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The BRECKINRIDGE PROJECT

Initial Effort

REPORT II

BRECKINRIDGE PROJECT DESIGN BASIS

MASTER

ASHLAND SYNTHETIC FUELS, INC.

AIRCO ENERGY COMPANY, INC.

PREPARED FOR

UNITED STATES DEPARTMENT OF ENERGY

UNDER COOPERATIVE AGREEMENT

NO. DE-FC05-80OR20717

DISCLAIMER

The information and data contained in this report are the result of an economic evaluation and a preliminary design effort and because of the nature of this work no guarantees or warranties of performance, workmanship, or otherwise are made, either expressed or by implication.

Volume Introduction
and Table of Contents

REPORT II

INTRODUCTION

The Breckinridge Project is a pioneer endeavor involving the engineering, construction, and operation of a commercial facility that will convert 23,000 tons per day of run-of-mine, high-sulfur coal into 50,000 barrels per day of liquid hydrocarbons. These products will be equivalent to those presently produced from crude oil.

The Initial Effort of the project, now complete, was executed under Cooperative Agreement No. DE-FC05-80OR20717 between the Department of Energy and the Participants, Ashland Synthetic Fuels, Inc., and Airco Energy Company, Inc. The Initial Effort produced a preliminary design, capital estimate, and economic analysis of the commercial plant, as well as a plan for the design, construction, and operation of that plant. The extensive and rigorous attention given to environmental, socioeconomic, safety, and health considerations during the Initial Effort is indicative of the high priority these issues will continue to receive throughout the life of the project.

The Breckinridge Energy Company, a partnership of several major corporations, is being formed to finance, own, manage, and share in the profits of the Breckinridge Project.

Report II is intended for the reader who is primarily interested in a less detailed discussion of the coal liquefaction process and Breckinridge facility than that presented in the eleven volumes of Reports IV and V.

This report presents an overview, history, and the Design Basis for the Breckinridge Project. The overview section describes the project goals and briefly introduces the coal liquefaction process. The report continues with a discussion of the history of the project and the H-Coal®

liquefaction process from its concept to the proposed commercialization of the technology. Following this part of the report are sections that describe the site, the coal liquefaction process, and the Breckinridge Facility. The report concludes with a summary of the eleven reports that contain the deliverable documentation of the Initial Effort or Development Phase of the project.

INITIAL EFFORT REPORTS REFERENCE

Report I - Executive Summary

Report II - Breckinridge Project Design Basis

Report III - Specifications
Volume 1 - Specifications A through J
Volume 2 - Specifications K through W

Report IV - Process Units
Volume 1 - Plants 26, 27 and 1
Volume 2 - Plants 2, 3 and 4
Volume 3 - Plants 5, 6 and 17
Volume 4 - Plant 7
Volume 5 - Plants 8, 9 and 10
Volume 6 - Plant 12
Volume 7 - Plants 15 and 18

Report V - Utilities and Offsites Units
Volume 1 - Plants 19, 20, 21, 22, 23 and 30
Volume 2 - Plants 31, 32, 33 and 34
Volume 3 - Plant 35
Volume 4 - Plants 36, 37, 38, 39, 40, 41, 42 and 44

Report VI - Project Management Plan

Report VII - Environmental, Socioeconomic, Safety and Health
Volume 1 - Introduction and Background
Volume 2 - Environmental Baseline
Volume 3 - Cultural and Socioeconomic
Volume 4 - Health and Safety

Report VIII - Capital Cost Estimate

Report IX - Operating Cost Estimate

Report X - Economic Analysis and Financial Plan

Report XI - Technical Audit
Volume 1 - Engineering Comparisons
Volume 2 - Engineering Comparisons
Volume 3 - Critical Design Areas
Volume 4 - Critical Review of the Design Basis
Volume 5 - Critical Review of the Design Basis

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Project Overview

1.0 PROJECT OVERVIEW

The Breckinridge Project has one predominate goal: to construct and operate a commercial facility that will convert 23,000 tons per day of run-of-mine, high-sulfur coal into 50,000 barrels per day of hydrocarbon products equivalent to those derived from crude oil. To be successful, the undertaking must meet the following objectives:

- Afford investors a fair return on their investment
- Help the nation achieve independence from foreign oil imports and provide a basis for replacement of declining domestic reserves
- Have a positive socioeconomic effect on the area in which the facility is located

1.1 RETURN ON INVESTMENT

The Breckinridge Project is a first-generation, capital-intensive facility. To provide a fair return on investment, this facility must be designed, constructed, and operated to achieve a maximum production of high quality products consistent with economic, environmental, and safety considerations.

Although the Breckinridge Project will be a pioneer facility, it will use a process that has been under development for more than twenty years. The process is based on thousands of hours of bench-scale and process development unit development. The process is basically the same as processes successfully used in commercial-scale plants for processing very heavy petroleum materials into commercial products. A large H-Coal® pilot plant in Catlettsburg, Kentucky, has been successfully operated using coal in a manner almost identical to that planned for the commercial facility. This pilot plant will continue to be operated to refine data which will be used in the design of the commercial facility. A considerable redundancy of parallel lines and installed spare equipment has been provided in the commercial facility design to insure a high reliability of production. Every precaution has been taken to forestall the difficulties frequently encountered with first generation facilities. Special emphasis has been given to equipment maintainability, and successful production at the earliest possible date after completion of construction is confidently expected.

By achieving full production at an early date and carefully controlling and minimizing the costs of engineering, construction, and operation wherever possible consistent with other project objectives, the project has a high probability of being an economic success.

The analysis provided in Report X, Economic Analysis and Financial Plan, includes a base case with sensitivities to product pricing, onstream factor, capital cost, and coal cost. The sensitivity analyses indicated that, within the limits of the variables tested, only product prices have a major impact on the profitability of the project. Since the base case forecast is judged to be conservative, any error in the forecast is expected to result in increased project profitability.

The economic analysis is based on 100 percent equity funding, since no other form of financing is presently available to the project. However, in anticipation of securing project debt funding through the Synthetic Fuels Corporation, the project sponsors have also evaluated the economics on the basis of such leveraging. The analysis is based on tax law existing prior to passage of the Economic Recovery Act of 1981. The results of this comparison for the base case are summarized in Table 1.

TABLE 1
ECONOMIC SUMMARY
(as spent dollars)

	DCF ROE Percent	Net Present Value Discounted @ 15 Percent
100 Percent Equity Funding	12.1	$ - 456MM
Debt Funding with $3 Billion Loan Guarantee	20.8	+ 337MM

The amount of capital required to finance the project is so large that a means of reducing the financial exposure of the participants is a critical issue. The U. S. Government's guarantee of loans to the maximum extent allowable is, therefore, essential and other incentives are highly desirable.

1.2 ENERGY INDEPENDENCE

The significance of the Breckinridge Project in helping achieve domestic energy independence can best be understood when viewed within the framework of declining crude oil reserves in the United States, the threat and historical occurrence of limitation on imported supplies of crude oil, and the requirements of the nation's transportation and industrial sectors for liquid fuels.

At the present rate of consumption domestic crude oil reserves are estimated as being sufficient for the next 20 years, with natural gas reserves being even smaller, in the range of a 10 to 15 year supply. The United States normally imports about 6.0 million barrels of crude oil and crude oil products on a daily basis, or about 40% of its daily use. With this level of imports the country is highly vulnerable to any limitation in its supply of crude oil, particularly since a very high percentage of our crude oil consumption is used in transportation and the generation of electricity. The threat of any curtailment in supply will be magnified to alarming proportions as import levels increase. Even though the import level has decreased recently, declining reserves and continued growth of the business sectors which use liquid fuels will undoubtedly overcome this decline and create additional growth in the volume of imports.

The cost of imported crude oil and products brought into the United States is estimated to be between seventy and one hundred billion dollars per year and constitutes a major reason for the change in the nation's balance of payments from a comfortable surplus to an alarming deficit in the recent past. The Breckinridge Project will help reduce this serious deficit by replacing the equivalent of about 700 million dollars per year of imported oil. While this is only on the order of one percent of the cost of present crude oil imports, it is a significant step towards a favorable balance of trade.

Alternative energy sources such as nuclear and solar power are mainly limited to generation of electricity or for localized heating purposes, whereas liquid synthetic fuels derived from other materials can produce products, including transportation fuels, that are replacements for those derived from crude oil. Coal, oil shale, and tar sands are the only naturally occurring domestic raw materials which exist in sufficient quantities to offset the energy equivalent of the large quantity of crude oil which is being imported.

One approach to replacing declining crude oil reserves and offsetting imported oil is the conversion of coal into clean burning liquid fuels. Coal is one of the most abundant energy sources within the United States. The nation has more than a 300 year supply at the current rate of energy use. Coal liquefaction (the conversion of coal into liquid hydrocarbons) by means of the H-Coal® process is the basis of the Breckinridge Project. Construction of the project will constitute a major building block in the establishment of a viable synthetic fuels industry in the United States when the project starts operations in 1988. It will then be one of the first commercial facilities to produce synthetic fuels from coal in this country.

The liquefaction of coal is not a new development; the Germans successfully operated pilot plants in the 1920's and were actually dependent on fuel produced in coal liquefaction plants for operating their aircraft during World War II. Since the war, several coal liquefaction plants have been built but have not been financially attractive commercial operations because of the competition of cheap and plentiful crude oil. The tremendous price increases imposed by the OPEC nations in recent years have materially reduced the competitive advantage of crude oil.

Within this framework the Breckinridge Project will meet several critical goals towards making the United States energy independent, as it will:

- Contribute to a reduction in the serious foreign trade deficit of the United States
- Constitute a building block in the establishment of the country's synthetic fuels industry
- Utilize domestic raw material which is in plentiful supply to offset the importation of a raw material with very limited reserves

1.3 SOCIOECONOMIC EFFECT

The facility will be built in Breckinridge County, Kentucky, and will have a very positive impact on an area which is considered to be economically depressed. Because of the depressed nature of the area, increasing the socioeconomic benefits derived from the project has been a primary objective and will continue to be a guiding principal throughout the life of the project. Many agencies, including the Commonwealth of Kentucky, have been extensively involved in the project.

The project will produce a large influx of capital into the region and will create thousands of new jobs during its construction and operation. In addition, hundreds of other jobs will be created in coal mining operations and in supplying support services to the facility operations.

Existing communities may be enlarged, or new ones established, to accommodate people associated with the work. New schools, health facilities, enlarged police and fire protection services, and expanded public utilities will undoubtedly follow. Service and retail facilities will be attracted to the area. All of these factors will enhance the quality of life in the region.

Environmental concerns are a major factor in socioeconomic considerations. The Breckinridge Project will be a good neighbor to the surrounding communities. Besides the prosperity it will bring to the area, it will be an excellent place to work.

Every provision is being made to ensure the safety and health of employees in the construction and operation of the facility. Extraordinary precautions have been taken to minimize the emission of gaseous, liquid, and solid waste materials from the plants. The project will meet and usually far exceed the regulatory provisions governing the operation of such facilities.

Project Background
and History

2.0 PROJECT BACKGROUND AND HISTORY

The history of the Breckinridge Project is discussed in this section beginning with the concept of original process through the steps which have been taken to prepare it for its current state of readiness for commercialization.

2.1 PROCESS CONCEPTUALIZATION AND DEVELOPMENT

The concept of the project goes back more than twenty years to invention of the ebullated bed reactor by Hydrocarbon Research, Incorporated (HRI). The ebullated bed reactor was originally developed for the catalytic hydrogenation of heavy oil extracted from Alberta tar sands. This oil is a very heavy bituminous material containing a small percentage of fine sand. Its treatment is, in certain respects, similar to the hydrogenation of coal, since a part of the reaction product is an inorganic ash or sand particulate material. The process of hydrogenation of heavy oils in an ebullated bed reactor to produce lighter, more useful oils is called the H-Oil® process; the process of hydrogenation of coal to produce liquid hydrocarbon fuels is called the H-Coal® process.

The H-Oil® process has been used in commercial plants since 1963 following the installation of a 2,500 BPSD unit in Lake Charles, Louisiana, which was used to process West Texas vacuum resid for conversion and desulfurization. The unit was subsequently expanded to 6,000 BPSD and used to desulfurize coker feed from sour vacuum residue. A larger unit was installed at Shuaiba, Kuwait, to produce distillate from 28,000 BPSD of 9.3 API vacuum bottoms. This plant has been highly successful since 1973. A third commercial H-Oil® plant was installed at Salamanca, Mexico, in 1973. This unit was designed for hydrocracking 18,500 BPSD of a mixture of lube oil extract, pitch from a solvent deasphalting process, and vacuum residue. It is capable of recycling vacuum gas oil to extinction while converting residuum to distillate.

