8.1 PROCESS DESCRIPTION

8.1.1 Case 13 Steam Balance

Units 43 and 47, steam and power generation, produce high pressure superheated steam to satisfy process reaction steam requirements and in-plant power requirements. To provide the 1,357,000 lb/hr of steam required for Case 13, the boiler plant consists of three (3) boilers, designed to produce 700,000 lb/hr each of 1500 psig/900°F steam, and associated equipment: precipitators, coal bunkers, coal conveyors, deaerators, a tempered water exchanger to provide 188.7×10^6 Btu/hr of heat from the gas cooling section to the treated water feeding the deaerators, boiler feed water pumps, ash handling equipment, flue gas ducting, exhaust stack, a blowdown system, and controls. This associated equipment has not been looked at in detail for the estimate basis.

All the steam produced form the boilers is letdown through three (3) back-pressure turbogenerators exhausting at 635 psig/693°F. These turbines generate a total of 33.3 megawatts (MW). This steam is reheated in a fuel gas fired superheater to 750°F. Excess 600 psig saturated steam, produced from process waste heat, is superheated in a separate fired superheater and combined with the 600 psig/750°F steam from the back pressure turbogenerators. This steam is used for gasification reaction steam and for turbine drivers. Excess 120 psig saturated steam, produced by waste heat from the gasification process, is used to drive two wet turbogenerators, condensing at 4" Hg and producing 30.5 MW of electric power. Total power produced in Case 13 is 63.8 MW while total power demand is 71.6 MW, resulting in a net import of 7.8 MW. The Case 13 estimate basis flow diagram is located in Section 8.2 of this volume.

8.1.2 Alternative Pressure Levels

A boiler pressure level study, independent of the estimate basis but based on the Case 13 steam and power requirements, was conducted. Steam balances were prepared with boilers operating at 600 psig/750°F, 900 psig/900°F, 1500 psig/900°F, and 2400 psig/1000°F.

8.1.2.1 600 psig System - With a 600 psig boiler, the steam requirement from the boiler was determined to be 1,845,100 lb/hr. This steam would be supplied by three 50 percent boilers. Saturated steam at 600 psig is not superheated to 750°F in this scheme, thus the boiler provides all the steam for gasification and all the steam for turbine drivers.

8.1.2.1 600 PSIG SYSTEM (Continued)

Assuming a boiler efficiency of 80 percent, coal consumption is 3056 short tons/stream day (ST/SD). These boilers require the same associated equipment listed for the estimate basis. The deaerator operates at 30 psia and 250°F and receives 60 psig low pressure saturated steam for deaeration.

All power produced in plant comes from two sets of wet turbogenerators. Excess 600 psig/saturated steam is exhausted at 4" Hg through two wet turbogenerators to produce a total of 39.5 MW. Excess 120 psig saturated steam is also used to drive two wet turbogenerators exhausting at 4" Hg and producing 30.2 MW. Total power produced is 69.7 MW, requiring 1.9 MW of import power to meet the plant power demand of 71.6 MW. The total surface condenser duty for this system condenser duty for this system (from condensing turbogenerators and turbine drivers) is 1.68×10^9 Btu/hr requiring 168,000 GPM of cooling water (assuming a 20°F cooling water temperature rise). Refer to Section 8.2 of this volume for a "Simplified Block Flow Diagram" of the system just described.

8.1.2.2 900 psig System - With boilers operating at 900 psig/900°F, the steam requirement is 1,686,200 lb/hr. This steam could be provided by three boilers rated at 850,000 lb/hr each. In this scheme, the boiler feed water is heated to 340°F (by excess 120 psig saturated steam) before entering the economizer section of the boiler. Coal consumption is 2732 ST/SD. The same associated equipment required for the boilers in the estimate basis is also required here.

Since process mechanical turbine drivers use 900 psig/900°F inlet steam, less steam is required from the 900 psig boilers than from the 600 psig boilers as a result of added efficiency. The remaining 900 psig steam is letdown through a 600 psig back-pressure turbogenerator producing 11.9 MW of electric power. The steam rate through this turbine is 79.4 lb/kw-hr which is considered too high to be an off the shelf piece of equipment. The steam exits this turbine at 802°F and is desuperheated to 750°F before entering the gasification section.

Excess 600 psig saturated steam passes through two turbogenerators condensing at 4" Hg to produce a total of 39.5 MW of electric power. Excess 120 psig saturated steam serves two function: 1) it preheats the BFW from 250°F (deaerator operating temperature) to 340°F, and 2) it passes through two turbogenerators condensing at 4" Hg producting a total

8.1.2.2 900 PSIG SYSTEM (Continued)

of 19.5 MW. Total power production for this system is 71.2 MW, requiring an import of 0.4 MW to meet the total electric power demand of 71.6 MW. The total condenser heat load (from condensing turbogenerators and turbine drivers) is 1.38 x 10^9 Btu/hr, requiring 138,000 GPM of cooling water (assuming a cooling water temperature rise of 20°F. Refer to Section 8.2 of this volume for a "Simplified Block Flow Diagram" of the system just described.

8.1.2.3 1500 psig System - A system with boilers producing 1500 psig steam was also investigated. This system employs an extraction turbine providing steam for boiler feed water preheating. At the time this study was conducted, the total extraction steam could not exceed 40 percent of the steam fed to the first stage of the extraction turbine. A balance for the 1500 psig boiler that meets this extraction criteria is not complete. An intermediate balance, in which the extraction ratio is 68 percent, is included as it incorporates the same general features as the final balance. The description that follows is for the intermediate balance included in Section 8.2.

This scheme incorporates two separate boiler feedwater systems: one for the process generators (low pressure BFW) and one for the boiler plant (high pressure BFW). The 188.7 MM Btu/hr of heat available from the tempered water system is split between the two feedwater systems. Enough energy (128.7 MM Btu/hr) is added to the low pressure BFW to heat it to 185°F, a 41°F approach to the 226°F operating temperature of the low pressure deaerator. The remaining heat available from the tempered water system (60.0 MM Btu/hr) is added to the high pressure BFW system. Excess 60 psig steam is condensed in an exchanger with the high pressure BFW adding another 29.1 x 10^6 Btu/hr. Two feedwater heaters in series provide additional heat from extraction steam. BFW enters the deaerator at 250°F. The high pressure deaerator operate at 67 psia and 300°F. Low pressure steam (120 psig) is provided to the deaerator by the extraction turbine.

The high pressure boiler feedwater is further heated by another series of two BFW heaters to 430°F before entering the economizer section of the boilers. In this balance, the boiler produces 2,200,700 lb/hr of 1500 psig/1000°F steam. This steam passes through a 600 psig back-pressure turbogenerator and generates 68.7 MW of electric power. No reheating to 750°F is required because of the steam's initial temperature of 1000°F.

8.1.2.3 1500 PSIG SYSTEM (Continued)

The steam exhausting from the back-pressure turbogenerators satisfies four needs: 1) it supplies steam to the final BFW preheaters, 2) it supplies reaction steam for the gasification process, 3) it supplies steam to drive compressors in the oxygen plant, and 4) it feeds the LP section of the extraction turbine. The mechanical turbine drives for Methanol Synthesis and the Rectisol compressors have been replaced with electric motor drives. This was done to consume excess power generated in this system, and conceptually improve the 1500 psig system. In a practical application this may not be possible due to the startup power requirements.

The extraction turbine generates 19.5 MW of electric power from a feed of 580,200 lb/hr of 600 psig/750°F steam. A total of 393,800 lb/hr of steam is extracted to supply the deaerator and BFW preheaters. Normally up to 40 percent of the maximum steam flow to the turbine maybe extracted, and in this non-converged steam balance 68 percent is shown as being extracted. The only way to reduce this amount is to increase boiler steam make and subsequent steam flow through the extraction turbine.

As in the previous schemes described, excess 600 psig and 120 psig steam are passed through separate condensing wet turbogenerators to produce a total of 70.2 MW of electric power. The total power produced in this 500 psig system is 152.4 MW, the total power requirement is 114 MW leaving 38.4 MW available for export. The condenser cooling load is 1.03×10^9 Btu/hr, requiring 103,000 GPM of cooling water (assuming a 20°F cooling water temperature rise). Refer to Section 8.2 of this volume for a "Simplified Block Flow Diagram" of the system just described.

8.1.2.4 2400 psig System - The 2400 psig balance is conceptually similar to the previously described 1500 psig system. The high pressure boiler feedwater system uses five feedwater preheaters, the deaerator operates at 131 psia/348°F and BFW enters the economizer at 480°F. The boilers require 6775 ST/SD of coal to produce 4,500,000 lb/hr of 2400 psig/1000°F steam. This steam is letdown to 635 psig/671°F through a back-pressure turbogenerator producing 171.3 MW of electric power. 445,900 lb/hr of this steam supplies steam to the final boiler feedwater heater, while the remaining 671°F steam returns to the boiler for reheating 750°F. This 600 psig/750° steam supplies the Rectisol, Methanol Synthesis, and Oxygen plant turbine drivers, the reaction steam for gasification and the extraction turbine

8.1.2.4 2400 PSIG SYSTEM (Continued)

requirements. Five extractions are taken from this turbine to supply steam to the four feedwater preheaters in addition to the deaerator. A total of 185.1 MW of electric power is produced from this extraction turbogenerator. This 2400 psig steam balance is converged as is noted by a 40 percent extraction ratio from the LP turbogenerator.

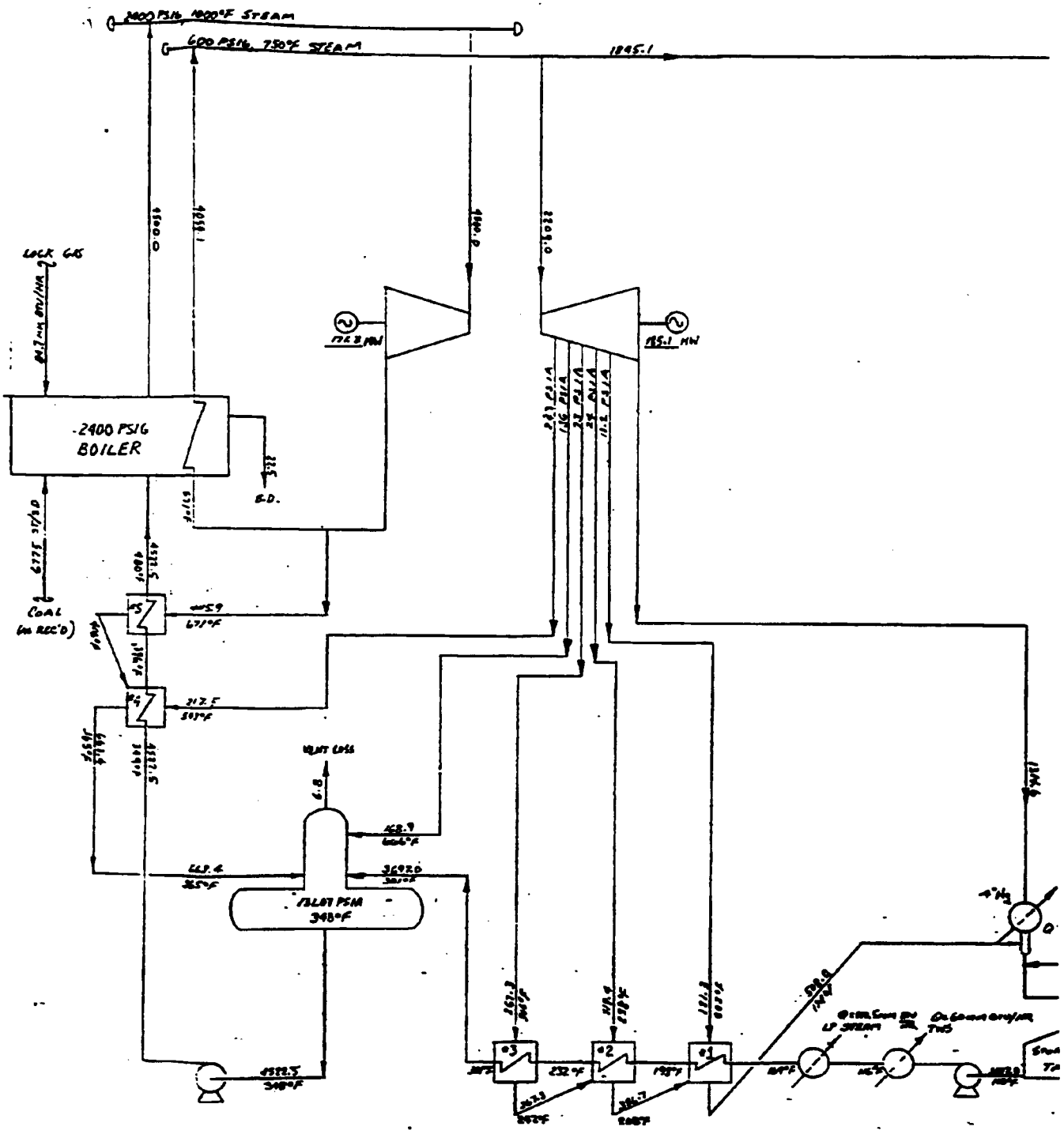
Excess 600 and 120 psig saturated steam passes through separate condensing wet turbogenerators to produce a total of 70.2 MW. The total power produced in this system is 471.1 MW for which the Tri-State plant consumes 71.1 megawatts of power, leaving 355 MW available for export. The total condenser cooling load is 2.91×10^9 Btu/hr requiring 291,000 GPM of cooling water (assuming a cooling water temperature rise of 20°F). Refer to Section 8.2 of this volume for a "Simplified Block Flow Diagram" of the system just described.

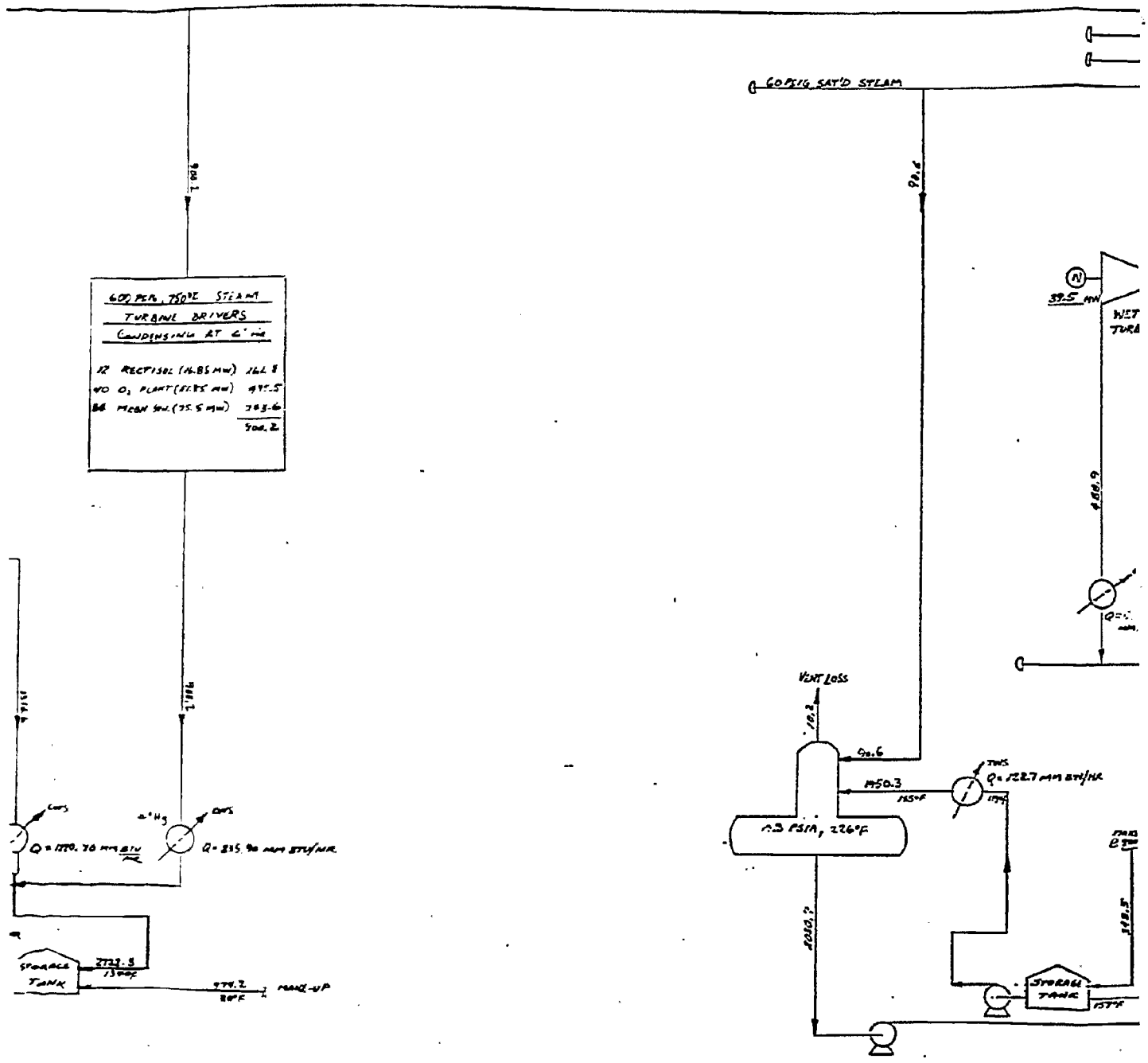
8.1.2.5 Computer Generated Steam Balances - These steam balances were also modeled on the computer and the resulting steam balances appear in Section 8.3. The 600 psig balance obtained from the computer is an exact model of the block flow diagram located in Section 8.2 and described earlier in this section. The 900, 1500, and 2400 psig balances obtained form the computer are similar models of the block flow diagrams in Section 8.2. These computer models provide a rapid means of updating and modifying the steam balance studies for future work.

