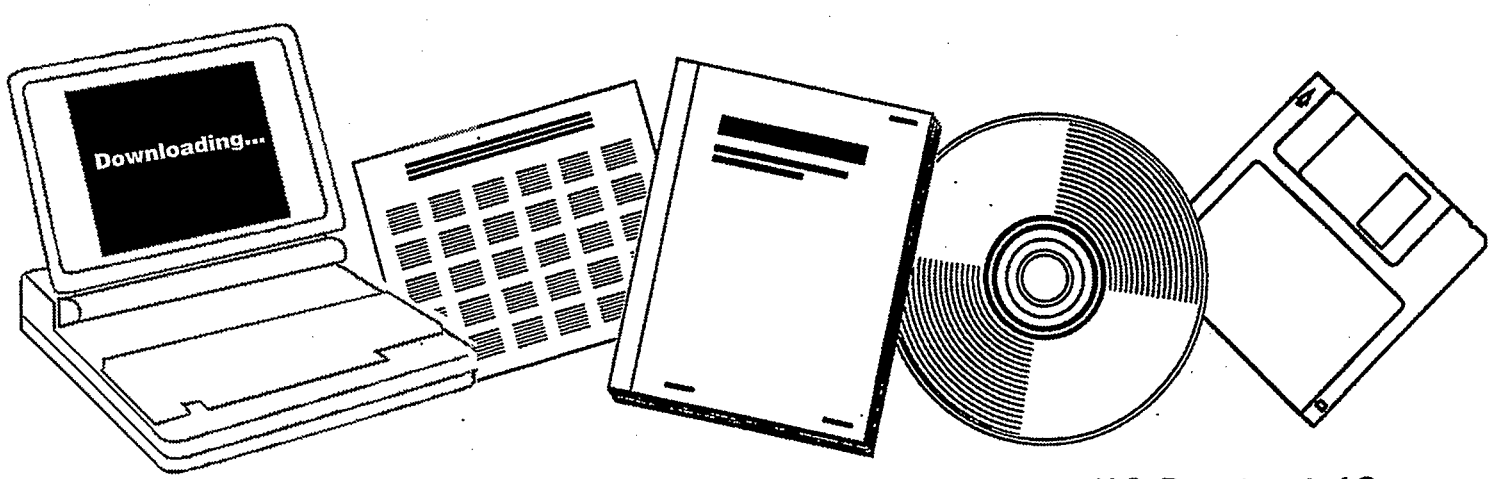
PRELIMINARY DESIGN SERVICES. RESEARCH AND DEVELOPMENT REPORT NO. 114. QUARTERLY REPORT, JULY--SEPTEMBER 1977

PARSONS (RALPH M.) CO., PASADENA, CALIF

1978



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PRELIMINARY DESIGN SERVICES

RESEARCH AND DEVELOPMENT REPORT NO. 114
QUARTERLY REPORT
FOR THE PERIOD: JULY - SEPTEMBER 1977

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

Under Contract No. EX-76-C-01-1775
February 1978

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

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. POGO Design

Authorization was received from ERDA to publish the report titled "Project POGO - Total Coal Utilization - COG Refinery Design Criteria" R&D Report No. 114, Interim Report No. 5. This report summarizes the results of Phase 1 work which defined the characteristics of the POGO design to be created. One hundred copies of this report were transmitted to ERDA on September 2, 1977.

Process designs for the following units were completed.

33 - Fuel Gas Generation
34 - Fuel Gas Acid Gas Removal
38, 39, 40 & 41 - Fire Water/Potable and Sanitary Water/ Raw Water/Effluent Water.

Designs for Unit 32 - Sulfur Plant and Unit 36 - Process Water Treating were completed. We completed flow sheet drafting for the unit flow sheets, completed the base case fixed capital investment estimate, and started process work on the alternate case process designs; the alternate cases are conceived to be located in Appalachia and the Rocky Mountain coal province.

The R&D report and preliminary economics were initiated for the base case.

B. Multi-Process Demonstration Plant Design

Coal handling facilities design and estimates were completed. Phase 1 utilities balance was completed. The sulfur recovery system was improved to meet environmental requirements for liquid effluents through conversion and removal of sodium thiosulfate as sodium sulfate. The sour water reclamation equipment specifications and assembled utility information was completed for Phase 2. Work continued on the power plant design.

C. Prestressed Concrete Pressure Vessels

We continued to investigate methods of constructing concrete coal gasification vessels. We concluded that internal metal vessel shells could be fabricated, assembled and erected as single units. In addition, these vessels can be leak-tested to insure membrane integrity prior to erection.

Flow diagrams for three types of vessels were prepared. Vessel schematics were prepared for a coal dissolver-separation section. The cooling system design for the gasifier vessel was completed.

