APPENDIX A

COST ESTIMATE FOR SHIP BOARD F-T PLANT

COST ESTIMATE

FOR 200 MM SCFD
FLOATING FISCHER-TROPSCH PLANT

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INTRODUCTION

This estimate of capital and operating costs was prepared for a 200 MM scfd associated gas Floating Fischer-Tropsch Synfuel Plant. The plant would be erected on a 1,030 feet VLCC. The estimate of the costs for the plantship that would be the platform for the synfuels plant was developed separately by others.

This plant was designed specifically to be erected on a plantship for operation at an offshore location. A steam-methane reformer was used to prepare the synthesis gas from the associated gas as it was considered more acceptable for a marine application than an oxygen plant and a partial oxidation syngas generator. Slurry bubble column reactors (SBCR), designed specifically for an Energy International cobalt catalyst, were used for the Fischer-Tropsch (F-T) synthesis.

CAPITAL COST ESTIMATE

A base design and estimate was prepared for a 60 MM scfd associated gas Fischer-Tropsch (F-T) barge mounted plant. The flowsheets for this design are shown in Drawings P-001, P-002, and P-003. These would be the same for the 200 MM scfd plant. Process Plants Consultants, Pittsburgh, PA prepared a sized and priced equipment list from these flowsheets. The prices are based on end of year 1996 prices. This list is shown in Table I.

A factored cost estimate was prepared for the 60 MM scfd plant based on the priced equipment list. The factors were adjusted to reflect that the plant would be erected on a barge and that a portion of certain construction elements such as foundations, structures and offsites would be part of the marine structure and were included in the barge cost. Also, the cost of bulk materials would be reduced because of short runs between equipment and most of the piping would be shop fabricated. These same issues would exist in the case of the 200 MM scfd plant erected on the VLCC; therefore, the same factors were used in both estimates.

The estimate for the 200 MM scfd associated gas plant was then extrapolated from the 60 MM scfd plant using factors derived from the size ratio raised to an 0.X power, for example $(3.33)^{.8}$. The exponent selected depended on whether the area was able to simply be expanded or, because of its size, required to use multiple units. The exponent 0.8 was used for the areas with multiple units.

Table I

PRICED EQUIPMENT LIST
(60 MM scfd Associated Gas Floating F-T Synfuels Plant)

Item	Name	Total Cost	Quoted By
MS-102	First Stage SygGas KO Drum	$ 144,942.00	Kennedy Tank
MS-103	CO_2 Recycle Comp Turbing Condenser Drum	11,786.00	Kennedy Tank
MS-104	Second Stage SynGas KO Drum	107,502.00	Kennedy Tank
MS-105	Reformer Steam Drum	682,563.00	PPC Calculations
PC-101 A/B	Recycle CO_2 Compressor	7,835,300.00	Centri-Dyne
PP-105 A/B	Recycle CO_2 Comp. Condensate Pump	7,000.00	Ingersoll-Dresser
PE-109 A/B	CO_2 Compressor Ejector	8,770.00	Graham Mfg. Co.
TT-101	Primary Steam Boiler	98,972.00	Baker Process
TT-103	Reactor Feed Heater	450,000.00	Heat Exch. Design
TT-104	Natural Gas Heater	104,181.00	Baker Process
TT-105	Process Water Vaporizer	920,000.00	Heat Exch. Design
TT-106	BFW Pre-Heater	85,154.00	Baker Process
TT-108	SynGas Cooler	1,100,000.00	Heat Exch. Design
TT-111 A-C	CO_2 Stripper Reboiler	990,000.00	Heat Exch. Design
TT-111 D	CO_2 Stripper Reboiler	79,832.00	Baker Process
TT-112	1st CO_2 Compr. Intercooler	261,408.00	Baker Process
TP-114 A/B W/E	CO_2 Ejector Vent Condenser	16,980.00	Baker Process
PC-101 A/B	PC-101 Turbine Steam Condenser	400,000.00	Accu-Temp Inc.
HF-101	Steam Reformer*	20,000,000.00	Foster Wheeler
AS-201	CO_2 Absorber	3,931,429.00	PPC Estimate
AS-202	CO_2 Stripper	2,522,422.00	PPC Estimate
MS-201	Striper Overhead KO Drum	40,494.00	Kennedy Tank
MS-202 A/S	Lean Amine Pump Condensate Surge Drum	21,394.00	Kennedy Tank
MS-203	Absorber KO Drum	79,308.00	Kennedy Tank
MS-204	Activated Carbon Bed	49,787.00	Kennedy Tank
MS-205	Amine Sump Tank	28,285.00	Kennedy Tank
PP-201 A/S	Lean Amine Pump	320,000.00	Ingersoll-Dresser
PP-202 A/S	Recycle Water Pump	8,000.00	Ingersoll-Dresser
PE-211 A/S	Lean Amine Pump Turbine Air Ejector	5,930.00	Graham Mfg. Co.
PP-204 A/S	Lean Amine Pump Turbine Cond. Pump	6,000.00	Ingersoll-Dresser
PP-205 A/S	Amine Sump Pump	6,000.00	Ingersoll-Dresser
TT-201 A-F	Lean/Rich Amine Exchanger	1,200,000.00	Heat Exch. Design
TT-202 A/B	Lean Amine Cooler	14,870.00	Baker Process
TT-204 TP-206 A/S	Stripper Condenser	360,000.00	Heat Exch. Design

