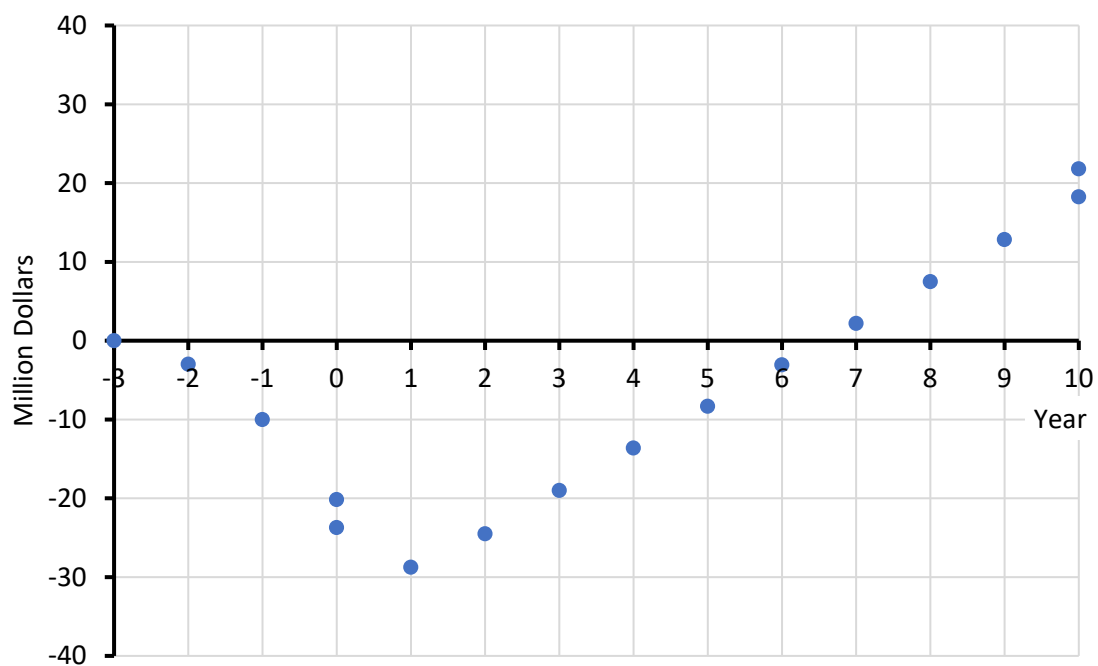


Figure 2. Cumulative cash position (from colorful worksheet) for atmospheric crude and light ends units processing 10,000 BPSD of Brent crude, as per Figure 6-2 in Peters, Timmerhaus, and West.