In order to convert coal to an acceptable substitute for petroleum, it is necessary to accomplish three things. Solid coal must be converted to a liquid by breaking up the large molecular structure; sulfur, nitrogen and oxygen contaminants must be eliminated; and ash must be removed.

The H-Coal® process is designed to directly meet the first two requirements. When coupled with a solids removal system the process will produce clean low-sulfur petroleum substitutes suitable for most types of hydrocarbon-based fuel and chemical uses regardless of the sulfur content of the coal used in the process.

In the H-Coal® process, coal is pulverized, mixed with a liquid derived from the process, then pumped into a reactor at 3,000 pounds per square inch pressure and a temperature of 850 degrees Fahrenheit. In the reactor this slurry is combined with hydrogen in the presence of a catalyst in what is known as an ebullating (agitated) bed. The liquid product derived from the process is then depressurized and fractionated into gases, liquids, and solids.

The ebullated bed reactor used in the H-Coal® process, shown in Figure 1, uses an upflow slurry of finely ground coal in oil and hydrogen to expand a catalyst bed; distribute slurry, gas and catalyst evenly across the reactor; and suspend the catalyst particles in random motion. This permits the system to operate under essentially isothermal conditions, while allowing optimum catalyst activity through the continuous addition and withdrawal of catalyst during operation. The expansion of the catalyst bed permits a moderate amount of inert solids to be present in the feed, and the isothermal bed eliminates the need for quench points. Ebullating action within the bed prevents dead spots and channels from forming and makes vapor-liquid redistribution devices unnecessary. The ebullating bed is unique to this technology in that it provides for continuous operation while permitting the removal of a portion of the spent catalyst and the addition of fresh catalyst to maintain constant conversion activity. The flexibility of the process, which has been demonstrated in the laboratory, also permits the use of bituminous, sub-bituminous, brown coals, and lignite. Moreover, it is anticipated that either a synthetic crude oil or power plant fuel can be manufactured as the primary product by simply adjusting the severity of treating in the process.

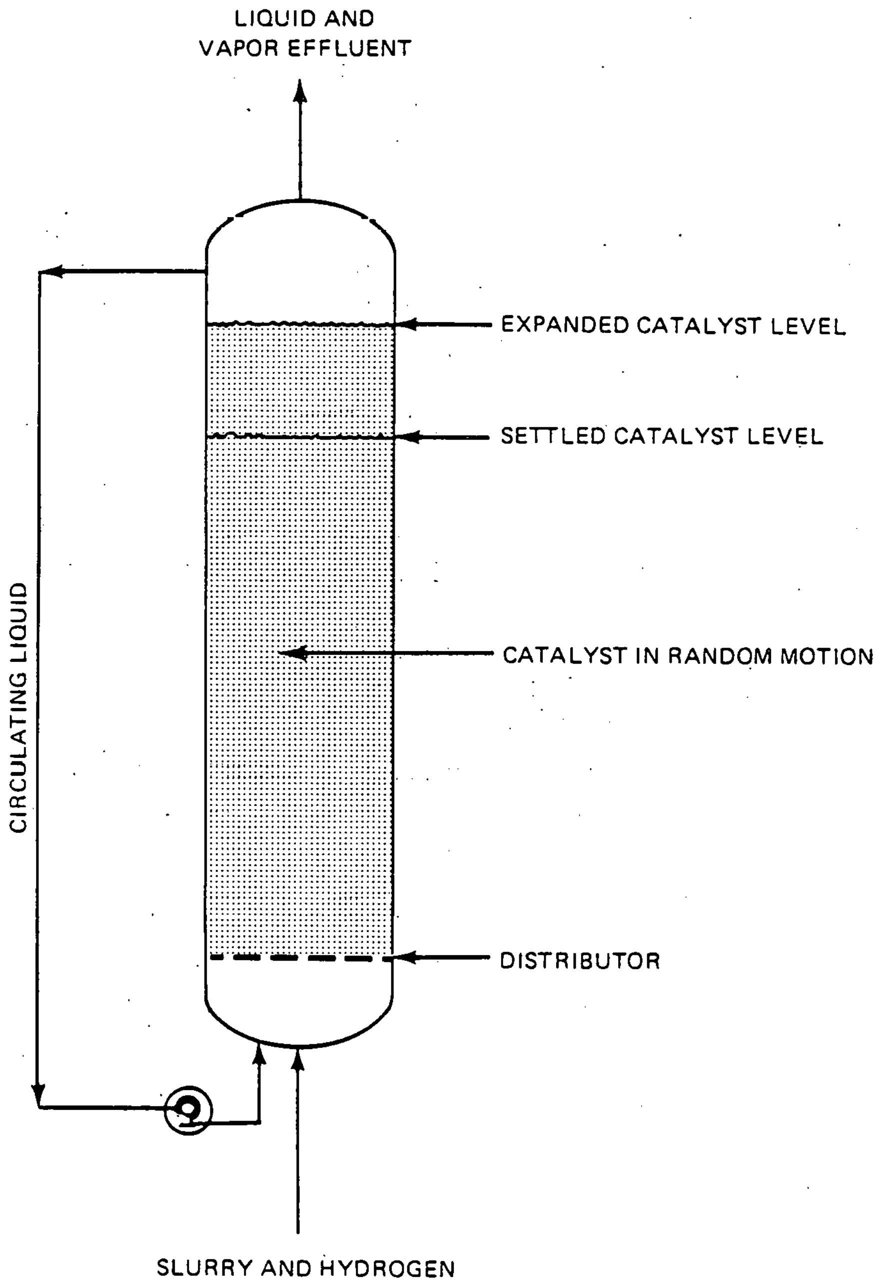
The versatility of the H-Coal® process is evident from the range of products. The synthetic crude (or syncrude) mode produces all distillate products. These either can be utilized in existing gasoline or fuel oil markets or they can be upgraded to such products as jet fuel, diesel, or petrochemicals. In the boiler fuel mode, the distillate products are minimized and heavy fuel oils are the main product.

The designs of the two operation modes are similar, except for the production of hydrogen. In the syncrude mode the heavy oil which contains ash is gasified to produce the hydrogen introduced at the beginning of the process. In the boiler fuel mode the heavy oil is further refined in a solids-liquid separation unit to produce an ash concentrate which is gasified for hydrogen production.

The Breckinridge Project will be the first commercial facility to use the H-Coal® process. It is based on more than seventeen years of development, from bench-scale and process development units through operation of a relatively large pilot plant. HRI initiated experiments on the process in 1964 with results sufficiently encouraging for the Office of Coal Research (OCR) to contract with them for a two million dollar, 3-year development program in early 1965.

Figure 1

THE EBULLATED-BED REACTOR



2.2 OFFICE OF COAL RESEARCH (OCR) PROGRAM

All work under the OCR contract was in the syncrude mode and was performed on two scales. The initial experiments were carried out in a bench-scale unit with a coal feed rate capacity of 25 lb/day. These units had the advantage of low inventory, quick start-up, rapid achievement of equilibrium following changes in conditions, and reasonably low operating labor costs.

The bench-scale unit program operated for over 8,000 hours in five different tests. These tests were as follows:

- Illinois No. 6 Coal (6,000 hours). Several experiments were involved
    - Catalytic cracker decant oil and anthracene oil, feed slurry oils which were not derived from coal, were tested for 2,800 hours. The most significant result was an improvement in conversion when hydrogenated anthracene oil was employed, probably as a result of a donor solvent effect
    - Space velocities of 15 to 45 lb/hr/ft^3 were evaluated
    - Process variable studies were conducted for 1,200 hours. Temperatures of 830°F to 860°F and pressures of 1,500 to 3,000 psi were evaluated
    - The effect of varying residuum content of feed slurry oil was tested for 1,000 hours. A vacuum column was used to vary the ratio of distillate to residuum in the slurry in order to demonstrate the effect of this ratio on yields
    - An alternate catalyst was studied for 1,000 hours. The nickel molybdenum catalyst available at that time was found to be no better than standard cobalt molybdenum
    - Evaluation of other process conditions were performed

- Wyodak Coal (1,550 hours). Yields were determined and compared with Illinois No. 6 coal
- North Dakota Lignite (550 hours). A yield comparison run was made
- Utah D Coal. A short yield comparison run was made
- Two-Stage Processing. A short run was made which employed PDU vacuum tower bottoms in place of coal feed to determine if a two-stage operation significantly enhances coal and residuum conversion

The flows derived from the bench-scale units were too small to sustain the continuous operation of product separation facilities that produce the slurry oil recycle streams envisioned for a commercial-scale unit. In addition, it was very difficult to control bed expansion on this scale and an internal screen was required in the bench-scale reactor. To overcome these limitations, a process development unit (PDU) capable of feeding up to 3 tons of coal per day was also developed and operated.

The PDU had several short runs before mechanical problems, due primarily to the erosive nature of the coal-oil slurry, were resolved. A 473-hour continuous run on Illinois No. 6 coal was then made, and the results provided a basis for correlating bench-scale and PDU yields.

Because the results of the first 18 months of the contract were highly successful, OCR requested that HRI submit a proposal for a 250 TPD pilot plant. This proposal was submitted on September 29, 1966. In September 1967, the contract was cancelled due to lack of funds.

2.3 INDUSTRIAL DEVELOPMENT WORK

From October 1967 to March 1968, HRI continued development work with its own funds. In March 1968, the Atlantic Richfield Company contracted with HRI for an enlarged research and development program. This program resulted in significant progress in H-Coal® process development and was concluded in 1970.

Following conclusion of this work, additional process variable studies in the syncrude mode were run on several coals in the bench units at constant temperatures and pressure. Space velocity and slurry composition were varied to determine conversion and yields for the following coals:

- Pittsburgh Seam - 1,400 hours of operation
- Texas Lignite - 1,200 hours of operation
- Black Mesa - 1,200 hours of operation
- Colorado - 1,400 hours of operation

In 1970, a 400-hour run was made on Australian Gelliondale brown coal. This proved to be a very reactive coal; conversions of over 80 percent were achieved, with less than 20 percent of the yield being residuum boiling above 975°F.

In early 1971 the boiler fuel mode of operation was demonstrated in a 716-hour bench unit run on Illinois No. 6 coal in a test jointly sponsored by HRI and the Atlantic Richfield Company. The test studied space velocities from 43.7 to 187.2 $lb/hr/ft^3$, pressures from 1,250 to 2,250 psi, and temperatures between 850°F and 875°F. The results were used to predict the conditions needed to arrive at a product with acceptable residuum and sulfur contents. An additional 2,000 hours on Illinois No. 6 coal confirmed these projections and tested other process improvements, such as the use of hydroclones to produce a high-residuum/low-solids recycle slurry oil and the effect of using a more coarsely ground coal feed.

HRI contracted with six major oil companies in 1972 and 1973 for financial support to accelerate the development of the H-Coal® process to a point where commercial-scale plants could be designed and built with confidence. HRI also conducted further bench and PDU development work at its Research and Development Center and performed further engineering studies and evaluations. Under industrial sponsorship, bench unit operations lasting almost 3,000 hours were carried out with Wyodak coal to determine yields and to test additional process features such as the use of coal dried with flue gas and the behavior of regenerated catalyst. A run of over 500 hours was made on Big Horn coal to verify its similarity to Wyodak coal.

The PDU was also operated during this period for almost 2,400 hours in the syncrude mode, which included 1,350 hours of operation on Illinois No. 6 coal and 1,050 hours on Wyodak coal. Recycle slurry oil was provided by both continuous product fractionation and the batch use of hydroclones on the reactor product slurry.

In summary, the bench-scale unit was operated for 1,600 days. Four bituminous coals, four sub-bituminous coals, and three lignites were tested, with Illinois No. 6 and Wyodak coals being the principal coals used. The PDU was operated for 174 days using Illinois No. 6 and Wyodak coals in the syncrude mode.

2.4 ERDA PILOT PLANT PROGRAM

In 1974 HRI entered into a contract (No. EX-76-C-011544) with the Energy Research and Development Agency (ERDA, now DOE) for further development of a program which would result in a large-scale pilot plant operation. This program had three phases. HRI continued the experimental work and PDU runs in Phase I and engineered a pilot plant. Phase II was to cover the construction of the pilot plant and Phase III its operation.

