PRELIMINARY DESIGN SERVICES. RESEARCH AND DEVELOPMENT REPORT NO. 114. ANNUAL REPORT, JANUARY--DECEMBER 1977

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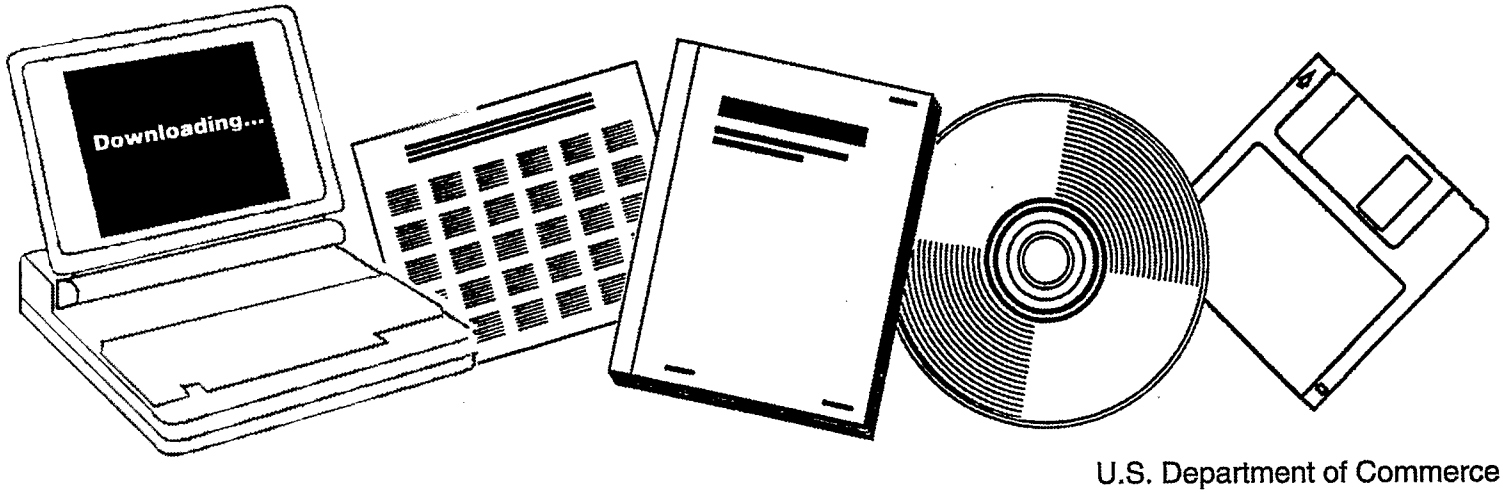

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PRELIMINARY DESIGN SERVICES

RESEARCH AND DEVELOPMENT REPORT NO. 114
ANNUAL REPORT
FOR THE PERIOD: JANUARY - DECEMBER 1977

Prepared by:
THE RALPH M. PARSONS COMPANY
100 West Walnut Street
Pasadena, California 91124

Under Contract No. EX-76-C-01-1775
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Prepared for
DEPARTMENT OF ENERGY
OFFICE OF ASSISTANT SECRETARY FOR ENERGY TECHNOLOGY
DIVISION OF COAL CONVERSION
Washington, D.C. 20545

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THIRD QUARTERLY REPORT

(Issued separately as FE-1775-14)

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(Issued separately as FE-1775-12)

FIRST QUARTERLY REPORT

(Issued separately as FE-1775-10)

ANNUAL REPORT SUMMARY

CALENDAR YEAR 1977

ANNUAL REPORT SUMMARY

PRELIMINARY DESIGN SERVICES

THE RALPH M. PARSONS COMPANY

I. OBJECTIVES

The objective of this work is to assist the Department of Energy (DOE) in its program to develop viable commercial coal conversion plants; to do this by preparing multiple conceptual designs/economic evaluations that provide a preview of design, operating characteristics and projected economics of commercial plants. Captive coal mines and power plants will be included in all designs.

The designs are to be based on use of selected data generated in the DOE experimental program. Recommendations are to be made for generation of additional basic, process and equipment performance data where appropriate.

II. IMPACT ON COAL CONVERSION TECHNOLOGY

The primary impact of this work is to provide DOE with a cohesive preliminary definition of the probable characteristics, potential performance, and projected economics of large future coal conversion complexes. This work provides a cost-benefit basis for establishing priorities for process and equipment development programs on high potential configuration designs.

The designs developed include:

- Complete preliminary process designs.
- Material and thermal efficiencies.
- Preliminary definition of
  - equipment characteristics
  - construction materials
  - environmental control facilities
  - plant site and coal mines facilities.
- Procedures for interfacing of coal mine and process plant.
- Procedure for interfacing of process plant and power plant/steam generation facilities.
- Operation requirements.
- Projected parametric economic analysis.

The results of the conceptual designs/economic evaluations provide:

- A basis for analysis of the impacts of capital costs, operating costs, and reliability factors on the viability of future coal conversion facilities.

- Assistance in defining specific requirements for additional data and development experience on the pilot plant scale in order to provide assurance that these future complexes will operate reliably and economically.

- Sufficient detail to permit periodic quantitative revision and updating as new and improved data and process concepts are developed in the program.

- Quantitative economic bases for selection of preferred processes.

The conceptual designs use basic coal conversion data generated in the pilot plants, process development units and laboratories to define the process configuration reactor sizes, and related design factors. There are, at this stage of development, varying qualities and quantities of data available to a designer. To complete a design, the available data was accumulated, evaluated, and in many cases correlations developed for use in the design. The design and data bases were summarized in the published report for each design, permitting independent judgement by the reader of the reliability of the design basis. Recommendations for procurement of additional data were made in many cases. In a few selected cases, the design was based on an extrapolation of existing data; these cases were clearly specified in the reports and the basis for the extrapolation presented. Experimental programs designed to confirm or modify the extrapolations in a parallel time frame with the design development were recommended. The conceptual designs are considered to be on a reasonably firm data basis consistent with the current state of development of the coal conversion industry.

III. PRESENT WORK AND ACCOMPLISHMENTS

A. General Accomplishments

1. Research and Development Reports

We completed four major R&D reports -

- "Fischer-Tropsch Complex Conceptual Design/Economic Analysis, Oil and SNG Production," R&D Report No. 114 - Interim Report No. 3, FE-1775.

- "Oil/Gas Complex Conceptual Design/Economic Analysis, Oil and SNG Production," R&D Report No. 114 - Interim Report No. 4, FE-1775-8.

- "Project POGO, Total Coal Utilization, COG Refinery Design Criteria," R&D Report No. 114 - Interim Report No. 5, FE-1775-11.

- "Project POGO - Coal Refinery Complex, Conceptual Design/Economic Analysis, Power-Oil-Gas-Other Products," R&D Report No. 114 - Interim Report No. 6, FE-1775-13.

The first three listed above were published and the fourth was in the process of being published in December 1977. Full references are listed in ATTACHMENT A located at the end of this summary report section.

2. Publications

In addition to the R&D reports, thirteen (13) invited articles describing the results generated by our contract work were published in major technical publications; these publications are listed in ATTACHMENT B located at the end of this summary report section.

3. Presentations

We completed nine (9) invited presentations to major technical groups in which we described the results of our work under this contract; these presentations are listed in ATTACHMENT C located at the end of this summary report section.

- Example: We served as Chairman and Co-Chairman for a "Poster Session" titled "Equipment Applications to Coal Conversion Operations" at the National American Institute of Chemical Engineers meeting in New York in November 1977. This invited participation is a product of our contractural work to define equipment uses, and further developments required, for coal conversion complexes.

  Twelve equipment firms made presentations covering a wide spectrum of equipment presently available and acceptable to coal conversion processes. Much of the equipment discussed is presently in coal conversion service, in the U.S. pilot plants and in South Africa.

4. Work-In-Progress

We completed approximately 75 percent of the preliminary design/ concept definition for a Multi-Process Demonstration Plant.

We began conceptual design/economic evaluation for three large prestressed concrete pressure vessels (PCPVs) for projected use in coal gasification and liquefaction plants. The projected performance and economics of the PCPVs will be compared with steel and alloy vessels for the same services.

Additional information describing key elements of the year's accomplishments are presented in the following paragraphs of this summary section, a detailed report on our fourth quarter activities which follows, and reports for the first three quarters of 1977 are appended to this report as Quarterly Reports.

B. Fischer-Tropsch Conceptual Design

The objective of this design was to define desirable characteristics and projected potential for large second-generation Fischer-Tropsch plants to be responsive to U.S. requirements.

The design includes a captive coal mine to produce 40,000 tons per day (TPD) of run-of-mine (ROM) coal in the Eastern region of the U.S. Interior Coal Province; see Reference 2 in ATTACHMENT A. After cleaning and preparation, 30,000 TPD of coal is converted to about 260 million standard cubic feet per day (scfd) of substitute natural gas (SNG) and 50,000 barrels per day (BPD) of liquids. The fuel products are premium quality, having nil sulfur, nitrogen and particulate matter.

Using flame sprayed catalytic heat exchange reactors, the thermal efficiency, coal to fuel products, is projected to be about 70 percent as shown in Figure 6 of the appended First Quarterly Report. The complex doesn't require a power plant for normal operation; energy required to generate the electrical power and steam for operation of the complex is recovered from heat resultant from gasification and exothermic reaction steps.

A number of process and equipment developments must be successfully completed to convert the design to reality; these developments are described in the report.

A process block flow diagram of the conceptual Fischer-Tropsch plant is shown as Figure 4 of the First Quarterly Report.

Projected required average product selling prices, fourth quarter 1977 dollars are:

PROJECTED FINANCIAL STRUCTURE	PROJECTED REQUIRED AVERAGE PRODUCT SELLING PRICE
100% Equity	$3.50 Per Million Btu
65/35 Ratio of Debt/Equity	2.55 Per Million Btu

Other financial parameters used include a five-year design-construction period, 9 percent interest rate, and a 20-year operating life. Further detail is given in the report.

Features of this design considered to be of major interest include:

- A product slate of high value commercial items.
- Nil carcinogenic exposure problems to personnel by in-process intermediates or finished products.

C. Oil/Gas Conceptual Design

This process design is based on the SRC II mode of processing in which unfiltered liquid effluent from the hydroliquefaction reactor is recycled to the reactor with a resulting increase in ash content, retention time and hydrogen consumption in the reactor to produce products which are primarily gases and liquids at ambient condition; see Reference 2 of ATTACHMENT B.

The captive coal mine would produce 47,000 TPD of ROM coal in the Eastern region of the Interior Coal Province. The process plant would convert 36,000 TPD of clean washed coal to about 165 million scfd of SNG and 75,000 BPD of liquid fuels. The projected thermal efficiency, coal to fuel products, is of the order of 75 percent. The conceptual design report defines process and equipment developments required to convert the design to reality.

A process block flow diagram of the conceptual Oil/Gas plant is shown as Figure 1 of the First Quarterly Report.

The projected required product selling prices using fourth quarter 1977 dollars and project parameters equal to those described earlier for the Fischer-Tropsch design are:

PROJECT FINANCIAL STRUCTURE	PROJECTED REQUIRED AVERAGE PRODUCT SELLING PRICE
100% Equity	$2.50 Per Million Btu
65/35 Ratio of Debt/Equity	1.95 Per Million Btu

D. POGO Conceptual Design

The POGO design represents a coal refinery with a captive coal mine; POGO is a DOE-generated acronym for Power-Oil-Gas-Other. Phase 1 of the design project was completed and the R&D report published; see Reference 3 of ATTACHMENT B. This included assessment of the technical and economic factors for candidates from each generic class of coal liquefaction process and recommendations for a preferred design basis for the final design.