Table I
(Continued)

Item	Name	Total Cost	Quoted By
W/e PE-211	Lean Amine Pump Turbine Ejector Condenser	12,000.00	Heat Exch. Design
W/e PP-201	Lean Amine Pump Turbine Condenser	64,658.00	Baker Process
TS-207	Reclaimer	35,316.00	Baker Process
GF-201 A/S	MEA Filters	11,992.00	Fauver Company
GZ-202 A/B/C	Inhibitor Additive Systems	6,000.00	PPC Estimate
GZ-203	Anti Foam Addition System	2,000.00	PPC Estimate
GK-223	H_2/CO Adjustment (Monsanto Prism Separator)	2,800,000.00	Permea-Mo/O'Brian
MS-301	High Temeprature Product Separator	3,335.00	ACS Industries
MS-302	Med. Temperature Product Separator	3,335.00	ACS Industries
MS-304	Purge Gas Separator	22,657.00	Kennedy Tank
MS-305 A-F	Syngas Reactor Steam Drum	168,852.00	Kennedy Tank
MR-306 A-F	Syngas Reactor	8,609,886.00	PPC Calculations
MS-391	Process Water Tank	67,544.00	Kennedy Tank
PC-301 A/B	Recycle Gas Compressor	3,861,200.00	Centri Dyne
PC-302 A/B	Purge Gas Compressors	1,900,000.00	Centri Dyne
FF-303 A-F	Syngas Reactor B.W. Circ. Pump	480,000.00	Ingersoll-Dresser
TT-301 A-F	Syngas Reactor Feed/Effluent Interchanger	2,160,000.00	Heat Exch. Design
TT-302 A-D	Product Condenser	1,880,000.00	Heat Exch. Design
TT-397	Purge Gas Cooler	95,369.00	Baker Process
AS-401	Product Stripper	18,690.00	Kennedy Tank
TT-401	Stripper Reboiler	31,026.00	Baker Process
TA-402	Product Cooler	20,595.00	PPC Estimates
MR-601 A/B	Natural Gas Desulfurizers	172,758.00	PPC Estimates
MS-802	Instrument Air Dryer	10,547.00	Kennedy Tank
MT-815	Biotreatment Package (Skid)	19,959.00	Kennedy Tank
MS-816	Evaporator Separation Vessel	19,717.00	Kennedy Tank
MS-817 (6 Total)	Fuel Drum	21,293.00	Kennedy Tank
PP-801 A-E/S	Sea Water Supply Pump	1,200,000.00	Ingersoll-Dresser
PP-803 A/S	High-Med. Pressure BFW Pump	260,000.00	Ingersoll-Dresser
PP-817 A/S	Desalinator Feed Pump	18,000.00	Ingersoll-Dresser
PP-818 A/S	BFW Makeup Pump	8,000.00	Ingersoll-Dresser
PP-830 A/S	Contaminated Sewer Pump	8,000.00	Ingersoll-Dresser
PC-832	Instrument Air Compressor	200,000.00	Centri Dyne
PC-833	Plant Air Compressor	200,000.00	Centri Dyne
PP-805 A/S	MP-BFW Pump	200,000.00	Ingersoll-Dresser
PP-891	Slop Pump	3,000.00	Ingersoll-Dresser
PP-892	Reaction Water Feed Pump	9,000.00	PPC Estimate
PP-893 A/B	Offloading Pumps	100,000.00	Ingersoll-Dresser