D. Supporting Areas

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

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

We continued our investigation of areas of environmental sensitivity of coal conversion where additional information is to be developed.

E. General

We presented four papers in the field of coal conversion technology.

- "The Analysis of Finned Catalytic Heat Exchanges" at the AIChE/ASME Heat Transfer Conference in Salt Lake City, Utah, August 16.
- "Environmental Factors for Fischer-Topsch Coal Conversion Technology" at the Second Pacific Chemical Engineering Congress sponsored by the AIChE in Denver, Colorado, August 29.
- "Potential Markets for Emerging Energy Technologies" at the Second Pacific Chemical Engineering Congress sponsored by the AIChE in Denver, August 30.
- "Conversion of Coal to Liquids by Fischer-Tropsch and Oil/Gas Technologies" at the Symposium on Comparative Synfuels Economics sponsored by the American Chemical Society in Chicago, Illinois, September 1.

III. DETAILED DESCRIPTION OF TECHNICAL PROGRESS

A. POGO Plant Design

1. Objectives

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 Province, the Appalachian Region of the Eastern Coal Province, and the Powder River Region of the Rocky Mountain Coal Province. The process employed in this plant design shall be the result of an economic selection from the candidate coal conversion processes available.

2. Activity This Quarter

We transmitted 100 copies of the Phase 1 report to ERDA. This report titled "Project POGO - Total Coal Utilization - COG Refinery Design Criteria" R&D Report No. 114, Interim Report No. 5, summarizes the results of comparisons made during the process of selecting the preferred combination of basic processes for the POGO design. The preferred configuration includes SRC II hydroliquefaction and pressurized flash pyrolysis. This combinaion, used successfully, can eliminate the need for filtration of unconverted coal and ash from the hydroliquefaction and pyrolysis operations.

The combination of processes contained in the POGO project design are also expected to result in economic advantages, because of their mutually beneficial inter-relation, which are not obtained from these processes as individual "stand alone" plants.

Work proceeded on development of the conceptual design. We completed process design, flow sheet preparation, material balances, material of construction reviews for the following units for the base case which is conceived to be located in the Eastern Region of the Interior Coal Province:

32 - Sulfur Plant
33 - Fuel Gas Generation
34 - Fuel Gas Acid Gas Removal
36 - Process Water Treating
38, 39, 40 & 41 - Fire Water/Potable and Sanitary Water/ Raw Water/Effluent Water

We began process work for the two alternate case POGO plant locations; these are the Rocky Mountain Region and Southern Appalachia Region. These designs are being based on typical local coal analyses.

We completed the POGO plant plot plan. Required area, exclusive of the coal mine, approximates 640 acres (one square mile).

We completed the fixed capital investment estimate; the estimated value is approximately $2.4 billion.

We started to develop estimates of operating costs and profitability.

We continued preparation of the R&D report including development of figures and tables. These include:

Coal Mining and Coal Preparation descriptions. Figure 1 illustrates the basic operations in these units.

Product characteristics for the six major products and two by-products involved for the base case.

The overall material balance; this is presented in Figure 2.

We completed preliminary definition of the predicted thermal efficiency; the predicted value is approximately 74 percent. The predicted efficiency of the power plant is approximately 43 percent (see Figure 3). The fuel gas and power generation systems are diagrammed in Figure 4.

We determined chemicals and catalyst requirements for the base case report.

We estimated process yields for the Rocky Mountain Region location. SRC yields were based on laboratory results on Wyodak seam coal.

We started prediction of process yields for the Southern Appalachia location coal. Information on SRC laboratory work using Pittsburg seam coals served as the basis, modified by the consideration of comparative iron contents of the coals.

We began to prepare the material balance for the Rocky Mountain Region location.

3. Activity Forecast Next Quarter

We will complete preparation of the R&D report; this will include the alternate location cases which are: Alternate 1, Southern Appalachia and Alternate 2, Rocky Mountain Region. The alternate cases design/analysis will include:

Utility Summaries
Block Flow Diagrams
Fixed Capital Investment Estimates
Economics

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 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 equipment to meet new requirements.

2. Activity This Quarter

We completed the design and equipment cost estimates for the coal unloading, storage and grinding facilities required for all three phases of the project.

A central rail and truck coal receiving, unloading, handling and storage area serves all three project phases. The original installation serves the Phase 1 plant. The subsequent Phase 2 and Phase 3 requirements are planned as expansions and equipment additions to the initial installation.

The Phase 1 sulfur recovery system, consisting of a proprietary acid gas sulfur removal process, requires disposal of a redox water solution purge stream containing sodium thiosulfate. This compound is ecologically objectionable. It was determined that further processing to convert the sodium thiosulfate to sodium sulfate was advisable. The initial assessment indicated that the processing could also recover redox solution.