The base case design for the POGO conceptual design/economic evaluation was completed; it was conceived to be located in the Eastern region of the Interior Coal Province. It is listed as Reference 4 of ATTACHMENT A. Preliminary assessments of plant capacity, product composition, and projected economics for similar type plants to be located in the Southern Appalachian and Rocky Mountain regions are also being developed. Each of the three designs has a captive coal mine. The overall material balances for the three designs are shown respectively as Figures 1, 2 and 3 of the Fourth Quarterly Report. A simplified block flow diagram for the base case design is shown as Figure 1 of the Second Quarterly Report.

The POGO Interior Coal Province Complex converts approximately 45,000 TPD of clean coal with an overall thermal efficiency of 74-75 percent to about 150 million scfd of SNG; 15,000 BPD of LPG; 35,000 BPD of pool gasoline; 27,000 BPD of distillate fuel oil; 1,600 TPD of a premium grade coke; and 1,000 megawatts of electrical power for sale as depicted in Figure 1 of the Fourth Quarterly Report. The power plant design, as illustrated in Figure 4 of the Third Quarterly Report, consists of combined cycle configuration which forms the basic building block of this generating station utilizing present state-of-the-art equip-m ment. This basic combined cycle plant has a thermal efficiency approximating 40 percent. The projected efficiency of the captive fuel gas production to electrical power for the POGO project is approximately 44 percent (see Figure 3 of the Third Quarterly Report). This improvement in power plant cycle efficiency is mainly attributable to the integration of the coal conversion process with the electrical generating station. The two main reasons for efficiency improvements are the supply of compressed air to the oxygen plant from the main axial flow compressors of the gas turbines resulting in savings in the number of energy conversion steps, and the integration of the power plant and process plant steam generating systems supplying common consumers.

E. Multi-Process Demonstration Plant Design

The purpose of this facility complex is to demonstrate the commercial feasibility of a variety of coal conversion processes that show potential in pilot plant operation.

This multi-process test facility is conceived to contain a low-pressure fuel-gas gasifier (Figure 3 of Second Quarterly Report), two intermediate-pressure synthesis-gas gasifiers (the entrained type is shown in Figure 5 of the Fourth Quarterly Report) and a fluidized bed type, a combined cycle power plant, and a Fischer-Tropsch plant producing pipeline gas and liquid products.

Common facilities for the three or more plants involved are provided. These include coal receiving, unloading, storage,

and grinding and mutually used offsite and ancillary services. The design was in a late state of completion at the end of the fiscal year. A simplified block flow diagram is shown as Figure 4 of the Fourth Quarterly Report.

F. Conceptual Design of Large Prestressed Concrete Pressure Vessels (PCPVs)

The concptual design and economic evaluation of four large pressure vessels (to 2,000 psig) for varying services constructed of prestressed concrete was begun. Sketches of the vessels are shown as Figures 4, 5, 6 and 7 in the Second Quarterly Report. These vessels potentially could have the advantage of providing large economic vessels for use in coal gasification and liquefaction plants without the limitation of availability of shop and field fabrication facilities required to roll and weld the thick wall sections required for metal vessels. The technical practicality and projected economics of the prestressed concrete vessels will be compared with metal vessels.

This application of PCPVs to coal conversion applications is an extension of other successful industrial applications. Large prestressed concrete pressure vessels have been used in the nuclear industry at pressures in the range of 600-700 pounds per square inch; in this pressure range they are normally referred to as prestressed concrete reactor vessels (PCPVs). Also, approximately 60 PCPVs have been constructed, or are planned for construction, for use as secondary containment vessels for nuclear power plants. For this use, the design pressure is approximately 60 pounds per square inch. The basic design techniques have been established. The objective of this work is to extend the design and performance experience for use in coal conversion plants.

A preliminary process flow diagram for the absorber is shown as Figure 5 of the Third Quarterly Report. Preliminary process flow diagrams for the gasifier and the dissolver-separator are shown as Figures 6 and 7 of the Fourth Quarterly Report.

A preliminary construction sequence for the integrated gasifier vessel is shown as Figure 8 of the Second Quarterly Report. Additional construction study efforts during the third and fourth quarters simplified the methods and also greatly reduced the construction time and costs.

G. Supporting Activities

1. Equipment Development

   a. Objective: To define equipment development programs to assure future reliable and viable operation of coal conversion processes.

b. Status: Major activity was in advanced large pressure vessel design/erection, liquid/solid separation, gas/solid separation, solids feed to gasifiers, filter cake drying equipment.

We organized and chaired a session on the subject of "Equipment Applications to Coal Conversion Operations" at a National AIChE Meeting as summarized under the "Present Work and Accomplishments" Section III of this summary report.

2. Construction Materials

a. Objective: To define materials of construction with adequate performance and acceptable cost for use in coal conversion plants.

b. Status: An active role was played in the ERDA Materials Evaluation and Materials Property Council Development programs. The performance of materials in pilot plant operations was monitored and materials were selected for the designs Parsons has in progress. Four papers were presented and/or published in this field.

3. Environmental Factors

a. Objective: To define facilities and procedures required for operation of environmentally acceptable coal conversion plants.

b. Status: Analysis and design of facilities required to assure environmental acceptability has now been completed for four coal conversion complexes. Papers have been presented and/or published describing these complexes.

The bases for defining performance of environmental control requirements for coal conversion facilities are being documented and contact maintained with the proper authorities as new standards are considered.

H. Plans for the Coming Year

We will complete the POGO alternate case designs and economic projections, and publish the report. We will complete the work on the Multi-Process Demonstration Plant Design and publish the results. We will also complete preliminary designs and economic evaluations for four large prestressed concrete pressure vessels, plus comparable steel and alloy vessels, and issue a report describing the results.

This contract is scheduled to expire during Fiscal Year 1978.

ATTACHMENT A

RESEARCH AND DEVELOPMENT REPORTS

1. O'Hara, J. B., A. Bela, N. E. Jentz, S. K. Khaderi, H. W. Klumpe, B. I. Loran, D. G. Reynolds and R. V. Teeple. "Fischer-Tropsch Complex Conceptual Design/Economic Analysis, Oil and SNG Production," R&D Report No. 114 - Interim Report No. 3, FE-1775-7. Prepared for the Energy Research and Development Administration, Washington, D.C., January 1977.

2. O'Hara, J. B., G. H. Hervey, S. M. Fass, N. E. Jentz, H. W. Klumpe, B. I. Loran, E. A. Mills and R. V. Teeple. "Oil/Gas Complex Conceptual Design/Economic Analysis, Oil and SNG Production," R&D Report No. 114 — Interim Report No. 4, FE-1775-8. Prepared for the Energy Research and Development Administration, Washington, D.C., March 1977.

3. O'Hara, J. B., N. E. Jentz, H. T. Syverson, G. H. Hervey and R. V. Teeple. "Project POGO, Total Coal Utilization, COG Refinery Design Criteria," R&D Report No. 114 - Interim Report No. 5, FE-1775-11. Prepared for Energy Research and Development Administration, Washington, D.C., August 1977.

4. O'Hara, J. B., A. Bela, N. E. Jentz, H. W. Klumpe, B. I. Loran, E. A. Mills, R. J. Newton and R. V. Teeple. "Project POGO - Coal Refinery Complex, Conceptual Design/Economic Analysis, Power-Oil-Gas-Other-Products," R&D Report No. 114 - Interim Report No. 6, FE-1775-13. Prepared for the Department of Energy, Washington, D.C., December 1977.

PUBLICATIONS

1. O'Hara, J. B. and R. V. Teeple. "Preliminary Economic Analysis Oil and Power by COED-Based Coal Conversion." Synthetic Fuels Processing, Comparative Economics, Marcel Dekker, New York, N.Y., Chapter XII, pages 287–318, 1977.

2. O'Hara, J. B., A. Bela, N. E. Jentz and S. K. Khaderi. "Fischer-Tropsch Plant Design Criteria," a CEP capsule published in Coal Processing Technology: a CEP Technical Manual, Vol. 3. Prepared by the Editors of Chemical Engineering Progress, pages 141-143, 1977.

3. O'Hara, J. B., G. H. Hervey, S. M. Fass and E. A. Mills. "Oil/Gas Plant Design Criteria." A CEP Capsule published in Coal Processing Technology; a CEP Technical Manual, Vol. 3. Prepared by the Editors of Chemical Engineering Progress, pages 154-155, 1977.

4. O'Hara, J. B., N. E. Jentz and W. J. Lochmann. "Material Challenges of Coal Liquefaction.: Chemical Engineering, Vol. 84, No. 8, pages 147–154, April 11, 1977.

5. Lochman, W. J. and R. D. Howell. "An Overview of . . . Equipment for Coal Conversion." Hydrocarbon Processing, Vol. 56, No. 5, pages 197–199, May 1977.

6. O'Hara, J. B., E. C. Becker, N. E. Jentz and T. Harding. "Petrochemical Feedstocks from Coal." Chemical Engineering Progress, Vol. 73, No. 6, pages 64-72, June 1977.

7. O'Hara, J. B. "Coal Liquefaction" ("Licuefaccion del carbon"). Ingenieria Quimica, Madrid, Spain, Vol. IX, Number 99, pages 163-171, June 1977.

8. Lochmann, W. J. and R. D. Howell. "Corrosion Design Problems in Coal Conversion Plants." Material Performance, Vol. 16, No. 7, pages 43–47, July 1977.

9. O'Hara, J. B., J. G. Vlahakis, E. C. Drucke and N. E. Jentz. "Potential Markets for Emerging Energy Technologies." Proceedings of the Second Pacific Chemical Engineering Congress (PACHEC '77), at the 84th National Meeting of American Institute of Chemical Engineers (AIChE), Denver, Colo., Vol. II, pages 1119-1130, August 28-31, 1977.

10. O'Hara, J. B., B. I. Loran, A. Bela and N. E. Jentz. "Environmental Factors for Fischer-Tropsch Coal Conversion Technology." Proceedings of the Second Pacific Chemical Engineering Congress (PACHEC '77), at the 84th National Meeting of American Institute of Chemical Engineers (AIChE), Denver, Colo., Vol. II, pages 855-863, August 28-31, 1977.

11. O'Hara, J. B., N. E. Jentz and R. V. Teeple. "Conversion of Coal to Liquids by Fischer-Tropsch and Oil/Gas Technologies" ("Conversion del carbon en productos liquidos por los metodos de Fischer-Tropsch y aceite/gas"). Ingenieria Quimica, Madrid, Spain, Vol. IX, No. 102, pages 101-113, September 1977.

12. O'Hara, J. B., N. E. Jentz and R. V. Teeple. "Conversion of Coal to Liquids by Fischer-Tropsch and Oil/Gas Technologies." Preprints of papers presented at the 174th National American Chemical Society (ACS) Meeting, Chicago, Ill., Vol. 22, No. 7, pages 20-50, August 29-September 1, 1977.

13. O'Hara, J. B., J. G. Vlahakis, E. C. Drucke and N. E. Jentz. "Potential Markets for Emerging Energy Technologies" ("Mercados Potenciales Parales Tecnologias Energetical Emergentes"). Energia, Madrid, Spain, Vol. 3, No. 5, September-October 1977.

PRESENTATIONS

1. Lochmann, W. J. and R. D. Howell. "Corrosion Engineering - Design Interface for Coal Conversion." Presented at the National Association of Corrosion Engineers (NACE) International Corrosion Forum, San Francisco, Calif., March 15, 1977.

2. O'Hara, J. B. and W. J. Lochmann. "Materials Requirements for Coal Liquefaction." Presented at the American Society for Metals (ASM) Material Requirements in Future Energy Systems Seminar, Chicago, Ill., April 7, 1977.

3. Callinan, J. P. and D. L. Burford. "The Analysis of Finned Catalytic Heat Exchangers." Presented at the AIChE/ASME Heat Transfer Conference, Publication No. 77-HT-67, Salt Lake City, Utah, August 15-17, 1977.