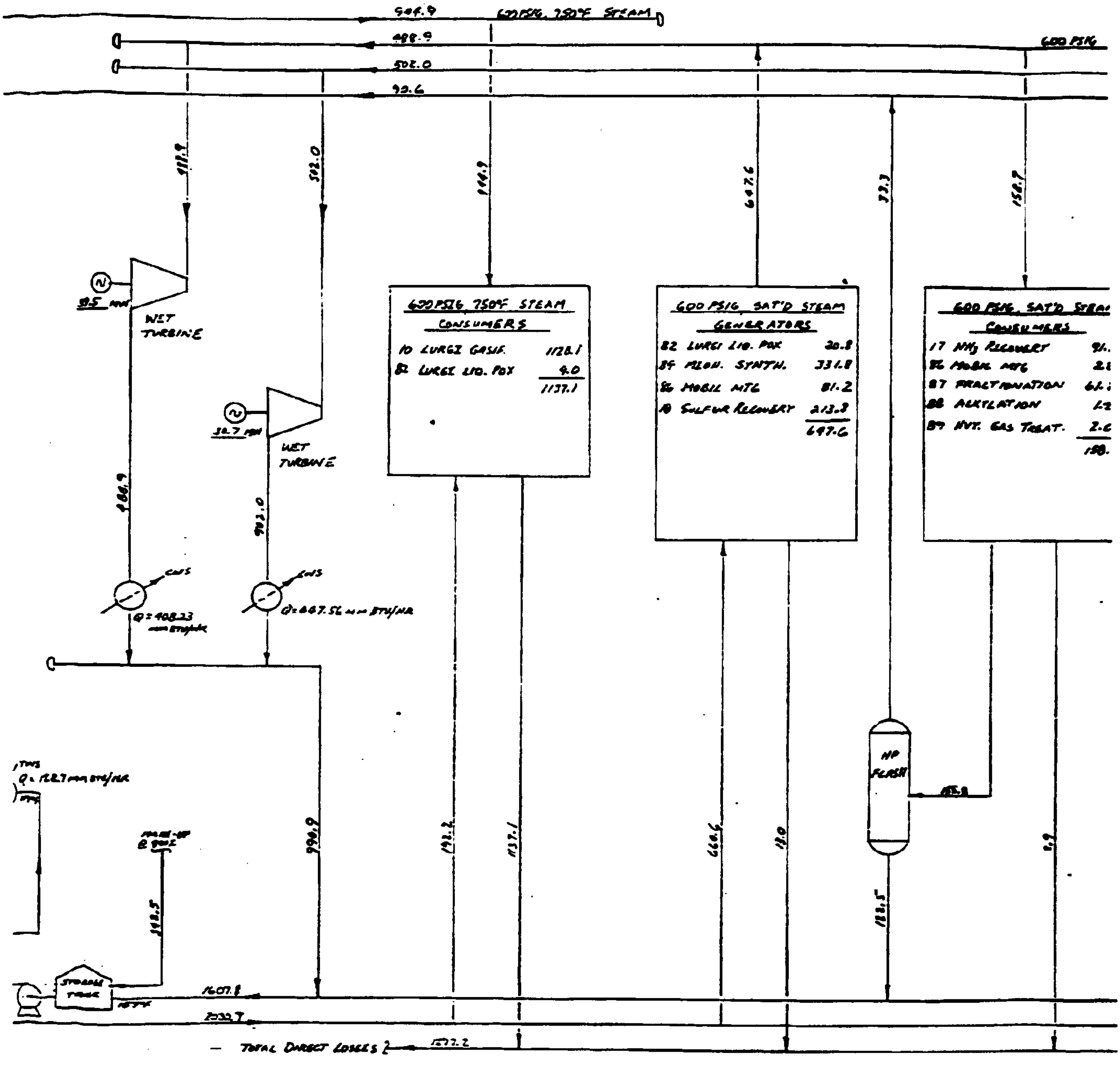
8.2 FLOW SHEETS

Included in this section are the following preliminary flow-sheets:

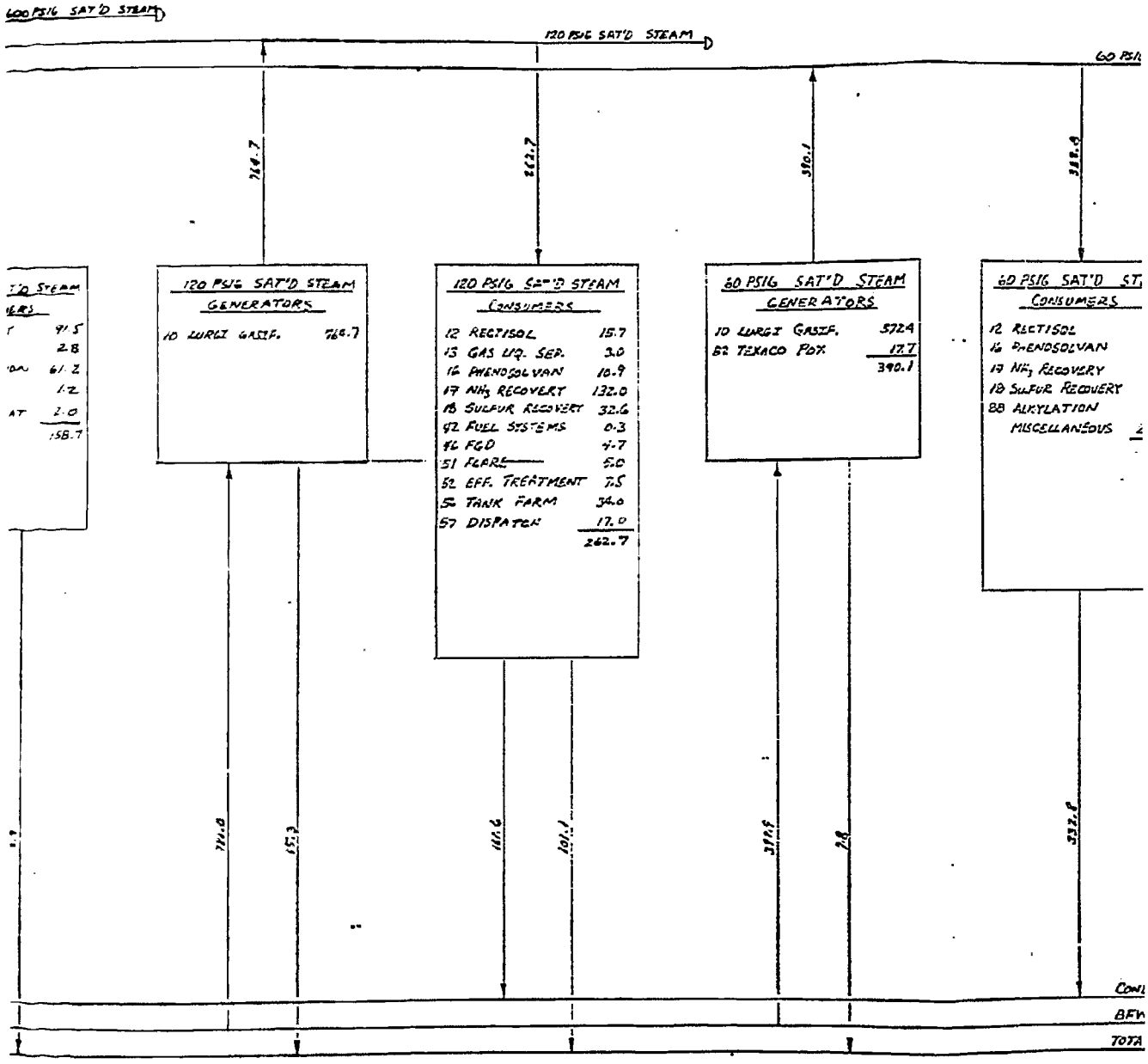
- Simplified Block Flow Diagram, 2400 psig steam level
- Simplified Block Flow Diagram, 1500 psig steam level
- Simplified Block Flow Diagram, 900 psig steam level
- Simplified Block Flow Diagram, 600 psig steam level
- Case 13 Steam Balance (2 pages)

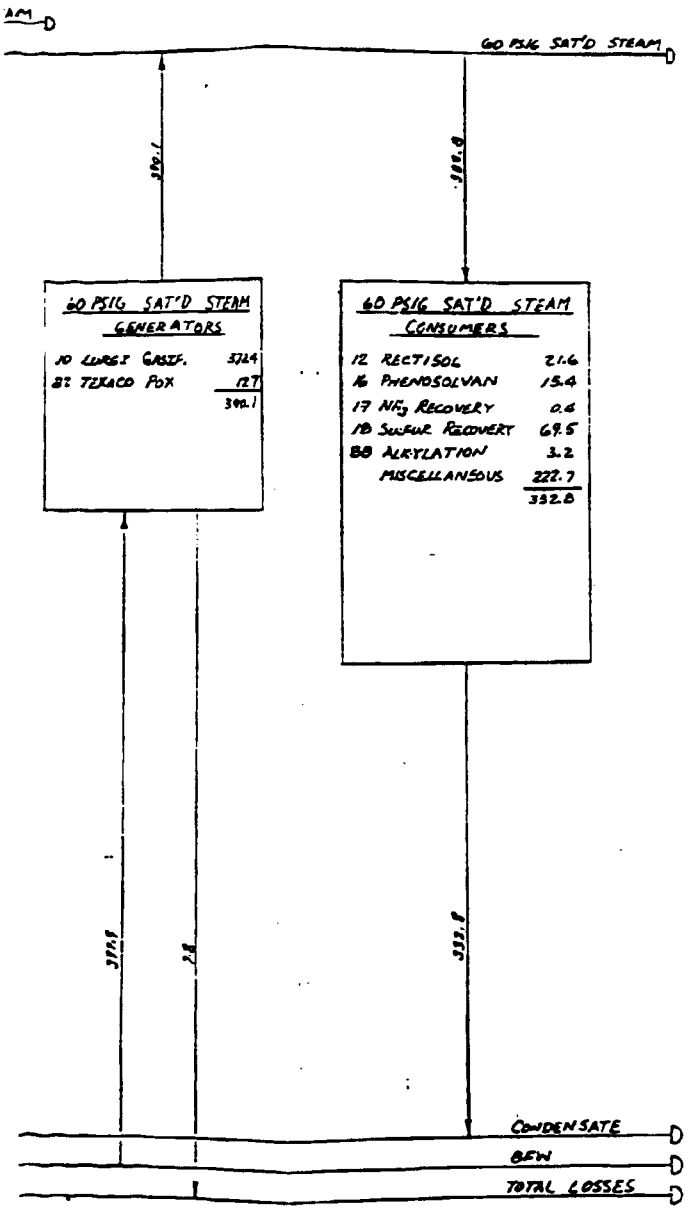

2400 PSIG, 1000°F STEAM
600 PSIG, 750°F STEAM
1845.1
LOCK GAS
2400 PSIG BOILER
B.D.
COAL (as REC'D)
HOT GAS
FLOAT PSM 348°F
LP STEAM


60 PSIG SAT'D STEAM
60 PSIG, 750°F STEAM
TURBINE DRIVERS
CONDENSING AT 6" Hg
12 RECIPSOL (16.85 MW) 162.8
40 O2 PLANT (51.85 MW) 495.5
86 MCGM SW. (75.5 MW) 703.6
900.2
39.5 MW
VENT LOSS
60.6
1450.3
Q = 1227 MM BTU/HR
Q = 1170.70 MM BTU
Q = 835.90 MM BTU/HR
STORAGE TANK
MAKE-UP



600 PSIG, 750°F STEAM
600 PSIG
WET TURBINE
WET TURBINE
600 PSIG, 750°F STEAM CONSUMERS
10 LURGI GASIF. 1128.1
82 LURGI LIQ. POX 9.0
1137.1
600 PSIG, SAT'D STEAM GENERATORS
82 LURGI LIQ. POX 20.8
84 METH. SYNTH. 331.8
86 MOBIL MTG 81.2
19 SULFUR RECOVERY 213.8
647.6
600 PSIG, SAT'D STEAM CONSUMERS
17 NH₃ RECOVERY
86 MOBIL MTG
87 FRACTIONATION
88 ALKYLATION
89 HVY. GAS TREAT.
HP FLASH
STORAGE TANK
TOTAL DIRECT LOSSES


600 PSIG SAT'D STEAM
120 PSIG SAT'D STEAM
60 PSI
766.7
262.7
390.1
120 PSIG SAT'D STEAM GENERATORS
10 LURGI GASIF. 766.7
120 PSIG SAT'D STEAM CONSUMERS
12 RECTISOL 15.7
13 GAS LIQ. SEP. 3.0
16 PHENOSOLVAN 10.9
17 NH3 RECOVERY 132.0
18 SULFUR RECOVERY 32.6
42 FUEL SYSTEMS 0.3
44 FGD 4.7
51 FLARE 5.0
52 EFF. TREATMENT 7.5
54 TANK FARM 34.0
57 DISPATCH 17.0
262.7
60 PSIG SAT'D STEAM GENERATORS
10 LURGI GASIF. 372.4
82 TEXACO POX 17.7
390.1
60 PSIG SAT'D ST
CONSUMERS
12 RECTISOL
16 PHENOSOLVAN
17 NH3 RECOVERY
18 SULFUR RECOVERY
88 ALKYLATION
MISCELLANEOUS
766.8
153.3
101.6
101.1
391.5
3.8
332.8
Cond
BFW
TOTA



NOTES:

(1) TOTAL POWER REQUIRED IS 71.6 MW, 426.6 MW IS GROSS POWER GENERATED.

(2) ALL FLOW RATES ARE GIVEN IN UNITS OF 10^3 LB/HR.

(3) ASSUMED BLOWDOWN OF 2% FOR PROCESS STEAM GENERATORS, AND 0.5% FOR THE 2400 PSIG BOILER PLANT.

(4) EFFICIENCY ASSUMED:
   a. 80% FOR BOILER
   b. 85% FOR BACKPRESSURE TURBO-GENERATOR
   c. 75% FOR WET TURBINES
   d. 80% FOR TURBINE DRIVERS