Phase I began in 1974 and had two objectives:

- PDU confirmation of key design features which involved
  - Demonstration of reliable operation
  - Resolution of any problems revealed in the PDU or engineering programs
- Detailed engineering design of a pilot plant which would operate in both the syncrude and boiler fuel modes, followed by procurement of equipment and a subcontract with ASFI for site preparation

The PDU design confirmation work was completed, with the following results:

- An operational demonstration in the boiler fuel mode which was an uninterrupted run to a catalyst life of 3,000 lb coal/lb catalyst (PDU Run No. 1)
- An operational demonstration of the boiler fuel mode at the high exit gas velocity that would occur in the pilot plant (PDU Run No. 2)
- A demonstration of the boiler fuel mode with high residuum concentration in the reactor (PDU Run No. 3)
- A demonstration of the syncrude mode with high residuum concentration in the reactor (PDU Run No. 4)
- Utilization of an on-line, continuous hydroclone system designed to achieve a high residuum concentration in the reactor (PDU Run No. 5). This run was used as the basis for process design for the pilot plant as well as the development phase of the Breckinridge Project
- Demonstration in the syncrude mode of an on-line antisolvent precipitation and settling system for solid-liquid separation
- Demonstration of improved reactor internals

The objectives of the PDU program were attained and the operability of the H-Coal® process was clearly demonstrated. HRI concluded that the process was feasible for scale-up to pilot plant size, that the design basis originally proposed for the pilot plant was adequate, and that no modifications were required.

Concurrent with the laboratory program, detailed engineering and equipment procurement were completed and site preparation work was started for the Catlettsburg, Kentucky, pilot plant. Environmental impact statements were prepared and permit applications filed.

In order to execute Phase II (Construction) and Phase III (Operations) of the Pilot Plant Program, ERDA (now DOE) entered into a contract with Ashland Synthetic Fuels, Inc. (ASFI) in 1976. ASFI was the management representative of a funding group which included the Commonwealth of Kentucky, the Department of Energy, the Electric Power Research Institute, Standard Oil of Indiana, Mobil Oil Company, Conoco Coal Development Company, and ASFI. The primary objective of the undertaking was to build and operate a pilot plant to convert 200 to 600 TPD of coal into as much as 1800 BPD of coal-derived liquid hydrocarbons.

Badger Plants, Inc. was selected as the construction contractor to install the pilot plant facilities adjacent to the Catlettsburg, Kentucky, refinery of Ashland Oil, Inc. Construction was initiated in December 1976. Adverse winter weather in 1977/1978 and in 1978/1979 delayed the work; however, operation of the pilot plant commenced in January 1980, and coal was introduced into the reactor in May 1980.

Several successful continuous runs of durations up to 130 days have been accomplished as of the date of this report and the viability of the process is clearly established. The 2-year program planned for Phase III is shown in Table 2.

The initial program of the Catlettsburg pilot plant may be completed prior to commencement of the detailed design of the commercial facility. However, the pilot plant will continue to be operated and will provide information that can be included in the final design and utilized in the equipment selection process. The purpose of the pilot plant is not to prove process operability (this was done at the 3 TPD PDU level), but to provide an engineering data base, an equipment testing facility, and confirm the yield structure. The size selected for the pilot plant was large enough to provide unquestionable scale-up factors for a commercial facility. The pilot plant program will also provide the data required for the final selection of construction materials and for the determination of routine maintenance and operability requirements.

The 200 to 600 TPD pilot plant feed rate may appear to be small compared with the 23,000 TPD feed rate of a commercial facility. However, the commercial facility will have eight multiple trains of parallel reactors and associated equipment, and scale factors must be compared relative to the rates anticipated in a single train. Comparable sizes of equipment for the H-Coal® pilot plant, the commercial-scale H-Coal® facility, and the Kuwait H-Oil® unit are given in Table 3. The H-Coal® scale-up factors for equipment are all well within sound engineering practice. Downstream equipment such as exchangers and columns are of conventional design. Furthermore, it should be noted that the sizes of the operational Kuwait H-Oil® unit and the planned H-Coal® commercial unit are nearly identical.

2.5 INITIAL EFFORT

On April 1, 1980, the United States Department of Energy, Ashland Synthetic Fuels, Inc., and Airco Energy Company, Inc. executed a Cooperative Agreement for an "Initial Effort" to design a commercial-scale

TABLE 2

PILOT PLANT PHASE III TECHNICAL MANAGEMENT PLAN

Year	Duration, Months	Space Velocity, lb/hr/ft	Operation Phase	Coal
1	3	-	Plant Shakedown	Oil (no coal)
	3	31	Break-in operation	Kentucky
	3	31	Syncrude Mode	Illinois
	3	31	Syncrude Mode	Wyodak
2	3	0-78	Start-up in Boiler Fuel Mode	Kentucky
	3	78	Boiler Fuel Mode	Illinois
	3	60	Intermediate Mode	Kentucky
	3	45	Intermediate Mode	Illinois

TABLE 3

EQUIPMENT SIZES FOR H-COAL® AND H-OIL® FACILITIES

Item	H-Coal® Pilot Plant	H-Coal® Commercial	H-Oil® Kuwait	H-Coal® Scale Factor
Reactor	5 ft	12 ft/train	13-1/2 ft	2.5
Heater tubes	4-1/2 inch	7 inch	5 inch	1.5
Charge pumps	100 GPM	600 GPM	1,200 GPM	5
Hydroclones	10 mm orifice each	10 mm orifice each	none	none

coal liquefaction facility using the H-Coal® process. This effort is now complete and the following primary objectives have all been achieved:

- Prepare a preliminary design of a commercial-scale facility
- Estimate the associated capital and operating costs
- Prepare an economic analysis of the commercial-scale facility
- Prepare a preliminary plan for the detailed engineering, procurement, construction, and operation of the commercial-scale facility
- Collect certain baseline environmental data

The participants engaged Hydrocarbon Research, Inc. (HRI), Bechtel, Inc., and Dames & Moore as subcontractors to perform the work. HRI developed the design for the six plants involved in the reaction and primary separation processes. Bechtel was assigned the primary responsibility for designing the remaining plants, preparing the capital cost estimate, preparing the project schedule, and developing the plan for the engineering, procurement, and construction of the commercial-scale facility. Dames & Moore collected the necessary baseline environmental data for the site and conducted preliminary soils investigations.

An ASFI project team directed and monitored the work of the three principal subcontractors. The team was also responsible for the operating cost estimate, the economic analysis, the financial plan, the technical audit, the management and operating plans for the project as well as the environmental, socioeconomic, safety and health aspects of the work.

Bechtel engaged five major subcontractors to execute certain highly specialized portions of the work. Roberts & Schaefer prepared the design for the Coal Washing plant. Airco provided the design for the Oxygen and

Cryogenic Hydrogen Purification plants. Davy McKee designed the Stack Gas Scrubbing plant. U.O.P. provided a preliminary process design for the Naphtha Hydrotreating and Reforming plant as well as feedstock characterization data for naphtha hydrotreating and reforming. Texaco provided the process information for the Texaco partial-oxidation gasifiers in the Gasification and Purification plant.

Concurrent with the Initial Effort, Ashland Synthetic Fuels, Inc. implemented the following activities:

- Selected a specific site for the commercial facility that has been dedicated to the Breckinridge Project by the Commonwealth of Kentucky
- Investigated coal supply sources and initiated negotiations with suppliers
- Conducted socioeconomic studies and held impact mitigation discussions with officials and leading citizens of communities near the facility site
- Submitted a preliminary application to the Synthetic Fuels Corporation for a government loan guarantee
- Initiated applications for the major construction and environmental permits
- Reviewed financial and technical aspects of the project with potential partners
- Developed a draft partnership agreement

These critical and other ongoing activities were all selected to support the primary objective of initiating engineering and procurement work on the Breckinridge Project in early 1982.

Prior to execution of the Cooperative Agreement, ASFI developed a very comprehensive definition of the scope of work for the Initial Effort that included an itemized list of the engineering drawings, narratives, and other descriptive materials or "deliverables" that were considered necessary to document the effort. This definition was included in the Cooperative Agreement.

The deliverables produced under the Initial Effort of the Cooperative Agreement are presented in eleven reports consisting of twenty-eight volumes. A summary of the reports can be found in Section 7.0 of this report.

The extensive development work performed over many years, bench-scale and PDU testing, the successful pilot plant operation, and completion of the Initial Effort provide a firm and adequate basis for proceeding immediately with the commercialization of the Breckinridge Project.

Site and Facility Description

3.0 SITE AND FACILITY DESCRIPTION

3.1 SITE

The Breckinridge Project site is located in Breckinridge County, Kentucky, along the Ohio River which forms the Kentucky-Indiana border. The site is about halfway between Louisville, Kentucky and Evansville, Indiana. This area of west-central Kentucky is characterized by the alluvial plain of the Ohio River giving way to steeply rolling hills on either side.

The dominant topographic features of this portion of the Ohio River valley were formed by glacial activity during the Pleistocene or glacial epoch. The site is located over a wide trench in the sandstone and shale bedrock that was eroded to about elevation 260 feet*. The channel was then filled with alluvial deposits of glacial sands and gravel and then overlaid with silty to clayey soils of glacial origin. Some localized minor deposits from flooding of the Ohio River has occured periodically since glaciation.

The site covers 1600 acres, of which about 70% is devoted to marginal farming operations. Heavy cropping of the site is not feasible due to poor soil conditions. The balance of the site is covered by hardwood forest. The general site plan located at the end of this section shows some of the topographic features of the site.

The Cannelton Dam and Locks, located some 16 miles downstream, control the Ohio River water level at the site to about 383 feet. Progressing east from the river, the site rises sharply to about elevation 400 feet at the top of the river bank and then gradually to elevation 415 feet at the branch line of the Louisville and Nashville Railroad, which is generally parallel with the river. The land then dips and rises

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*All elevations are referenced to mean sea level datum.

again to a mean elevation of 415 feet at Kentucky State Highway 144, which is parallel with the railroad. Much of the land between the highway and the river bank is within the river's 100 year flood elevation of 409 feet. East of the highway the land is gently rolling and gradually rises to a high point of 440 feet. Near the eastern property line, the contour rises sharply to above 600 feet.

A small stream called Town Creek is located in the southern part of the site. The main body of the creek is influenced by the pool elevation of the Ohio River. Tributaries which are generally dry ravines run away from the main creek in a northerly direction.

The project facilities will be installed primarily in the area north of Town Creek and east of the highway. Some facilities such as water handling and treatment will be installed between the river and the railroad and will be suitably diked from floods. Facilities on the river include water intake, coal barge receiving docks, and the product barge shipping dock. The navigation channel of the Ohio River is west of the center of the river and presents no interference with facilities located on the river. Since the channel is fairly straight, the river at the docking facilities will tend to be self-cleaning. The coal handling facilities will be located on the north part of the site, the main processing facilities in the middle, and tankage to the south. Solid waste disposal will be in an area located about 2 miles from the site proper.

The waste disposal areas are located on the Town and Bull Creek watersheds, east and southeast of the site. The major differences in the topography as compared to the main plant site are that the terrain is steeper and the bedrock is overlain by only 1 to 5 feet of soil in steeper areas and by 25 feet of soil in the flatter areas. Vegetation cover is also heavier.