4. O'Hara, J. B., J. G. Vlahakis, E. C. Drucke and N. E. Jentz. "Potential Markets for Emerging Energy Technologies." Presented at the Second Pacific Chemical Engineering Congress (PACHEC '77) at the 84th National Meeting of American Institute of Chemical Engineers (AIChE), Denver, Colo., August 29, 1977.

5. O'Hara, J. B., B. I. Loran, A. Bela and N. E. Jentz. "Environmental Factors for Fischer-Tropsch Coal Conversion Technology." Presented at the Second Pacific Chemical Engineering Congress (PACHEC '77) at the 84th National Meeting of American Institute of Chemical Engineers (AIChE), Denver, Colo., August 29, 1977.

6. O'Hara, J. B., N. E. Jentz and R. V. Teeple. "Conversion of Coal to Liquids by Fischer-Tropsch and Oil/Gas Technologies." Presented at the 174th National American Chemical Society (ACS) Meeting, Chicago, Ill., September 1, 1977.

7. Loran, B. I. "Specific Environmental Aspects Specific to Coal Conversion." Presented at the 3rd Environmental Protection Agency (EPA) Symposium on Environmental Aspects of Fuel Conversion Technology, III, Hollywood, Fla., September 15, 1977.

8. O'Hara, J. B. Chairman of the Session on Equipment Applications to Coal Conversion Operations for the 70th Annual Meeting of American Institute of Chemical Engineers (AIChE), New York, N.Y., November 13–17, 1977.

9. O'Hara, J. B., A. Bela, N. E. Jentz and H. W. Klumpe. "Project POGO – A Coal Refinery." Presented at the 70th Annual Meeting of American Institute of Chemical Engineers (AIChE), New York, N.Y., November 14, 1977.

FE-1775-16

PRELIMINARY DESIGN SERVICES

RESEARCH AND DEVELOPMENT REPORT NO. 114

QUARTERLY REPORT

For the Period: October - December 1977

Prepared by:

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For:

Department of Energy
Washington, D.C. 20545

Under Contract No. EX-76-C-01-1775

April 1978

QUARTERLY REPORT

FOURTH QUARTER
CALENDAR YEAR 1977

FOURTH QUARTERLY REPORT

PRELIMINARY DESIGN SERVICES

THE RALPH M. PARSONS COMPANY

I. OBJECTIVE AND SCOPE OF WORK

The objective is to develop preliminary designs and economic evaluations for a number of types of coal conversion plants. The following designs are included in the scope of work:

- Conceptual commercial plant for a coal-oil-energy-development (COED) plant
- Oil/Gas plant to produce liquid fuels plus substitute natural gas (SNG)
- Commercial-scale Fischer-Tropsch plant with motor fuel and SNG as the main products
- Coal conversion plant to produce power, oil, gas, and other products (POGO)
- Facilities complex capable of demonstrating the commercial feasibility of a variety of coal conversion processes that show promise during pilot plant operations

  The facilities will be considered for conversion of coal to:

  1. Low-to-high Btu fuel gas
  2. Methanol/motor fuel by Fischer-Tropsch process
  3. Clean liquid fuels by alternate liquefaction processes

- Prepare conceptual designs, define construction procedure and develop economics for three types of prestressed concrete pressure vessels for use in coal conversion plants.

In addition, supporting efforts will be provided for the above activities. These efforts include planning and progress monitoring, equipment development, construction materials development, and environmental factors.

II. SUMMARY OF PROGRESS TO DATE

A brief review of the status of the major active design efforts is given below, followed by a more detailed reporting on the progress of individual tasks.

A brief summary of results by assigned tasks follows.

A. POGO Plant Design

During the past quarter we completed the draft of the POGO R&D Report for the base case, which is located in the Eastern Region of the Interior Coal Province. Drafts of the sections describing plants conceived to be located in the Southern Appalachia, and Rocky Mountain Regions were also completed. Table 1 compares the coal analyses for these locations with that for the base case.

The results for each case included, among other items,

- Fixed capital investment estimates
- Operating costs
- Profitability analyses
- Design bases

Preliminary publication work has been started for the final R&D report.

B. Multi-Process Demonstration Facility

We redesigned the heat recovery system for Plant 2 which contains process gasifiers plus a combined cycle power plant, to increase the production of distilled water for boiler feed requirements. We initiated design of the Phase 1 low pressure fuel gasification design system to encorporate high reliability heat exchange systems downstream of the gasifier. This system will also increase steam generation capability in the gas cooling steps.

C. Prestressed Concrete Pressure Vessels

We completed revision of the vessel design to reflect information generated during the equipment takeoff work for the vessels. We began studies on the maximum rate of anticipated pressure increase for the integrated gasifier concept; also the cool-down rate for these vessels. We completed studies on the effects of various temperature transients.

We continued our analysis of construction methods for the prestressed concrete pressure vessels and completed materials take-offs for the prestressed concrete pressure vessels.

D. Supporting Areas

We continued work on development of equipment needs with vendors of valves, solids-gas separation equipment, and feeders.

The review of materials of construction of coal conversion plants continued.

We continued our investigation of areas of environmental sensitivity for coal conversion complexes with emphasis on needs for additional information needs.

E. General

We presented an invited paper titled

"Project POGO - A Coal Refinery." This was presented to the 70th Annual AIChE Meeting held in New York City on November 15, 1977.

We participated in the following conferences on coal conversion technology:

- "Panel on Coal." We served as designated Discussor at the AIChE Conference on Chemical Feedstock Alternatives, Houston, Texas, October 3, 1977.
- "Equipment Applications to Coal Conversion Operations." We served as Chairman and Co-Chairman of this Session held at the 70th Annual AIChE Meeting in New York City on November 16, 1977.

We completed preparation of the following R&D Interim Report for publication:

- "Project POGO - Coal Refinery Complex, Conceptual Design/ Economic Analysis," R&D Report No. 114 - Interim Report No. 6, FE-1775-14. Prepared for the Department of Energy, Washington, D.C., December 1977.

III. DETAILED DESCRIPTION OF TECHNICAL PROGRESS

A. POGO Plant Design

1. Objective

To develop preliminary designs of three coal processing plants which will produce power, oil, gas and other products. The plants are to be located in the Eastern Region of the Interior Coal Region, Southern Appalachia, and the Rocky Mountain Coal Province. The processes employed in this plant design shall be the result of an economic selection from the candidate coal conversion processes available.

2. Activity This Quarter

a. We completed the final draft of the R&D report describing the design and projected economics for the base case which is the Eastern Region of the Interior Coal Province. It was transmitted to Department of Energy for review on November 12.

b. We completed the final draft of the sections for the R&D report covering the Southern Appalachia and Rocky Mountain Region plants and mine location cases. Pre-draft work accomplished included:

- Development of fixed capital investment estimates for both cases
- Computation of operating costs for both cases
- Computation of profitabilities
- Definition of design bases for each case

c. Table 1 compares the coal analyses which constitute the bases for process design, for the three locations.

d. Figures 1, 2 and 3 give the material balances for the base case, the Southern Appalachia and Rocky Mountain Region plants and mine locations, respectively.

e. Publication work was begun on the final R&D report.

3. Activity Forecast Next Quarter

We will print and transmit to you multiple copies of the R&D report.

B. Multi-Process Demonstration Plant

1. Objective

To develop preliminary designs for a facilities complex capable of demonstrating the commercial feasibility of a variety of coal conversion processes that show promise during the pilot plant scale operations. These designs shall be multi-process modules. The completed facility shall include modules of facilities which can be common to two or more other processes; also, it will provide allowances for future modification and/or replacement of various pieces of equipmnent to meet new requirements.

2. Activity This Quarter

a. We redesigned the heat recovery system for the Plant 2 in order to produce an increased quantity of distilled water to meet increased boiler feed water requirements:

- Raw water having a minimum of chemical treatment is evaporated and condensed.
- The alternate of demineralization was considered and rejected.

b. We reviewed alternate high temperature heat exchange systems for the product gas from the gasifier. After analysis of alternatives we selected steam superheating and steam generation and completed the design.

c. Alternate cases of feeding coal slurry directly to the medium pressure Plant 2 gasifier to eliminate the drying step were investigated; these included:

1. Preheating slurry feed to afford complete vaporization of water when fed to the gasifier.
2. Preheating slurry feed to the bubble point and feeding to the gasifier.

Improved thermal efficiency would result from elimination of the drying step but oxygen consumption would be higher. This was not deemed attractive; the drying step was retained.

d. We completed the Plant 1 utility summary.

e. We began writing the process descriptions.

f. We continued work on the revised design of the Plant 1 low pressure fuel gas gasification unit.

g. We updated the Block Flow Diagram to reflect the final designs and outputs; this is shown as Figure 4.

h. We worked on the Plant 2 and Plant 3 utility summaries.

3. Activity Forecast Next Quarter

We will complete the revised Plant 1 design and revise the fixed capital investment estimate.

We will complete the process descriptions and work on the economics for all three plants in the facility complex.

We will complete preparation of the final report draft.

We will complete the design and economics of a fluidized bed gasifier for Plants 2 and 3 operation. This would be installed in parallel with an entrainment type gasifier illustrated in Figure 5.

C. Prestressed Concrete Pressure Vessels

1. Objective

To prepare preliminary designs, technical analyses of construction and operating performance, and economics for three types of prestressed concrete pressure vessels. These will be compared against conventional steel pressure vessels in the same duties. The three types are:

a. A large, high pressure, 25-foot ID by 125-foot tangent-to-tangent gasifier reactor vessel. The process flow diagram is shown as Figure 6.

b. A combination of a large dissolver reactor vessel and a flash drum. These vessels would operate at about 2,025 psig and 805°F. The process flow diagram is shown as Figure 7.

c. A large diameter absorber column operating at about 1,075 psig and 150°F. This vessel will have internal components such as trays.

2. Activity This Quarter

A process flow diagram illustrating the duty requirements for the gasifier vessel is shown in Figure 6.

The detailed drawings of the prestressed concrete pressure vessels were reviewed.

We began studies on the maximum anticipated pressure buildup and pressure rise rate for the integrated gasifier concept. We continued preparation of equipment take-offs and cost estimates for the vessels.

We completed studies of the thermal effects of various heat transfer conditions for the vessels. This includes emergency situations such as refractory failures and cooling water failure as well as normal cool-down rates. We also continued our analysis of construction methods for the prestressed concrete pressure vessels and we completed materials take-offs for the prestressed concrete pressure vessels.

We began preparation of equipment lists for both the concrete and steel pressure vessel cases and a draft of the R&D report.

3. Activity Forecast Next Quarter

1. Prestressed Concrete Pressure Vessels

We will complete preparation of the final fixed capital investment estimate for all cases, complete the studies on maximum pressure buildups in the integrated gasification vessel and continue preparation of the R&D report.

D. Equipment Development

1. Objective

To define the equipment and control system development programs required to assure reliability of coal conversion processes being developed. To recommend appropriate development programs to Department of Energy.

2. Activity This Quarter

We organized and chaired a poster session entitled "Equipment Applications to Coal Conversion Operations" which was presented at the 70th Annual Meeting of the American Institute of Chemical Engineers in New York, November 16. Twelve major manufacturers presented equipment lines including coal feeding, solids from gas separation, insulating and refractories, slag disposal, valves, instrumentation, gas compression, pumps, sulfur recovery and power recovery.

3. Activity Forecast Next Quarter

We will continue to monitor the status of equipment development programs by vendors and others.

E. Materials of Constructions

1. Objective

To define the preferred materials of construction for use in coal conversion projects.

2. Activity This Quarter

We reviewed the materials of construction for the prestressed concrete pressure vessel study.