No. REVISION	PROCESS BLOCK FLOW DIAGRAM STEAM GENERATION STUDY STEAM BALANCE CASE 13 2400 PSIG STEAM		
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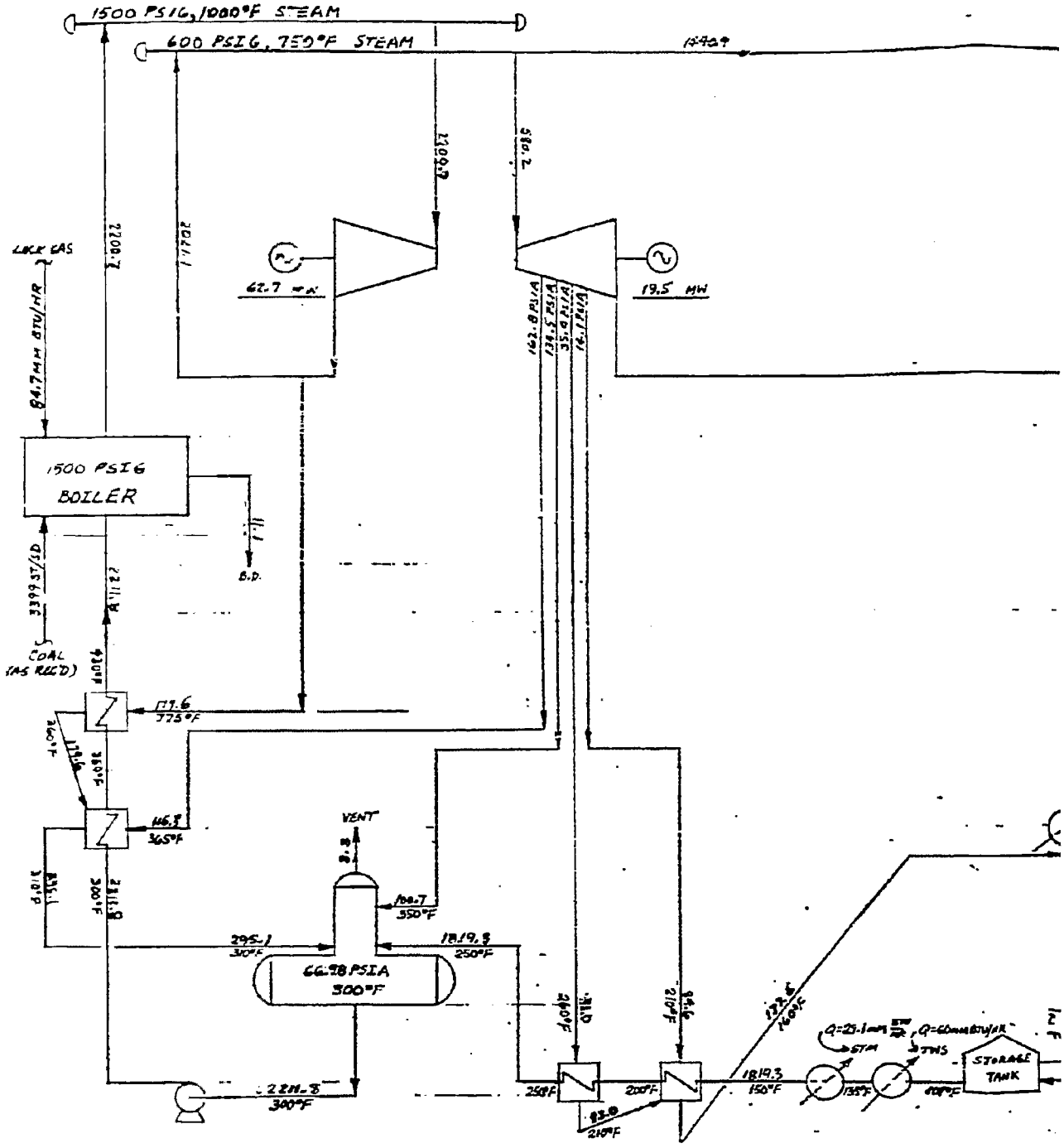
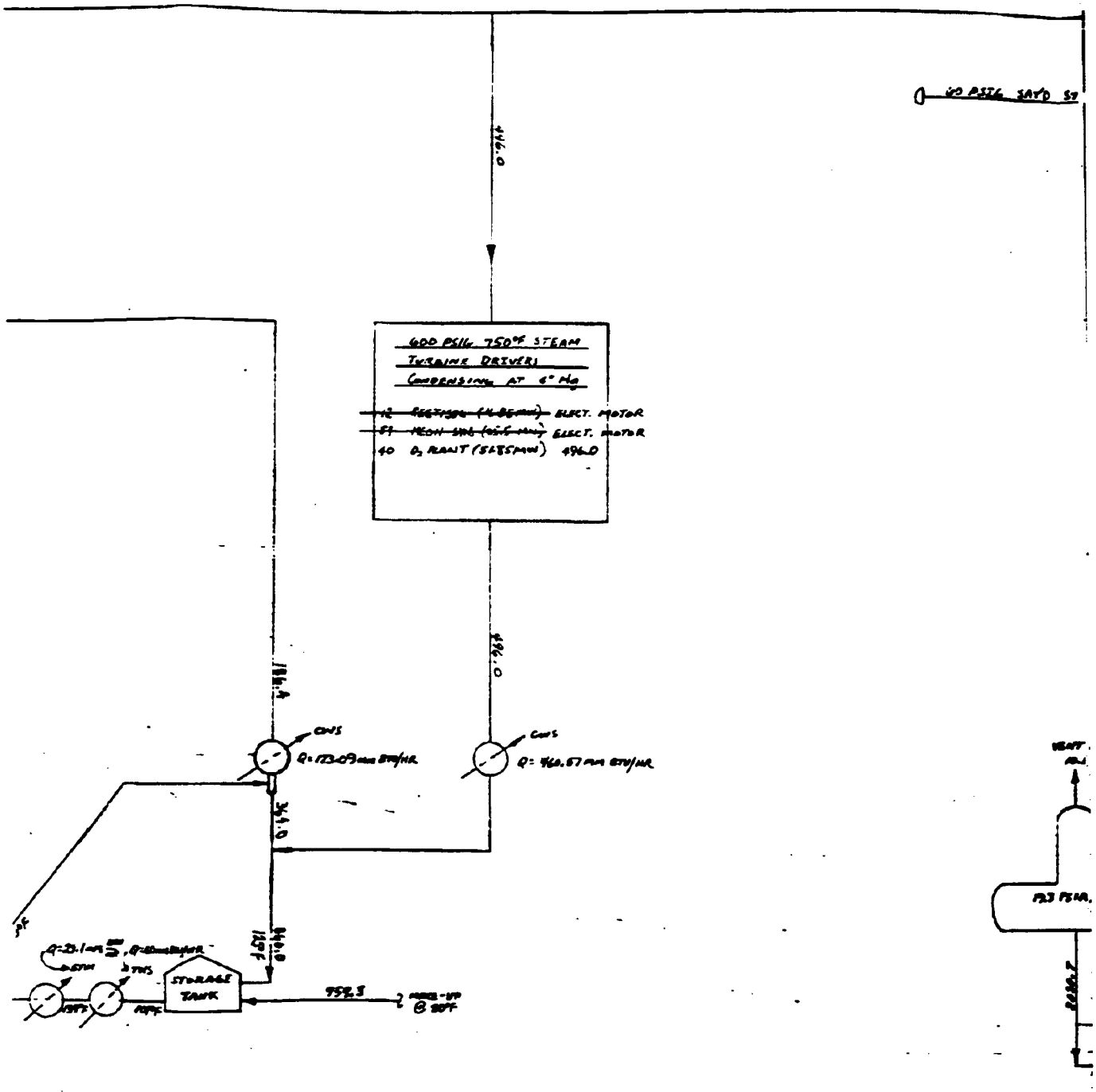
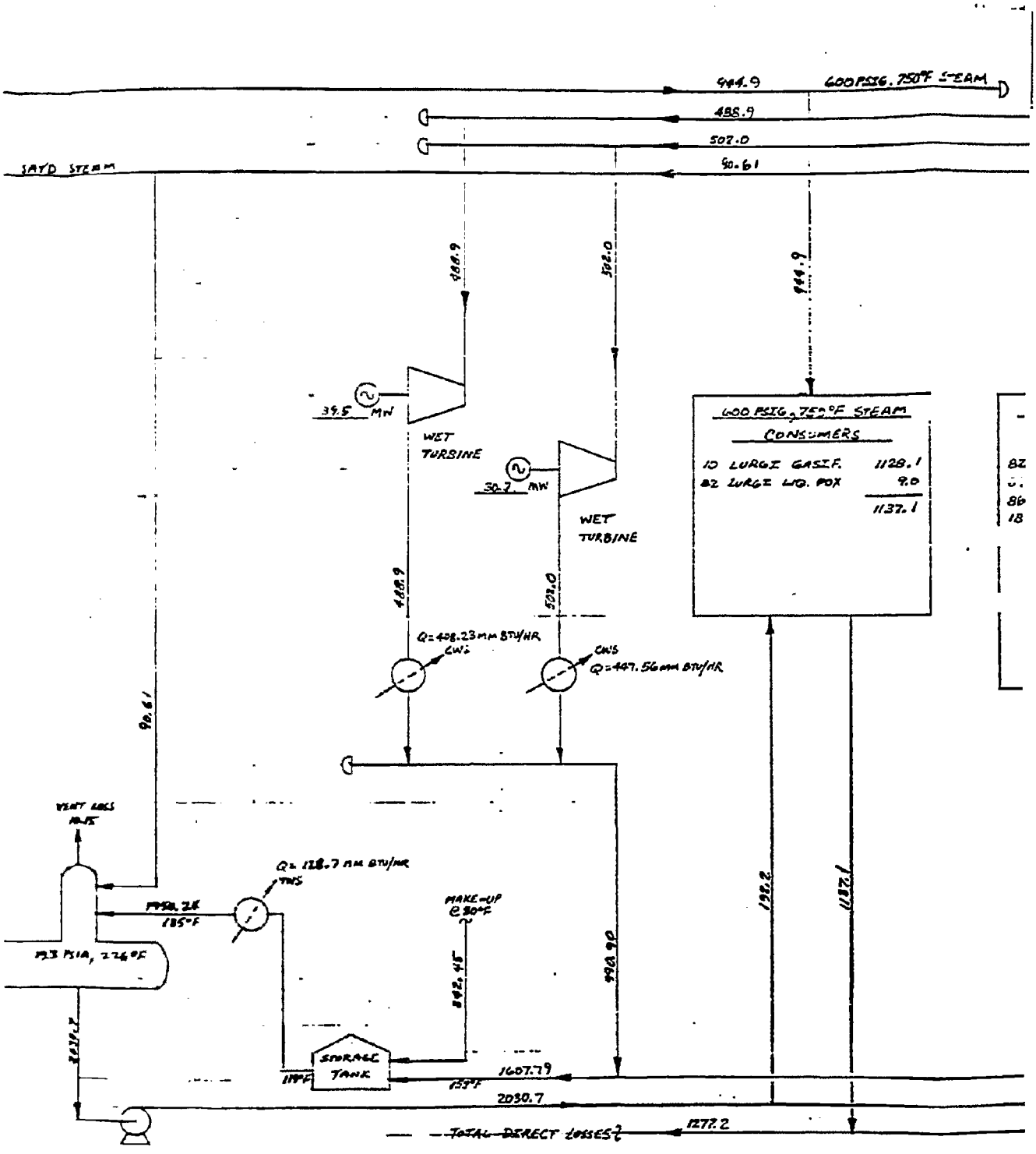
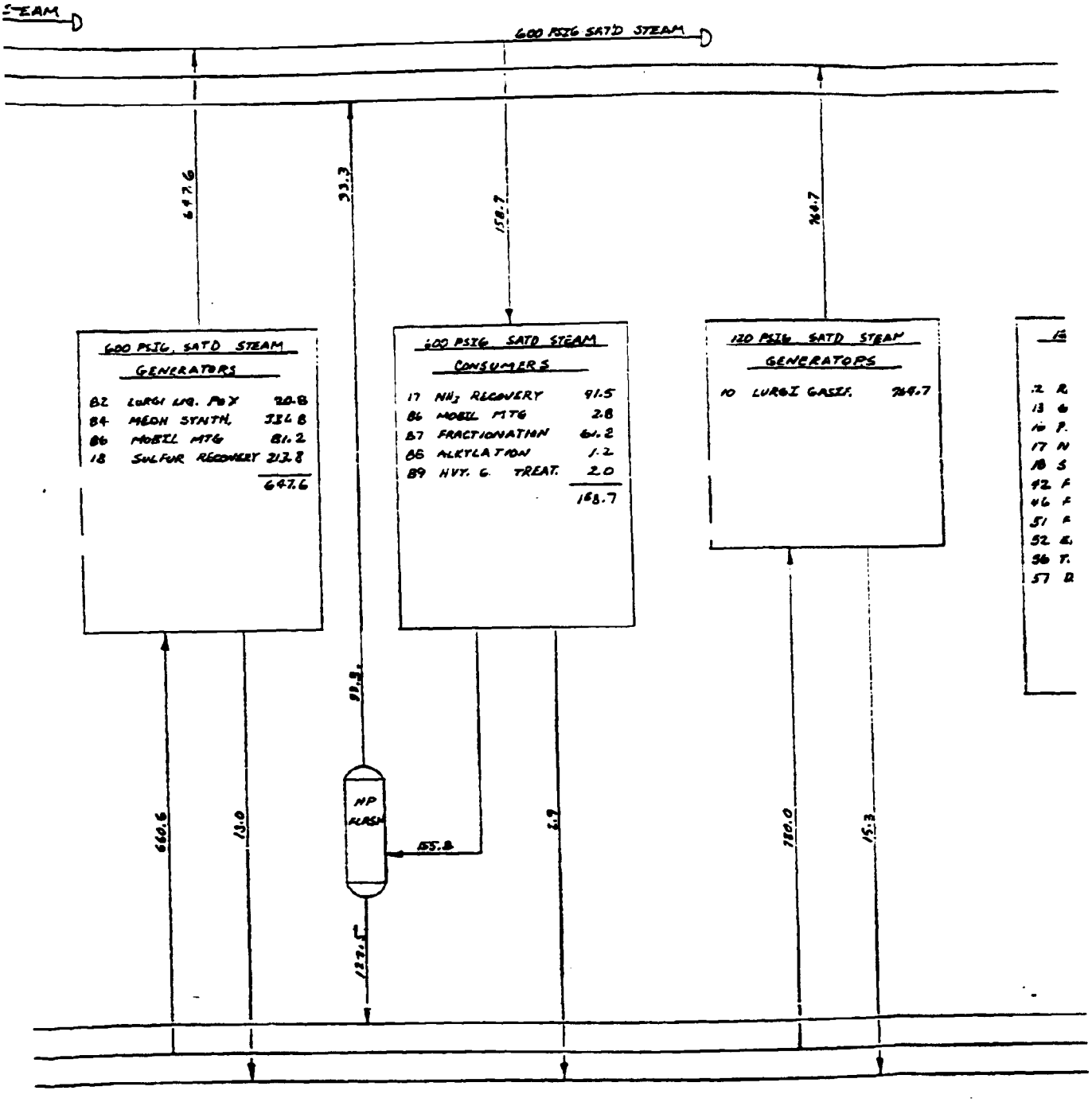
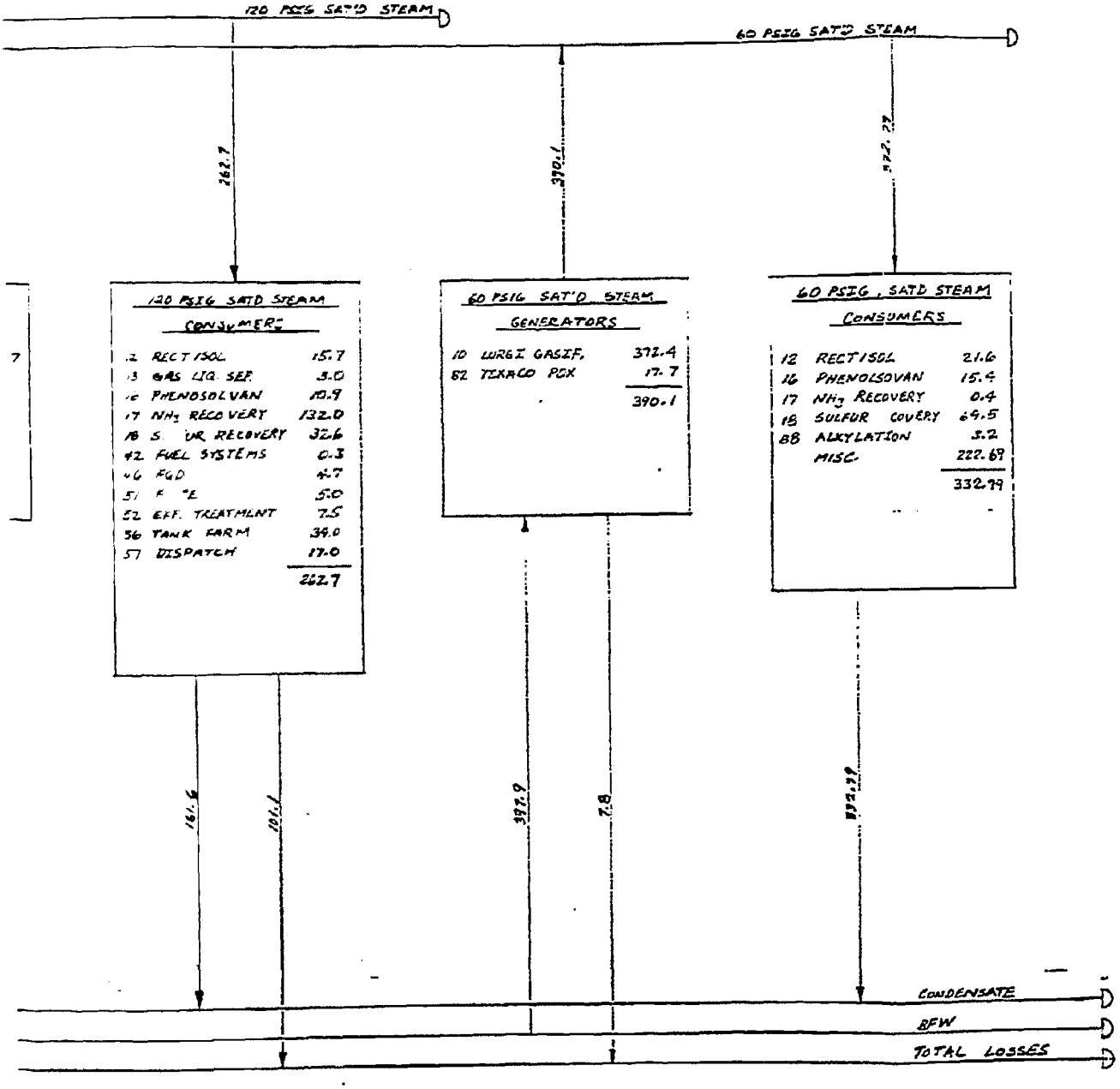
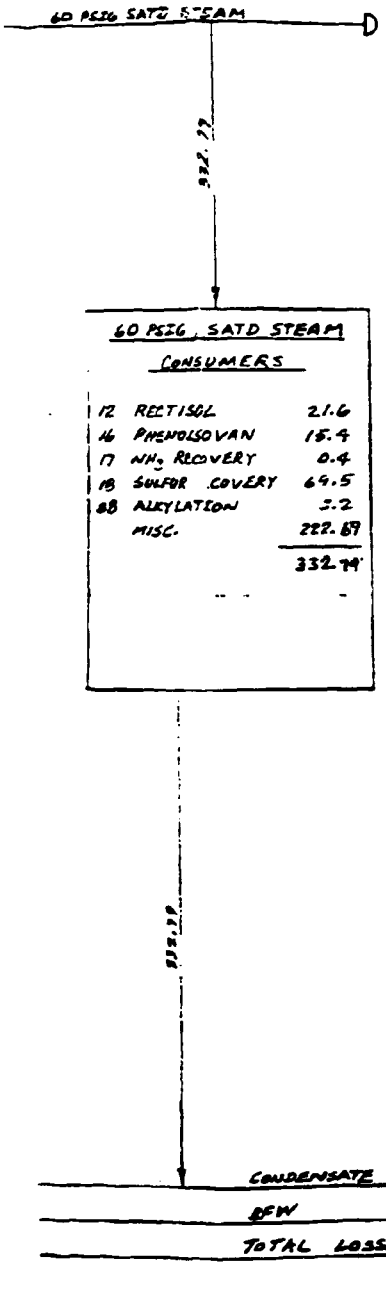

1500 PSIG, 1000°F STEAM
600 PSIG, 750°F STEAM
62.7 MW
19.5 MW
1500 PSIG BOILER
B.D.
3399 ST/SD
COAL (AS REC'D)
VENT
66.98 PSIA
300°F
STORAGE TANK


600 PSIG 750°F STEAM
TURBINE DRIVER
CONDENSING AT 6" Hg
40 D₂ PLANT (SLESSMAN) 496.0
496.0
496.0
181.4
344.0
151
CWS
CWS
STORAGE TANK
952.5
MAKE-UP @ 80°F
150 PSIA


944.9
600 PSIG. 750°F STEAM
488.9
507.0
SAT'D STEAM
90.61
488.9
507.0
944.9
39.5 MW
WET TURBINE
30.7 MW
WET TURBINE
600 PSIG, 750°F STEAM
CONSUMERS
10 LURGI GASIF. 1128.1
82 LURGI LIQ. FOX 9.0
1137.1
488.9
507.0
Q=408.23 MM BTU/HR
CWS
Q=447.56 MM BTU/HR
CWS
90.61
VENT GASES
Q= 128.7 MM BTU/HR
TWS
MAKE-UP @ 80°F
942.45
990.90
136.2
1137.1
STORAGE TANK
1607.79
2030.7
1277.2
TOTAL DIRECT LOSSES


STEAM
600 PSIG SATD STEAM
647.6
33.3
158.7
740.7
600 PSIG, SATD STEAM GENERATORS
B2 LURGI LIQ. POX 20.8
B4 MEOH SYNTH. 314.8
B6 MOBIL MTG 81.2
18 SULFUR RECOVERY 213.8
647.6
600 PSIG SATD STEAM CONSUMERS
17 NH3 RECOVERY 91.5
B6 MOBIL MTG 2.8
B7 FRACTIONATION 61.2
B8 ALKYLATION 1.2
B9 HVY. G. TREAT. 2.0
158.7
120 PSIG SATD STEAM GENERATORS
10 LURGI GASIF. 740.7
HP FLASH
155.8
660.6
13.0
2.9
740.0
15.3


120 PSIG SAT'D STEAM
60 PSIG SAT'D STEAM
262.7
390.1
332.79
120 PSIG SATD STEAM
CONSUMERS
12 RECT/SOL 15.7
13 GAS LIQ. SEP. 3.0
16 PHENOSOLVAN 10.9
17 NH3 RECOVERY 132.0
18 SULFUR RECOVERY 32.6
42 FUEL SYSTEMS 0.3
46 FGD 4.7
51 [illegible] 5.0
52 EFF. TREATMENT 7.5
56 TANK FARM 34.0
57 DISPATCH 17.0
262.7
60 PSIG SAT'D STEAM
GENERATORS
10 LURGI GASIF. 372.4
62 TEXACO POX 17.7
390.1
60 PSIG, SATD STEAM
CONSUMERS
12 RECT/SOL 21.6
16 PHENOLSOVAN 15.4
17 NH3 RECOVERY 0.4
18 SULFUR COVERY 69.5
88 ALKYLATION 5.2
MISC. 222.69
332.79
CONDENSATE
BFW
TOTAL LOSSES



NOTES:

1) TOTAL POWER REQUIRED IS 113.99 MW, 152.4 MW IS GENERATED.
2) ALL FLOWRATES ARE GIVEN IN UNITS OF 10^3 LB/HR.
3) ASSUMED BLOWDOWN OF 2% FOR PROCESS STEAM GENERATORS, AND 0.5% FOR THE 1500 PSIG BOILER PLANT.
4) EFFICIENCY ASSUMED:
   a. 80% FOR BOILER
   b. 80% FOR BACKPRESSURE TURBO-GENERATOR
   c. 75% FOR WET TURBINES
   d. 85% FOR TURBINE DRIVERS
5) THE extraction turbine in this balance does not meet the 40% maximum allowable extraction (it is 68%), thus the steam rate (and coal fired to boiler) must be increased before it can be compared to the 2400 PSIG SYSTEM.