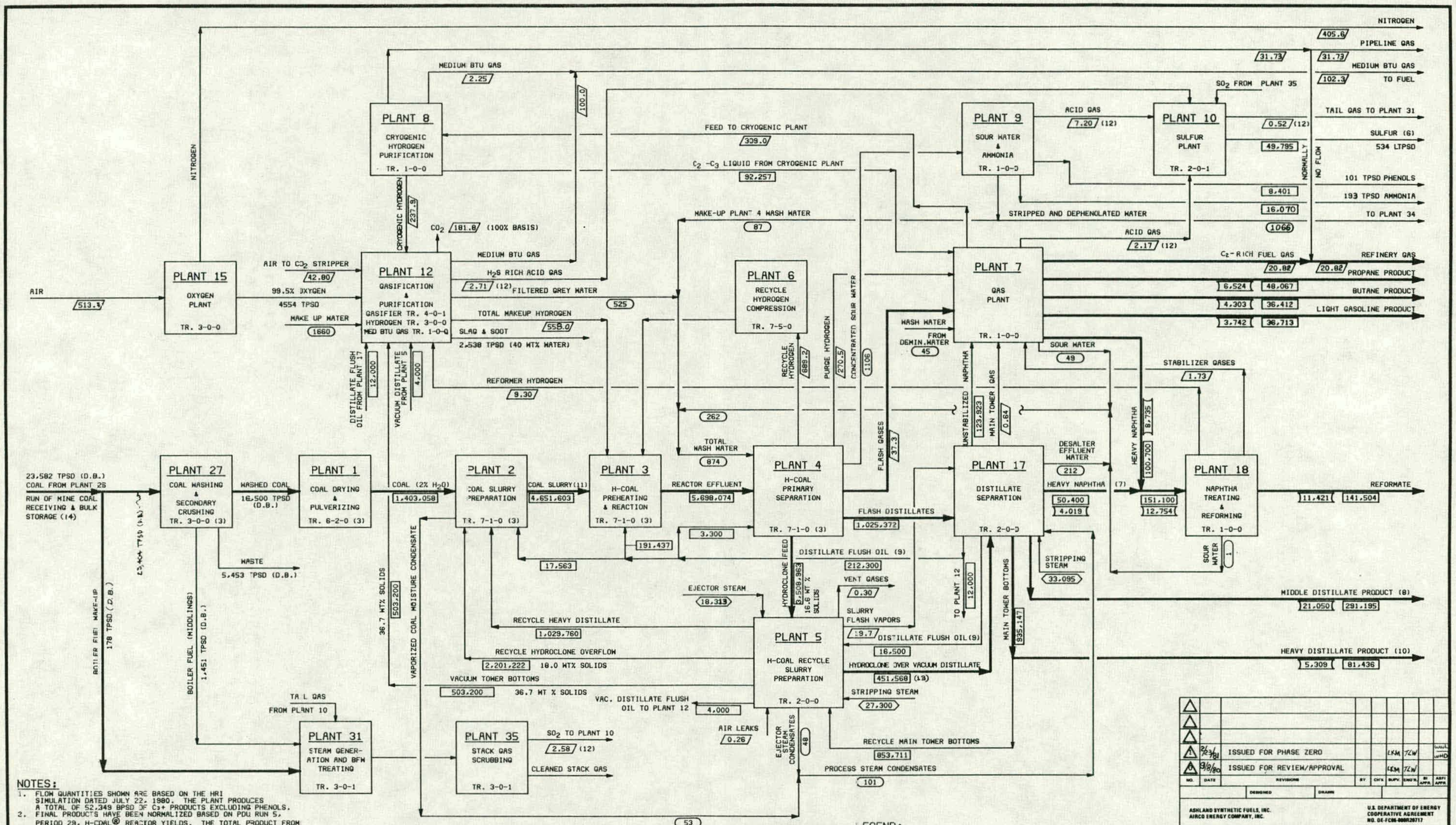
Due to the alluvial nature of the soils at the site, it is anticipated that extensive site preparation work will be required. It is expected that several feet of the silty clay soil will be removed, replaced, and recompacted to a level adequate to support roads and minor foundations that are not sensitive to settlement. Major equipment and structural foundations will be set on piling. The final grade of most of the facilities will be between elevation 415 and 420.

3.2 FACILITY

The Breckinridge Project facility consists of thirty-six distinct units which are identified as "Plants" throughout these reports. Of these plants, sixteen are identified as "Process Plants", which are those directly involved in the conversion of coal to liquid products and the processing of those raw materials into marketable products. The remaining twenty plants are "Offsite Plants" and "Utility Plants", which are those essential to the project but not directly involved in the liquefaction of the coal or production and purification of the products.

Most of the Process Plants and some of the other Plants contain either multiple lines of parallel facilities which are identified as "trains" or a group of parallel units that are interconnected to allow operation of selected units or trains. This flexibility allows the various trains or units to operate independently of each other and optimizes the on-stream factor of the project. Altogether, more than eighty operating entities can be identified within the project.

A very complete process and material flow description for each of the Process, Offsite, and Utility Plants, including detailed process flow diagrams and other pertinent data, is presented in Reports IV and V. The purpose of this report is to give a more condensed description of the preliminary process design basis for the Process Plants, and to describe the flow of material in Offsite and Utility Plants. The discussion of the plants also provides a description of key physical features. Reference to the Overall Block Flow Diagram Drawing 50-D-B-01 and the Overall Site Plant Drawing 50E-A-1, may be helpful in following the description.



NOTES:

1. FLOW QUANTITIES SHOWN ARE BASED ON THE HRI SIMULATION DATED JULY 22, 1980. THE PLANT PRODUCES A TOTAL OF 52,349 BPSD OF C_3+ PRODUCTS EXCLUDING PHENOLS.
2. FINAL PRODUCTS HAVE BEEN NORMALIZED BASED ON PDU RUN 5, PERIOD 29, H-COAL® REACTOR YIELDS. THE TOTAL PRODUCT FROM THE SIMULATION IS 1555 LB/HR LESS THAN THE TOTAL PDU YIELDS DUE TO COMPUTER CONVERGENT LIMITATIONS.
3. TRAIN NOS.(A-B-C) REPRESENT THE FOLLOWING:
   A = NO. OF OPERATING TRAINS,
   B = COLD SPARES,
   C = HOT SPARES.
4. D.B. = DRY BASIS.
5. SOUR WATER AND WASH WATER FLOW RATES ARE BASED ON 8 WT % SALTS IN CONCENTRATED SOUR WATER.
6. SULFUR BALANCE IS BASED ON THE ACTUAL SULFUR QUANTITY USED IN THE HRI SIMULATION AND BECHTEL HYDROGEN PLANT DESIGN. SULFUR PLANT DESIGN IS 540 LTPSD.
7. PLANT 17 HAS BEEN ADJUSTED TO GIVE A HEAVY NAPHTHA SIDEDRAW FROM THE MAIN TOWER BASED ON THE HRI SIMULATION DATED AUGUST 10, 1980.
8. MIDDLE DISTILLATE PRODUCT HAS BEEN REDUCED TO REFLECT THE PRODUCTION OF PHENOLS. PHENOLS MAY BE BLENDED INTO MIDDLE DISTILLATE IF THERE IS NO MARKET DEMAND.
9. FLUSH OIL RATES SHOWN ARE BASED ON 7/22/80 HRI SIMULATION. UPDATED RATES OBTAINED FROM PUMP VENDORS ARE GIVEN IN THE PLANT 39 DESIGN BASIS.
10. HEAVY DISTILLATE PRODUCT HAS BEEN REDUCED BY 14001 LB/HR FROM THE NORMALIZED PDU RATE TO COMPENSATE FOR ADDITIONAL FLUSH OIL REQUIRED.
11. FOR CONSISTENCY WITH 7/22/80 HRI SIMULATION, FLOW RATE NO. FOR THIS STREAM INCLUDES THE VAPORIZED COAL MOISTURE CONDENSATE.
12. FLOW RATES SHOWN ARE BASED ON SULFUR COMPOUNDS ONLY.
13. FLOW RATE SHOWN IS ADJUSTED FROM THE JULY 22 HRI SIMULATION TO MATCH THE ACTUAL DESIGN FLOW RATES FOR BOTH VACUUM TOWER BOTTOMS AND VACUUM DISTILLATE FLUSH OIL.
14. RUN OF MINE COAL FEED RATE SHOWN IS ON DRY BASIS. PLANT 27 DESIGN COAL INCLUDES 4% BY WEIGHT SURFACE MOISTURE PLUS 7% INHERENT MOISTURE FOR A TOTAL OF 11%.

LEGEND:

- Rectangle: LIQUID OR SOLIDS FLOW RATE, LBS/HR, WET BASIS
- Parallelogram: GAS FLOW RATE, MMSCFD
- Rounded box: PROCESS WATER OR SOUR WATER RATE, GPM
- Hexagon: STRIPPING STEAM, LBS/HR
- Bracketed box: BPSD, DRY BASIS

NO.	DATE	REVISIONS	BY	CH'K	SUPV.	ENG'R.	BI APPR.	ASFI APPR.
1	2/23/81	ISSUED FOR PHASE ZERO		LKM	TLW		WWL WHD
0	9/8/80	ISSUED FOR REVIEW/APPROVAL		LKM	TLW		

DESIGNED | DRAWN

ASHLAND SYNTHETIC FUELS, INC.
AIRCO ENERGY COMPANY, INC.

U.S. DEPARTMENT OF ENERGY
COOPERATIVE AGREEMENT
NO. DE-FC05-80OR20717

BRECKINRIDGE PROJECT

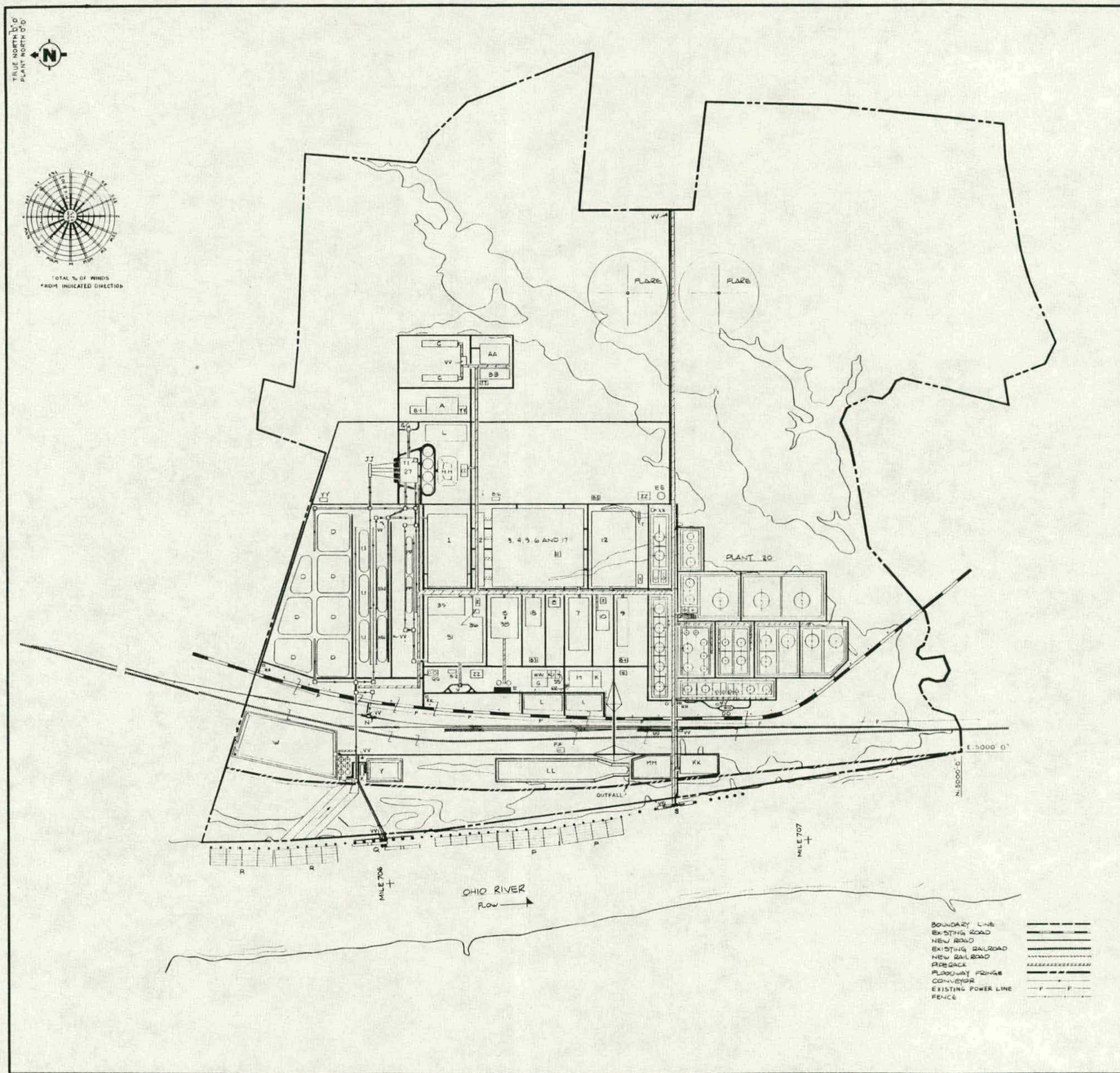
BRECKINRIDGE COUNTY | PHASE ZERO | KENTUCKY