We received materials of construction for the high temperature section of its MPDP plant design. We attended a Materials Properties Council Phase V Meeting on December 2, 1978 in San Antonio, Texas.

3. Activity Forecast for Next Quarter

We will continue to support design efforts by supplying materials of construction specification.

F. Environmental Considerations

1. Objective

To define environmental factors for proposed coal conversion complexes, to define facilities required for the coal conversion complexes to meet environmental standards, and to define product quality standards to meet environmental regulations for product users.

2. Activity This Quarter

We completed preparation of the environmental section of the R&D report for the POGO design; this included preparation of a process flow diagram specific to projected environmental effects.

3. Activity Forecast Next Quarter

We will continue to review the preliminary design work for the multi-purpose demonstration facility. Specific environmental areas requiring consideration will be analyzed and discussed with the design engineers.

G. General

We received a request from DOE to review a report titled "Assessment of Materials Technology" prepared under DOE sponsorship.

We received notice from Chemical Engineering Progress that the paper "Project POGO - A Coal Refinery" was accepted for publication. This paper was presented on November 14, 1977 at the Annual Meeting of the American Society of Chemical Engineers.

We received notice from Chemical Engineering Progress that the paper "Environmental Factors for Fischer-Tropsch Coal Conversion Technology" was accepted for publication in a future CEP Technical Manual.

We received a request from DOE to publish a collection of our publications. We began work on a compilation of our publications to be titled "Coal Conversion Applications, Collected Works 1972 through 1977." This publication should be released to DOE-TIC next quarter for publication.

Parsons was invited to present papers at the 1978 American Institute of Chemical Engineers National Meeting in Philadelphia on June 4-8, 1978 on the subjects of air emissions from new energy sources and production of chemicals and petrochemicals from coal.

Table 1 - Feed Coal Analyses, POGO Project

Analyses	Base Case Eastern Region Interior Coal Province		Alternate Case 1 Southern Appalachian Region		Alternate Case 2 Rocky Mountain Region
	Coal to Process	Coal to Feed Gas Generation	Coal to Process	Coal to Feed Gas Generation	Coal to Process and Fuel Gas Generation
Proximate Analysis (Wt.%)					
Moisture	2.7	2.7	2.7	2.7	2.7
Ash	6.3	8.0	6.3	8.0	8.0
Volatile Matter	38.8	38.1	32.4	31.8	44.2
Fixed Carbon	52.2	51.1	58.6	57.5	45.1
Total	100.0	100.0	100.0	100.0	100.0
Higher Heating Value Btu/lb	12,633	12,425	13,841	13,590	11,211
Ultimate Analysis (Wt.%)					
Carbon	71.5	70.1	77.2	75.7	66.3
Hydrogen	4.9	4.8	4.8	4.8	4.7
Nitrogen	1.4	1.4	1.6	1.6	1.0
Sulfur	3.9	3.9	1.6	1.6	0.8
Oxygen	9.3	9.1	5.8	5.6	16.5
Moisture	2.7	2.7	2.7	2.7	2.7
Ash	6.3	8.0	6.3	8.0	8.0
Total	100.0	100.0	100.0	100.0	100.0

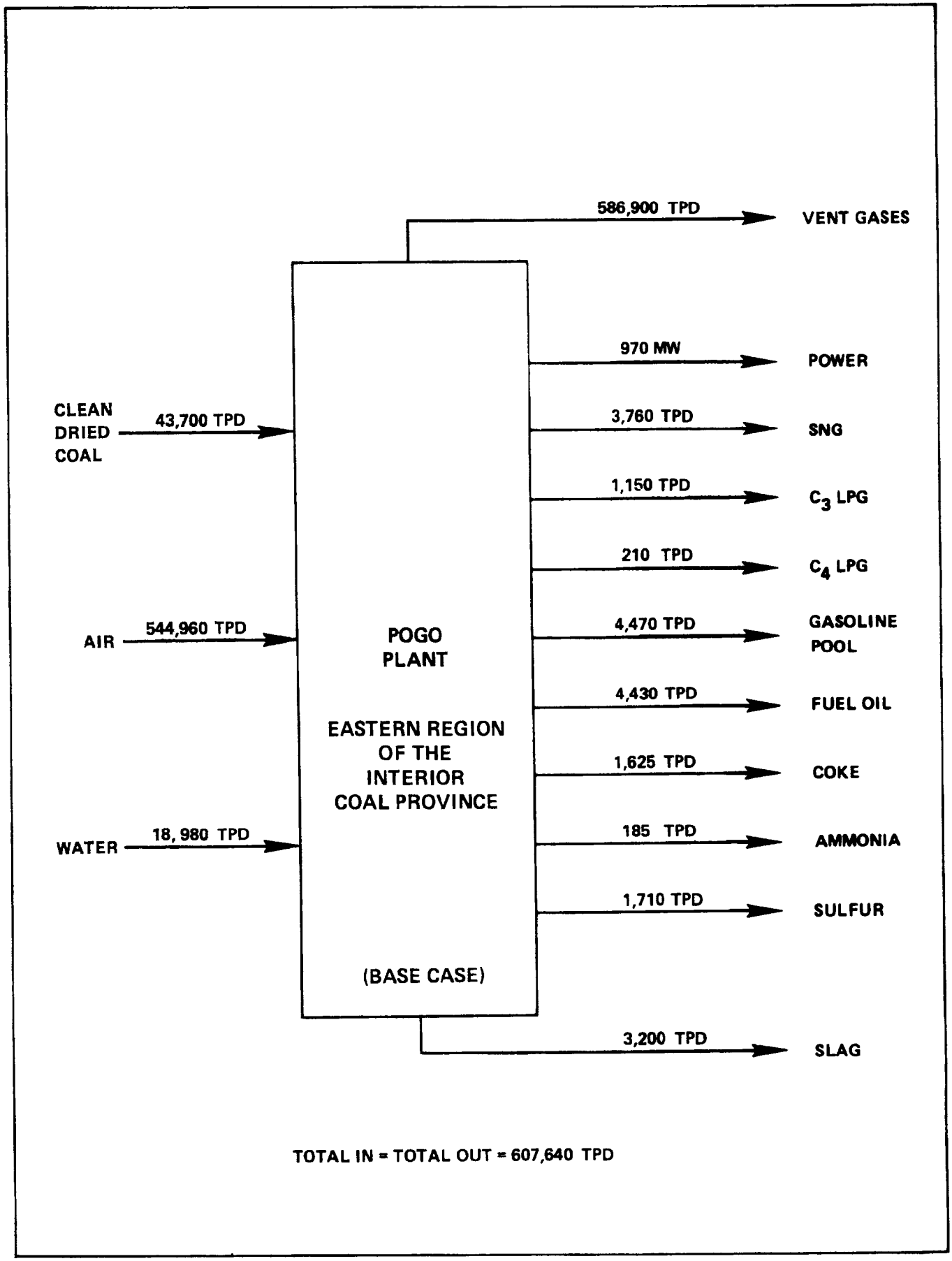

Figure 1 - Overall Material Balance - Base Case
POGO Process and Power Units

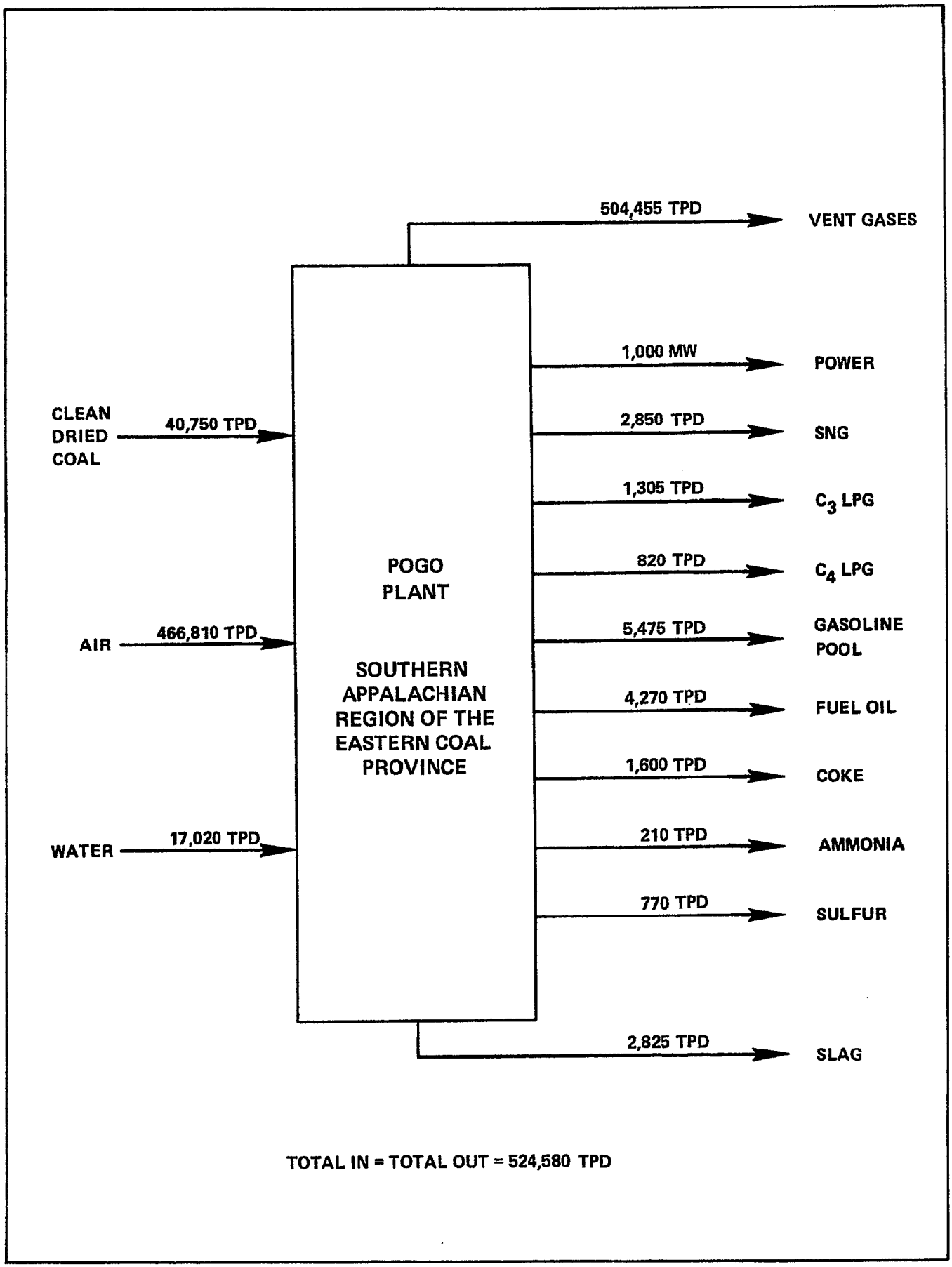

Figure 2 - Overall Materail Balance - Southern Appalachian Region Alternate POGO Process and Power Charts