3. Activity Forecast Next Quarter

We will complete the sulfur plant design for Phase 1.

We will advance the fixed capital investment estimate for all phases and will start work on the offsite support facilities for the Phase 1 plant.

We will complete the final total complex block flow diagram showing all phases. We will complete the fixed capital investment estimates for all three phases, and begin work on the economics.

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 large, high pressure, 25-foot ID X 125-foot tangent-to-tangent gasifier reactor vessel.

A combination of a large dissolver reactor vessel and a flash drum. These vessels would operate at about 2,025 psig and 850°F.

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

The method of construction and erection of the concrete vessels was investigated. It was found that the internal metal vessel shells could be fabricated, assembled, and erected as single units. This technique should save considerable time in the overall construction of the concrete

vessels as it avoids interference between the various crafts. We also determined that the vessels can be leak-tested to insure membrane integrity prior to erection.

Flow diagrams containing the principal elements were prepared for the gasification unit, the coal dissolving and separation unit and for the absorber unit. These flow sheets represent typical process units in coal gasification and coal hydroliquefaction processes. The absorber unit is shown in Figure 5. All of these units are of very large capacity to represent future process plant requirements.

Analyses of the internal concrete stress levels was continued. The conclusions indicate that the concrete pressure vessel load factor should be 1.10 to 1.15 times the normal stress levels. The design stress levels for the concrete are given below:

In confined state allowable membrane compressive stress	= 2,500 psi
In confined state allowable local compressive stress	= 3,500 psi
In confined state allowable local tensile stress	= 3,000 psi

It is believed that these values are conservative and may be modified as further studies are conducted.

Studies were also conducted on the effects of shrinkage, creep, heat of hydration and bonding of the prestressing tendons.

We finalized the cooling system design for the gasifier vessel and continued review of construction methods. The design selected for the gasifier is shown in Figure 6.

3. Activity Forecast Next Quarter

We will continue to develop equipment cost estimates. We will revise equipment drawings for the vessels to reflect the latest design and construction philosophy. We will continue studies on method of fabrication and erection of the vessels. We will commence studies on maximum pressure build-up and on cooldown rates for the vessels.

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 developmental programs to ERDA-FE.

2. Activity This Quarter

We continued follow-up activities with gas cleaning equipment and valve manufacturers.

We began an investigation of rotary feeders for use in coal conversion processing.

We are keeping abreast with coal feeding developmental work.

We attended the Conference on Coal Feeding Systems held June 21-23 at the California Institute of Technology, Pasadena, California.

3. Activity Forecast Next Quarter

We will continue follow-up on the status of vendor programs and investigate new applicable items of equipment.

E. Materials of Construction

1. Objective

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

2. Activity This Quarter

We completed the material selection services in support of the POGO and MPDP projects.

3. Activity Forecast Next Quarter

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

F. Environmental Considerations

1. Objective

To define environmental factors for proposed 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

The preliminary designs of the separate units in the Multi-Process Demonstration Plant and of the POGO complex were reviewed as they were completed. The environmental acceptability and compliance with specific environmental laws and regulations were assessed. We continued the review of unit designs for the POGO and Multi-Process Demonstration Plant as they were completed.

3. Activity Forecast Next Quarter

We will begin writing the environmental section for the POGO R&D report.

G. General

We met with ERDA personnel on July 28 and August 11 in Pasadena to review the project status.

We presented four papers:

- "The Analysis of Finned Catalytic Heat Exchanges" at the AIChE/ASME Heat Transfer Conference in Salt Lake City, Utah, August 16.
- "Environmental Factors for Fischer-Tropsch Coal Conversion Technology" at the Second Pacific Chemical Engineering Congress sponsored by the AIChE in Denver, Colorado, August 29.
- "Potential Markets for Emerging Energy Technologies" at the Second Pacific Chemical Engineering Congress sponsored by the AIChE in Denver, August 30.
- "Conversion of Coal to Liquids by Fischer-Tropsch and Oil/Gas Technologies" at the Symposium on Comparative Synfuels Economics sponsored by the American Chemical Society in Chicago, Illinois, September 1.