OVERALL BLOCK FLOW DIAGRAM

BECHTEL HOUSTON | JOB NO. 14222 | DRAWING NO. 50-D-B-1 | REV. 1

22 X 34 "D" SIZE

KCL21G 05/07/81 MJ



LEGEND

1. COAL DRYING AND PULVERIZING
2 COAL SLURRY PREPARATION
3 H-COAL PREHEATING AND REACTION
4 H-COAL PRIMARY SEPARATION
5 H-COAL RECYCLE SLURRY PREPARATION
6 H-COAL RECYCLE HYDROGEN CONCENTRATION AND COMPRESSION
7 GAS PLANT
8 CRYOGENIC HYDROGEN PURIFICATION
9 SOUR WATER TREATING
10 SULFUR PLANT
12 GASIFICATION AND PURIFICATION
15 OXYGEN PLANT
17 DISTILLATE SEPARATION
18 NAPHTHA TREATING AND REFORMING
20 TANKAGE
21 INTERCONNECTING PIPING (PIPERACKS)
22 RIVER LOADING FACILITIES
23 RAIL AND TRUCK LOADING
26 COAL RECIEVING AND STORAGE
27 COAL WASHING AND SECONDARY CRUSHING
31 STEAM GENERATION AND B.F.W TREATING
32 WATER SYSTEM
33 FIRE SYSTEM
34 WASTE WATER TREATMENT PLANTS
35 STACK GAS SCRUBBING
36 INSTRUMENT AIR AND PLANT AIR SYSTEM
38 INERT GAS SYSTEM
39 PURGE AND FLUSH OIL SYSTEM
42 WASTE SLUDGE INCINERATOR

A WAREHOUSE
B-1 THRU B-6 MAINTENANCE BUILDINGS
C COOLING TOWERS (PLT 32)
D DEAD COAL (PLT 26)
E LIQUID OXYGEN AND NITROGEN UNLOADING
F WATER INTAKE
G CHANGE HOUSE
H FIRE STATION
J FIRST AID STATION
K CAFETERIA
L PARKING
M ADMINISTRATION
N RAILROAD COAL UNLOADING (PLT 26)
P FULL BARGES, 24 BARGE TOW (PLT 22)
Q COAL UNLOADING DOCK (PLT 22)
R EMPTY BARGES, 24 BARGE TOW (PLT 22)
S LIQUID LOADING DOCK (PLT 22)
T SWITCH GEAR | ZZ SUBSTATION
U RAW COAL (PLT 26)
V FLY ASH UNLOADING AREA (PLT 31)
W RAW WATER POND
X CSP RUNOFF TREATING AREA (PLT 34)
Y COAL STORAGE PILES (CSP) RUNOFF POND (PLT 34)
Z CONTROL ROOM
AA COOLING TOWER SOFTENING AND FILTRATION (PLT 32)
BB WASTE WATER CONCENTRATION AND EVAPORATION SYSTEM (PLT 34)
CC ASH HANDLING (PLT 31)
DD TANK TRUCK LOADING (PLT 23)
EE FIRE WATER TANK (PLT 33)
FF SANITARY SEWAGE TREATMENT PLANT (PLT 34)
GG REFUSE BUNKER (PLT 27)
HH EMERGENCY POND (PLT 27)
JJ PLANT FEED BUNKER (PLT 26)
KK POST TREATMENT OF STRIPPED SOUR WATER (PLT 34)
LL OILY WATER SURGE POND (PLT 34)
MM OILY WATER TREATMENT (PLT 34)
NN CLEAN COAL STORAGE (PLT 26)
PP BOILER FUEL STORAGE (PLT 26)
QQ SUMP AND TANK FOR INCINERATOR (PLT 42)
RR GATE HOUSE | VV OPERATOR SHELTER
SS GUARD/SECURITY HOUSE | WW LABORATORY
TT OPERATING EQUIPMENT ROOM | XX SPECIAL CLEANING
UU RAIL LOADING (PLT. 23) | YY GARAGE

NOTES

1 SITE COORDINATES N5000'0 E5000'0' ARE ESTABLISHED AT THE MOUTH OF TOWN CREEK AT THE INTERSECTION OF THE WATER LINE OF THE OHIO RIVER
II REFERENCE: COMMONWEALTH LAND TITLE INSURANCE COMPANY PHILADELPHIA PENNSYLVANIA FILE No. K-085292
2 HIGH POINT OF FINISHED GRADE ELEVATION 00'-0" EQUALS ELEVATION 415'-0" ABOVE M.S.L.
3. NORMAL WATER ELEVATION OF OHIO RIVER IS EL 382.3 AT RIVER MILE 706.
4. MEAN HIGHWAY ELEVATION IS EL. 415'-0"
5. TOP OF RAILROAD BALLAST EL. IS 415'-0"

REFERENCE DRAWINGS

50E-A-4 INDEX DRAWING
50E-A-6 CONSTRUCTION REQUIREMENT STUDY

0 200 400 600 800 1000
1"=400'-0"
GRAPHIC SCALE

NO	DATE	REVISIONS	BY	CHK	SUPV	ENGR	PJ APPR	ASPT APPR
△								
△								
△								
△1	1/29/81	ISSUED FOR PHASE ZERO	RP	JK	JK	HS		
△0	4.4.80	ISSUED FOR REVIEW AND APPROVAL	R	JK	JK	MP HS		

SCALE 1"=400' | DESIGNED J. KUTLIK | DRAWN T. ROBERTSON

ASHLAND SYNTHETIC FUELS, INC.
AIRCO ENERGY COMPANY, INC.

U.S. DEPARTMENT OF ENERGY
COOPERATIVE AGREEMENT
NO. DE-FC05-80OR20717

BRECKINRIDGE PROJECT

BRECKINRIDGE COUNTY | PHASE ZERO | KENTUCKY

OVERALL SITE PLAN

HOUSTON

JOB NO.	DRAWING NO.	REV
14222	50E-A-1	1

34 X 44 "E" SIZE

Process Plants

4.0 PROCESS PLANTS

4.1 COAL RECEIVING AND STORAGE - PLANT 26

The Coal Receiving and Storage plant contains most of the facilities for receiving, unloading, transporting, and storing the 23,000 tons of coal that is processed daily by the project. The design of the coal unloading facilities allows for receipt of coal by either rail or barge.

Rail shipments are received in unit trains of approximately 100 cars each, containing about 10,000 tons of coal per train. The trains move slowly across a series of receiving hoppers. An automated tripper opens the rapid discharge gates on the rail cars and the coal drops into the hoppers by gravity. The train movement, car spotting, and car dumping are automated so as to require minimum operator attention. A unit train can be unloaded in 4 to 5 hours. The design basis allows for an average of two and one-half trains to be unloaded per day during two shifts.

The receiving hoppers are located below grade and are equipped with grizzlies. The coal is discharged from the hoppers through vibrating feeders onto a 3,000 TPH conveying system which transports the coal to the storage area feed conveying system.

Barge shipments are received in tows of twelve barges with each barge having a capacity of 1500 tons of coal. Provision is made for docking both full and empty barges. A work tug moves the barges in and out of the unloading position. The barges are unloaded with a bucket wheel unloader having a maximum capacity of 5,000 tons per hour. In the unloading position, the barges are moved back and forth beneath the unloader under control of an operator. The unloader scoops the coal out of the barge and feeds it to a belt conveyor with a rated capacity of 5000 tons per hour which discharges into a surge bin. The unloading requires two passes of the barge. The second pass is a clean-up operation and the rate is much slower than in the initial pass. The average unloading rate is about 2,800 tons per hour or one tow per shift.

The surge bin serves to control variations in the unloading rate. A vibrating feeder feeds a conveyor which in turn transports the coal to the coal storage area feed conveyor system at a rate of 3,000 tons per hour. As previously mentioned, coal from the rail or barge unloading facility is transported by separate conveyor systems to discharge points on the coal storage area feed conveyors. The coal is then transported by either of the two 3,000 TPH conveyors in this system to the coal storage area. The longest conveyor run in the entire feed system is about 2000 feet. Tramp iron magnets for separating scrap iron and provisions for weighing and sampling the coal are included in the design of the coal conveying systems.

The coal storage area includes "live" and "dead" storage. The live or working piles contain some 90,000 tons each and occupy a rectangular area of some 48 acres that is approximately 2300 feet long and 900 feet wide. Three live piles are used to provide surge capacity between coal unloading operations and the coal washing operation. Since coal will be received from at least three different sources with different ash contents, the live piles can also permit segregation by source, and, if desirable, each of the individual piles can be further subdivided to permit segregation of coal from additional sources. Each live pile is about 500 feet long, 100 feet wide, and 50 feet high.

The dead storage piles, which occupy an irregular space of some 42 acres, are intended to offset interruptions in the delivery of coal due to adverse weather conditions, floods, labor difficulties, and other unusual occurrences. The dead storage piles contain sufficient coal to sustain the plant for fifty days. This amounts to about 850,000 tons of washed coal, or the equivalent of 1,250,000 tons of run-of-mine coal. The finished surfaces of the piles are treated to limit the penetration of air and moisture and thus reduce wind loss, degradation, and the possibility of spontaneous combustion. The combined dead and live coal storage capacity is equivalent to approximately sixty days of the requirements of the facility.

The coal storage area feed conveyor can discharge to either the stacker-reclaimers in the live pile areas or to auxiliary stackers in the dead coal storage area. Both types of equipment deliver the coal by means of adjustable inclined-belt conveyors. The stacker-reclaimer reclaims coal by means of a bucket-type conveyor which is also inclined and adjustable.

The reclaimer arm of the stacker-reclaimer recovers the coal from the live piles and delivers it to a belt conveyor system with a capacity of 2,400 tons per hour. Coal in dead storage is reclaimed with mobile equipment such as bulldozers and front-end loaders. When reclaiming, the coal is pushed to reclaim hoppers that discharge back to the belt conveyor system described above.

The belt conveyor system provides considerable flexibility. The coal from the live piles can be delivered to the Coal Washing plant, or can bypass that plant and go to either the Coal Drying and Pulverizing plant or the Steam Generation and Boiler Feedwater Treating plant.

The plant design allows the Coal Washing plant to operate on either a single grade of coal or on a blend of two or more grades, depending on the characteristics of the coal. If blending is required, a portion of one of the live piles is converted to a blending pile. By feeding the stacker-reclaimer alternatively from the various segregated coal piles, a blended pile is constructed of thin layers of each of the grades being blended. When the reclaimer cuts through these layers transversely, it delivers a suitably blended product to the coal washing facilities. Any prewashed coal that is received can be segregated in the live piles, routed to bypass the washing facilities, or blended with other grades for further washing. Subject to the capacity of the coal washing facilities, all coal is washed as soon as possible after it is received and then stored in either the live or dead piles.

4.2 COAL WASHING - PLANT 27

The Coal Washing plant is fed by run-of-mine coal which will be washed to reduce its ash and pyritic sulfur content prior to being fed to other Process Plants. Three products are generated - a low ash clean coal, a middlings coal that has a higher ash content and is used as boiler fuel, and a waste product consisting of refuse.

The plant will be designed with three parallel trains, each having a design throughput capacity of 600 tons per hour. Maximum capacity of each train is 700 tons per hour. The desired end products are 16,500 TPD of clean dry coal and 1850 TPD of middling coal for boiler fuel.

Plant coal feed is provided by a feed bunker with a capacity of 2500 tons. The bunker has several outlets discharging onto individual vibratory feeders which in turn discharge onto separate plant feed belt conveyors. The bunkers are 435 feet from the main coal washing building and discharge coal onto the plant feed conveyors just above grade level. The conveyors then rise some 115 feet to their entry point at the top of the main building.

The coal is fed onto a raw coal screen that separates the coal into 3/8 x 0 and 3 x 3/8 inch portions. The 3 x 3/8 inch portion is passed across a prewetting screen and then into primary heavy media vessels where the low-ash coal (coal with a specific gravity of less than 1.40) is floated out, washed on a screen, crushed to 1-1/2 x 0 inch and fed to the Coal Drying and Pulverizing plant by conveyor. The heavier material from the primary heavy media vessel underflows to the secondary heavy media vessel where the middlings (coal with a specific gravity of 1.4 to 1.6) are floated out, washed on a screen and crushed to 1-1/2 x 0 inch and fed to the Steam Generation and Boiler Feedwater Treating plant by conveyor.