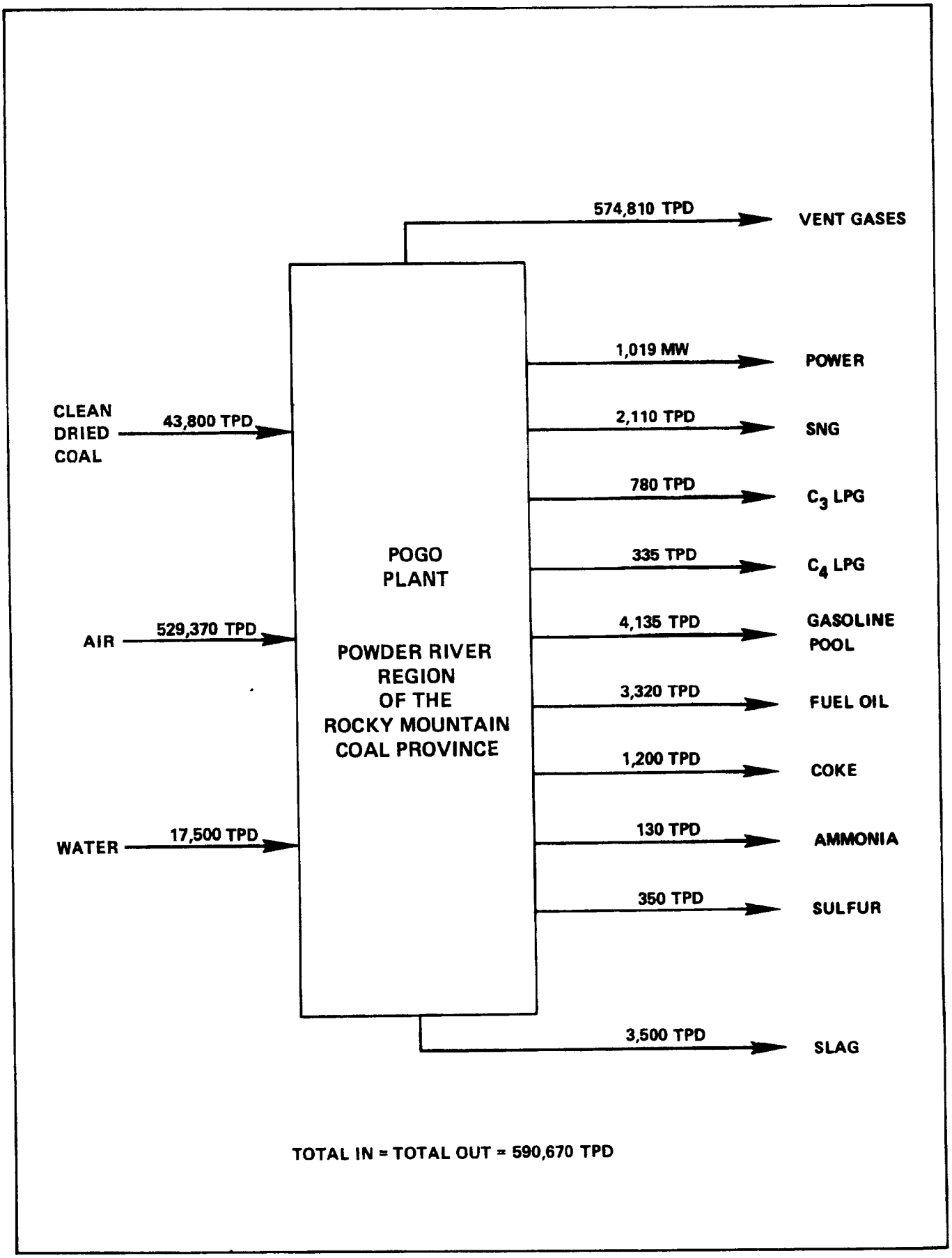

Figure 3 - Overall Material Balance - Rocky Mountain Region Alternate POGO Process and Power Charts