Table I
(Continued)

Item	Name	Total Cost	Quoted By
PP-894	Demineralized Water Pump	3,500.00	Ingersoll-Dresser
PP-895 A/S	Demineralized Feed Pump	7,000.00	Ingersoll-Dresser
TT-813	Desalinator OVHD. Condenser	321,051.00	Baker Process
TT-814	Desalinator Evaporator	343,982.00	Baker Process
TT-815	Cargo Heating Coils	115,807.00	PPC Estimate
GY-801 A/S	Turbo Generator	1,300,000.00	Centri Dyne
GV-803	Deaerator	120,000.00	Accu-Temp Inc.
GZ-804	Demineralizer	1,100,000.00	US Filter
GS-891	Oil/Water Separator	6,573.00	Dempler Co.
GS-892	N_2 Generator (Kemp Nitrogen Gen. Mod. 295-30)	43,262.00	PPC Estimate
-----	Added Heat Exchanger, P&ID, P-003	95,369.00	PPC Estimate
	TOTAL	**$70,059,582.00**	

*Total Lump Sum Installed cost for the steam reformer was $40MM; equipment only was estimated at $20MM.

Table II below lists the cost categories and whether the costs were included in the plant estimate plantship estimate, operating costs or excluded.

Table II

Cost Category	Included in Plant Costs	Included in Plantship Costs	Included in Operating Costs	Excluded
1. Plant Factored Estimate	X			
2. Overhead	X			
3. Fees	X			
4. Plantship Estimate		X		
5. Plantship Allowance		X		
6. Plantship Mooring and Towing		X		
7. Operating Costs			X	
8. Maintenance Costs			X	
9. Catalyst and Chemicals			X	
10. Royalties			X	
11. Escalation				X
12. Contingency				X
13. Start-up Allowance				X
14. Spare Parts				X
15. Working Capital				X
16. Owner's Costs				X
17. Taxes and Financing Costs				X

Table III shows both the capital cost estimate for the base, factored, 60 MM scfd floating F-T synfuels plant and the extrapolated estimate for the 200 MM scfd floating F-T plant.

Table III

CAPITAL COST ESTIMATE SUMMARY, M$
FLOATING F-T SYNFUELS PLANTS

Cost Element	60 MM scfd Plant	200 MM scfd Plant
Equipment	70,060	171,811
Material and Bulks	31,100	76,267
Labor & Construction Indirects	52,660	129,137
Home Office Engineering & Overhead	9,700	23,789
Construction Fees	7,700	18,773
TOTAL PLANT	**171,220**	**419,887**

For comparison purposes, the following Table IV shows a unit breakdown of the synfuels plant estimates.

Table IV

CAPITAL COST ESTIMATE SUMMARY, M$
FLOATING F-T SYNFUELS PLANTS

Area	Unit	60 MM scfd Plant	200 MM scfd Plant
100	Reforming	81,396 X $(3.33)^{.8}$	213,258
200	CO_2 Removal	21,326 X $(3.33)^{.6}$	43,932
200	H_2/CO Adjustment	6,843 X $(3.33)^{.8}$	17,929
300	F-T Synthesis	47,053 X $(3.33)^{.8}$	123,276
400	Stabilization	173 X $(3.33)^{.6}$	356
600	H_2S Removal	422 X $(3.33)^{.8}$	1,106
800	Offsites & Utilities	14,007 X $(3.33)^{.3}$	20,030
	TOTAL PLANT	**171,220**	**419,887**

OPERATING COST ESTIMATE - 200 MM scfd GAS FEED CASE

Most operating costs, particularly labor manning levels and costs are site specific. Therefore, this operating cost estimate is meant to be only an indication of the general level of cost and will need to be re-estimated for a specific location and project.