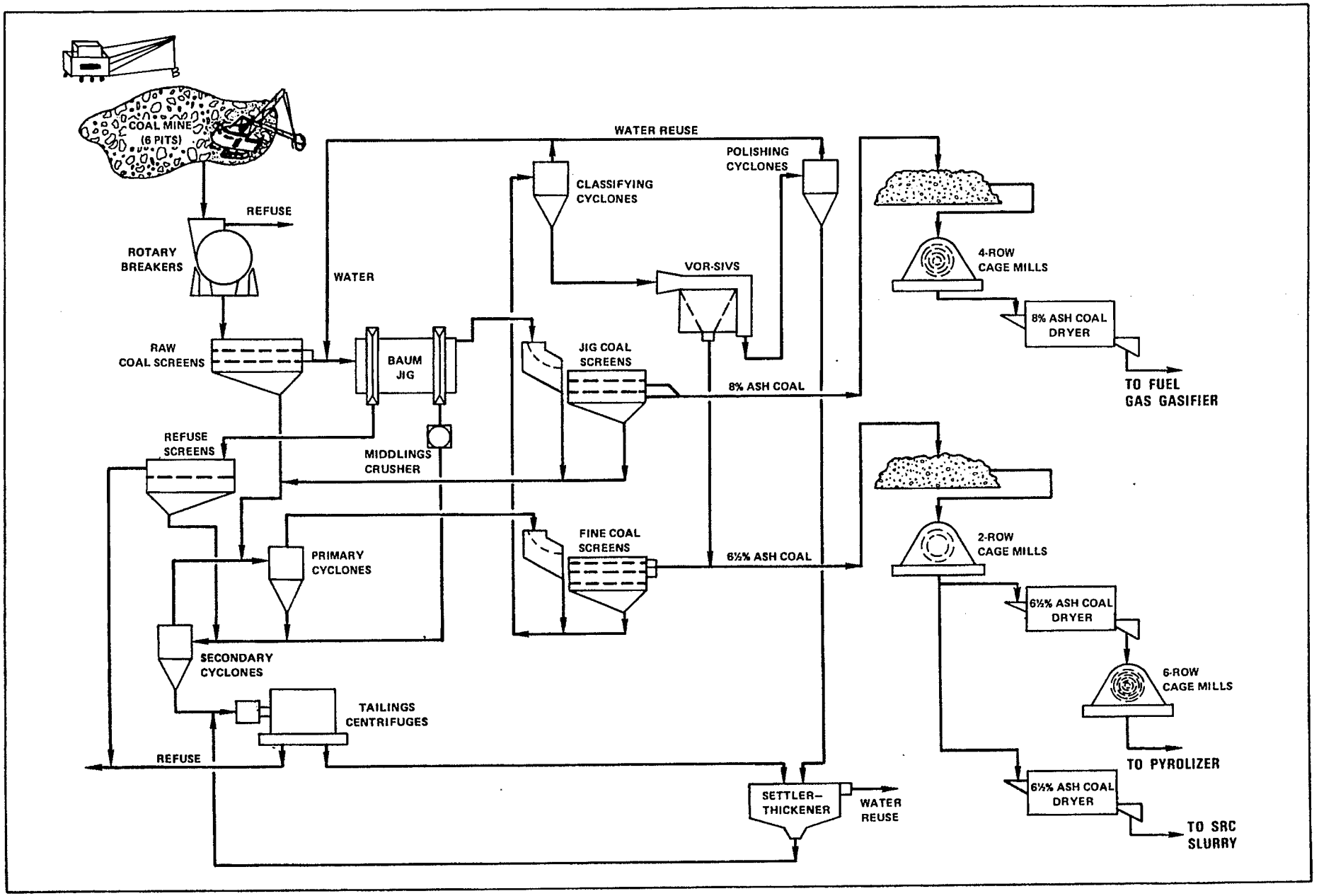


Figure 1 - Coal Mining and Preparation Areas