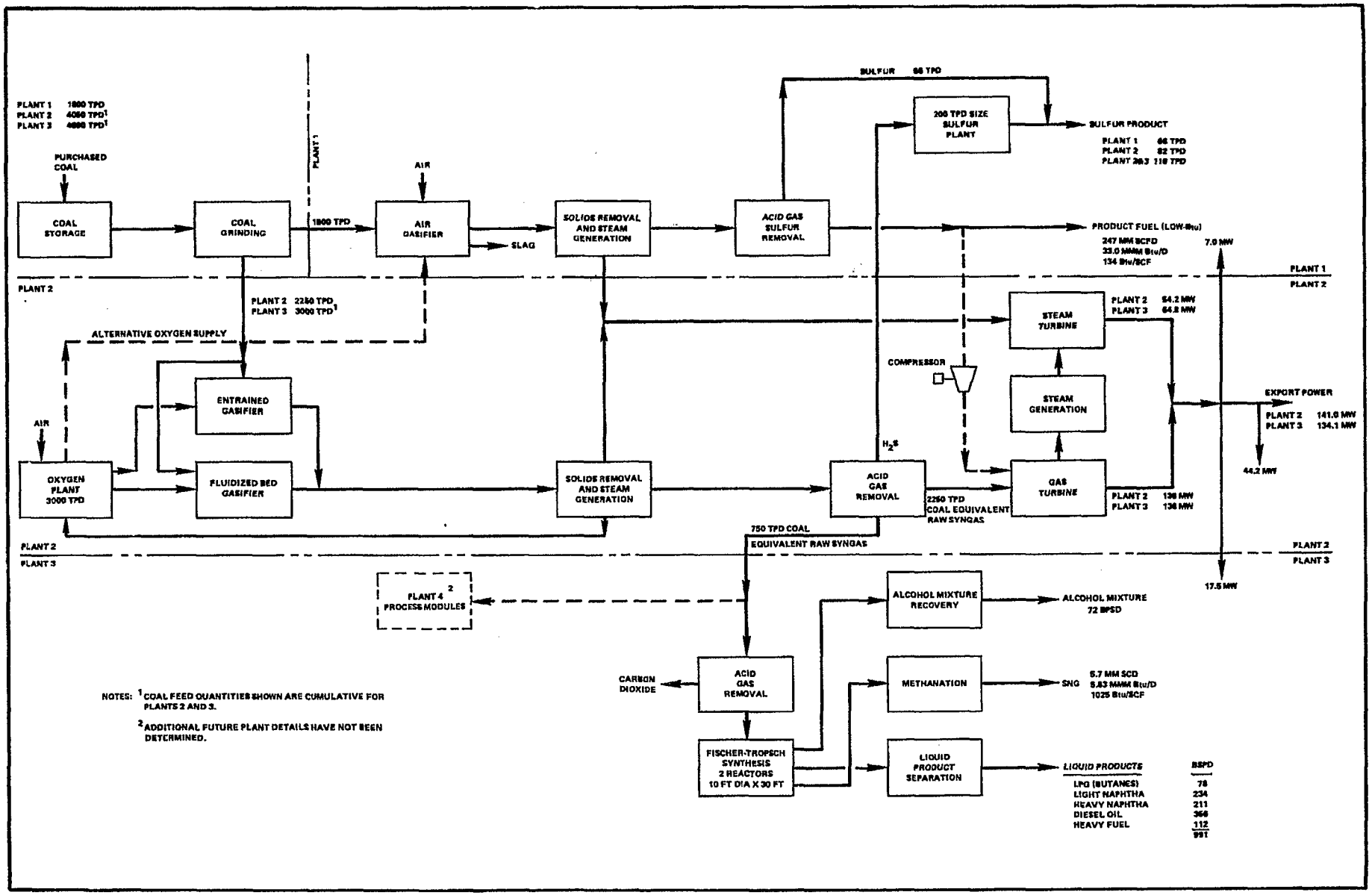

Figure 4 - Simplified Block Flow Diagram
Multi-Process Demonstration Plant

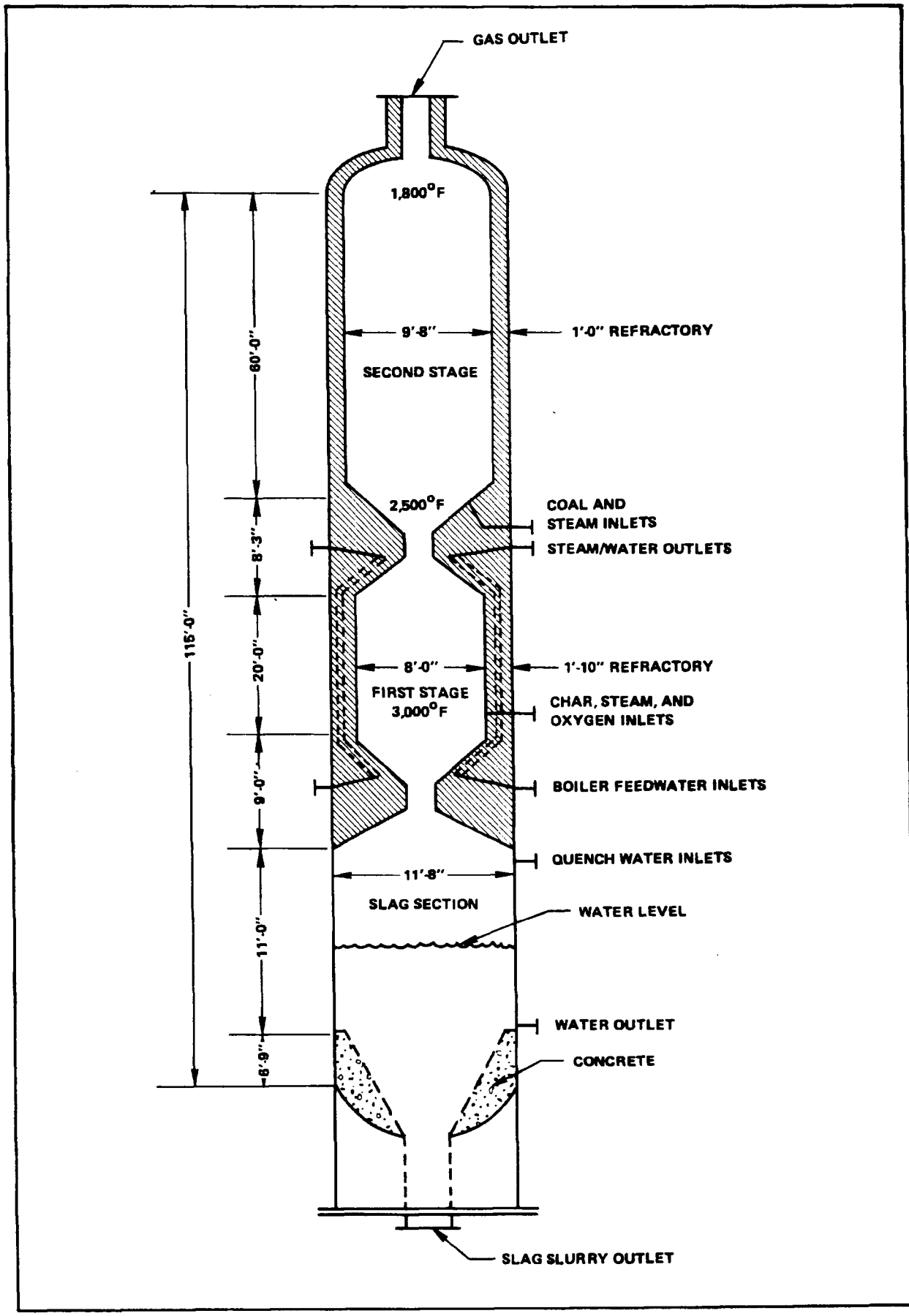

Figure 5 - Intermediate - Btu Gasifier
Multi-Process Demonstration Plant

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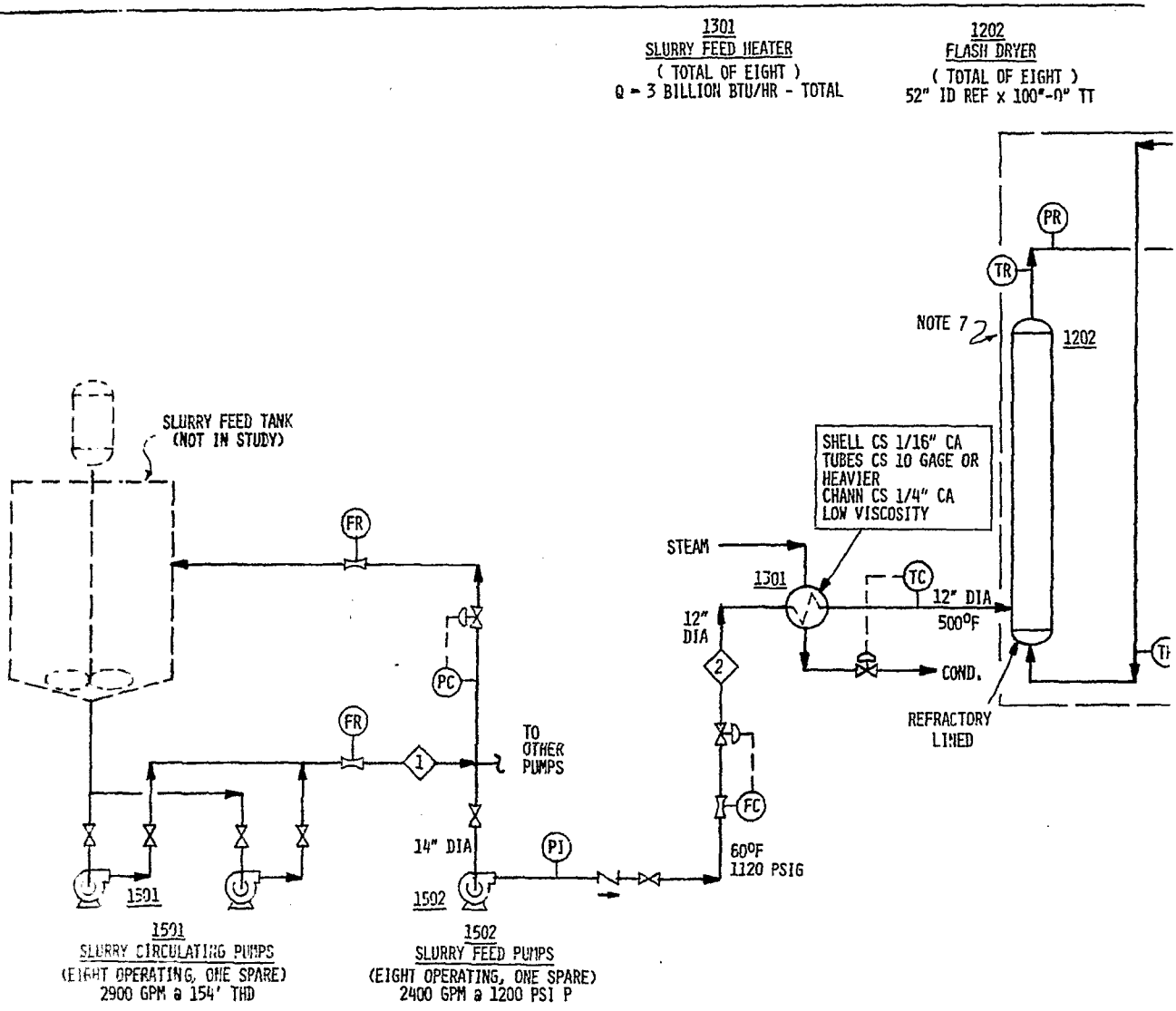
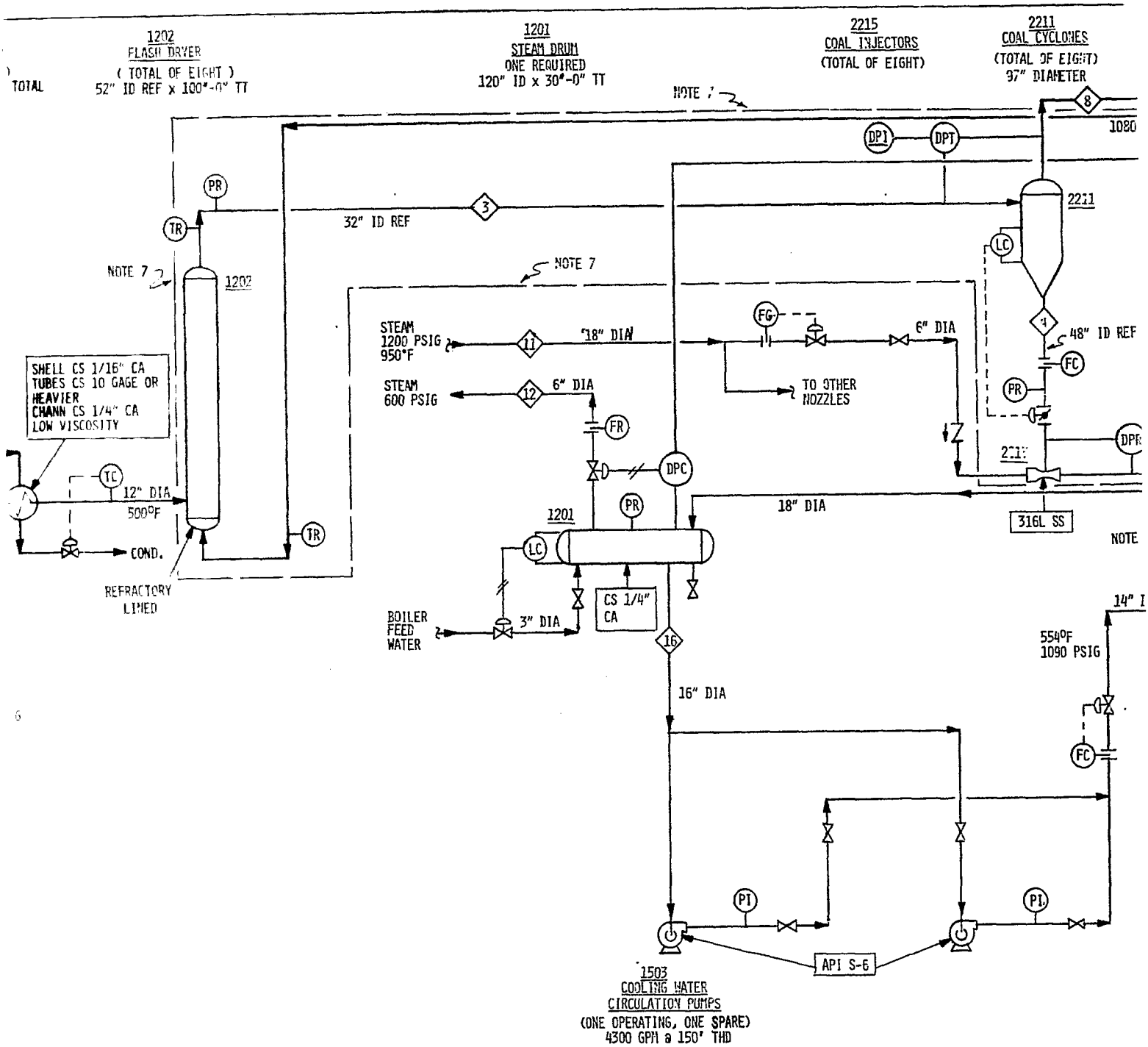
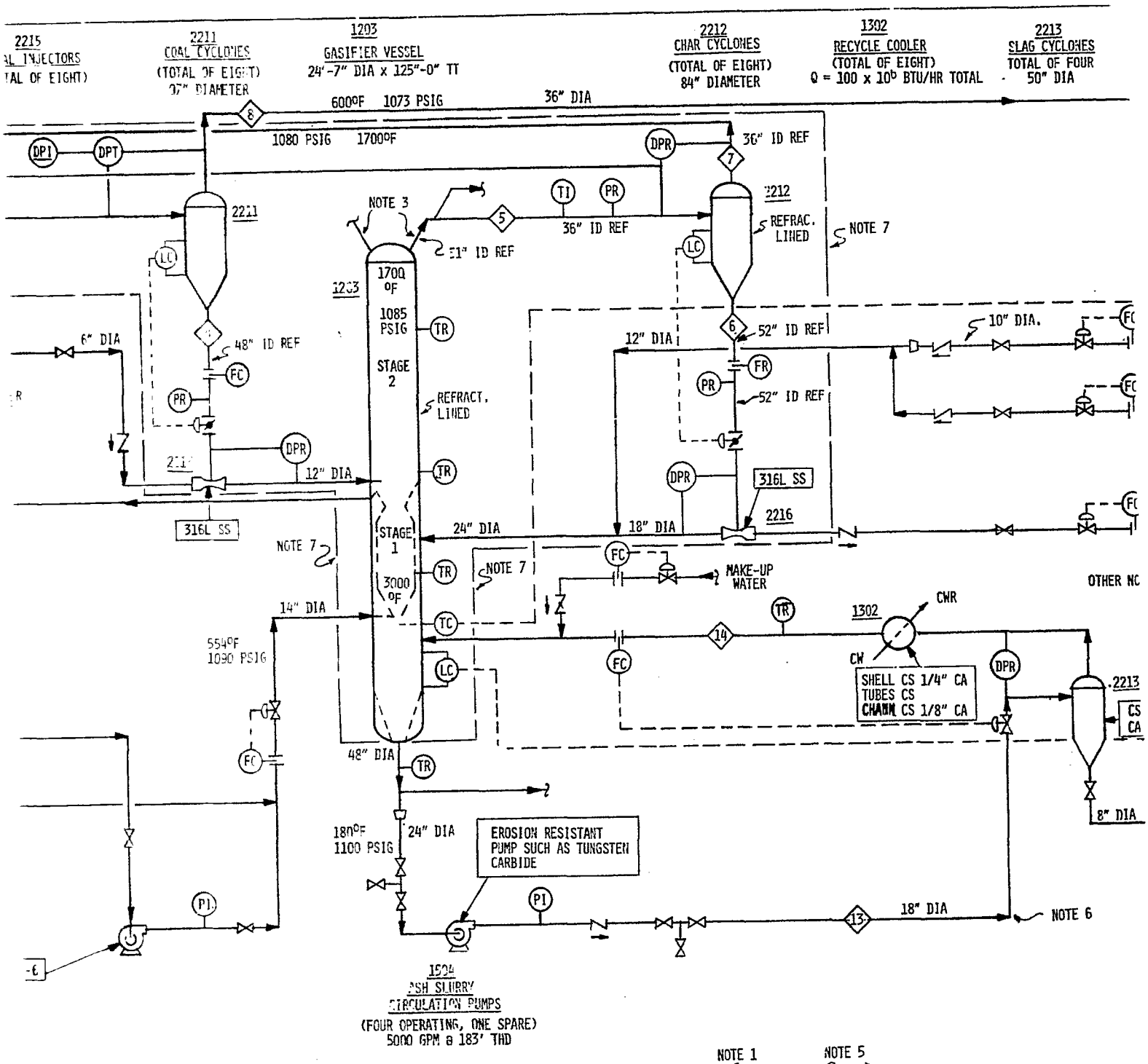


STREAM NO.	1	
GASES MOLS/HR		
H_2	-	-
CH_4	-	-
CO	-	-
CO_2	-	-
H_2O	-	-
H_2S	-	-
NH_3	-	-
N_2	-	-
O_2	-	-
Total Mols	-	-
Total Lbs	-	-
SOLIDS AND LIQUIDS LBS/HR		
C	3.96×10^6	3.28
H	$.27 \times 10^6$	0.22
O	$.52 \times 10^6$	0.43
N	$.07 \times 10^6$	0.06
S	$.22 \times 10^6$	0.18
Ash	$.72 \times 10^6$	0.69
H_2O	7.15×10^6	5.92
Total	12.91×10^6	10.69
Total Lb/Hr	12.91×10^6	10.69