6 REVISIONS	PROCESS BLOCK FLOW DIAGRAM STEAM GENERATION STUDY STEAM BALANCE CASE 13 1500 PSIG STEAM
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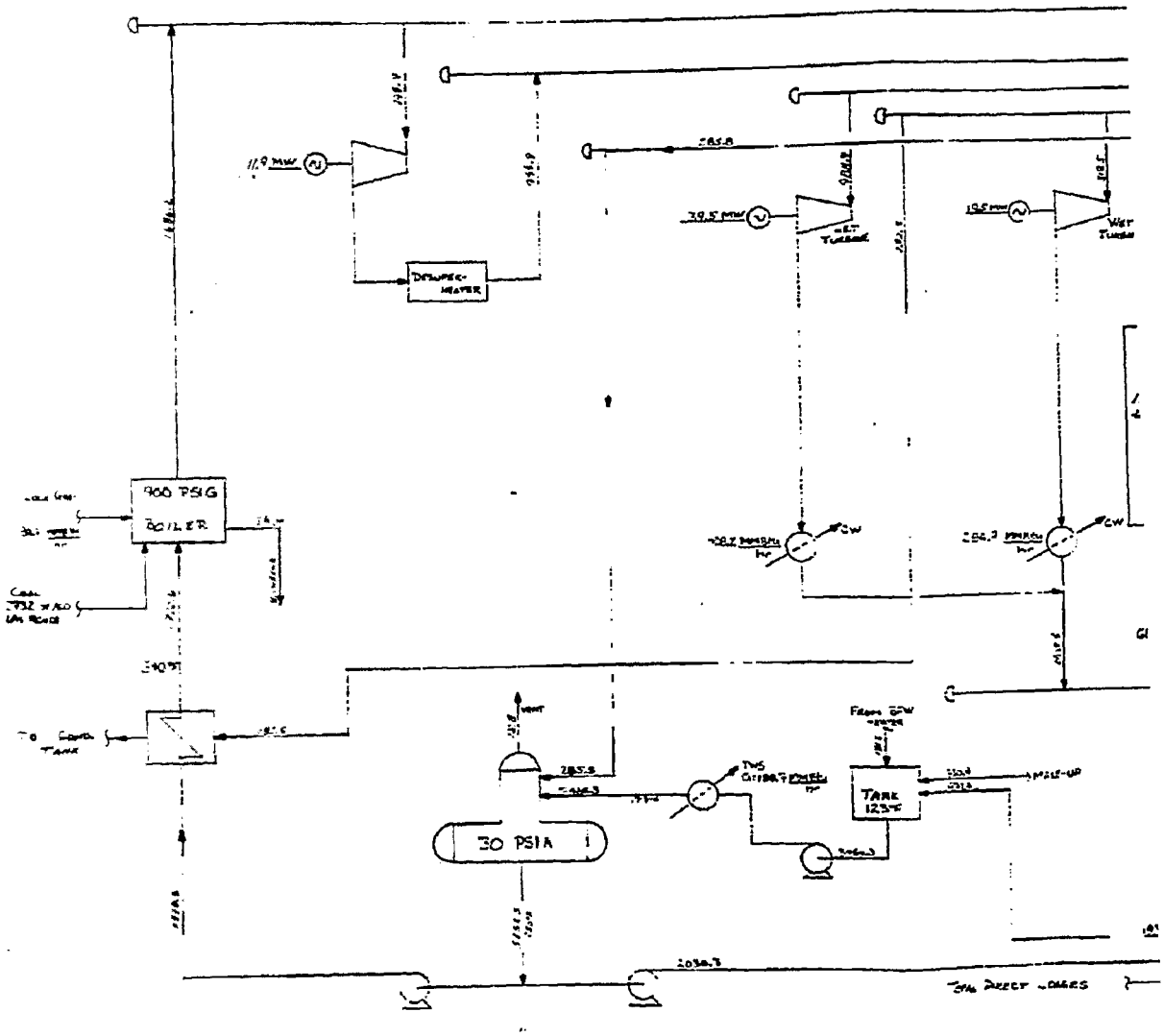
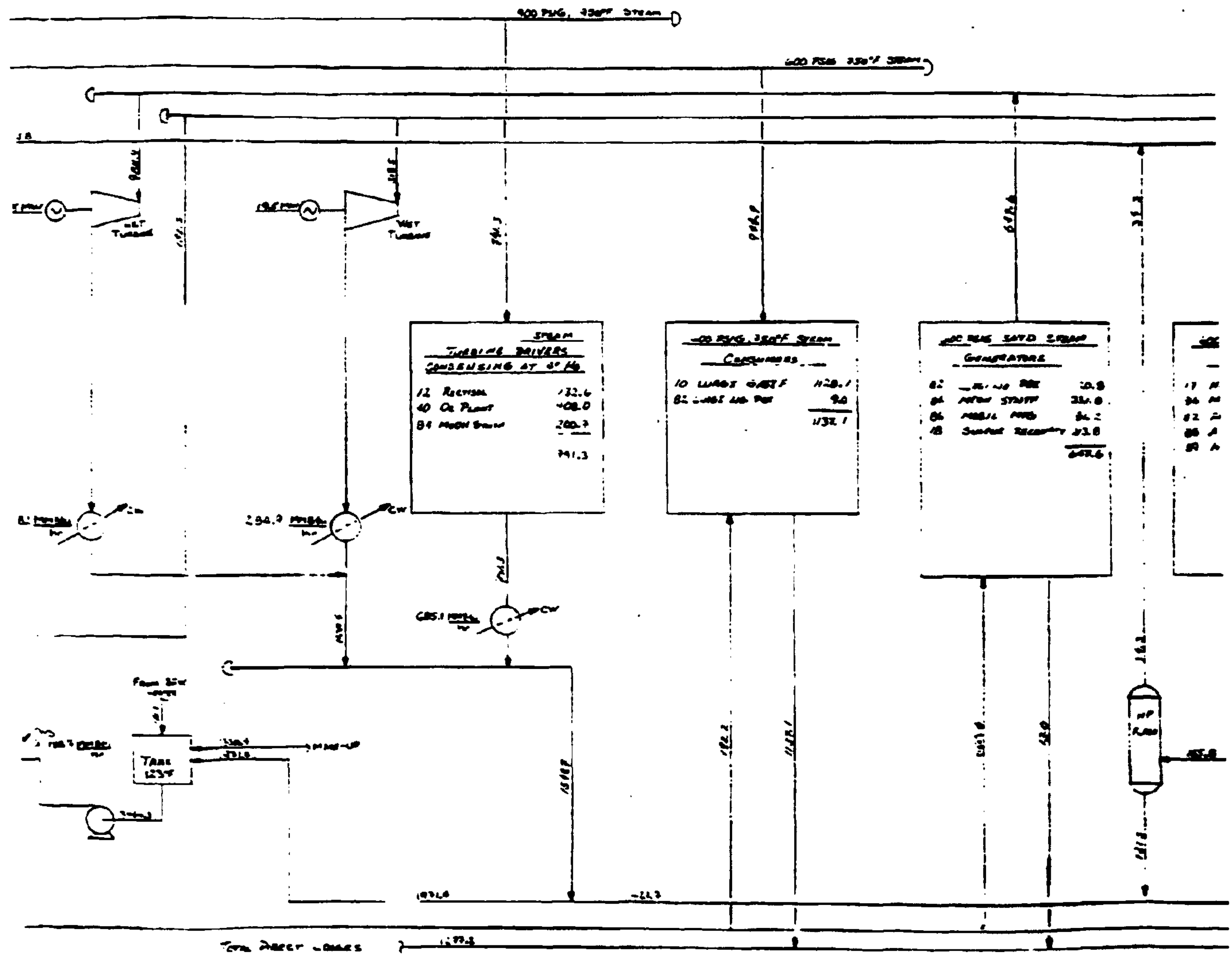
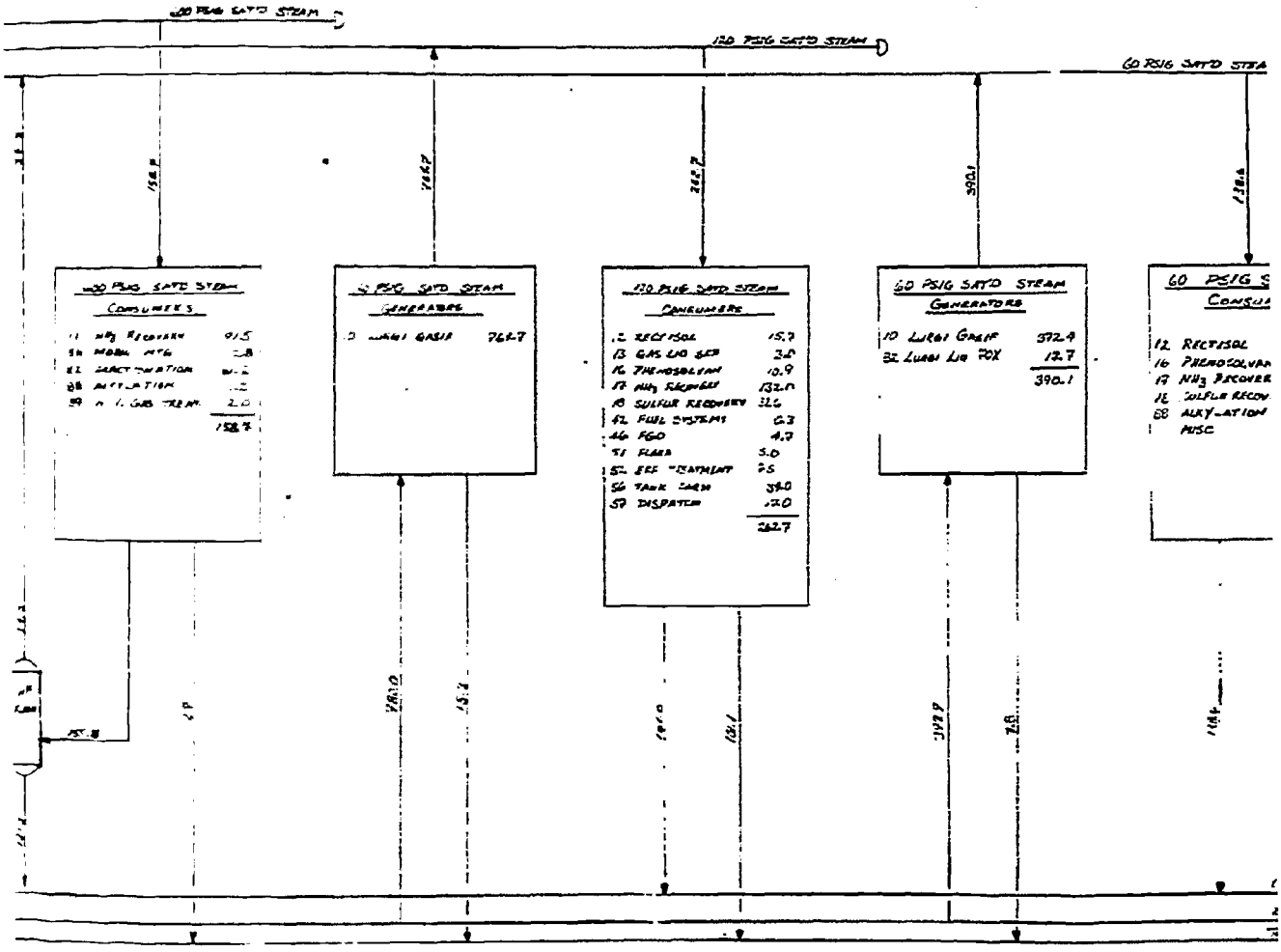

900 PSIG
BOILER
30 PSIA
TANK
12.5%
DEAERATOR
HEATER



900 PSIG, 750°F Steam
Wet Turbine
Wet Turbine
Steam
Turbine Drivers
12 Rectisol 132.6
40 Oil Plant 408.0
200.7
741.3
Consumers
10 428.1
1132.1
Generators
CW
CW
CW
Tank
Make-Up
Total Direct Losses

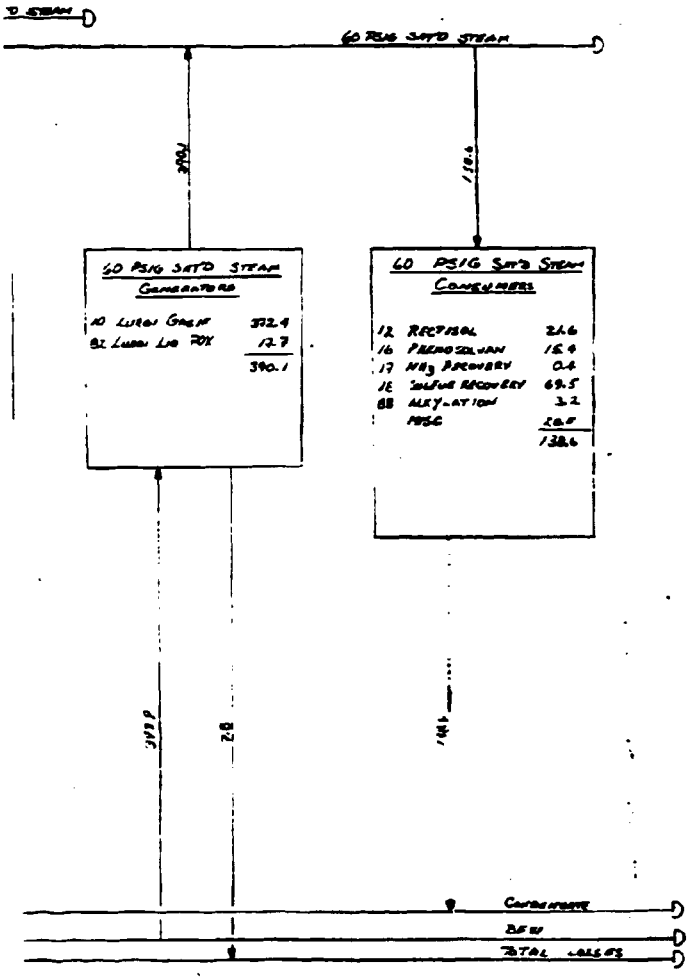
NOTES:

1) TOTAL POWER REQUIRED IS 31.6 MW, .
2) ALL FLOWRATES ARE GIVEN IN UNITS
3) ASSUMED BLOWDOWN OF 2% FOR
4) EFFICIENCY ASSUMED:
   a) 80% FOR BOILER
   b) 80% FOR BACKPRESSURE TUR
   c) 75% FOR WET TURBINES
   d) 85% FOR TURBINE DRIVERS



NOTES:

1) TOTAL POWER REQUIRED IS 74.6 MW, 36.9 MW IS GENERATED.
2) ALL FLOWRATES ARE GIVEN IN UNITS OF 10^3 lb/hr.
3) ASSUMED BLOWDOWN OF 2% FOR ALL STEAM GENERATORS
4) EFFICIENCY ASSUMED:
   a) 85% FOR BOILER
   b) 80% FOR BACKPRESSURE TURBINE
   c) 75% FOR WET TURBINES
   d) 85% FOR TURBINE DRIVERS



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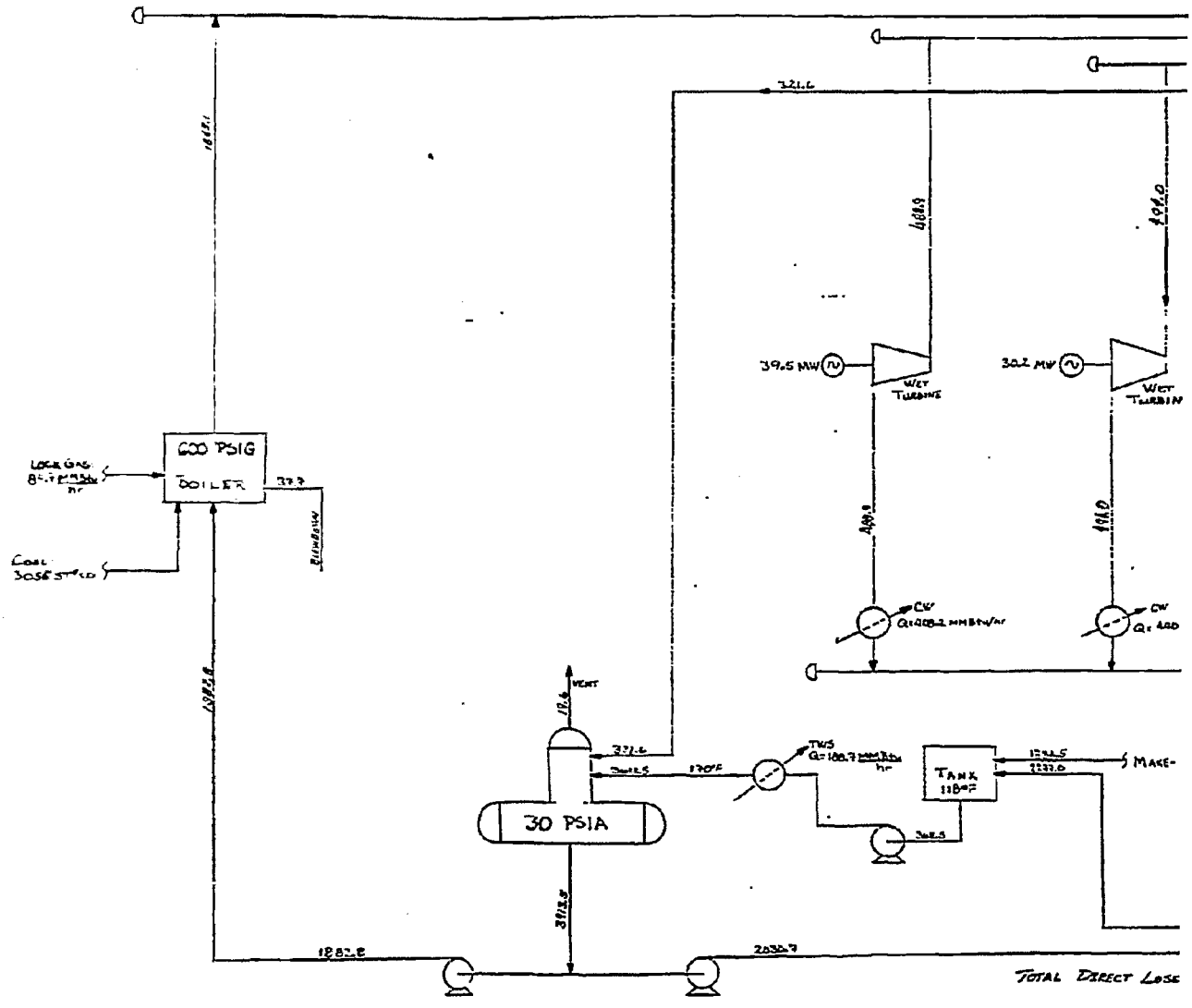
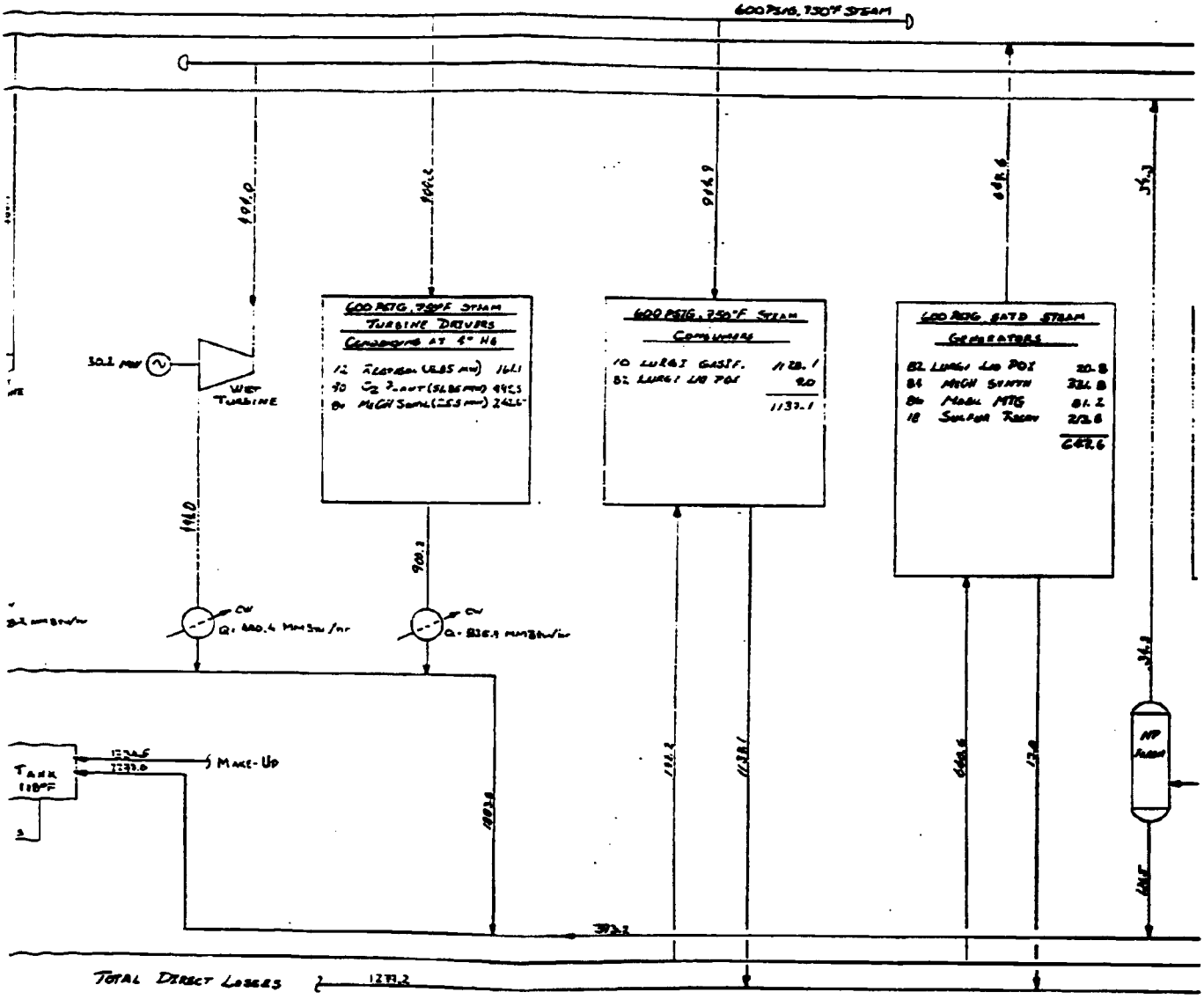
S. D. MARTS