POGO Coal Conversion Complex

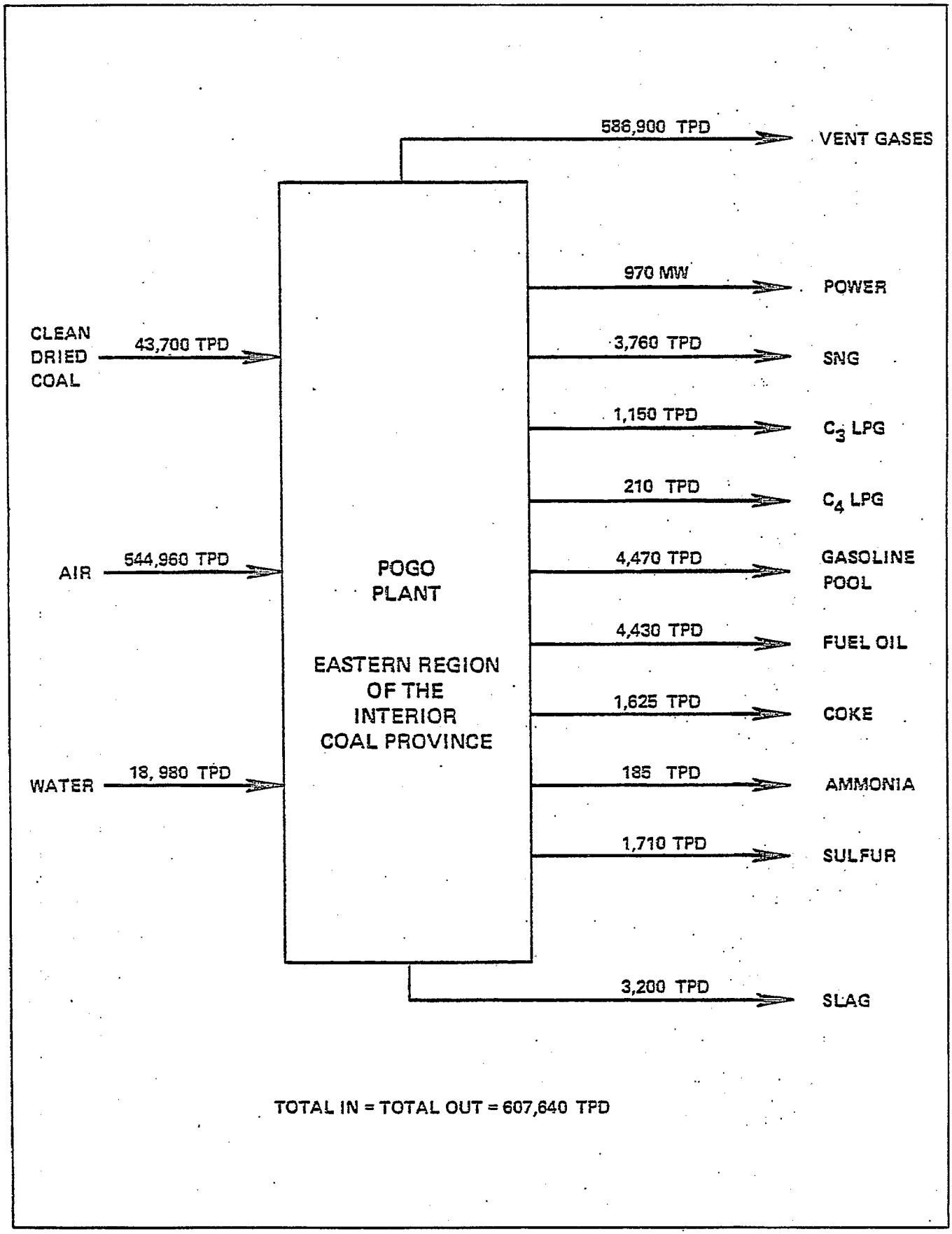
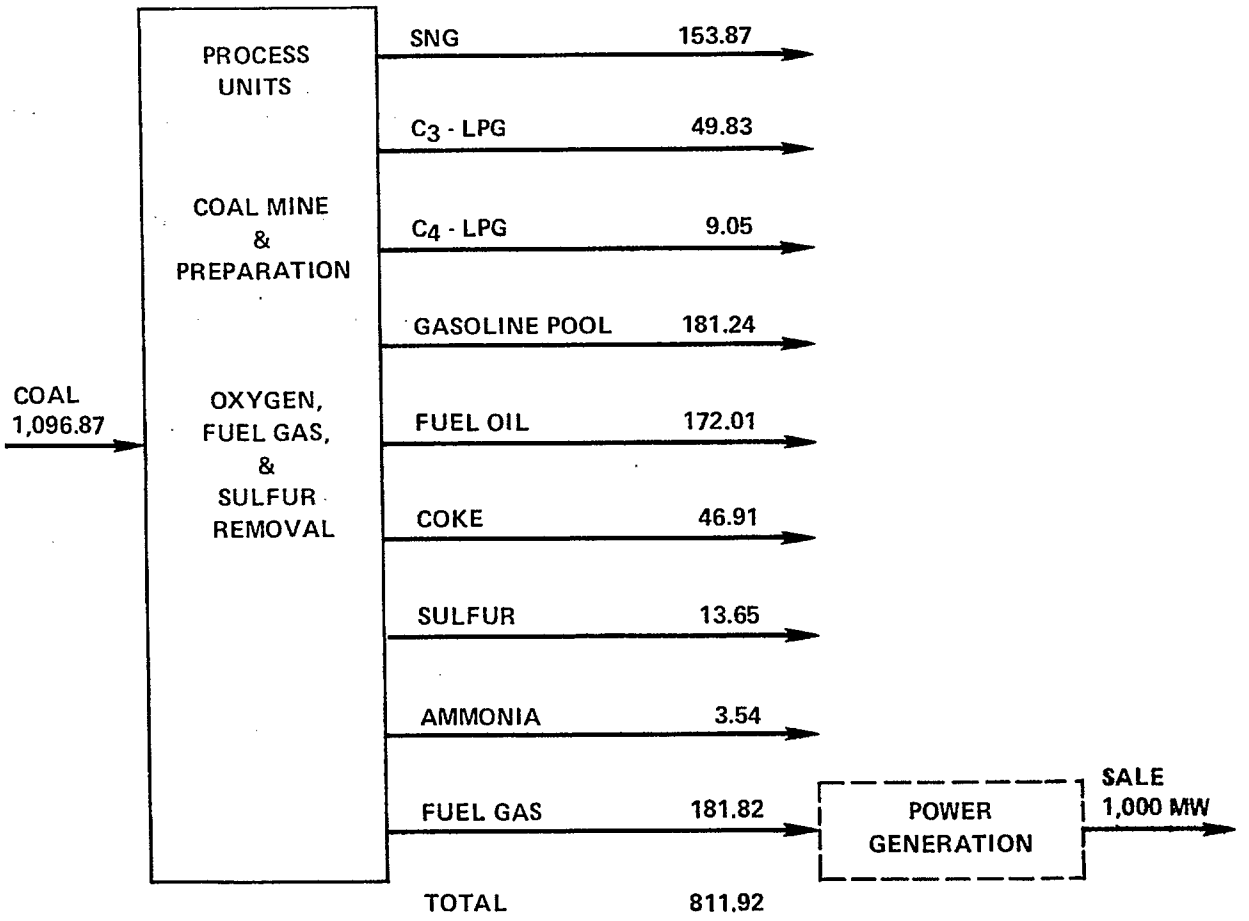