The underflow from the secondary heavy media vessel is screened and washed and the coarse refuse (material that is 3 x 3/8 in size) is then conveyed to a 500 ton truck loading bin. The bin discharges through vibratory feeders which dump the refuse into trucks for disposal in the solids waste disposal area.

The 3/8 x 0 inch fines from the raw coal screens are screened and washed on desliming screens. The 3/8 inch x 28 mesh fraction from the desliming screens is separated from the reject material in primary heavy media cyclones. It is then screened, washed, centrifuged, and fed by the clean coal conveyor to the Coal Drying and Pulverizing plant.

The underflow from the primary heavy media cyclones is screened, washed, and the middlings separated in the secondary heavy media cyclones. These fine middlings are then screened, washed, centrifuged, and discharged to the conveyor carrying the coarser middlings to the Steam Generation and Boiler Feedwater Treating plant.

The 28 x 0 mesh material from the desliming screens is separated from the wash liquor in primary and secondary hydroclones, fed to flotation cells and filtered. The fine coal in the primary hydroclone overflow is separated in classifier cyclones, washed, and centrifuged. Both coals are then discharged to the clean coal conveyor and transported to the Coal Drying and Pulverizing plant.

The separated dilute heavy media slurry is collected, centrifuged, and thickened before being recirculated. Magnetite is added to the thickener as required to adjust the density of the heavy media.

A thickener removes the refuse from the water used in washing the fine coals. Underflow refuse material from the primary and secondary heavy media cyclones is screened, washed, collected in sumps, and pumped to a mixing facility for disposal.

The plant occupies an area of about 20-1/2 acres located between the cooling towers and the Coal Drying and Pulverizing plant. The coal washing equipment is installed in a multistory building approximately 160 feet by 280 feet and 80 feet high. An adjacent service building contains offices, change rooms, a maintenance shop, electrical equipment, and similar facilities. Each of the three coal washing trains is a complete entity and can be operated independently. Each train occupies three bays of the building in one direction and eight bays in the other. A service bay is provided between adjacent trains. The raw coal screens; the classifying, primary heavy media, and secondary heavy media cyclones; and the magnetite thickener overflow head tank are located on the sixth floor of the building. The prewetting screens and primary heavy media vessels are mounted on the fifth floor. The small clean-coal screens, the secondary heavy media vessel, the coarse middlings screen, the primary rejects screen, the small refuse screen, the small middlings screen, the magnetite separators, and the magnetite bin are located on the fourth floor. The third floor supports the clean-coal centrifuges, the clean-coal filter, the three desliming screens, refuse screen, coarse middlings crusher, and small middlings centrifuge. The top of the magnetite thickener also extends through this floor. The primary cyclones, the middlings transverse conveyor, the cyclone magnetic separators, the vessel magnetic separators, and the magnetite thickener are located on the second floor.

The ground floor contains the clean-coal, coarse refuse, and boiler fuel conveyors; two rows of sumps and tanks with pumps; air compressors; the gland water tank; the vacuum pumps; and the filter blower. The large (130-foot diameter) static thickeners and the emergency pond are located outside the building.

4.3 COAL DRYING AND PULVERIZING - PLANT 1

The clean coal must be dried and pulverized prior to being slurried for the reaction process. These steps are accomplished in the Coal Drying and Pulverizing plant. The end product of this plant is a pulverized coal containing less than 2% moisture and with a consist of 99.5% passing a 28 mesh screen and 50% passing a 200 mesh screen. The plant contains eight trains (six in operation and two spares) with a nominal capacity of 16,500 TPD of coal on a dry basis. This provides adequate standby capacity for the slurrying operation. The plant operates on a continuous basis.

The plant occupies an area about 1000 feet by 600 feet located adjacent to the Coal Slurry Preparation plant between the coal washing facilities and the boilers. The incoming feed conveyors deliver the coal to any one of eight elevated pulverizer feed bins. The bins are located in a row and each has a capacity of 500 tons. Coal can be delivered from either the storage area or directly from the Coal Washing plant. A weigh feeder beneath the silo controls the rate of feed to a pulverizer/dryer system. A pulverizer is located beneath each bin and is swept by hot air from a direct-fired air heater, allowing for concurrent pulverizing and drying. The hot air and pulverized coal are pulled through a cyclone by a main exhaust fan. The cyclone separates most of the coal from air. The air is then recycled to the air heater. A portion of the air exiting the cyclone is bled through a bag filter to atmosphere to prevent build-up of moisture in the circulating air stream. Each pulverizer system is rated at 130 TPH.

The pulverized coal that has been separated in the cyclone or discharged from plant bag houses is fed by an air slide conveyor to a coal dust bunker. There are four of these bunkers, each fed by two of the coal drying and pulverizing lines. Fluidizing pads in the bottom of each coal dust bunker aid the flow of coal to three pneumatic pumps which are mounted beneath each of the bunkers. One of these pneumatic pumps is a spare; a diverter valve enables it to be substituted for either of the other two in case of need. The pneumatic pumps deliver the coal to a service bunker for each of the eight downstream slurry trains. Diverter valves permit an individual pneumatic pump to deliver coal to one of four downstream slurry trains, with the result that each of the eight downstream trains can be fed from two of the coal dust bunkers, thereby providing the system with both surge capacity and flexibility. The service bunker feeds to the premixer through a weigh hopper which controls the feed rate both accurately and uniformly. The hopper also has provisions for varying the feed rate as desired.

A nitrogen compressor furnishes motivating gas for the pneumatic pumps and the fluidizing pads in the bottom of each of the four coal dust bunkers. Nitrogen also serves to blanket the dust bunkers and the downstream service bunkers. It is returned to the compressor from these various points of usage after first passing through a baghouse and blower. The coal dust bunkers are vented through a baghouse mounted on each bunker.

4.4 COAL SLURRY PREPARATION - PLANT 2

In the Coal Slurry Preparation plant, the pulverized coal is mixed with recycled oil from downstream plants to form a slurry for feed to the H-Coal® Preheating and Reaction plant. There are eight trains in the Coal Slurry Preparation plant, each of which operates independently of the others but in series with a train of the downstream H-Coal® Preheating and Reaction plant.

The eight trains in the plant occupy an area about 260 feet by 1,000 feet. The trains are identical except that they are arranged in opposite-hand pairs. Piperacks are located across the feed end of the area and between each pair of trains. The main equipment is mounted in a steel structure.

Beginning at the feed end of a train, the first equipment encountered is the air-cooled prewetting oil cooler mounted above the piperack. Past this fin fan are the elevated pulverized coal surge bin and weigh feeder which are actually a part of the preceding Coal Drying and Pulverizing plant. Beneath the bin and feeder is the coal prewetting feed conveyor which runs horizontally at an elevation of about 100 feet above grade into the side of the slurry vortex mix tank. This mix tank delivers the slurry into the slurry surge tank mounted in the next bay, some 20 feet above grade. The slurry surge tank overhead condenser is mounted at the upper elevation in the last bay. The slurry surge tank overhead receiver is mounted at about 40 feet above grade. The scrubber overhead receiver is located beneath the surge tank. Pumps are mounted at grade between the structure and the piperack. The hydroclone overflow emergency cooler is located at grade outside the structure on the side away from the piperack, and the noncondensibles knockout drum is mounted at grade at the end of the structure.

The coal for each train is discharged from a 500 cubic foot service bunker alternately onto one of two weighing devices. The coal is 99.8% minus 28 mesh in size, contains some 2% moisture, and is at 170°F. It is mixed with two recycle oil streams recycled from downstream plants. One of these streams is hydroclone overflow from the H-Coal® Recycle Slurry Preparation plant that contains unconverted coal and residue ash in a heavy residuum containing oil at about 700°F. The second oil stream is a blend of vacuum tower overhead liquid product from the H-Coal® Recycle Slurry Preparation plant and fractionator bottoms from the H-Coal® Distillate Separation plant. This second stream is free of solids and is cooled as necessary to control the temperature of the coal-oil mixture.

Slurry preparation consists of prewetting and mixing. The prewetting occurs in a twin screw mixer in which the blended oils from the vacuum stripper and fractionator, which have been cooled to 130°F, are sprayed on the pulverized coal as it is being turned over in the mixer. This mixture is then fed into a tank where it is mixed with the hydroclone overflow oil. Inside the tank there is an open-top vortex mixer in which the oil and coal are violently agitated by a high-speed agitator. The mixture forms a vortex, overflows the vortex section, and flows through the space between the inner and outer vessel and then out through a bottom opening which is connected to the slurry surge tank. Cooled blended oil is sprayed around the top of the mixing tank and uncooled blended oil is sprayed on the walls of the tank to wash down the dust. This operation washes the entire contents from the mixing operation into a slurry surge tank which contains a top-mounted agitator and baffles to keep the mixture thoroughly slurried. The surge tank is vented to a fired heater in the H-Coal® Preheating and Reaction plant through a scrubber where vapors are thoroughly contacted by the remaining portion of the hot blended oil from the vacuum tower and fractionator. This scrubbing oil drains into the slurry surge tank.

Nozzles, equally spaced about the bottom of the slurry surge tank, feed the slurry to three centrifugal slurry booster pumps which, in turn, feed the high-pressure reciprocating reactor feed pumps in the H-Coal® Preheating and Reaction plant. Two of the booster pumps operate in parallel and the third is a spare. The pumps have sufficient capacity so that about one-third of the pumped slurry is returned to the slurry surge tank. This enables the reactor feed pumps to take suction from a circulating stream and eliminates dead ends that would permit the solids to settle out of the slurry.

The hot oils in the slurrying operation flash off any moisture remaining in the coal. The resulting coal and oil slurry contains about 38.5% solids of which 30% is fresh coal and the remainder is ash and other solids.

4.5 H-COAL® PREHEATING AND REACTION - PLANT 3

In the H-Coal® process, a slurry of finely pulverized coal and recycle oil is reacted with hydrogen in the presence of a catalyst at high temperature and pressure to produce liquid and gaseous products. The primary process steps in the H-Coal® Preheating and Reaction plant consist of raising the slurry to reactor pressure, preheating the feed streams, and reacting the feed. The plant has eight identical parallel trains which are constructed in opposite-hand pairs.

The H-Coal® Preheating and Reaction plant occupies an area about 1,000 feet by 560 feet. Each train is served on alternate sides by a unit piperack and an access road. The first equipment at the feed end is a row of large positive displacement slurry feed pumps. The air-cooled exchanger for the cooling medium of the pump transmissions is mounted above the piperack. Beyond the feed pumps is a large rectangular slurry heater and a vertical, cylindrical hydrogen heater. The boiler feedwater drum and the pumps that feed boiler feedwater to the convection coils in the hydrogen heater are located between the heaters and piperack. A transverse road used by trucks transporting fresh or spent catalyst is encountered after the heaters. The reactor structure is next in line. It is a heavy-walled cylindrical vessel mounted vertically in a steel structure with the reactor base some 64 feet above grade. The structure above the reactor extends approximately 195 feet above grade. This structure supports the various equipment used in charging and discharging the catalyst including a catalyst feed hopper, catalyst withdrawal and feed drums, as well as a tank, pump, and exchanger for the oil used as a transport medium in the transfer operation. Beyond the reactor structure is a heavy-walled product separator, which is mounted vertically approximately 30 feet above grade. In the same bay with the product separator are five drums and two pumps used in cooling the two-phase product from the reactor product separator. In the next bay reactor effluent exchangers are mounted near grade. At a higher level are two waste heat boilers and the closed-loop hot oil exchangers. Also located in this bay is the intermediate-pressure slurry flash drum of the H-Coal® Primary Separation plant which is described in the following section.

The coal and oil slurry is raised to the reactor pressure by high-pressure reciprocating pumps. Each of the eight trains has three slurry feed pumps, two of which are operated in parallel with the third serving as a spare. The feed pumps take suction from a slurry circulation line from the Coal Slurry Preparation plant and pump the slurry through the slurry heater and into the reactor. The slurry feed pumps are driven by constant speed motors through a variable speed hydraulic coupling and a gear reducer. Before the slurry enters the preheater, a small stream of hydrogen is fed into the slurry stream. This hydrogen stream serves to promote heat transfer and to improve flow characteristics of the stream in the heater. The slurry heater in each train is a direct-fired box type with an air preheat system. The slurry is pumped through coils in the radiant section. Further heat efficiency is achieved by generating steam in the convection section. The outlet slurry temperature is controlled somewhat below the reactor temperature so that the heat of reaction generated in the reactor is balanced by the sensible heat absorbed by the slurry after entering the reactor.