The initial charge of catalysts and chemicals is shown in Table V.

Table V

INITIAL CHARGE OF CATALYSTS AND CHEMICALS

Item	Pounds	$/Pound	Cost, M$
Reformer Catalyst	840,000	5.00	4,200
ZnO	260,000	0.65	170
MEA	1,000,000	0.60	600
Inhibitors	20,000	9.00	180
Activated Carbon	50,000	1.00	50
EI Cobalt F-T Catalyst	240,000	30.00	7,200
TOTAL			**12,400**

The annual usage rate for catalysts and chemicals is shown in Table VI.

Table VI

ANNUAL COST OF CATALYSTS AND CHEMICALS

Item	Pounds/Year	Cost/Year, M$
Reformer Catalyst	168,000	840
ZnO	530,000	345
MEA	486,000	295
Inhibitors	20,000	180
Activated Carbon	100,000	100
EI Cobalt F-T Catalyst	48,000	1,440
TOTAL		**3,200**

It is estimated that it will require approximately 14 operators per shift plus technical support and supervision. A manning table is shown in Table VII. This does not include any personnel required to operate the plantship or any oil and associated gas recovery operations.

Table VII

OPERATIONS MANNING TABLE

Job Title	Man Cost/Year, M$	Total Cost/Year, M$
13 Operators / Shift = 52	50	2,600
1 Operating Foreman / Shift = 4	55	220
2 Supervisors = 2	65	130
3 Engineers = 3	60	180
4 Laboratory Staff = 4	50	200
2 Clerks / Secretaries = 2	40	80
3 Operator Assistants = 3	40	120
TOTAL		**3,530**