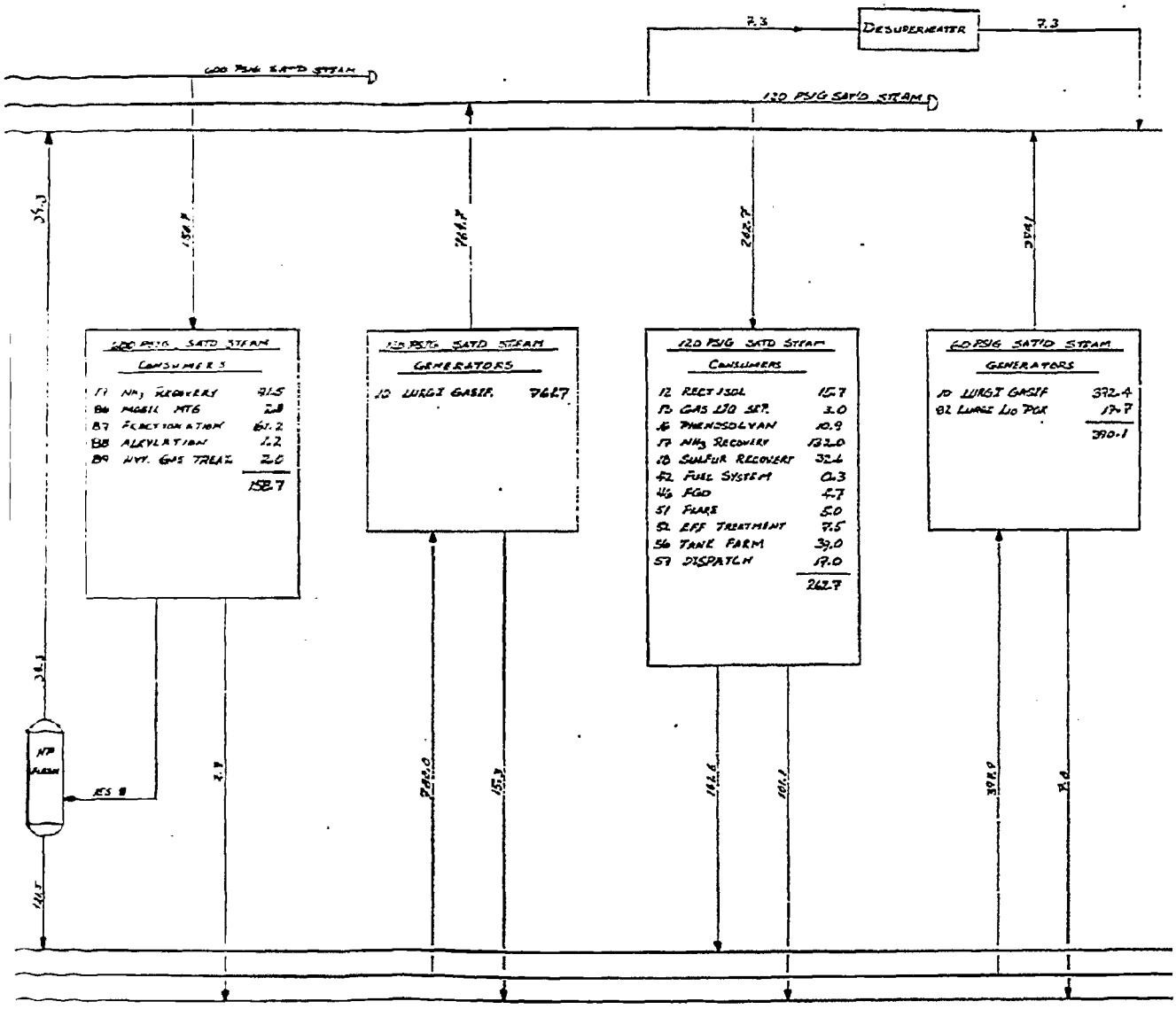
PROCESS BLOCK FLOW DIAGRAM
STEAM GENERATION STUDY
STEAM BALANCE CASE 13
900 PSIG SYSTEM

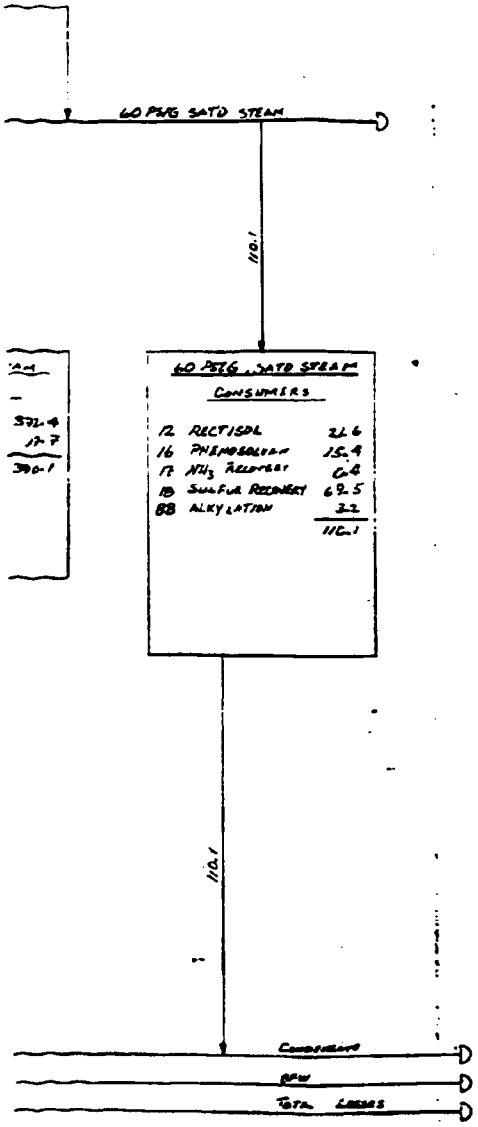
TRI-STATE SYN FUELS CO.

REVISION	DATE	CONTRACT NO.
		835504


600 PSIG
BOILER
30 PSIA
39.5 MW
30.2 MW
WET TURBINE
WET TURBIN
321.6
VENT
TANK
MAKE-
TOTAL DIRECT LOSE


600 PSIG, 750° STEAM
600 PSIG, 750°F STEAM
TURBINE DRIVERS
CONDENSING AT 4" HG
600 PSIG, 750°F STEAM
COMPUTERS
600 PSIG GATD STEAM
GENERATORS
WET TURBINE
CW
Q= 880.4 MM Btu/hr
CW
Q= 838.9 MM Btu/hr
TANK 110°F
MAKE-UP
TOTAL DIRECT LOSSES


DESUPERHEATER
7.3
7.3
600 PSIG SAT'D STEAM
120 PSIG SAT'D STEAM
35.3
156.8
746.8
242.7
394.1
600 PSIG SATD STEAM
CONSUMERS
71 NH3 RECOVERY 71.5
86 MOBIL MTG 2.8
87 FRACTIONATION 61.2
88 ALKYLATION 1.2
89 HYT. GAS TREAT 2.0
158.7
150 PSIG SATD STEAM
GENERATORS
10 LURGI GASIF. 746.7
120 PSIG SATD STEAM
CONSUMERS
12 RECTISOL 15.7
13 GAS LIQ SEP. 3.0
16 PHENOSOLVAN 10.9
19 NH3 RECOVERY 132.0
18 SULFUR RECOVERY 32.6
42 FUEL SYSTEM 0.3
46 FGD 4.7
51 FLARE 5.0
52 EFF TREATMENT 7.5
56 TANK FARM 39.0
57 DISPATCH 17.0
262.7
60 PSIG SATD STEAM
GENERATORS
10 LURGI GASIF 372.4
82 LURGE LIQ POX 17.7
390.1
35.3
HP FLARE
ES 8
2.9
746.0
155.7
144.6
101.1
394.9
3.6
144.5



NOTES:

1. TOTAL POWER REQUIRED IS 71.6 MW, TOTAL POWER PRODUCED IS 69.3 MW.
2. ALL FLOWRATES ARE GIVEN IN UNITS OF 10^3 lb/hr.
3. BLOWDOWN OF 2% IS ASSUMED FOR ALL STEAM GENERATORS.
4. EFFICIENCIES ASSUMED:
   a) 80% FOR BOILER
   b) 75% FOR WET TURBOGENERATORS
   c) 80% FOR TURBINE DRIVERS

S.D. MARTS

PROCESS BLOCK FLOW DIAGRAM

STEAM PRESSURE GENERATION STUDY

CASE 13 600 PSIG BALANCE

TRI-STATE SYNFUELS COMPANY

REVISION:	DATE:	CONTRACT:
		835504

8.3 MATERIAL BALANCE

The steam balances for Case 13 and the pressure level study (600, 900, 1500, and 2400 psig), based on Case 13 steam and power requirements, are included on the flow diagrams located in Section 8.2. The steam and power requirements are estimates based on available information from process licensors or pro-rated from previous work on similar units.

The four (4) material balances presented in this section are the results of modeling the steam system pressure study on a computer. The steam balance with the boiler operating at 600 psig/750°F is identical to the block flow diagram of the 600 psig/750°F system located in Section 8.2. The three other balances (900 psig, 1500 psig, and 2400 psig) differ from the block diagram of the corresponding pressure located in Section 8.2. These latter three (3) computer steam balance models were not updated to represent the steam systems located in Section 8.2, but are included here as examples of computer modeling.

CALCULATED PROPERTIES FOR EACH WATER/STEAM STREAM

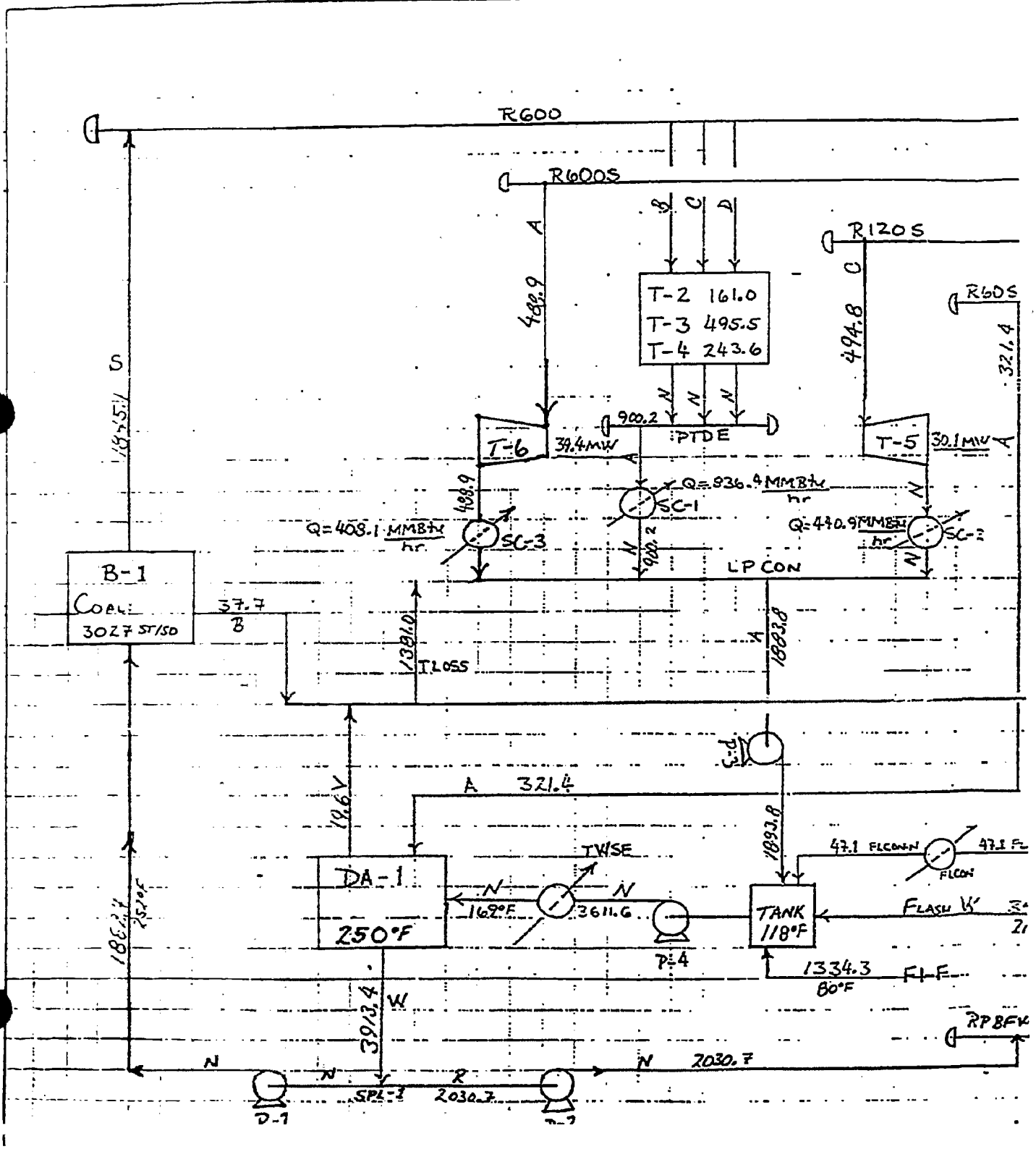
REV: 10/05/81
CONTRACT: 535504
STEAM BALANCE CASE13
BY STAN HARTS

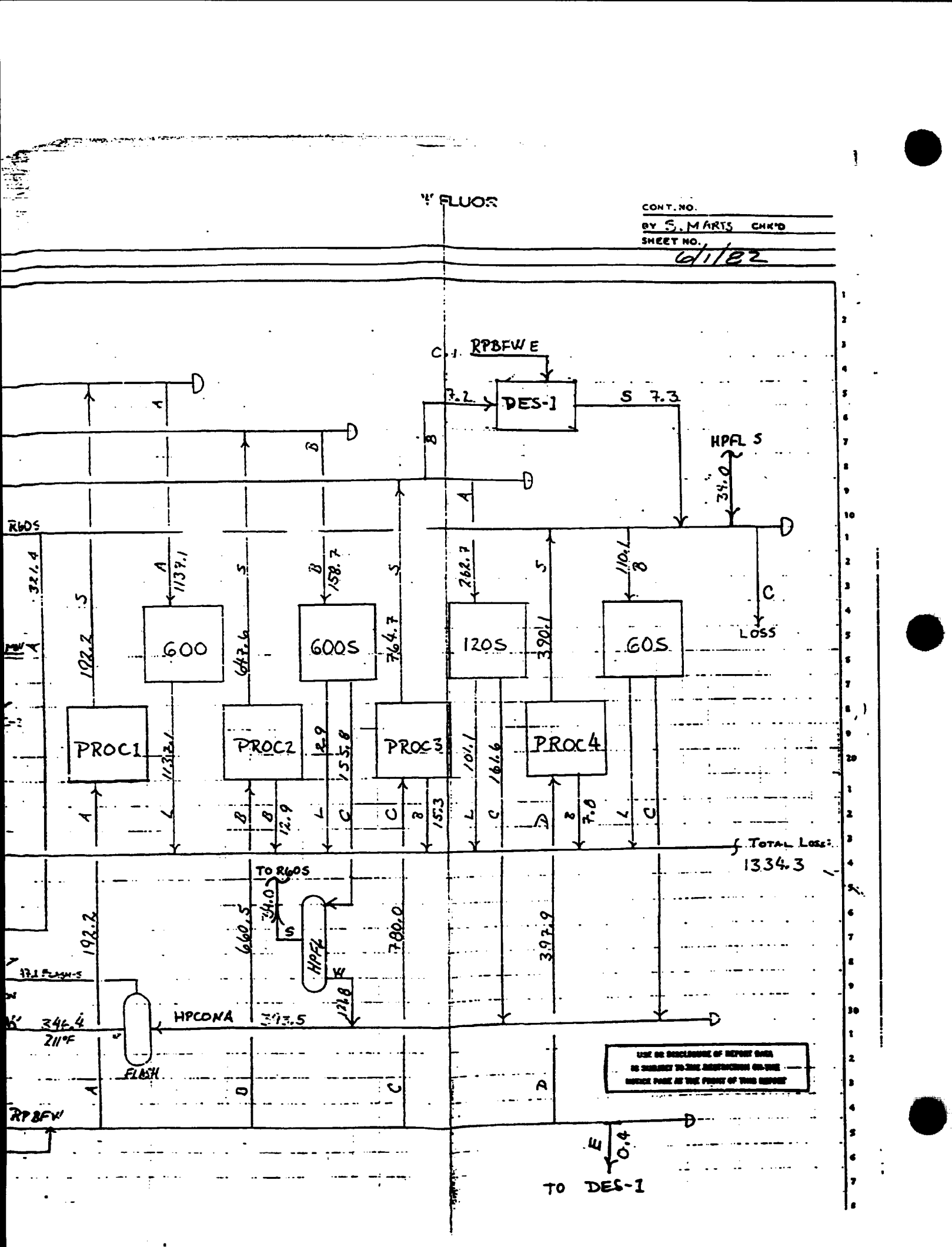
DATE: 04/29/92
CUSTOMER: TVA STATI
LOCATION: 4T2-FL-N2
PAGE: 5