STREAM NO.	1	2	3	4	5	6	7	8	9	10	11
GASES MOLS/HR											
H_2	-	-	113,310	-	113,310	-	113,310	113,310	-	-	-
CH_4	-	-	51,230	-	51,230	-	51,230	51,230	-	-	-
CO	-	-	132,460	-	132,460	-	132,460	132,460	-	-	-
CO_2	-	-	72,070	-	72,070	-	72,070	72,070	-	-	-
H_2O	-	-	408,880	-	87,950	-	87,950	408,880	-	101,760	50,880
H_2S	-	-	5,270	-	5,270	-	5,270	5,270	-	-	-
NH_3	-	-	4,200	-	4,200	-	4,200	4,200	-	-	-
N_2	-	-	1,320	-	1,320	-	1,320	1,320	1,320	-	-
O_2	-	-	-	-	-	-	-	-	64,570	-	-
Total Mols	-	-	788,740	-	467,810	-	467,810	788,740	65,890	101,760	50,880
Total Lbs	-	-	15.58×10^6	-	9.80×10^6	-	9.80×10^6	15.58×10^6	2.10×10^6	1.33×10^6	0.92×10^6
SOLIDS AND LIQUIDS LBS/HR											
C	3.96×10^6	3.28×10^6	3.50×10^6	3.30×10^6	3.50×10^6	3.29×10^6	220,000	196,600	-	-	-
H	$.27 \times 10^6$	0.22×10^6	0.22×10^6	0.21×10^6	-	-	-	13,400	-	-	-
O	$.52 \times 10^6$	0.43×10^6	0.43×10^6	0.40×10^6	-	-	-	25,500	-	-	-
N	$.07 \times 10^6$	0.06×10^6	0.06×10^6	0.05×10^6	-	-	-	3,800	-	-	-
S	$.22 \times 10^6$	0.18×10^6	0.18×10^6	0.17×10^6	-	-	-	10,900	-	-	-
Ash	$.72 \times 10^6$	0.60×10^6	0.66×10^6	0.62×10^6	1.08×10^6	1.02×10^6	60,000	35,800	-	-	-
H_2O	7.15×10^6	5.92×10^6	0.14×10^6	0.13×10^6	-	-	-	8,200	-	-	-
Total	12.91×10^6	10.69×10^6	5.19×10^6	4.89×10^6	4.58×10^6	4.31×10^6	270,000	294,200	-	-	-
Total Lb/Hr	12.91×10^6	10.69×10^6	20.77×10^6	4.89×10^6	14.38×10^6	4.31×10^6	10.07×10^6	15.87×10^4	2.10×10^6	1.33×10^6	0.92×10^6



NOTE 1 NOTE 5

	9	10	11	12	13	14	15	16	17	18	19
3,310	-	-	-	-				-			113,310
1,230	-	-	-	-				-			51,230
2,460	-	-	-	-				-			132,460
2,070	-	-	-	-				-			72,070
9,880	-	101,760	50,880	1,940	Note 2	Note 2	Note 2	-	Note 2	Note 2	247,470
5,270	-	-	-	-				-			5,270
4,200	-	-	-	-				-			4,200
1,320	1,320	-	-	-				-			1,320
-	64,570	-	-	-				-			-
5,740	65,890	101,760	50,880	1,940				-			627,330
10^6	2.10 x 10^6	1.33 x 10^6	0.92 x 10^6	35,000							12.67 x 10^6
6,600	-	-	-	-	32,600	1,600	31,000	-	97,300	378,000	2,000
3,400	-	-	-	-	-	-	-	-	6,600	25,800	130
5,500	-	-	-	-	-	-	-	-	12,600	49,200	250
1,800	-	-	-	-	-	-	-	-	1,900	7,300	40
0,900	-	-	-	-	-	-	-	-	5,400	21,000	110
5,800	-	-	-	-	569,300	28,500	540,800	-	17,700	69,000	350
8,200	-	-	-	-	8.92 x 10^6	7.60 x 10^6	1.26 x 10^6	1.57 x 10^6	1,458,000	5,677,400	80
4,200	-	-	-	-	9.52 x 10^6	7.60 x 10^6	1.83 x 10^6	1.57 x 10^6	1.60 x 10^6	6.23 x 10^6	2,970
10^6	2.10 x 10^6	1.33 x 10^6	0.92 x 10^6	35,000	9.52 x 10^6	7.60 x 10^6	1.83 x 10^6	1.57 x 10^6	1.60 x 10^6	6.23 x 10^6	12.68 x 10^6

NOTES:

1.

2.

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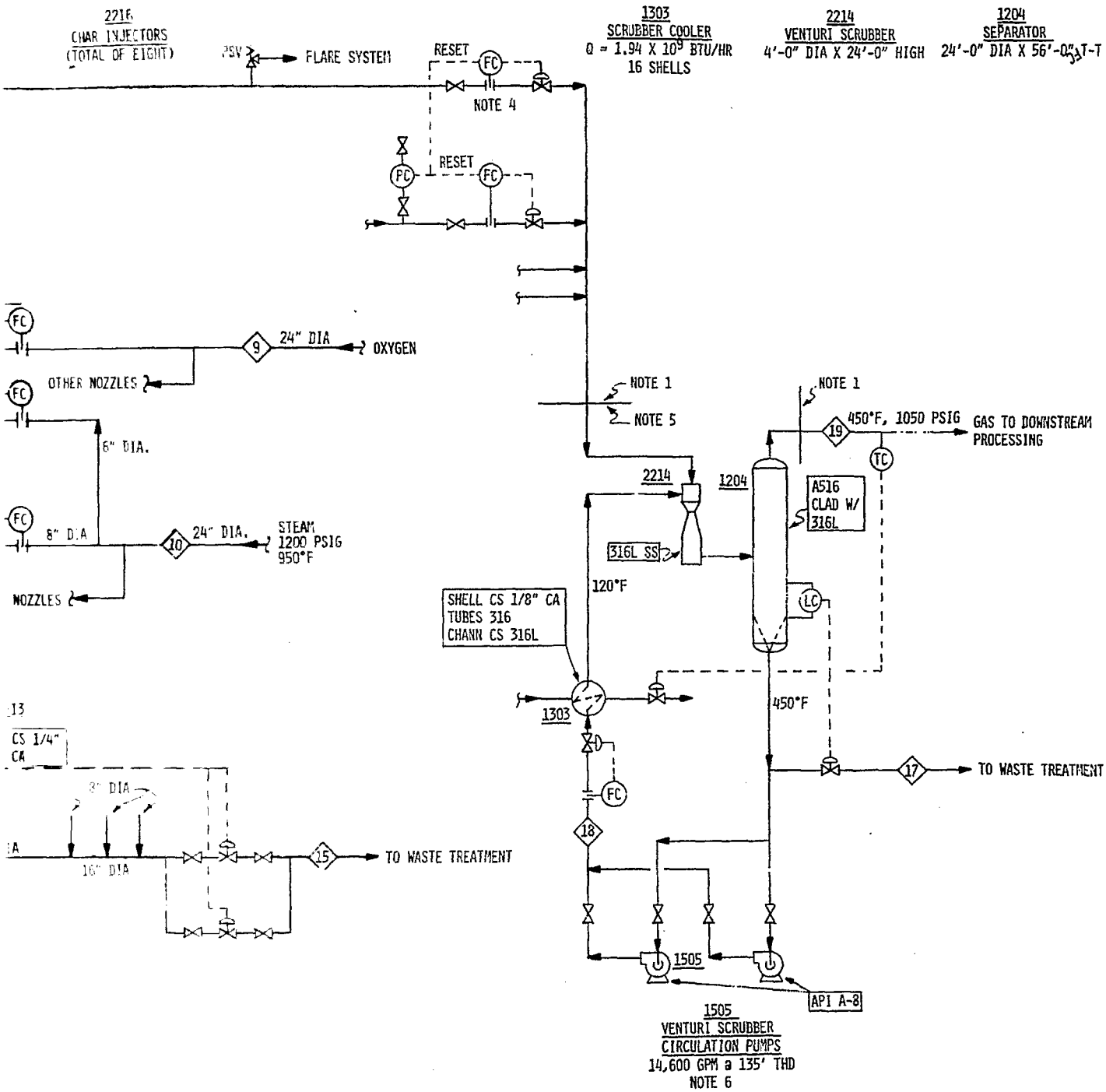
7.



1. ALL FLOW RATES TOTAL FOR TRAIN. TWO TRAINS REQUIRED.
2. DISSOLVED GASES ARE NOT INCLUDED AS THEY ARE RECOMPRESSED INTO MAIN GAS STREAM.
3. FOUR NOZZLES ON GASIFIER VESSEL TWO PARALLEL BRANCH LOOPS FROM EACH NOZZLE.
4. PRESSURE CONTROLLER TO RESET FLOW CONTROLLERS FOR EIGHT PARALLEL PATHS.
5. FOUR PARALLEL TRAINS TO HANDLE GAS FROM TOTAL PLANTS (BOTH TRAINS).
6. ONE LOOP SHOWN, FOUR LOOPS TOTAL.
7. ALL EQUIPMENT WITHIN THIS AREA TO BE IN PRE-STRESSED CONCRETE PRESSURE VESSEL.