Figure 2 - Overall Material Balance
POGO Process and Power Units - Base Case



ALL FIGURES ARE MMM BTU/D HHV

PROCESS THERMAL EFFICIENCY:

$$\frac{811.92}{1,096.87} \times 100 = 74.0\%$$

POWER GENERATION EFFICIENCY (BASED ON GAS):

$$\frac{1,000,000 \text{ KW} \times 24 \times 3,413 \text{ BTU/KWH}}{187,440,000,000} \times 100 = 43.7\%$$

Figure 3 - Projected Thermal Efficiencies
POGO Coal Conversion Complex

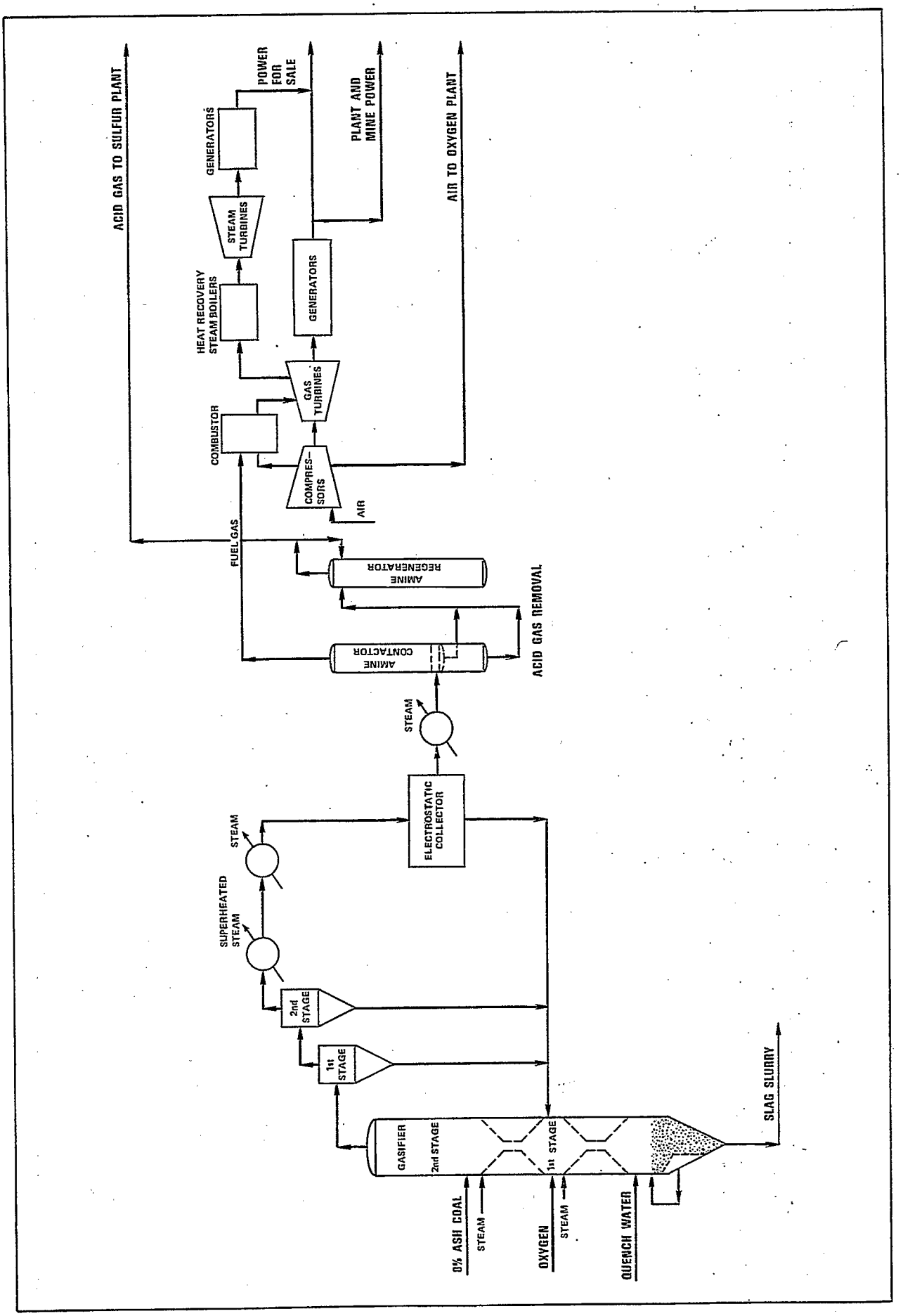
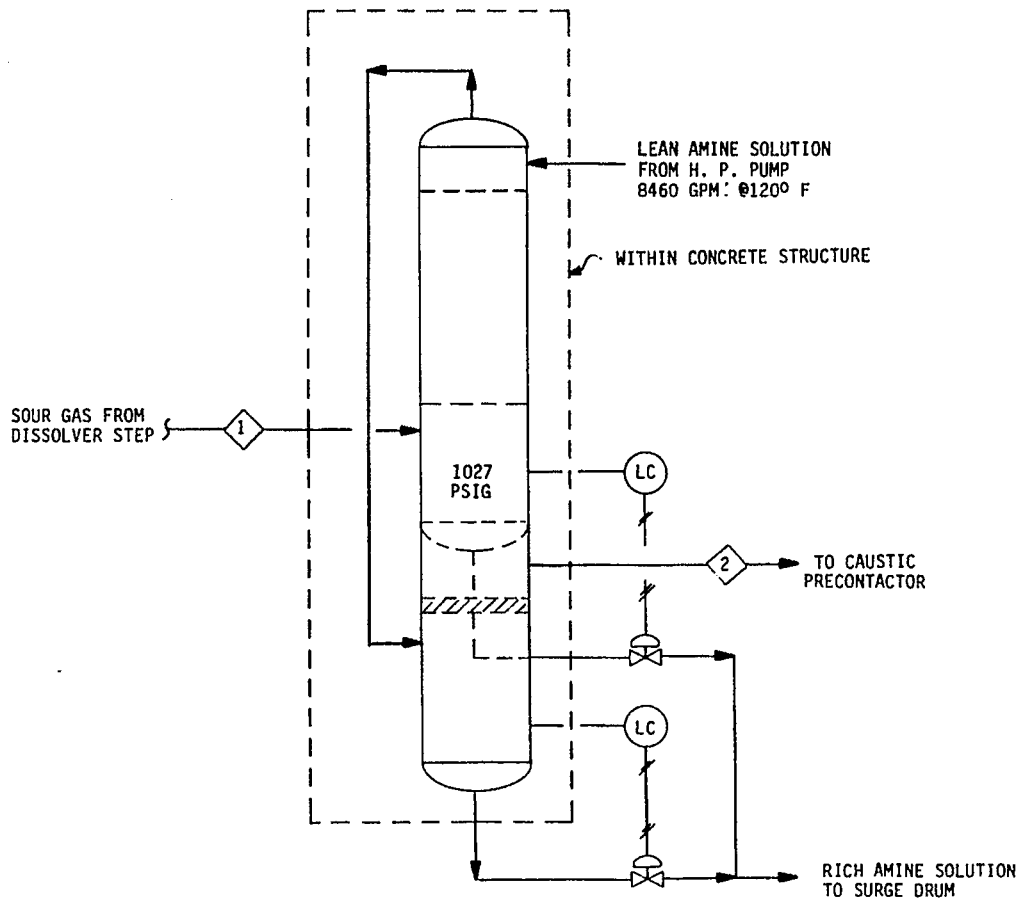


Figure 4 - Power Generation System
POGO Coal Conversion Complex



COMPONENT	◇1 GAS TO CONTACTOR	◇2 GAS FROM CONTACTOR
H_2 Mols/Hr	113,756	113,598
N_2	2,803	2,798
CO	8,004	7,997
CO_2	1,173	---
NH_3	16	---
H_2S	3,371	---
H_2O	148	148
CH_4	41,650	41,587
C_2H_6	4,798	4,791
C_3H_8	4,285	4,280
C_4H_{10}	1,417	1,415
IBP-200°F	259	258
200-300°F	88	88
300-350°F	5	5
350-400°F	1	1
400-450°F	---	---
TOTAL MOLS/HR	181,773	176,966
LB/HR	1,816,392	1,647,375
MSCFH	69,078	67,158
M.W.	9,993	9,309