600 PSIG System

STREAM NAME	FLOW LBS/HR	TEMP F	PRESSURE PSIA	ENTROPY BTU/LB-F	ENTHALPY BTU/LB	VOLUME CUFT/LB	QUALITY FRAC
R600 B	161047.2	750.0	614.4	1.61	1379.630	1.1035	1.0000
R600 C	495491.0	750.0	614.4	1.61	1379.630	1.1035	1.0000
R600 D	243637.4	750.0	614.4	1.61	1379.630	1.1035	1.0000
SC-1 N	900175.7	125.3	2.0	0.17	93.292	0.0162	0.0
SC-2 N	494761.5	125.3	2.0	0.17	93.292	0.0162	0.0
SC-3 N	488900.0	125.3	2.0	0.17	93.292	0.0162	0.0
SPL-1N	1882730.3	250.3	30.0	0.37	218.934	0.0170	0.0
SPL-1R	2030679.8	250.3	30.0	0.37	218.934	0.0170	0.0
T-2 N	161047.2	125.3	2.0	1.76	1022.461	160.9222	0.9087
T-3 N	495491.0	125.3	2.0	1.76	1022.461	160.9222	0.9087
T-4 N	243637.4	125.3	2.0	1.76	1022.461	160.9222	0.9087
T-5 N	494761.5	125.3	2.0	1.70	964.406	154.3321	0.8715
T-6 N	488900.0	125.3	2.0	1.60	928.039	144.5709	0.8163
TANK A	3611613.4	118.0	14.4	0.16	85.991	0.0162	0.0
TLOSSA	1334321.7	250.3	30.0	0.72	470.643	3.6724	0.2663
TWSE N	3611613.4	170.3	40.0	0.25	138.386	0.0165	0.0
120S C	161600.0	349.9	134.4	0.50	321.639	0.0180	0.0
120S L	101100.0	349.9	134.4	0.50	321.639	0.0180	0.0
60S C	110100.0	307.1	74.4	0.45	277.002	0.0175	0.0
60S L	0.0	307.1	74.4	0.45	277.002	0.0175	0.0
600 C	0.0	488.8	614.4	0.68	474.699	0.0202	0.0
600 L	1137100.0	488.8	614.4	0.68	474.699	0.0202	0.0
600S C	155800.0	488.8	614.4	0.68	474.699	0.0202	0.0
600S L	2900.0	488.8	614.4	0.68	474.699	0.0202	0.0

600 PSIG SYSTEM : COMPUTER OUTPUT




FLUOR
CONT. NO.
BY S. MARTS CHK'D
SHEET NO.
6/1/82
C.1. RPBFW E
DES-1
7.2
S 7.3
HPFL S
34.0
RBOS
600
600S
120S
60S
PROC1
PROC2
PROC3
PROC4
LOSS
C
TOTAL LOSS:
1334.3
TO RBOS
34.0
HPCONA
HPCFF
FLASH
RPBFW
TO DES-1
USE OR DISCLOSURE OF REPORT DATA
IS SUBJECT TO THE RESTRICTION ON THE
NOTICE PAGE AT THE FRONT OF THIS REPORT

CALCULATED PROPERTIES FOR EACH WATER/STEAM STREAM

REV: 10/15/81
CONTRACT: 8[illegible]504
STEAM BALANCE CASE1>
BY STAN HARIS

DATE: 03/26/82
CUSTOMER: TRI STATE
LOCATION: A12-F1-N2
PAGE: 4

900 PSIG System

STREAM NAME	FLOW LBS/HR	TEMP F	PRESSURE PSIA	ENTROPY BTU/LB-F	ENTHALPY BTU/LB	VOLUME CUFT/LB	QUALITY FRAC
B-1 V	33455.6	541.5	975.0	0.74	538.091	0.0215	0.0
B-1 S	1653833.1	900.0	975.0	1.62	1449.390	0.7811	1.0000
BD1 A	36000.0	307.1	74.4	0.56	366.814	0.5974	0.0993
BD2 A	104219.5	211.0	14.4	1.47	953.611	21.7900	0.7976
BFWMIC	169979.6	325.7	164.4	0.47	296.365	0.0177	0.0
BFWMIX	1497758.9	340.0	959.0	0.49	312.660	0.0178	0.0
DA-1 V	18757.0	250.3	30.0	1.70	1164.149	13.7436	1.0000
DA-1 X	3791491.2	250.3	30.0	0.37	218.934	0.0170	0.0
DES-1S	244900.0	750.0	614.4	1.61	1379.630	1.1035	1.0000
F-1 F	1381419.5	80.0	20.0	0.09	48.090	0.0161	0.0
FLASHS	51008.7	211.0	14.4	1.75	1150.095	27.3138	1.0000
FLASHX	382912.9	211.0	14.4	0.31	179.136	0.0167	0.0
HPCONX	434914.6	307.1	74.4	0.47	294.454	0.1302	0.0193
HPFL S	34145.4	307.1	74.4	1.63	1181.711	5.8586	1.0000
HPFL X	121754.6	307.1	74.4	0.45	277.002	0.0175	0.0
LOSS A	1241100.0	349.9	134.4	0.68	462.230	0.5555	0.1615
LPCONA	1562865.6	125.3	2.0	0.17	93.292	0.0162	0.0
MISC N	41065.0	315.8	84.4	0.46	286.009	0.0176	0.0
P-1 N	1697798.9	252.3	975.0	0.37	222.901	0.0170	0.0
P-2 N	2053612.2	251.7	675.0	0.37	221.642	0.0170	0.0
P-3 N	1562865.6	125.4	24.4	0.17	93.382	0.0162	0.0
P-4 N	3497177.8	126.8	50.0	0.18	94.894	0.0162	0.0
PROC1B	0.0	488.8	614.4	0.68	474.699	0.0202	0.0
PROC1S	192200.0	750.0	614.4	1.61	1379.630	1.1035	1.0000
PROC2B	12900.0	488.8	614.4	0.68	474.699	0.0202	0.0
PROC2S	547600.0	488.8	614.4	1.44	1203.441	0.7511	1.0000
PROC3B	15300.0	349.9	134.4	0.50	321.639	0.0180	0.0
PROC3S	764700.0	349.9	134.4	1.58	1192.291	3.3467	1.0000
PROC4B	7500.0	307.1	74.4	0.45	277.002	0.0175	0.0
PROC4S	390100.0	307.1	74.4	1.63	1181.711	5.8586	1.0000
PTDE A	741945.4	125.3	2.0	1.75	1018.294	160.2005	0.9046
RPBFWA	192200.0	251.8	614.4	0.37	221.642	0.0170	0.0
RPBFWB	660500.0	251.8	614.4	0.37	221.642	0.0170	0.0
RPBFWC	730000.0	251.8	614.4	0.37	221.642	0.0170	0.0
RPBFWD	397900.0	251.8	614.4	0.37	221.642	0.0170	0.0
RPBFWE	23012.2	251.8	614.4	0.37	221.642	0.0170	0.0
R12DSA	262700.0	349.9	134.4	1.58	1192.291	3.3467	1.0000
R12DSB	332020.2	349.9	134.4	1.58	1192.291	3.3467	1.0000
R12DSC	1699979.8	349.9	134.4	1.58	1192.291	3.3467	1.0000
R60S A	272930.4	307.1	74.4	1.63	1181.711	5.8586	1.0000
R60S B	1101300.0	307.1	74.4	1.63	1181.711	5.8586	1.0000
R60S C	41065.0	307.1	74.4	1.63	1181.711	5.8586	1.0000

CALCULATED PROPERTIES FOR EACH WATER/STEAM STREAM

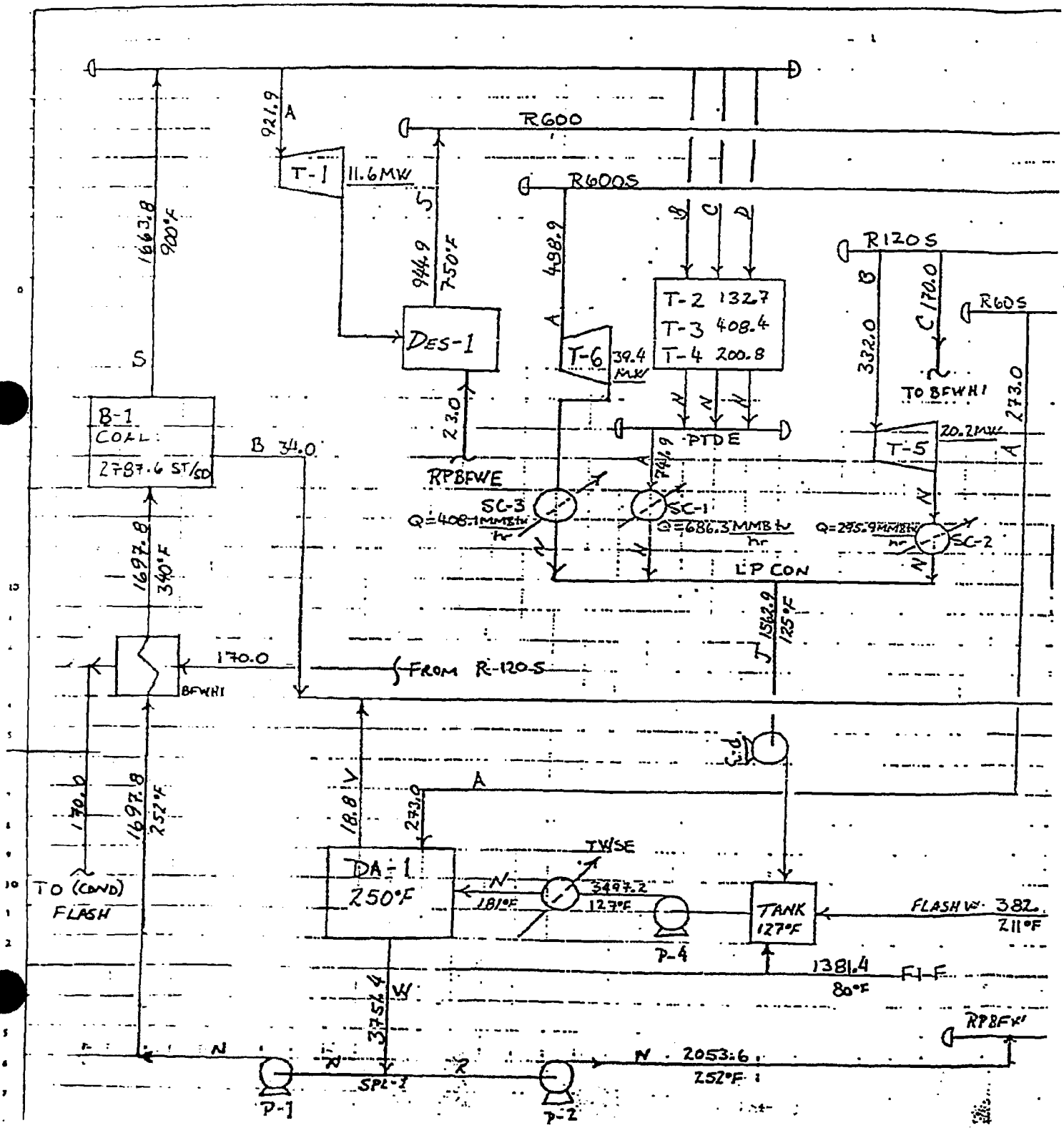
REV: 10/05/81
CONTRACT: 535504
STEAM BALANCE CASE13
BY STAN MARTS

DATE: 03/26/82
CUSTOMER: TRI STATE
LOCATION: AT2-F1-N2
PAGE: 5

900 PSIG System

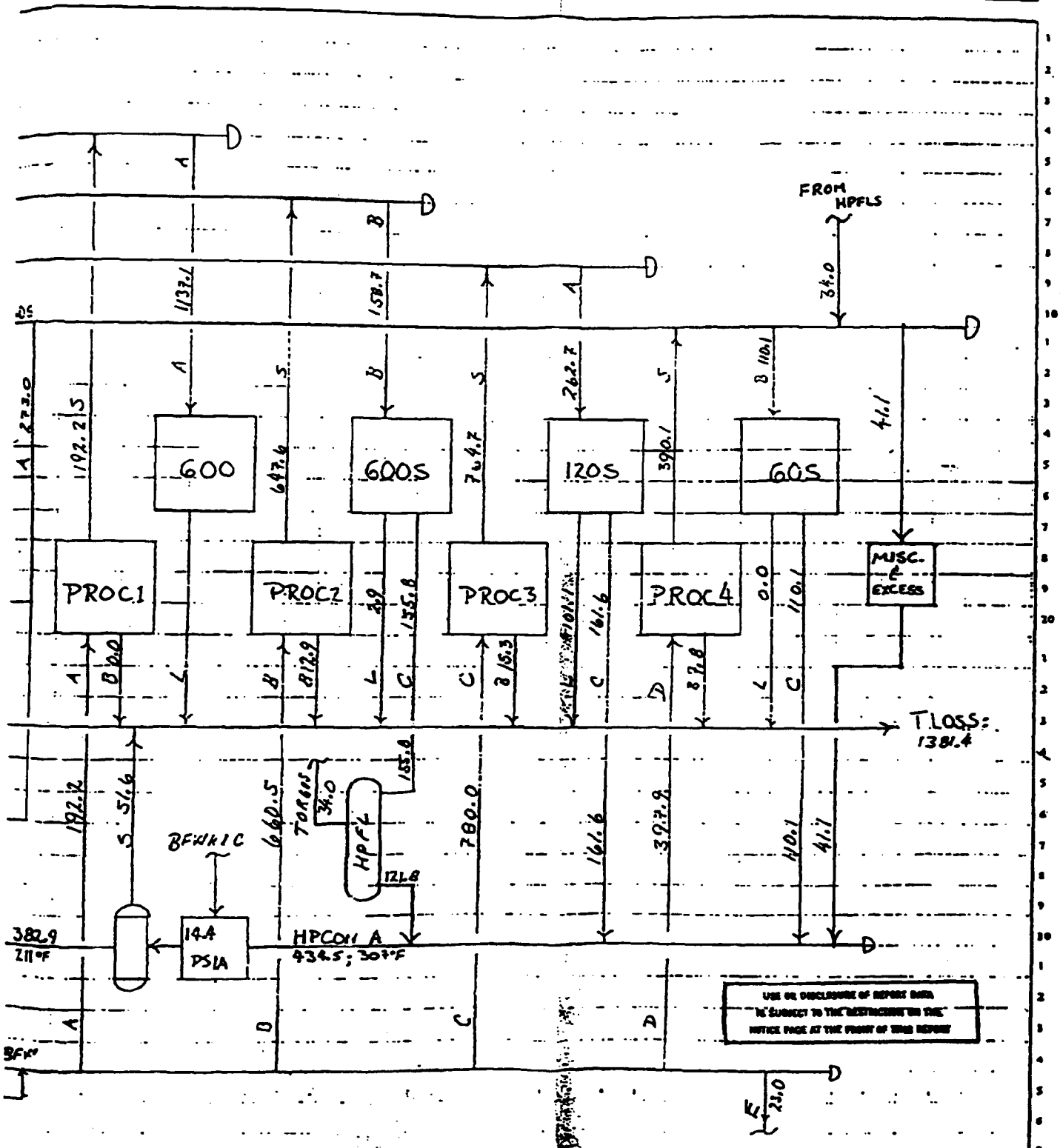
STREAM NAME	FLOW LBS/HR	TEMP F	PRESSURE PSIA	ENTROPY BTU/LB-F	ENTHALPY BTU/LB	VOLUME CUFT/LB	QUALITY FRAC
R600SA	488900.0	488.8	614.4	1.44	1203.441	0.7511	1.0000
R600SB	158700.0	488.8	614.4	1.44	1203.441	0.7511	1.0000
R600 A	1137100.0	750.0	614.4	1.61	1379.630	1.1035	1.0000
R900 A	921987.8	900.0	914.4	1.62	1451.634	0.8362	1.0000
R900 B	132738.8	900.0	914.4	1.62	1451.634	0.8362	1.0000
R900 C	408395.1	900.0	914.4	1.62	1451.634	0.8362	1.0000
R900 D	200811.5	900.0	914.4	1.62	1451.634	0.8362	1.0000
SC-1 N	741945.4	125.3	2.0	0.17	93.292	0.0162	0.0
SC-2 N	332020.2	125.3	2.0	0.17	93.292	0.0162	0.0
SC-3 N	488900.0	125.3	2.0	0.17	93.292	0.0162	0.0
SPL-1N	1697768.9	250.3	30.0	0.37	218.934	0.0170	0.0
SPL-1R	2053612.2	250.3	30.0	0.37	218.934	0.0170	0.0
T-1 N	921987.8	801.7	614.4	1.63	1408.536	1.1617	1.0000
T-2 N	132738.8	125.3	2.0	1.75	1018.294	160.2005	0.9046
T-3 N	408395.1	125.3	2.0	1.75	1018.294	160.2005	0.9046
T-4 N	200811.5	125.3	2.0	1.75	1018.294	160.2005	0.9046
T-5 N	332020.2	125.3	2.0	1.70	984.406	154.3321	0.8715
T-6 N	488900.0	125.3	2.0	1.60	928.039	144.5709	0.8163
TANK A	3497177.8	126.8	14.4	0.18	94.747	0.0162	0.0
TLOSSA	1381419.5	211.0	14.4	0.78	496.851	8.9488	0.3272
TWSE N	3497177.8	180.8	40.0	0.26	148.851	0.0165	0.0
120S C	161600.0	349.9	134.4	0.50	321.639	0.0180	0.0
120S L	101100.0	349.9	134.4	0.50	321.639	0.0180	0.0
60S C	110100.0	307.1	74.4	0.45	277.002	0.0175	0.0
60S L	0.0	307.1	74.4	0.45	277.002	0.0175	0.0
600 C	0.0	488.8	614.4	0.68	474.699	0.0202	0.0
600 L	1137100.0	488.8	614.4	0.68	474.699	0.0202	0.0
600S C	155800.0	488.8	614.4	0.68	474.699	0.0202	0.0
600S L	2900.0	488.8	614.4	0.68	474.699	0.0202	0.0

900 PSIG SYSTEM 3-29-82



FLUOR

CONT. NO. 5,35504
BY J. MACTS CHK'D
SHEET NO.