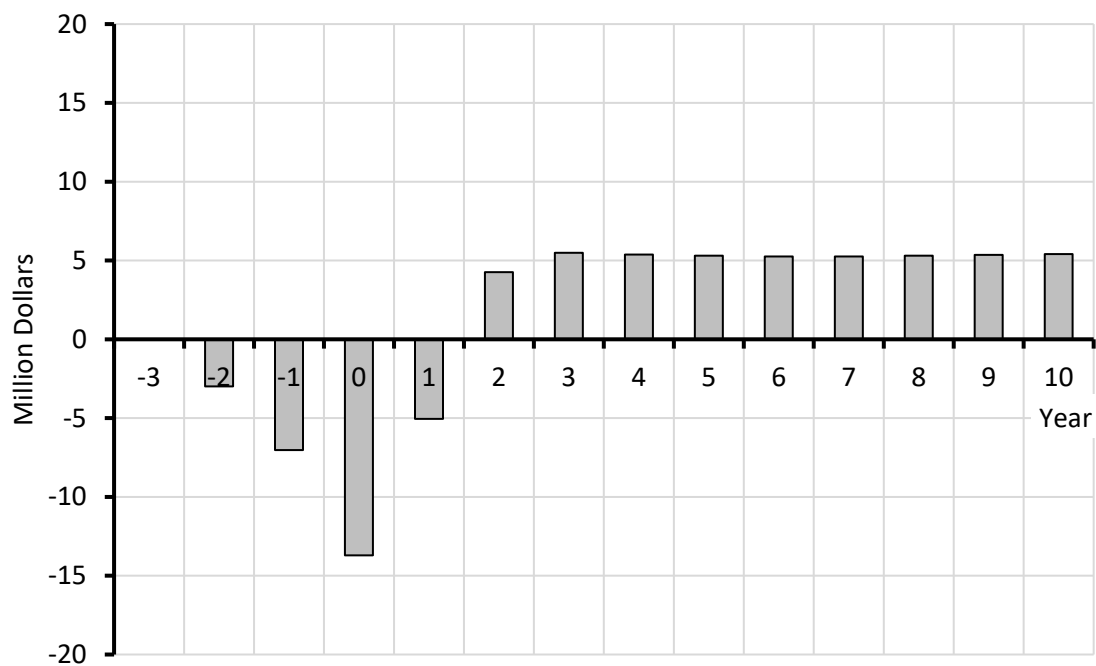


Figure 3. Annual cash flows (from colorful worksheet) for atmospheric crude and light ends units processing 10,000 BPSD of Brent crude, as per Figure 7-4 in Peters, Timmerhaus, and West.

Table 1. Exposure and safety factors for crude oil and distillates.

Species or Fraction	Human Toxicity		Flammability Limits, % in air		Flashpoint, °C	Autoignition Temp., °C	NFPA 704 [6]		
	LD50	LC50	LFL	UFL					
Methane	N/A	500,000 ppm 2h mouse 325 g/m ³ 2h mouse [7] 658 mg/L 4h rat [8]	5.3 [9]	14.0 [9]	-188 [4]	537 [9]	2 [9]	4 [9]	3 [9]
Ethane	N/A	658 mg/L 4h rat [10]	3.0 [11]	12.5 [11]	-135 [11]	472 [11]	1 [11]	4 [11]	0 [11]
H ₂ S	N/A	713 ppm 1h rat [12] 673 ppm 1h mouse [12] 634 ppm 1h mouse [12] 444 ppm 4h rat 4h [12] 700 mg/m ³ 35 min rhesus monkey [13]	4.0 [13]	44.0 [13]	-82.4 [12]	260 [13] 232 [12]	4 [13]	4 [13]	0 [13]
LPG	N/A	> 30 mg/L 4h rat [14]	1.8 [15]	13.0 [15]	-5 [15]	400-450 [15]	2 [15]	4 [15]	0 [15]
Naphtha	>5,000 mg/kg rat (oral) [16] >2,000mg/kg rabbit (dermal) [16]	>5 mg/L 4h rat [16]	1.1 [17]	5.9 [17]	37.8 [16]	288 [17]	2 [16]	4 [17]	0 [16]
Gas Oil	>5,000 mg/kg rabbit (dermal) [18] >5,000 mg/kg rabbit (oral) [18]	>6 mg/L 4h rat inhalation [18]	0.6 [18]	6.5 [18]	52 [18] 52-96 [19]	257 [18] 257 [19]	1 [18]	2 [18]	0 [18]
Residuum	>2,000 mg/kg rabbit (dermal) [20] >5,000 mg/kg rat (oral) [20]	>94.4 mg/m ³ 5h rat [20]	N/A	N/A	204 [20] 158-275 [21]	485 [20]	0 [20]	3 [20]	0 [20]
Crude Oil	>2,000 mg/kg rabbit (dermal) [22] >4,300 mg/kg rat (oral) [23]	3.95 mg/L [24]	1 [25]	7 [25]	-29 [23] 0-40 [25]	454 [25]	2 [25]	3 [25]	0 [25]