FIGURE 6

REV NO	CUST APPR	DATE	REVISION	BY	PROC ENGR	CHECK	CHIEF PROC. ENGR	CHIEF OPER ENGR	PROG DIR
0			INITIAL ISSUE	RR					

PROCESS FLOW DIAGRAM
25 FOOT DIA. GASIFICATION REACTOR
PRESTRESSED CONCRETE CONCEPT

THE RALPH M PARSONS COMPANY PASADENA, CALIFORNIA	JOB NO. 5435-6	DWG NO. R-1-FS-1	REV 0

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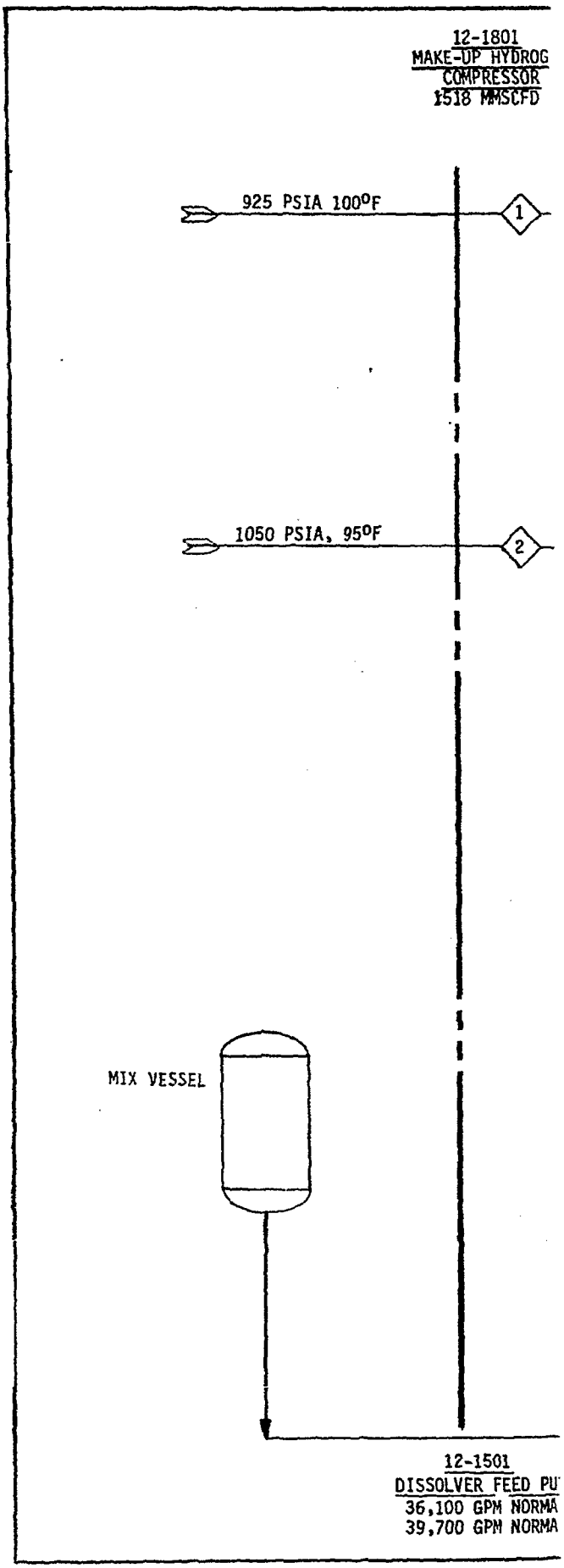
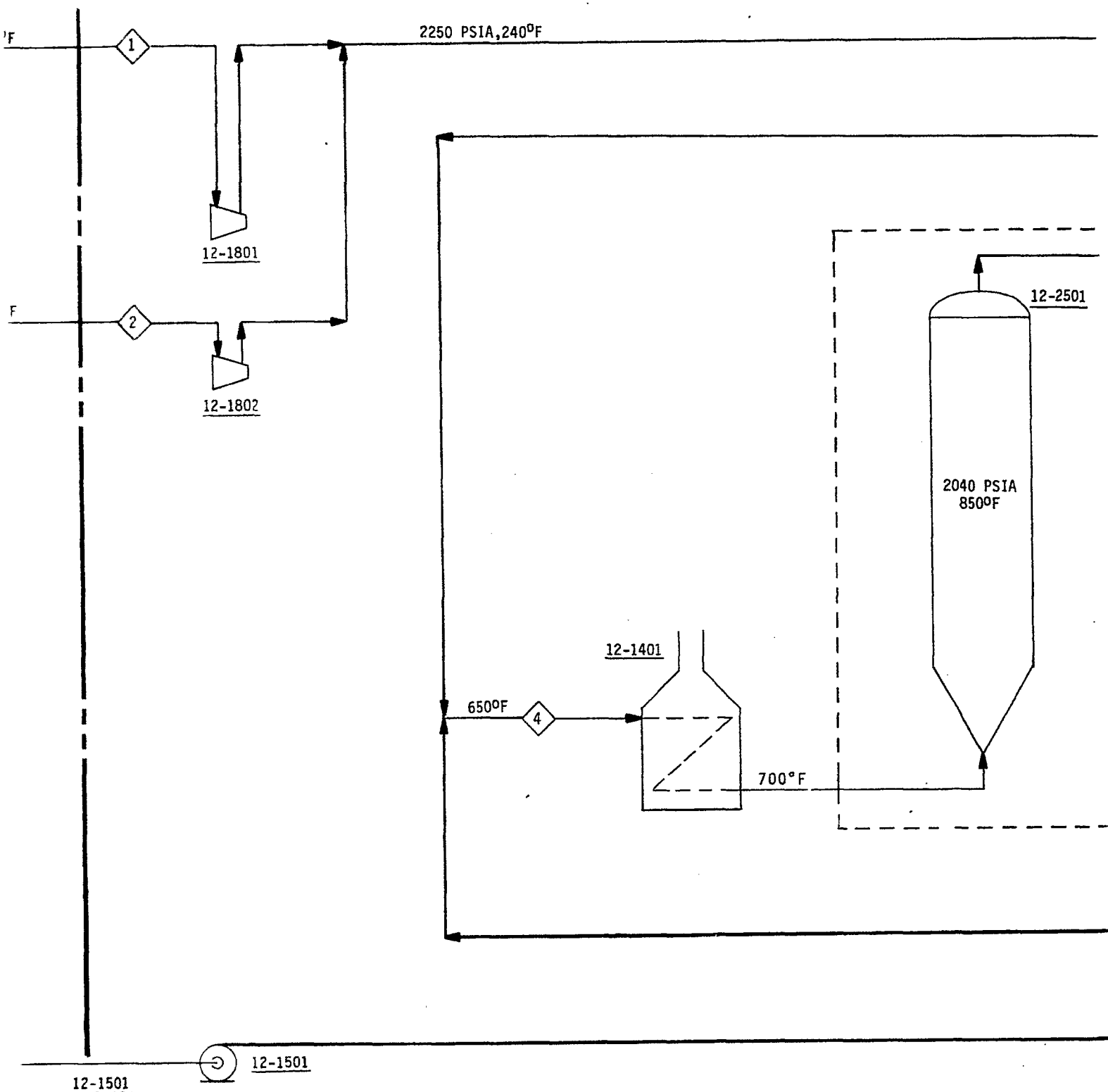

12-1801
MAKE-UP HYDROG
COMPRESSOR
1518 MMSCFD
925 PSIA 100°F
1
1050 PSIA, 95°F
2
MIX VESSEL
12-1501
DISSOLVER FEED PU
36,100 GPM NORMA
39,700 GPM NORMA

12-1801
MAKE-UP HYDROGEN
COMPRESSOR
1518 MMSCFD

12-1802
RECYCLE HYDROGEN
COMPRESSOR
897 MMSCFD

12-1401
DISSOLVER
PREHEATER
1522 MMBTU/HR

12-2501
DISSOLVER
33'-4" DIA.
BY 122' TT



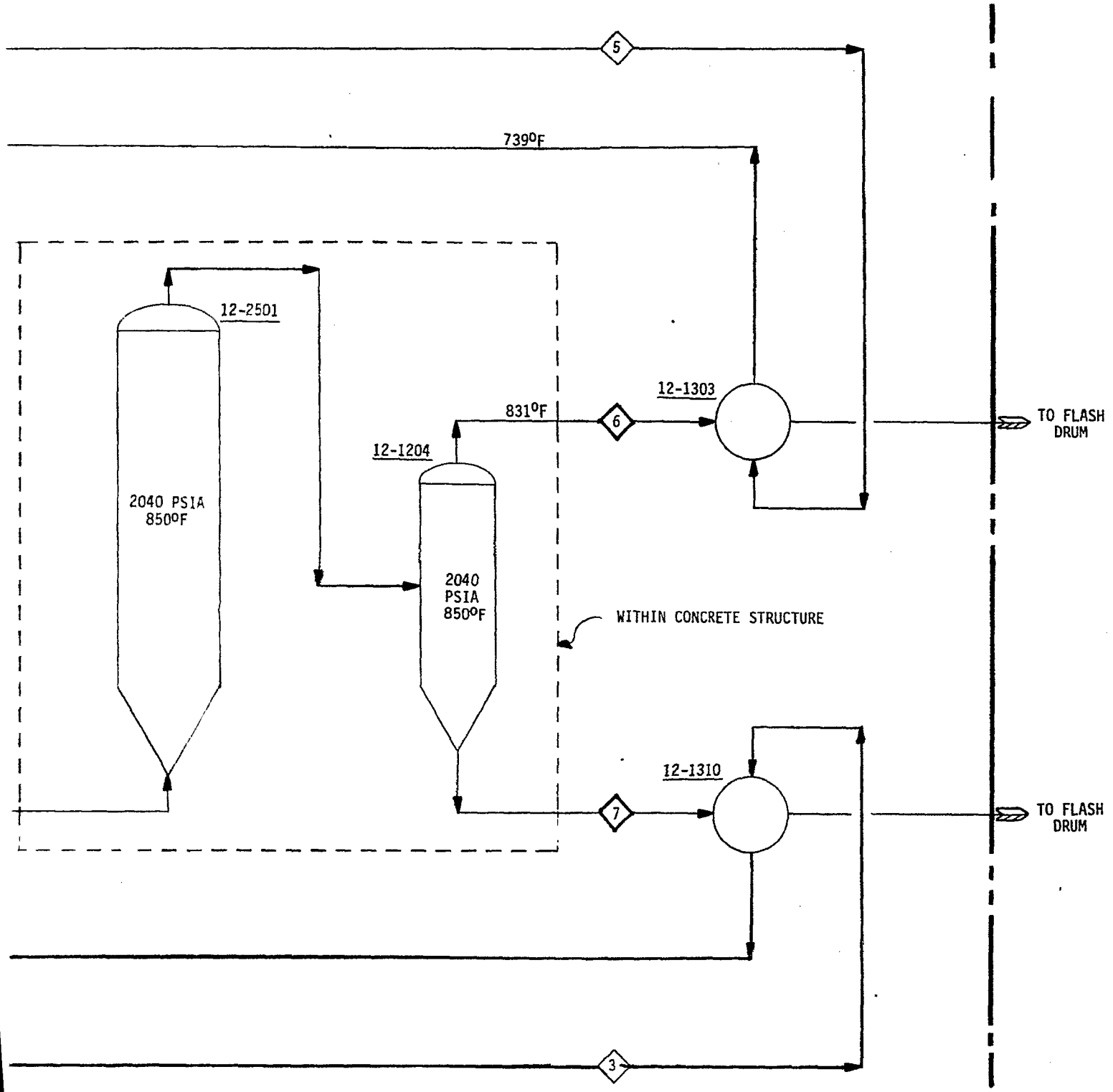
12-1501
DISSOLVER FEED PUMP
36,100 GPM NORMAL
39,700 GPM NORMAL

12-2501
DISSOLVER
33'-4" DIA.
BY 122' TT

12-1204
HIGH PRESSURE
PRIMARY SEPARATOR
27'-0 'DIA .BY 36'-0" TT

12-1303
HP SEPARATOR
VAPOR-FEED
GAS EXCHANGER
1008 MMBTU/HR

12-1310
MP SEPARATOR SLURRY
FEED EXCHANGER
1797 MMBTU/HR.



COMPONENT	① MAKE-UP HYDROGEN	② RECYCLE HYDROGEN	③ SLURRY TO DISSOLVER	④ SLURRY & GAS TO FURNACE	⑤ TOTAL HYDROGEN GAS	⑥ HP SEPARATOR VAPOR	⑦ HP SEPARATOR SLURRY
H_2 MOLES/HR.	132,590	94,308	---	226,898	226,898	103,460	9,989
N_2	1,827	945	---	2,772	2,772	1,681	1,090
CO	5,582	2,422	---	8,004	8,004	5,396	2,608
CO_2	166	---	---	166	166	1,142	199
NH_3	---	---	---	---	---	594	87
H_2S	86	---	---	86	86	3,451	423
H_2O	127	---	105	229	229	7,288	158
C_1	26,317	768	---	27,085	27,085	36,846	4,496
C_2	---	---	---	---	---	3,885	849
C_3	---	---	---	---	---	3,534	732
NC_4	---	---	---	---	---	1,274	300
IBP-200	---	---	---	---	---	310	95
200-400	---	---	---	---	---	1,791	1.387
400-450	---	---	---	---	---	388	533
450-500	---	---	---	---	---	285	509
500-600	---	---	285	285	---	586	1,687
650+	---	---	34,507	34,507	---	1,412	38,576
RESIDUE	---	---	37	37	---	---	70
ASH	---	---	126	126	---	---	126
COAL (MAF)	---	---	427	427	---	---	---
TOTAL MOLES/HR	166,696	98,442	35,488	300,626	265,138	172,735	63,916
LB/HR	909,536	296,750	19,866,890	21,073,176	1,206,286	2,491,344	18,581,832
BPD	---	---	1,097,886	---	---	---	1,100,316
MMSCD	1,518.213	896.589	---	---	2,414.8	1.578.8	---
MW	5.456	3.014	559.82	---	4.55	14.37	290.73
LB/GAL	---	---	10.340	---	---	---	9.650

FIGURE 7

REV NO	CUST APPR	DATE	REVISION	BY	PROC ENGR	CHECK	CHIEF PROC ENGR	CHIEF OPER ENGR	PRO DI
0				SRD					

PROCESS FLOW DIAGRAM
DISSOLVER - SEPARATOR
PRESTRESSED CONCRETE
PRESSURE VESSEL

THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA	JOB NO. 5435-6	DWG. NO. R-1-FS-2	RE 0

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