CALCULATED PROPERTIES FOR EACH WATER/STEAM STREAM

REV: 10/05/81
CONTRACT: 99999
STEAM BALANCE CASE 1
BY STATE POINTS
1500 PSIG System

DATE: 08/10/82
CUSTOMER: INI STATE
LOCATION: ATP-FL-N2
PAGE: 4

STREAM NAME	FLOW LBS/HR	TEMP F	PRESSURE PSIA	ENTROPY BTU/LB-F	ENTHALPY BTU/LB	VOLUME CUFT/LB	QUALITY FRAC
B-1 A	23522.2	602.7	1575.0	0.82	621.121	0.0268	0.0
B-1 S	1442693.2	900.0	1575.0	1.55	1426.230	0.4636	1.0000
BD1 A	33800.0	307.1	74.4	0.53	377.115	0.0039	0.1107
BD2 A	2[illegible]78.2	211.[illegible]	14.4	1.63	1064.459	24.6093	0.9118
BFWHIC	2[illegible]417.8	4[illegible]	370.0	0.61	415.264	0.0192	0.0
BFWHLW	167[illegible]11[illegible]	4[illegible]	1575.0	0.56	377.656	0.0165	0.0
DA-1 W	[illegible]	[illegible]	30.0	1.76	1164.149	12.7455	1.0000
DA-1 S	[illegible]	[illegible]	[illegible]	0.37	218.934	0.0170	0.0
DEG-1D	3[illegible]	107.1	74.4	1.65	1181.711	5.8586	1.0000
F-1 F	14 [illegible]78.2	[illegible]	20.0	0.07	48.030	0.0161	0.0
FLASHA	191[illegible]3.8	211.[illegible]	14.4	1.76	1150.045	27.6158	1.0000
FLASHB	5[illegible]91[illegible]	211.[illegible]	14.4	0.31	179.159	0.0167	0.0
HPCONJ	718917.6	307.1	74.4	0.59	385.727	0.7195	0.1202
LOSS A	1241100.0	349.9	134.4	0.68	402.230	0.5555	0.1615
LPCONJ	1392305.0	125.3	2.0	0.17	-93.292	0.0162	0.0
P-1 N	1676115.6	253.6	1600.0	0.37	225.525	0.0169	0.0
P-2 N	2034508.8	251.7	675.0	0.37	221.642	0.0170	0.0
P-3 N	1392305.0	125.4	24.4	0.17	93.382	0.0162	0.0
P-4 N	3439198.0	119.9	50.0	0.16	87.988	0.0162	0.0
PROC1B	3600.0	488.8	614.4	0.68	474.699	0.0202	0.0
PROC1S	192200.0	750.0	614.4	1.61	1379.630	1.1035	1.0000
PROC2B	12900.0	488.8	614.4	0.68	474.699	0.0202	0.0
PROC2S	647600.0	488.8	614.4	1.44	1203.441	0.7511	1.0000
PROC3B	15300.0	349.9	134.4	0.50	321.639	0.0180	0.0
PROC3S	764700.0	349.9	134.4	1.58	1192.291	3.3467	1.0000
PROC4B	7800.0	307.1	74.4	0.45	277.002	0.0175	0.0
PROC4S	390100.0	307.1	74.4	1.63	1181.711	5.8586	1.0000
PTDE 1	900175.7	125.3	2.0	1.76	1022.461	100.9222	0.9087
RPBFWA	196000.0	251.8	614.4	0.37	221.642	0.0170	0.0
RPBFWB	560500.0	251.8	614.4	0.37	221.642	0.0170	0.0
RPBFWC	780000.0	251.8	614.4	0.37	221.642	0.0170	0.0
RPBFWD	397900.0	251.8	614.4	0.37	221.642	0.0170	0.0
RPBFWE	108.8	251.8	614.4	0.37	221.642	0.0170	0.0
R120SA	262700.0	349.9	134.4	1.58	1192.291	3.3467	1.0000
R120SB	9870.7	349.9	134.4	1.58	1192.291	3.3467	1.0000
R120SC	492129.3	349.9	134.4	1.58	1192.291	3.3467	1.0000
R1500A	1642593.2	900.0	1514.4	1.56	1428.653	0.4842	1.0000
R60S A	288979.4	307.1	74.4	1.63	1181.711	5.8586	1.0000
R60S B	110100.0	307.1	74.4	1.63	1181.711	5.8586	1.0000
R600SA	488900.0	488.8	614.4	1.44	1203.441	0.7511	1.0000
R600SB	158700.0	488.8	614.4	1.44	1203.441	0.7511	1.0000
R600 A	1137100.0	750.0	614.4	1.61	1379.630	1.1035	1.0000

[illegible] STREAM

REV: [illegible]
CONTRACT: [illegible]
STEAM BALANCE [illegible]
BY STEAM [illegible]

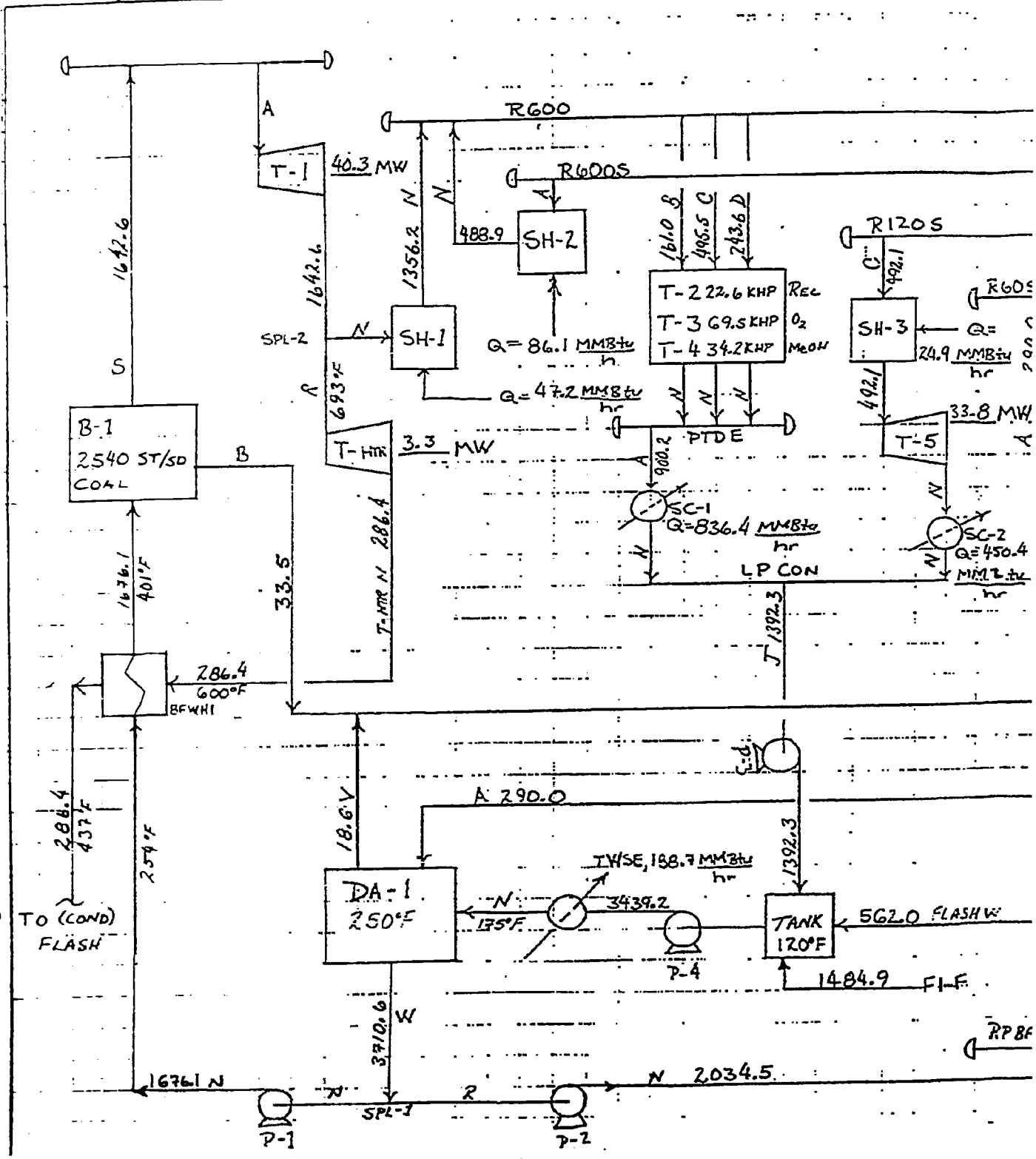
DATE: 03/16/82
CUSTOMER: THE STATE
LOCATION: [illegible]
PAGE: 5

1500 PSIG System

STREAM NAME		FLOW LB/HR	TEMP F	PRESSURE PSIA	ENTROPY BTU/LB-F	ENTHALPY BTU/LB	VOLUME CUFT/LB	QUALITY FRAC
R600	C	1[illegible]7.8	750.0	614.4	1.61	1379.630	1.1035	1.0000
R600	C	[illegible]	750.0	614.4	1.61	1379.630	1.1035	1.0000
R600	C	2[illegible]7.4	750.0	614.4	1.61	1379.630	1.1035	1.0000
SC-1	N	[illegible]175.7	159.3	3.0	0.17	78.252	0.0162	0.0
SC-2	N	[illegible]	159.3	3.0	0.17	78.252	0.0162	0.0
SH-1	N	[illegible].7	750.0	614.4	1.61	1379.630	1.1035	1.0000
SH-2	N	[illegible]	750.0	614.4	1.61	1379.630	1.1035	1.0000
SH-3	N	[illegible]	750.0	614.4	1.61	1379.630	1.1035	1.0000
SPL-1	N	[illegible]115.6	493.3	614.4	0.97	218.934	0.0170	0.0
SPL-1R	N	[illegible]	493.3	614.4	0.97	218.934	0.0170	0.0
SPL-2	N	[illegible]175.7	649.4	649.4	1.57	1344.815	0.9770	1.0000
SPL-2R	N	[illegible]417.6	649.4	649.4	1.57	1344.815	0.9770	1.0000
T-HTR	N	[illegible]417.6	600.0	420.0	1.58	1305.791	1.4007	1.0000
T-1	N	1642593.2	649.4	649.4	1.57	1344.815	0.9770	1.0000
T-2	N	161047.2	165.3	2.0	1.76	1022.461	160.9222	0.9087
T-3	N	495491.0	125.3	2.0	1.76	1022.461	160.9222	0.9087
T-4	N	243637.4	125.3	2.0	1.76	1022.461	160.9222	0.9087
T-5	N	482129.3	125.3	2.0	1.74	1008.446	156.4952	0.8950
TANK	A	3439198.0	119.8	14.4	0.16	87.841	0.0162	0.0
TLOSSA		1484676.2	211.0	14.4	0.85	542.674	10.2371	0.3744
TWSE	N	3439198.0	174.7	60.0	0.25	142.655	0.0165	0.0
120S	C	1[illegible]00.0	349.8	134.4	0.50	321.639	0.0180	0.0
120S	L	101100.0	349.8	134.4	0.50	321.639	0.0180	0.0
60S	C	119100.0	307.1	74.4	0.45	277.002	0.0175	0.0
60S	L	0.0	307.1	74.4	0.45	277.002	0.0175	0.0
600	C	0.0	488.8	614.4	0.66	474.699	0.0202	0.0
600	L	1187100.0	488.8	614.4	0.66	474.699	0.0202	0.0
600S	C	1[illegible]00.0	488.8	614.4	0.66	474.699	0.0202	0.0
600S	L	2900.0	488.8	614.4	0.66	474.699	0.0202	0.0

1500 PSIG SYSTEM: RUN #2 3/17/82

- BFW HEATING
- ATMOSPHERIC FLASHING OF HP CONDENSATE
- DEAERATOR PRE
- COLLECT ALL



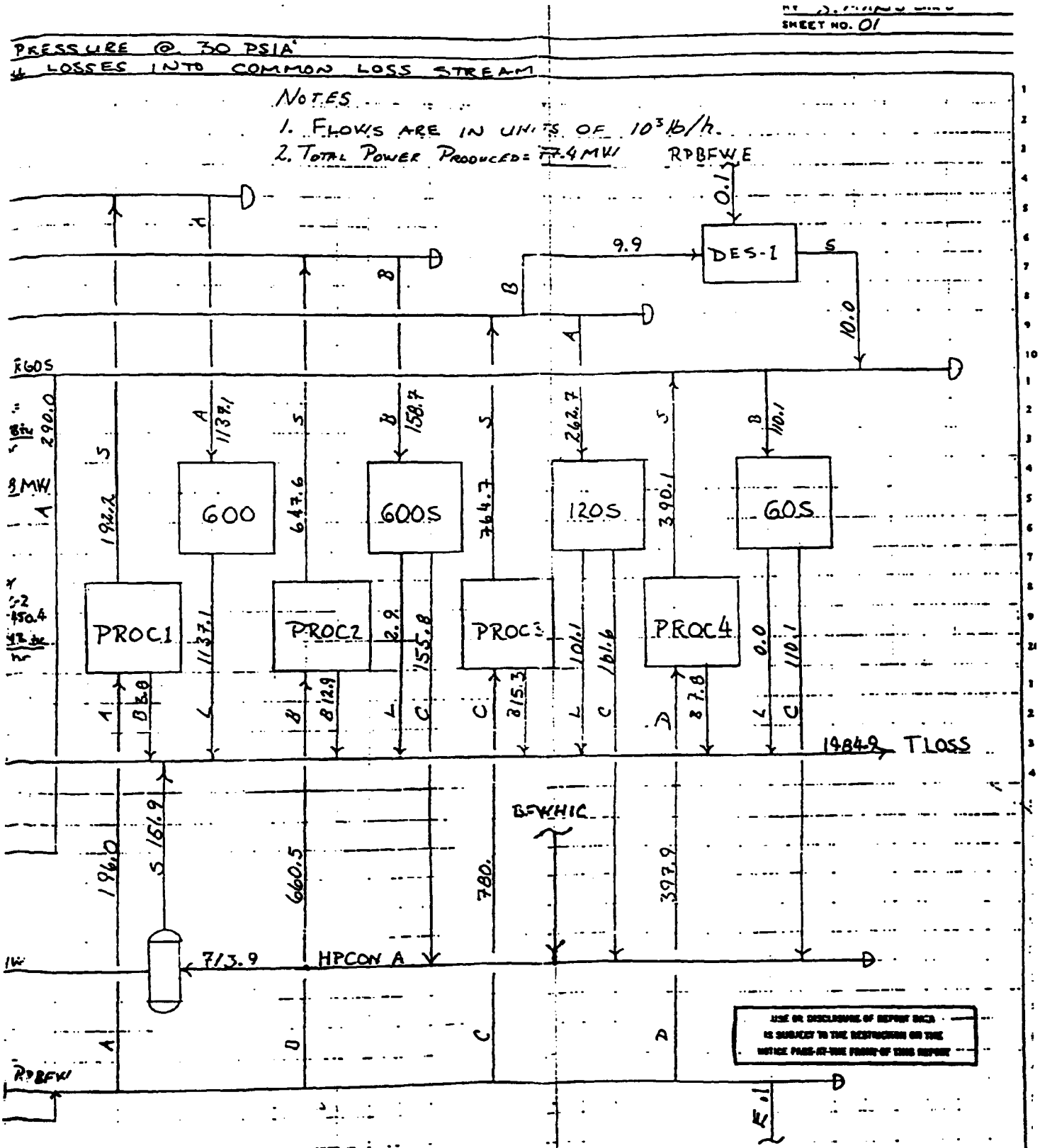
SHEET NO. 01

PRESSURE @ 30 PSIA

LOSSES INTO COMMON LOSS STREAM

NOTES

1. FLOWS ARE IN UNITS OF 10^3 lb/h.
2. TOTAL POWER PRODUCED = 77.4 MW



STREAM NAME	FLOW LBS/HR	TEMP F	PRESSURE PSIA	ENTROPY BTU/LB-F	ENTHALPY BTU/LB	VOLUME CUFT/LB	QUALITY FRAC
ADJ-1N	695050.3	494.8	649.4	1.44	1202.849	0.7091	1.0000
ADJ-2N	283985.1	398.5	243.0	1.53	1200.774	1.8947	1.0000
ADJ-3N	334706.9	305.8	75.0	1.63	1181.352	5.9645	1.0000
B-1 B	27700.3	370.7	2650.0	0.93	750.877	0.0256	0.0
B-1 S	5512355.4	1050.0	2650.0	1.54	1486.143	0.3028	1.0000
BFWH1C	158627.4	199.0	12.2	0.29	167.085	0.0166	0.0
BFWH1W	4337950.2	196.0	220.0	0.29	166.515	0.0166	0.0
BFWH2C	159315.9	234.0	24.0	0.34	202.343	0.0169	0.0
BFWH2W	4337950.2	232.0	210.0	0.34	200.779	0.0169	0.0
BFWH3C	334706.9	302.0	75.0	0.44	271.806	0.0175	0.0
BFWH3W	4337950.2	301.0	200.0	0.44	270.957	0.0175	0.0
BFWH4C	283985.1	395.1	243.0	0.56	369.848	0.0186	0.0
BFWH4W	5540055.7	390.0	2700.0	0.56	373.840	0.0183	0.0
BFWH5C	695050.3	491.0	649.4	0.68	477.293	0.0202	0.0
BFWH5W	5540055.7	480.0	2650.0	0.66	464.868	0.0196	0.0
CMB-1J	5316985.6	310.1	200.0	0.45	280.345	0.0175	0.0
DA-1 V	27700.3	348.0	131.1	1.58	1191.877	3.4268	1.0000
DA-1 W	5540055.7	348.0	131.1	0.50	319.632	0.0180	0.0
EX60 N	4337950.2	164.0	250.0	0.24	132.503	0.0164	0.0
F-1 F	1000300.6	80.0	20.0	0.09	48.090	0.0161	0.0
HPCONA	979035.4	350.0	243.0	0.50	321.930	0.0180	0.0
HPSTMN	5512355.4	1000.0	2415.0	1.53	1460.388	0.3191	1.0000
LPCONA	652650.2	202.8	12.2	0.39	229.397	1.9282	0.0600
P-1 N	4337950.2	100.3	250.0	0.13	68.966	0.0161	0.0
P-2 N	5540055.7	355.1	2750.0	0.50	331.246	0.0178	0.0
P-3 N	3337649.6	125.1	50.0	0.17	93.154	0.0162	0.0
PTDE A	900175.7	125.3	2.0	1.76	1022.461	160.9222	0.9087
R2400A	5512355.4	1000.0	2414.4	1.53	1460.408	0.3192	1.0000
R600 A	2972229.5	750.0	614.4	1.61	1379.630	1.1035	1.0000
R600 B	243637.4	750.0	614.4	1.61	1379.630	1.1035	1.0000
R600 C	161047.2	750.0	614.4	1.61	1379.630	1.1035	1.0000
R600 D	495491.0	750.0	614.4	1.61	1379.630	1.1035	1.0000
R600 E	944900.0	750.0	614.4	1.61	1379.630	1.1035	1.0000
SC-1 N	1784823.8	125.3	2.0	0.17	93.292	0.0162	0.0
SC-2 N	900175.7	125.3	2.0	0.17	93.292	0.0162	0.0
SH-1 N	4817305.1	750.0	614.4	1.61	1379.630	1.1035	1.0000
SPL-1N	695050.3	669.6	649.4	1.56	1330.510	0.9496	1.0000
SPL-1R	4817305.1	669.6	649.4	1.56	1330.510	0.9496	1.0000
SPL-2N	283985.1	555.6	243.0	1.63	1295.501	2.3762	1.0000
SPL-2R	2088244.4	555.6	243.0	1.63	1295.501	2.3762	1.0000
SPL-3N	250770.4	449.7	136.0	1.64	1249.016	3.8270	1.0000
SPL-3R	2437474.0	449.7	136.0	1.64	1249.016	3.8270	1.0000

CONTRACT: 332564 2115
STEAM BALANCE CASE13
BY STAN MARTS
400 PSIG System

CUSTOMER: TRI STATE
LOCATION: AT2-F1-N2
PAGE: 161

STREAM NAME	FLOW LBS/HR	TEMP F	PRESSURE PSIA	ENTROPY BTU/LB-R	ENTHALPY BTU/LB	VOLUME CUFT/LB	QUALITY FRAC
SPL-4N	334706.9	348.1	73.0	1.66	1204.369	6.3624	1.0000
SPL-4R	2102767.0	348.1	73.0	1.66	1204.369	6.3624	1.0000
SPL-5N	159315.9	237.8	24.0	1.68	1135.299	16.5011	0.9743
SPL-5R	1943451.2	237.8	24.0	1.68	1135.299	16.5011	0.9743
SPL-6N	158627.4	202.8	12.2	1.70	1097.192	30.2701	0.9490
SPL-6R	1784823.8	202.8	12.2	1.70	1097.192	30.2701	0.9490
T-1 N	5512355.4	669.6	649.4	1.56	1330.510	0.9496	1.0000
T-10 N	243637.4	125.3	2.0	1.76	1022.461	160.9222	0.9087
T-2 N	2972229.5	559.6	249.0	1.63	1295.501	2.3762	1.0000
T-3 N	2666244.4	449.7	136.0	1.64	1249.016	3.8270	1.0000
T-4 N	2437474.0	348.1	73.0	1.66	1204.369	6.3624	1.0000
T-5 N	2102767.0	237.8	24.0	1.68	1135.299	16.5011	0.9743
T-6 N	1943451.2	202.8	12.2	1.70	1097.192	30.2701	0.9490
T-7 N	1784823.8	125.3	2.0	1.74	1006.776	156.2060	0.8933
T-8 N	495491.0	125.3	2.0	1.76	1022.461	160.9222	0.9087
T-9 N	161047.2	125.3	2.0	1.76	1022.461	160.9222	0.9087
TANK1A	4337950.2	100.0	20.0	0.13	68.050	0.0161	0.0
TCONDA	3337649.6	125.0	2.0	0.17	92.961	0.0162	0.0
TWSE N	4337950.2	114.2	240.0	0.15	82.797	0.0162	0.0
600 C	0.0	488.8	614.4	0.68	474.699	0.0202	0.0
600 L	944900.0	488.8	614.4	0.68	474.699	0.0202	0.0