REV NO	CURR APPR	DATE	REVISION	BY	PROC ENGR	CHECK	CHIEF PROC ENGR	CHIEF OPER ENGR	PROC DIR
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FLOW DIAGRAM
ABSORBER
PRESTRESSED CONCRETE
PRESSURE VESSEL

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Figure 5 - Absorber Flow Diagram
Prestressed Concrete Pressure Vessel

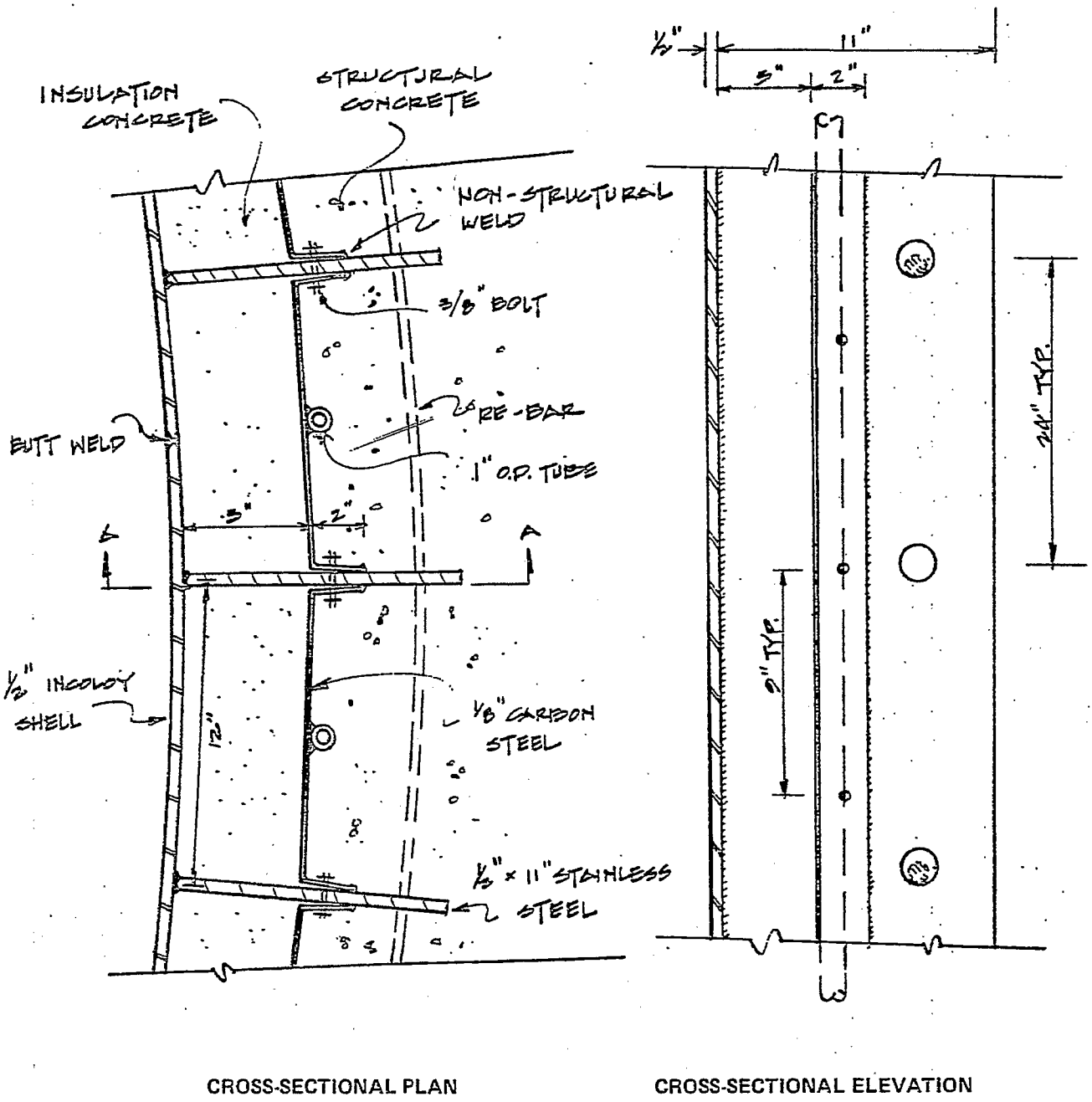

Figure 6 - External Cooling System
Prestressed Concrete Pressure Vessel

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