The hydrogen feed stream is a combination of hydrogen recycled from the downstream separation of the reaction products and make-up hydrogen which is generated in partial-oxidation gasifiers in the Gasification and Purification plant. The hydrogen for the reaction is preheated by heat exchange with the reactor effluent vapor before being fed to the hydrogen heater. The hydrogen heater is a fired, vertical, cylindrical heater and the hydrogen is heated in its radiant section coils. Thermal efficiency is improved by generating steam in coils in the lower portion of the convection section. Above the steam coils are additional coils for preheating the boiler feedwater used to generate steam in both the hydrogen and slurry heater convection sections. A boiler feedwater and steam separating drum is provided and the steam generated in the two heaters is fed to the 600-pound steam system.

The slurry and hydrogen streams are fed to the bottom of the reactor through separate nozzles. The reactor is charged with a bed of catalyst. The hydrogen and coal react in the presence of the recycled oil and catalyst at a temperature of 850°F and a pressure of 3,000 psi. The ebullating effect is caused by the upward flow of the feed streams and by a recycle stream through the catalyst. An ebullating pump is mounted below the reactor and recycles liquid from the top to the bottom of the reactor from where it passes up through the catalyst at a controllable rate. This upward flow also expands the catalyst bed. Since the catalyst has a higher settling velocity than the coal or the recycled solids in the oil, the catalyst bed can be expanded by controlling the ebullating pump rate until all of the catalyst is suspended above the bottom of the reactor in a constantly agitated, or ebullated, state. The height of the ebullating catalyst bed can be precisely controlled by varying the pump speed.

The ebullation effect allows intimate and repeated contact between the catalyst and the reactants. This results in a smooth reaction in which there is very little temperature differential across the reactor as the exothermic heat of the reaction raises the coal slurry feed stream to the reaction temperature.

A unique feature of the ebullated bed reactor is that fresh catalyst can be added to the reactor and spent catalyst removed without interruption of normal operations.

The reaction products, which contain only small traces of catalyst, overflow from the top of the reactor to a product separator which operates at essentially reactor pressure. The gases and light hydrocarbons flow from the top of the product separator and, after heat exchange with the incoming hydrogen feed stream, are fed to the downstream H-Coal® Primary Separation plant. The heavy oil which contains unreacted coal, ash, and other solids is also fed to this plant as a separate stream.

4.6 H-COAL® PRIMARY SEPARATION - PLANT 4

The system of eight parallel processing trains continues through the H-Coal® Primary Separation plant where the two reactor effluent streams are further separated by pressure let-down and/or cooling, followed by flashing and separation. The seven main streams exiting from this plant and their next destination are as follows:

- Stream #1 - high-pressure, hydrogen-rich gases to the H-Coal® Recycle Hydrogen Compression plant
- Stream #2 - high-pressure, hydrogen-rich purge gases to the Gas Plant
- Stream #3 - medium-pressure hydrocarbon vapors to the Gas Plant
- Stream #4 - low-pressure, high-temperature slurry to the H-Coal® Recycle Slurry Preparation plant
- Stream #5 - low-pressure, high-temperature heavier distillate to H-Coal® Distillate Separation plant
- Stream #6 - low-pressure hydrocarbon vapors to the Gas Plant
- Stream #7 - low-pressure, low-temperature lighter distillate to the H-Coal® Distillate Separation plant

This plant is essentially a continuation of the H-Coal® Preheating and Reaction plant, and occupies an area of 1,000 feet by 390 feet. The eight flash drums involved in each train vary in diameter from 4-1/2 feet to 9-1/2 feet and in length from 13-1/2 feet to 29 feet. The two slurry flash drums are vertical and all others are horizontal. Beginning at the feed end of a train, the first equipment is the intermediate-pressure slurry flash drum mounted in the first bay along with the final exchangers of the H-Coal® Preheating and Reaction plant. The low-pressure slurry flash drum is located in the second bay adjacent to the piperack beyond which is a structure that contains the reactor effluent vapor exchanger, the intermediate-pressure vapor/hot distillate exchanger, the low-pressure vapor/hot distillate exchanger, and the intermediate-pressure waste heat boiler. The final reactor effluent vapor/hot oil exchanger of the H-Coal® Preheating and Reaction plant and the high-pressure warm flash drum are located at the ground level of this structure. The next four bays contain a structure supporting four overhead air-cooled exchangers. The first two of these bays contain the reactor effluent vapor condenser overhead with the low-pressure warm flash drum beneath it. The intermediate-pressure warm flash drum and the high-pressure cold flash drum are located at grade. The low-pressure cold flash drum is supported in the structure in the second bay and the intermediate-pressure cold flash drum is mounted at grade. The third bay contains the reactor vapor effluent condensate cooler overhead, and the sour water surge drum is mounted in the structure beneath it. The last bay contains the intermediate-pressure warm flash condenser, the low-pressure gas cooler, and the wash water receiver.

A tabulation of flash drums located in this plant is listed below.

- The high-pressure warm flash drum and the high-pressure cold flash drum that handle the vapor stream from the reactor to produce streams #1 and #2
- The intermediate-pressure warm flash drum and the intermediate-pressure cold flash drum that produce stream #3 from the slurry intermediate-pressure flash vapors

- The intermediate-pressure slurry flash drum and the low-pressure slurry flash drum handle only the liquid stream from the reactor and produce stream #4
- The low-pressure warm flash drum and the low-pressure cold flash drum produce streams #5, #6, and #7 from low-pressure slurry flash vapors

The vapor stream from the reactor is cooled to 550°F in an exchanger in the H-Coal® Preheating and Reaction plant. It is separated in the H-Coal® Primary Separation plant by flashing in the high-pressure warm flash drum. The vapor is then further cooled to 374°F by exchange with the hydrogen feed stream which feeds the H-Coal® Preheating and Reaction plant. Following this exchange the vapor stream is mixed with water to prevent precipitation of inorganic salts and is further cooled to 130°F in an air-cooled exchanger. The stream is then flashed in a high-pressure cold flash drum, and the vapor stream is split into streams #1 and #2.

The condensate from the high-pressure warm flash drum is cooled to 130°F in an air-cooled exchanger and combined with the reactor liquid stream. The condensate from the high-pressure cold flash drum is let down to 715 psi and fed to the intermediate-pressure cold flash drum.

The liquid stream from the reactor is let down in pressure to 735 psi and quenched with the cooled condensate from the high-pressure warm flash drum described above. The quenched stream is then separated in the intermediate-pressure slurry flash drum. The resulting vapor stream is cooled to 550°F by exchange with the downstream low-pressure, high-temperature distillate (stream #5), and then flashed in the intermediate-pressure warm flash drum. The vapor from this flash is cooled to 130°F in an air-cooled exchanger after water injection to prevent deposition of inorganic salts. This stream and the condensate from the high-pressure cold flash drum is then flashed in the intermediate-pressure cold flash drum. The resulting medium-pressure hydrocarbon vapors constitute stream #3.

The bottoms from the intermediate-pressure slurry flash drum are let down to 75 psi and fed to the low-pressure slurry flash drum. The low-pressure, high-temperature bottoms from this drum constitute stream #4. The condensate from the intermediate-pressure warm flash drum is let down to 60 psi and fed to the low-pressure warm flash drum. Condensate from the intermediate-pressure cold flash drum is let down to 50 psi and fed to the low-pressure cold flash drum.

The vapor stream from the low-pressure slurry flash drum is the second stream cooled by exchange with the low-pressure, high-temperature distillate (stream #5) whose temperature is thereby increased. The vapor stream then passes through a waste heat boiler where it is cooled to 450°F by generation of 150 psi steam. This stream and the 60 psi condensate from the intermediate-pressure warm flash drum are then flashed in the low-pressure warm flash drum. The resulting condensate constitutes the low-pressure, high-temperature, heavier distillate stream #5.

The vapor stream from the low-pressure warm flash drum is cooled to 130°F in an air-cooled exchanger and, along with the 50 psi condensate from the intermediate-pressure cold flash drum, is flashed in the low-pressure cold flash drum. The resulting streams constitute the low-pressure, hydrocarbon vapor stream #6, and the low-pressure, low-temperature, light distillate stream #7.

Water separation boots are provided on the three low-temperature flash drums and the low-pressure warm flash drum. Separated water is collected in the sour water surge drum and pumped to sour water tankage. Vapors flashed off in this drum are vented to the overhead vent compressor in the H-Coal® Distillate Separation plant. Water for the injection streams comes from the desalter in the H-Coal® Distillate Separation plant and is stored in a wash water receiver. Reciprocating pumps elevate the water to high pressure.

4.7 H-COAL® RECYCLE SLURRY PREPARATION - PLANT 5

The slurry separated as bottoms from the low-pressure slurry flash drum in the H-Coal® Primary Separation plant is pumped to the H-Coal® Recycle Slurry Preparation plant. This plant consists of two independent and identical trains, with each train serving four of the eight upstream trains. The basic process in this plant uses hydroclones to separate the slurry into two streams. The overflow stream has a lower concentration of solids than the underflow. The overflow is flash-cooled and returned to the H-Coal® Preheating and Reaction plant as part of the feed slurry oil make-up. The underflow is processed to recover the more valuable hydrocarbon products before the residuum material and solids are sent to the Gasification and Purification plant as material for hydrogen generation.

The two H-Coal® Recycle Slurry Preparation plant trains are separated by a central piperack. They are grouped with the eight trains of the H-Coal® Recycle Hydrogen Compression plant and the two trains of the H-Coal® Distillate Separation plant in an area about 1,000 feet by 300 feet.

Each train, beginning at the feed end, consists of a hydroclone feed control drum, a hydroclone underflow drum, and a hydroclone overflow drum, which are all vertical. Behind these drums are the hydroclones. Next is an access road followed by the atmospheric and vacuum flash drums, both of which are horizontal. Beyond these drums are the five vacuum flash condensers followed by the vacuum flash condensate drum and then a line of pumps which handle the vacuum flash products. A large tank for handling the hydroclone overflow surge and its pumps lie between the two trains, and next to this tank is the atmospheric stripper and the pumps for the bottoms from this tower. The final equipment is beyond a piperack and consists of the vacuum tower start-up heater and its associated surge drum and pumps, and the vacuum tower and its associated exchangers, drums, and pumps.

The slurry from four of the upstream trains is delivered to the hydroclone feed control drum from where it is pumped to a bank of twelve hydroclones, two of which are spares. The hydroclones split the stream into high-solids and low-solids streams which are collected in the hydroclone overflow and underflow drums.

The slurry stream from the hydroclone overflow drum is pumped to the hydroclone overflow atmospheric flash drum where it flashes to a lower temperature. The flashed vapors are sent to the H-Coal® Distillate Separation plant. The slurry flows to the hydroclone overflow vacuum flash drum where it is flashed to an even lower temperature under vacuum. The cooled slurry from this drum is pumped to the slurry mix tank in the H-Coal® Slurry Peparation plant. A hydroclone overflow surge tank is provided to accommodate variations in the rates of production and requirements of recycle slurry.

The vapor stream from the hydroclone overflow vacuum flash drum passes through two waste heat boilers and into a condensate drum. The condensate is sent to the desalter flash drum in the H-Coal® Distillate Separation plant. The vapor is condensed with a steam jet and the stream is sent to the plant's desalter.

Slurry from the hydroclone underflow drum is pumped to the upper section of an atmospheric stripper where it is steam-stripped in a multitray column with 50 psi steam. The stripped bottom liquids are then pumped to a vacuum tower. The vapor from this atmospheric stripper, together with vents from the hydroclone feed, overflow drums, and underflow drums are sent to the fractionator flash drum in the H-Coal® Distillate Separation plant.

The bottoms from the atmospheric stripper are fed to the upper chamber of a vacuum tower. Stripping steam is fed beneath the bottom plate of the lower chamber of the vacuum tower. The stripped vacuum tower bottoms are pumped to the Gasification and Purification plant. The overhead stream is condensed and the stream is sent to the desalter unit in the H-Coal® Distillate Separation plant.

The vacuum tower is maintained under vacuum by a three-stage vacuum system. Interstage condensers are water-cooled. The third-stage condenser is vented through a water seal pot to the firebox of the feed preheater in the H-Coal® Distillate Separation plant. The condensate from the vacuum tower jet system is pumped to the desalter in the H-Coal® Distillate Separation plant. A gas-fired start-up heater is provided for the vacuum tower.