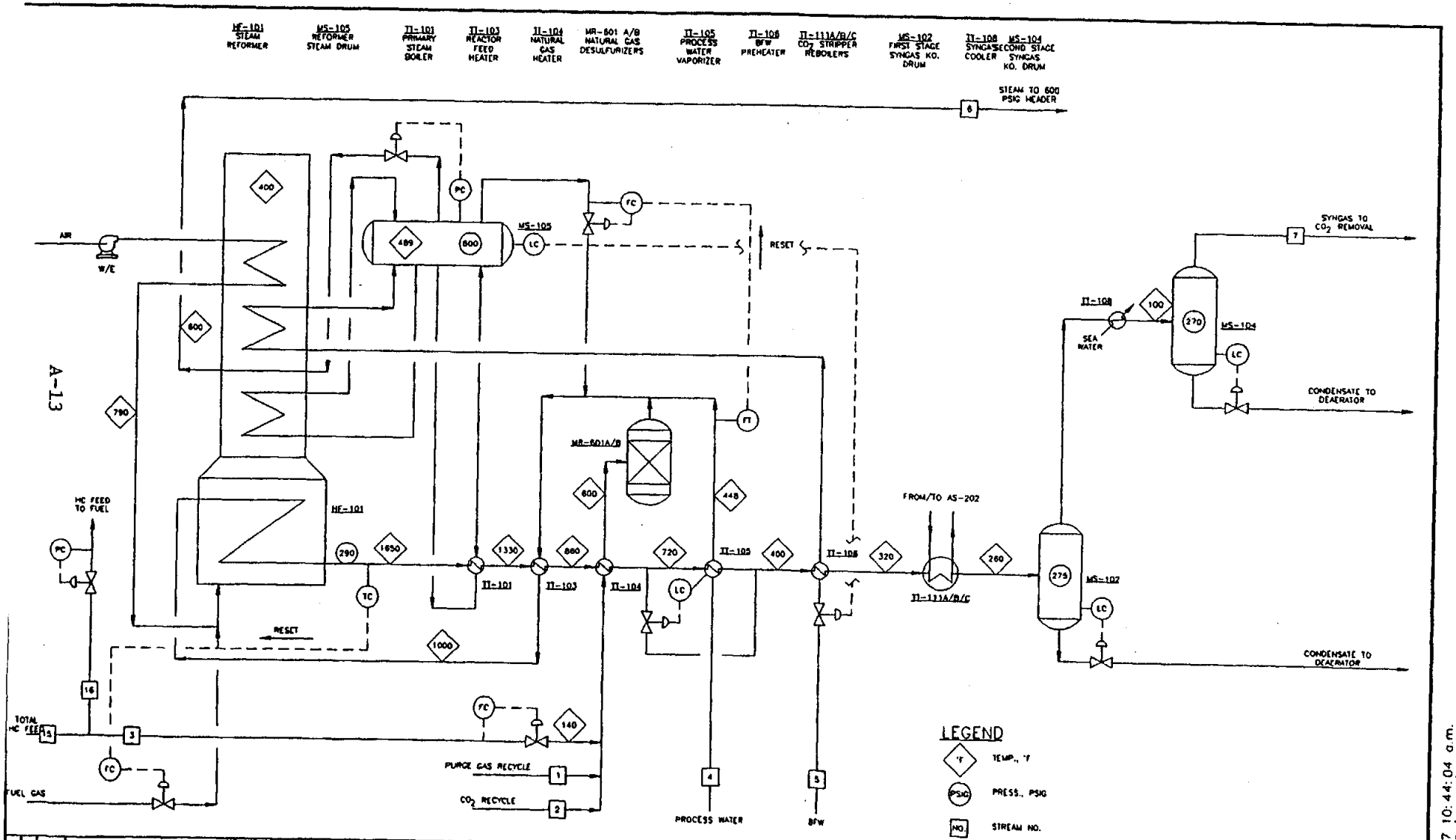
The F-T plant maintenance costs are estimated at 3.2% of the total plant cost. This is exclusive of any plantship maintenance and repair costs. With materials being 66% and labor being 33% this gives $9.1 MM/year for materials and $4.5 MM/year for maintenance labor.

Power is assumed to be self-generated from waste gases from the F-T process and the cost of the generators is in the plantship estimate. Water will be mostly seawater plus recovered water from the F-T reaction; therefore, there will be no standard usage charge. However, a $1.00 MM/ year charge is estimated for water treatment costs. The associated gas feed to the plant is assumed to be priced at $0.50/1000 cu. ft.

Table VIII

OPERATING COST ESTIMATE
200 MM scfd F-T SYNFUELS PLANT

Item	M$/Year
CONSUMABLES	
Catalysts and Chemicals	3,200
Power (self-generated)	---
Water Treatment	1,000
OPERATING and MAINTENANCE	
Operating and Maintenance Labor	8,000
Maintenance Materials	9,100
Operating Supplies	900
GENERAL and ADMINISTRATIVE OVERHEAD	11,200
CONTINGENCY	3,600
SUBTOTAL	37,000
ASSOCIATED GAS	35,000
TOTAL	**72,000**



A-13

REVISIONS	NO	DATE	DESCRIPTION	BY

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Pittsburgh, Pennsylvania

SCALE: N.T.S.
DRAWN BY: J.P.W.
DATE: 8-22-96
DESIGNED/CHKD BY: R.E.H.
PPC APPR.:
CUST. APPR.:
ENERGY INTERNATIONAL
PITTSBURGH, PA