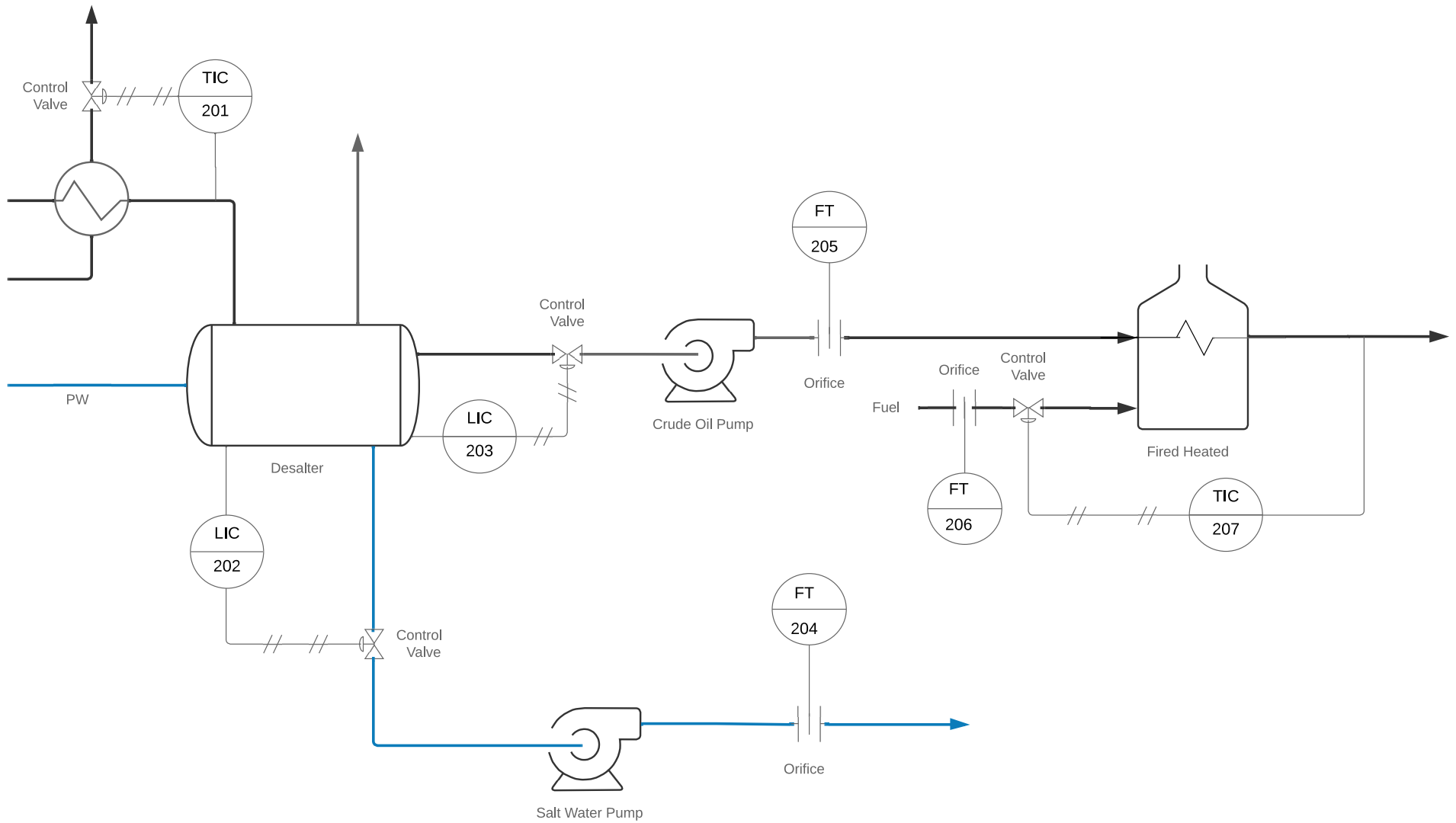
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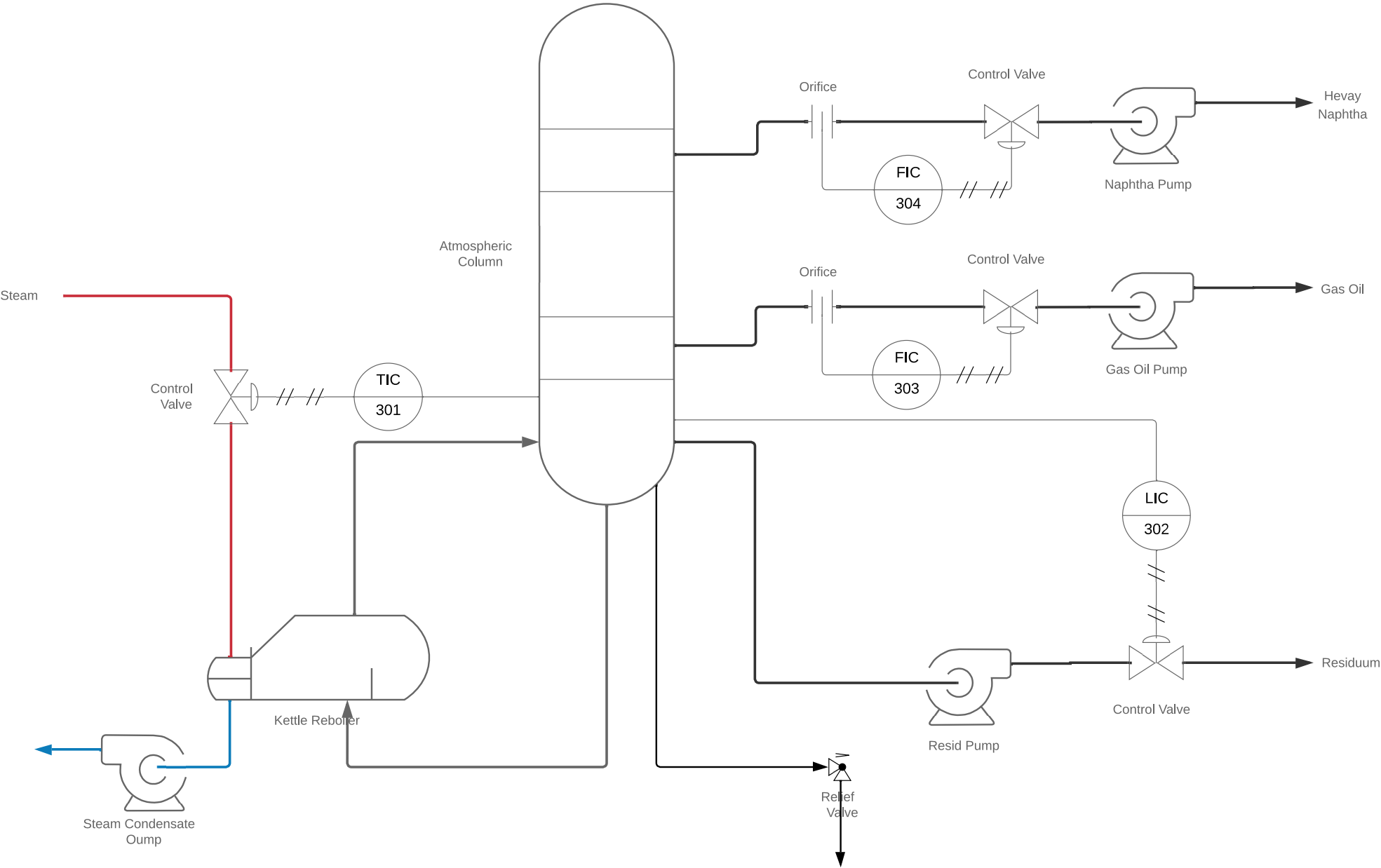
Desalter and Fired Heater

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Atmospheric Crude Unit - Tower Bottom and Side Streams

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Atmospheric Crude Unit - Tower Top

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