1

UNIT SUMMARY

REV: 10/05/81
CONTRACT: 332564 2115
STEAM BALANCE CASE13
BY STAN MARTS

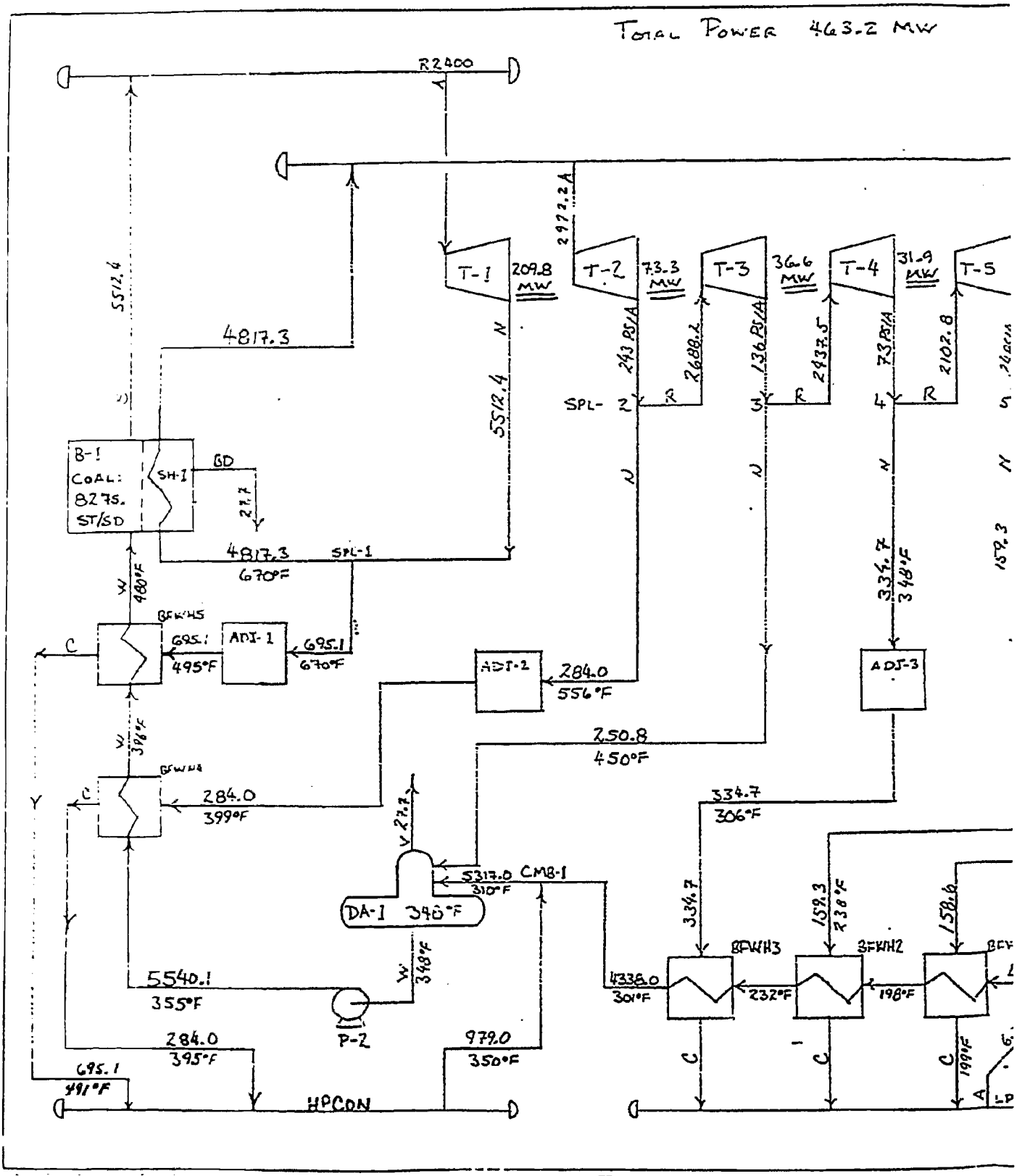
DATE: 04/09/82
CUSTOMER: TRI STATE
LOCATION: AT2-F1-N2
PAGE: 162

STEAM/WATER FEED

SHEET NUMBER 1
ITEM NUMBER F-1
DESCRIPTION MAKE-UP

STREAM NAME	F-1 F
QUALITY	0.0
STEAM, LBS/HR	0.0
CONDENSATE, LBS/HR	1000300.6
TOTAL, LBS/HR	1000300.6
TEMPERATURE, F	80.00
PRESSURE, PSIA	20.00
ENTHALPY, BTU/LB	48.09

2400 PSIG SYSTEM
RUN #1



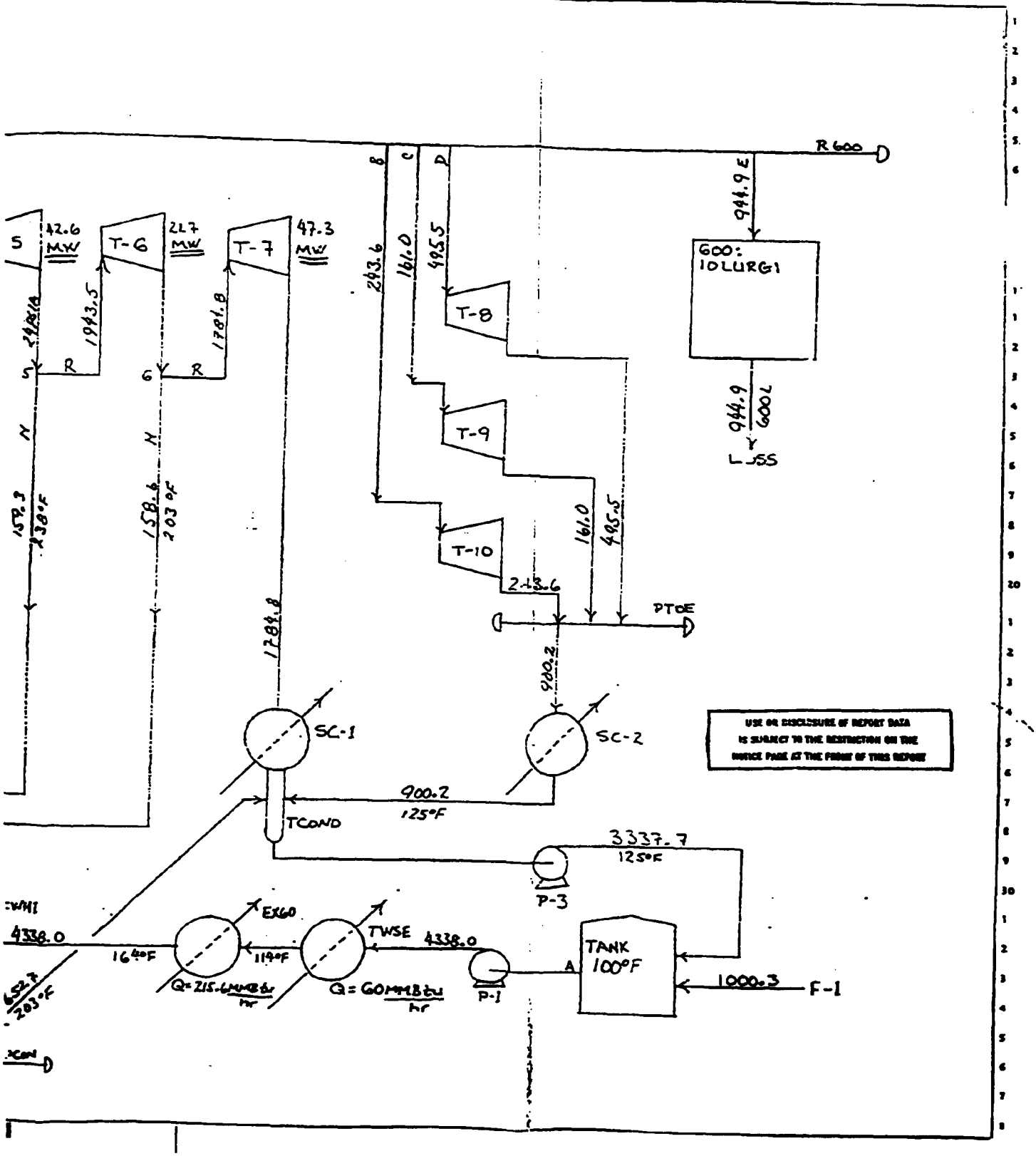
FLUOR

CONT. NO.

BY RO CHK'D

SHEET NO.

6/1/82



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8.4 ACCOMPLISHMENTS AND DECISIONS MADE AND FINALIZED

Initial steam balance case studies were assembled using the feasibility study as a general basis. Certain starting assumptions were made, such as a 1500 psig boiler, steam pressure levels, efficiencies for both the boiler and turbines, superheater and surface condenser requirements, and zero net power export. To satisfy the prerequisite of zero net power requirement a turbogenerator (either condensing or back-pressure) served as a fly-wheel for the system providing power by utilizing high pressure 1500 psig/900°F steam. This provided two advantages for the case study work. It first provided a fairly common basis for factoring the cost between cases. This, assuming the feasibility study cost estimate was correct, provided accurate pricing for each of the subsequent cases. Secondly, it provided an efficient means of generating the cases quickly. Timing was a major factor in the case study developmental work.

The feasibility study consisted of six coal-fired boilers designed to produce 1.02 MM lb/hr each of 1500 psig/900°F steam including associated equipment such as precipitators, coal bunkers, coal conveyor, deaerators, boiler feed water pumps, ash handling collection and transport system, flue gas ducting, exhaust stack, blowdown systems, and controls. The power generation facilities consisted of five turbogenerators. Three turbogenerators were driven by back-pressure turbines using 1500 psig/900°F steam exhausting at 650 psig/703°F. This 703°F steam was superheated in the boiler to 750°F to provide superheat requirements for Lurgi gasification and large steam turbine mechanical drivers. All excess 120 psig steam was superheated to 438°F and used to drive two turbogenerators which exhausted at 4" Hg. This set the basis for the case study work. Numbers for steam generated, power generated, superheater duty and surface condenser heat loads were prorated off the feasibility study whenever possible. Case balances proceeded from Case 1 through 12 and then to a reduced Case "7R". At this point it was felt that a closer look at the cost and delivery schedule for the boiler plant was required.

Fluor Power Services assembled a cost package for both a 2500 psig/1000°F and 1500 psig/900°F steam boiler configuration. This cost package was then used as a basis for subsequent case study work. Case study work proceeded from 7R1 through 7R10, 13, 14, and 15 at which time Case 13 was selected for a detailed analysis. Fluor then conducted a detailed study for the boiler pressure levels of 2400 psig/1000°F, 1500 psig/900°F, 900 psig/900°F, and 600 psig/750°F.

Case 13 was used as a basis for studying the four boiler pressure levels. During a status review of Fluor's progress, it was decided to eliminate the detailed study of 1500 psig and 900 psig boiler levels.

8.4 ACCOMPLISHMENTS AND DECISIONS MADE AND FINALIZED (Continued)

The 1500 psig boiler was eliminated from detailed study because the cycle is less thermally efficient than the 2400 psig power cycle. Since the 1500 psig boilers are not a power industry standard, they could result in higher capital cost and 6-7 months longer delivery time than the 2400 psig system.

The 900 psig boiler scheme was eliminated because it is impractical from an equipment standpoint, as steam produced in the boiler must pass through a 900 to 635 psig backpressure turbogenerator to supply gasification. This backpressure turbogenerator would be a large inefficient and costly piece of equipment. With the elimination of these two pressure levels, the study was then to focus on a 2400 psig/1000°F system and the 600 psig/750°F system. It was the general opinion that a 2400 psig boiler system would be more attractive to a potential utility company partner, as the 2400 psig boiler is an industry standard normally installed by utility companies.

The 600 psig boiler has the advantage of being able to meet process and turbine driver requirements with the least capital cost and lowest coal consumption rate. Preliminary estimates indicate that 1.9 megawatts of the required 71.6 megawatts of power required for the Case 13 plant would have to be imported if a 600 psig boiler system were used.

The 2400 psig boiler system consists of three 50 percent capacity, coal-fired boilers designed to produce 2.25 MM lb/hr each of high pressure steam. All steam produced in the boiler flows through the high pressure section of the turbogenerator train where some steam is extracted for boiler feed water preheating. All high pressure exhaust steam, 635 psig/671°F, is then reheated to 750°F in the boiler to supply gasification, mechanical drivers, and low pressure turbogenerator requirements. The primary difference between this high pressure scheme and the low pressure scheme is that forty percent of the steam flow through the low pressure turbogenerator is extracted for feedwater preheating of 480°F (The maximum extraction rate allowed from an extraction turbine is 40 percent of the inlet steam rate). The large preheat requirement is typical of a commercial boiler, and inflates the flow through the high pressure section to maintain the extraction ratio in the low pressure section. This directly affects the size of the boiler and the required steam flow. The balance of the steam flow through the low pressure turbogenerator is condensed and pumped through a polishing unit to a deaerator operating at 348°F. Excess 600 psig saturated and 120 psig saturated steam is run through separate condensing wet turbogenerators, thus eliminating the need for separately fired superheaters. The condensate generated in the process

8.4 ACCOMPLISHMENTS AND DECISIONS MADE AND FINALIZED (Continued)

area does not mix with the condensate generated in the power plant area. The only cross-tie between the power plant and the process plant is a single 600 psig/750°F steam supply line to the Lurgi gasification unit.

A 2400 psig system has the capability to produce large amounts of export power. The current, unoptimized, 2400 psig system as detailed in Section 8.2 could produce up to 355 megawatts of export power. This 355 megawatts would require a coal feed to the boilers of approximately 6775 ST/SD. This amount of coal would equate to a fine requirement equal to 50 percent of the plant total or approximately 13,000 ST/SD total. By changing the configuration of the 2400 psig system (i.e., High Pressure Condensing Drivers) the amount of export power could be reduced, although to utilize a standard utility boiler layout, export power cannot be reduced to zero. Should future market studies indicate that export power is not realistic then the benefits of a 2400 psig system are greatly reduced.

The alternative is a 600 psig boiler system which consists of three 50 percent capacity coal-fired boilers designed to produce 923,000 lb/hr each of 750°F steam. Excess 600 psig saturated and 120 psig saturated steam is run through separate condensing wet turbogenerators thus again eliminating the need for separately fired superheaters. This scheme is a likely choice in the event a utility company partner does not exist. The currently invisioned 600 psig system produces within 2 megawatts of the required plant energy demand. The coal feed to the boilers is approximately 3056 ST/SD. This amount of coal would equate to a fines requirement equal to 33 percent of the plant total, or approximately 9390 ST/SD total. This system is less efficient than the 2400 psig system but offers lower capital and operating cost. Total plant coal feed is reduced by 3600 ST/D.

Selection of either the 2400 psig or 600 psig boiler pressure levels offer their own advantages depending on the specific job needs. The 2400 psig configuration maximizes fines usage and provides a handsome export of power, but requires a considerable capital investment.

The 600 psig configuration offers the least capitally intensive scheme with moderate fines consumption, and no export of power. Regardless of the path selected certain items such as wet turbines require further investigation. Both schemes have eliminated fired superheaters on the 600 psig saturated and 120 psig saturated steam headers. It is the current consensus that the added cost of wet turbines would be more than offset by the savings of not installing fired

8.4 ACCOMPLISHMENTS AND DECISIONS MADE AND FINALIZED (Continued)

superheaters, even considering the added maintenance requirements of wet turbines. To be certain this conclusion is correct, a cost comparison study should be made, and vendors contacted to verify cost, efficiency, maintenance requirements, and wet turbine availability.

The high pressure system requires some additional optimization to reduce steam production. Consideration should be given toward high pressure, 1800 psig and above, mechanical drivers. Installating experience plots for Mitsui, General Electric, and Siemens indicate equipment availability and reliability up to 1800 psig. It is anticipated that there could be a significant cost reduction if high pressure machines are used. The second item to consider in the high pressure system is the availability of a commercially standard turbogenerator trains which exhaust at 635 psig from the high pressure section.

Currently, the delivery for a 600 psig, 900 psig, 1500 psig, and 2400 psig boiler required 26, 28, 42, and 36 months respectively for the first unit. This schedule will vary depending on the industry work load, so it should be reconfined before a final selection is made. If the boiler still remains the critical path, then this would influence the final selection.

8.5 CURRENT STATUS

A study was being conducted to determine which pressure the steam plant boiler should be operated at, using the Case 13 steam and power requirements. Block flow diagrams (and steam balances) have been completed for systems with boiler pressures of 600, 900, 1500, and 2400 psig. A computer model has also been made for each of these systems, but the computer models with boiler pressures of 900, 1500, and 2400 psig are not up to date with their respective block flow diagrams. Preliminary equipment lists and duty specifications have been written for the 600 and 2400 psig boiler systems.

Coincidental with the boiler pressure level study, wet turbogenerators, which have a major impact on steam balance configuration, were to be investigated. At this point, the block flow diagram (See Section 8.3) show saturated steam being passed through a wet turbogenerator, eliminating the need for a separately fired superheater. Further information on maintenance and cost is required before any final recommendation can be made.

The following list details the basis for the Case 13 steam balance and pressure level study. The Case 13 steam balance data was factored from previous case study work, but the

8.5 CURRENT STATUS (Continued)

pressure level study utilized exact thermodynamic data from either the "Westinghouse Theoretical Steam Rate Table" or the "Keenan and Keyes Steam Tables".

- 80 percent boiler efficiency
- 10,219 Btu/lb Heating Value of Coal Fines
- 80 percent efficiency for Back-Pressure Turbines
- 80 percent efficiency for Condensing Turbines
- 75 percent efficiency for Wet Turbines
- Boiler Feedwater Temperature to economizer section of the boiler

a) 2400 psig/1000°F	480°F
b) 1500 psig/1000°F	430°F
c) 900 psig/900°F	340°F
d) 600 psig/750°F	250°F

- 71.6 megawatts is the plant electric load
- Plant HP Load - (126,322BHP) O_2, Rectisol, MEOH
- 944,900lb/hr of 600 psig/750°F required for Gasification Process
- Surface Condenser Heat Duty

120 psig, SATD./4" Hg	891.5 Btu/lb
600 psig, SATD./4" Hg	834.9 Btu/lb

8.6 LICENSORS AND EVALUATIONS

At the present time no boiler manufacturers have been contacted to evaluate the price and delivery schedule for each of the 600 and 2400 psig boilers proposed in the boiler pressure level study. The proposed sizes and description of these systems are described in Section 8.1.

In addition to proration of the feasibility study cost estimate, Fluor Power Services (FPS) conducted a boiler pressure level cost evaluation of a 1500 psig/900°F and 2500 psig/1000°F for Case 7R steam system configuration. This FPS cost evaluation package (See Volume V) as a basis for subsequent case study work up through Case 13.