PROCESS FLOW DIAGRAM
F-T TECHNOLOGY
STEAM REFORMING & SULFUR REMOVAL

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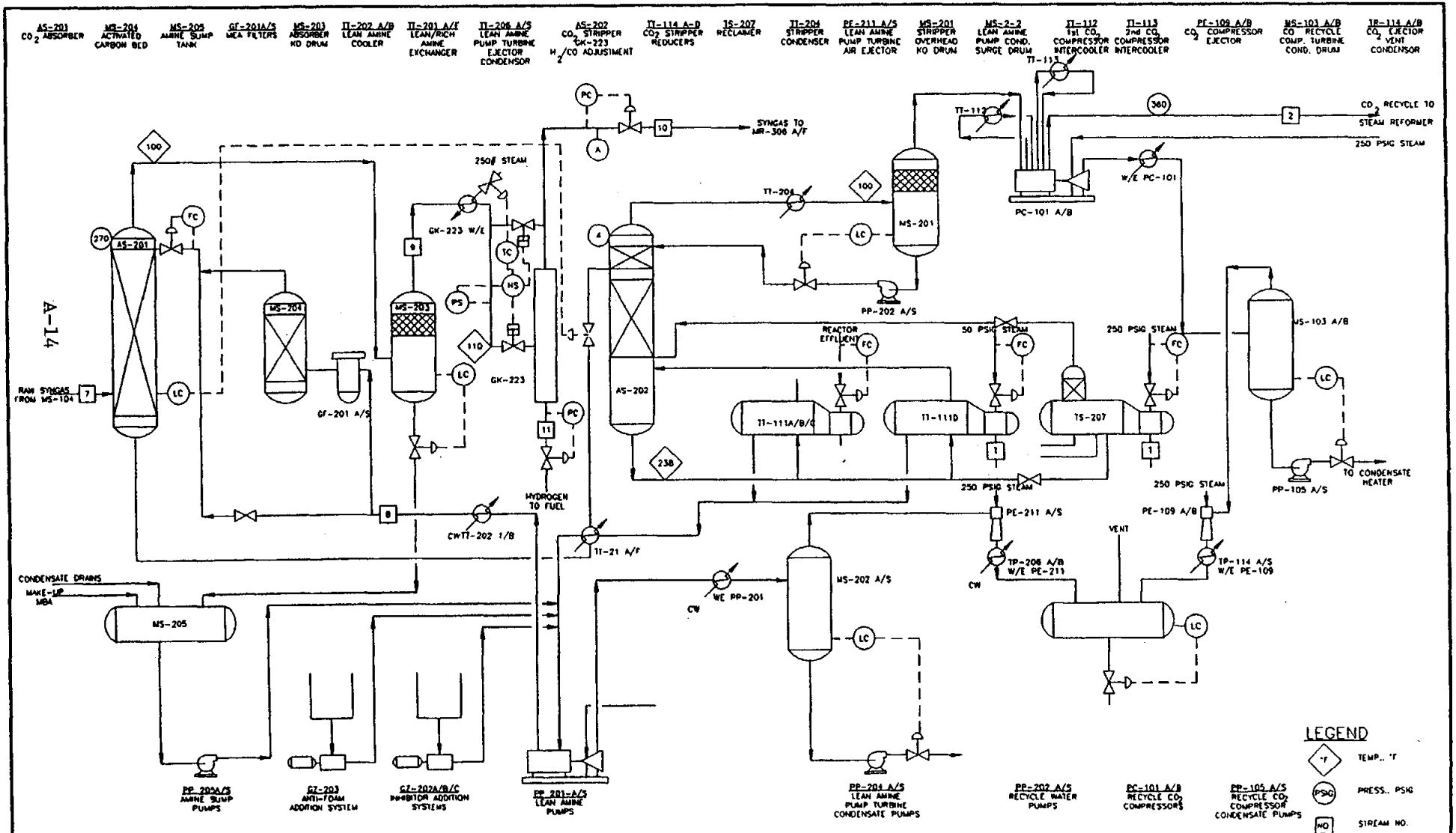

A-14

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PPC APPR.:
CUST. APPR.:

ENERGY INTERNATIONAL
PITTSBURGH, PA

PROCESS FLOW F
F-T TECHNO
CO_2 REMOVAL & H_2/C ...TMENT

50100300 | P-002 | REV-A

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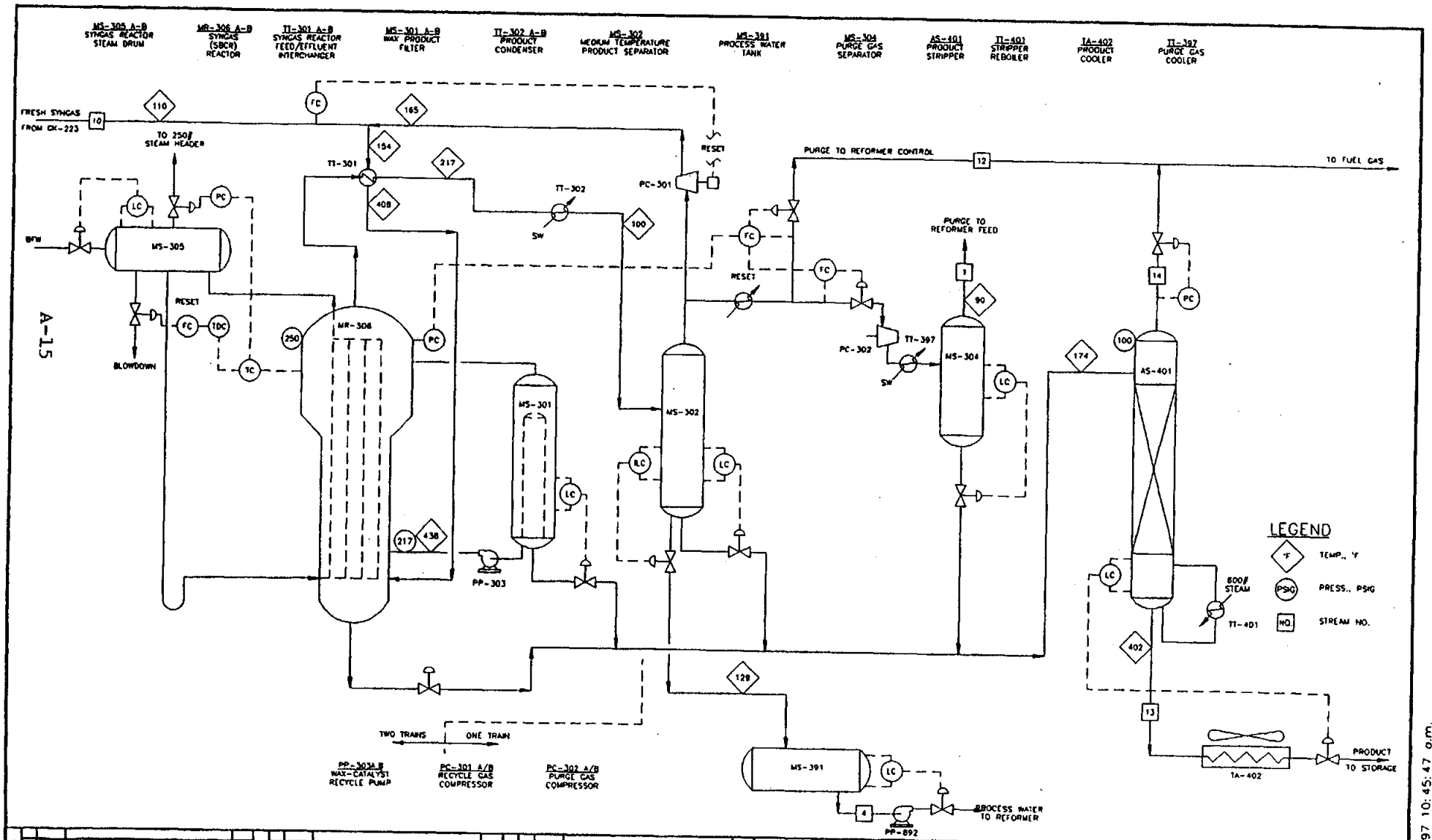

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ENERGY INTERNATIONAL
PITTSBURGH, PA

PROCESS FLOW DIAGRAM
F-T TECHNOLOGY
SYNTHESIS & PRODUCT RECOVERY

50100300 | P-003 | REV-A

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