4.8 H-COAL® RECYCLE HYDROGEN COMPRESSION - PLANT 6

The H-Coal® Recycle Hydrogen Compression plant is the last of four consecutive plants that contain a series of identical parallel trains. In this plant most of the gas produced in the H-Coal® Preheating and Reaction plant (from which condensibles were removed in the H-Coal® Primary Separation plant) are recompressed and recycled to the H-Coal® Preheating and Reaction plant. The compressors merely recompress the gas to make up the pressure drop in the cycle.

The plant primarily consists of twelve compressors of which four serve as spares. The compressors are electric-driven, reciprocating machines capable of boosting the inlet pressure by 350 psi. A compressor suction drum protects the compressor in each line from any entrainment.

The compressors of the H-Coal® Recycle Hydrogen Compression plant are located in four compressor buildings, each of which serves two of the preceding trains. There are three compressors in each compressor house, one for each train and a common spare. The four compressor houses are located between the two hydroclone stations of the H-Coal® Recycle Slurry Preparation plant. The suction surge drums for each of the two trains are located between the piperack and the building. The air-cooled exchanger for cooling the excess compressed hydrogen that is being recycled to the suction drum for control is mounted above the piperack.

A general description of the overall hydrogen system may help to clarify the function of this plant. The hydrogen required in the process is derived from three sources: replacement hydrogen to replace that which has been chemically consumed in the reaction process; a purified hydrogen stream; and the recycle hydrogen stream. (The combination of the first two streams is called make-up hydrogen.)

The principal source of replacement hydrogen is the Gasification and Purification plant where Texaco partial-oxidation gasifiers are employed to generate a synthesis gas from the vacuum tower bottoms of the H-Coal® Recycle Slurry Preparation plant. This syngas is subjected to shift conversion and desulfurization before being compressed to reactor pressure. A minor source of replacement hydrogen is the Naphtha Hydrotreating and Reforming plant.

The purified hydrogen and the recycle hydrogen are primarily derived from the vapor streams from the H-Coal® Primary Separation plant. These vapor streams are hydrogen-rich and contain methane, nitrogen, and other noncondensibles which must be removed to prevent their build-up. This is accomplished by removing purge streams from the recycle gas and sending them to the Gas Plant along with other gas streams which were separated in the H-Coal® Primary Separation plant. The noncondensibles are largely removed in the Gas Plant and the Cryogenic Hydrogen Purification plant.

The purified hydrogen stream is mixed with the replacement hydrogen derived in the Naphtha Hydrotreating and Reforming plant, which in turn is mixed with the replacement hydrogen from the Gasification and Purification plant. The combined stream is then compressed to reaction pressure in the compressor section of the Gasification and Purification plant.

This make-up stream flow is controlled by the pressure in the high-pressure cold flash drum. The make-up is mixed with the recycle hydrogen stream from the recycle compressors, and the entire hydrogen feed stream is preheated in the exchangers in the H-Coal® Primary Separation and H-Coal® Preheating and Reaction plants.

4.9 H-COAL® DISTILLATE SEPARATION - PLANT 17

The H-Coal® Distillate Separation plant receives distillable material from the H-Coal® Primary Separation plant and the H-Coal® Recycle Slurry Preparation plant and fractionates it into narrower cuts for further treatment or final products. Light naphtha and overhead vapor are sent to the Gas Plant for further processing to LNG and straight-run gasoline. The heavy naphtha cut is sent to the Naphtha Hydrotreating and Reforming plant. Middle distillate is sent to storage for shipment. A flush oil cut is sent to intermediate storage for various flushing requirements in the plant. Some heavy distillate is sent to storage as a product, although some is stored in intermediate storage and recycled as required for flushing and purging; the greatest portion is recycled back to the H-Coal® Recycle Slurry Preparation plant.

The plant has two independent and identical trains which operate in parallel. Each train is dedicated to processing distillable material from four trains of the H-Coal® Primary Separation plant and one train of the H-Coal® Recycle Slurry Preparation plant. The two trains of the H-Coal® Distillate Separation plant are located at the downstream end of the compressor buildings of the H-Coal® Recycle Hydrogen Compression plant.

One train is located on each side of the central access road that traverses the reaction and separation area.

The first items of equipment in each train are the direct-fired fractionator feed heater followed by the fractionating tower, which dominates the area. Each fractionater is 14-1/2 feet in diameter and 167 feet high. After the tower are the flush oil stripper and mid-distillate stripper mounted one above the other, followed by a piperack with the air-cooled exchangers involved in the operation of the fractionator mounted above it. A two-tiered structure which supports the other drums and exchangers associated with the fractionator operation is next, with the fractionator vent gas compressors mounted at grade near its center. Also at grade near this structure are the waste heat boilers that are used to cool the fractionation products along with the middle and heavy distillate pumparound fractionator feed exchangers. Above this equipment are the fractionator preflash drum, the fractionator overhead receiver, the overhead coalescer, and the fractionator overhead trim condenser. The structure also contains the flush oil pumparound/fractionator feed exchangers and the compressor aftercooler. The compressor suction drum is mounted at an intermediate level in the structure above the compressors. The last items of equipment in the train are the desalter flash drum, the desalter, the desalter wash/effluent exchanger, and the fractionator feed pumps.

The principal feed materials are the light and heavy condensate streams from the H-Coal® Primary Separation plant and the hydroclone vacuum condensate from the H-Coal® Recycle Slurry Preparation plant. Lesser feed constituents include hot vapor streams and sour water from the vacuum tower, the hydroclone overflow vacuum system in the H-Coal® Recycle Slurry Preparation plant, as well as condensate from the slurry mix tank overhead condenser in the Coal Slurry Preparation Plant.

The light condensate and the hydroclone vacuum condensate are mixed and flashed and then treated in a desalter. The salt-free hydrocarbons from the desalter are preheated through a series of exchangers utilizing the pumparounds of middle distillate, flush oil, and fractionator bottoms. The preheated and desalted oil is then mixed with the heavy condensate from the H-Coal® Primary Separation plant and the combined stream, after flashing, is pumped through the radiant section of the fired fractionator feed heater to the flash section of the fractionator. Coils in the convection section of the heater conserve heat by preheating the combustion air and superheating steam for stripping steam requirements in both the distillate separation process and the H-Coal® Recycle Slurry Preparation plant.

Each fractionator has 48 trays of different types. The vapor from the top of the tower is cooled and the light naphtha is condensed and separated in the fractionator overhead receiver. This light naphtha is pumped through a coalescer and then sent to the Gas Plant for further treatment. A portion of the light naphtha is refluxed to the top tray of the fractionator.

The vapor separated from the light naphtha in the overhead receiver is combined with vapor from the sour water surge drum in the H-Coal® Primary Separation plant and fed through a knockout drum to the vent gas compressor. The compressed gas is cooled and sent to the multistage compressors in the Gas Plant.

Several trays lower in the fractionator a heavy naphtha stream is withdrawn and sent to the Naphtha Hydrotreating and Reforming plant. A portion of this stream is withdrawn at the fractionator, cooled in an air-cooled exchanger, and returned to the tower as reflux a few trays above its withdrawal point. A second sidestream is also withdrawn and returned, without temperature change, to a lower tray.

Middle distillate is withdrawn about two thirds of the way down the tower and stripped with superheated steam before being pumped through a waste heat boiler and an air-cooled exchanger that lower its temperature to 130°F before it is sent to the middle distillate storage tanks. Similarly, flush oil is withdrawn part way up the tower, stripped with superheated steam, and then pumped through a waste heat boiler and an air-cooled exchanger that lower its temperature to 140°F before it is sent to the flush oil storage tanks. Pumparound streams from the middle distillate and flush oil draws are heat-exchanged with the stream from the desalter, trim-cooled in air-cooled exchangers and returned to the tower two or three trays above the draw point. The vapors from the two strippers are reintroduced into the fractionator on the same tray as the return flow from the corresponding feed preheat exchangers.

The heavy distillate from the bottom is pumped through the heavy distillate/fractionator feed exchangers. The partially cooled stream from the exchangers is cooled to 180°F in a series of two waste heat boilers and an air-cooled exchanger before being delivered to storage tanks. Although this material is a final product, it is also used as an intermediate for flushing. A side stream is taken before the air-cooled exchanger and sent to the H-Coal® Recycle Slurry Preparation plant for use in prewetting the coal and as a component of the reactor feed slurry.

4.10 GAS PLANT - PLANT 7

The Gas Plant, in conjunction with the Cryogenic Hydrogen Purification plant, processes the lighter products of the upstream plants to remove hydrogen sulfide, separate liquid and gaseous products, and further purify some of the materials. It is fed with hydrocarbon streams from the H-Coal® Primary Separation, H-Coal® Distillate Separation, and Naphtha Hydrotreating and Reforming plants. It produces three final products which are sent to product storage: propane, butane, and light straight-run gasoline. It also produces ethane-rich fuel gas for the internal fuel gas system along with other streams that require additional processing, such as: a hydrogen-rich stream that is separated and purified in the Cryogenic Hydrogen Purification plant; acid gas that is sent to the Sulfur plant; heavy naphtha that is sent to the Naphtha Hydrotreating and Reforming plant; and a sour water stream that is sent to the Sour Water Treating plant.

The Gas Plant has only one train; however, this train has seven basic sections. These sections are:

- Gas compression
- Acid gas scrubbing
- Liquid and gas drying
- Product fractionation
- LPG sweetening
- Naphtha sweetening
- Refrigeration

The Gas Plant is located between the Cryogenic Hydrogen Purification plant and the Sulfur Plant. It occupies an area about 665 feet by 225 feet. A piperack extends down the center of the area. Beginning at the feed end, the gas compression section is on the left of a central piperack. It consists of the gas compressor and turbo expanders and the associated knockout drums, exchangers, separator drums, and pumps. Next in line is the acid gas scrubbing section with the high-pressure and low-pressure DEA absorber towers and the DEA regenerator with drums and exchangers associated with each tower adjacent to that tower. The air-cooled exchangers are mounted above the piperack. The pumps are mounted in a line just outside the piperack. The drying section is next, with the gas and liquid dryers in line alongside the piperack and the asociated exchangers and drums between and on each side of them. On the other side of the piperack is the product fractionation section with the butane wash, propane wash, deethanizer, and the debutanizer towers in a line. The towers are separated by exchangers and drums associated with the operation of each, followed by the naphtha splitter depropanizer with its related drums and exchangers. The light naphtha caustic wash, Merox treatment, sand filter, and sieve sweeteners are located next. Three air-cooled exchangers are mounted above the piperack. Pumps are located adjacent to the rack on both sides. The refrigeration section is in a corner of the plant near the product fractionation section. This section has two complete and independent trains. Each train contains a three-stage compressor, condensers, three wet and three dry drums used in producing the three levels of refrigeration, and a surge drum.

The various feed streams are first brought to a nominal pressure of 700 psi in the gas compression section. Low-pressure streams are compressed to this pressure, while high-pressure feed streams are expanded to reduce their pressure to operating levels. Streams already at the operating pressure bypass the initial compression or expansion steps. The streams also pass through knockout drums and separators to remove sour water and naphtha. The gas is sent to the DEA absorber, naphtha to the liquid drying section, and sour water to storage or treating.

The acid gas scrubbing section removes H_2S and CO_2 by scrubbing feed gas with diethanolamine (DEA). This unit contains two DEA absorbers, one that scrubs the high-pressure gas from the gas compression section, while the second scrubs a lower-pressure fuel gas stream from the downstream deethanizer. A common DEA regenerator serves to remove the acid gas from the DEA streams from both absorber towers. The sweet fuel gas from the low-pressure absorber is sent to the plant fuel system. Acid gas from the DEA regeneration is sent to the Sulfur Plant. The sweetened gas stream from the high-pressure DEA absorber is cooled to 60°F and separated. The separated gas and condensate streams are then sent to the drying section as separate streams.

The drying section has two feed streams, one gas and the other liquid. The respective streams are dried in separate vessels packed with activated alumina. The gas stream and part of the liquid stream are the result of cooling the gas from the DEA absorber to 60°F. The dried gas stream is fed to the butane wash column of the product fractionation section. The condensate resulting from the cooling is mixed with a naphtha stream from the second-stage separator in the gas compression section, dried, and sent to the deethanizer in the product fractionation section.

The product fractionation section consists of a pretreatment and a fractionation section. The gas stream is preheated prior to sending a feed stream to the Cryogenic Hydrogen Purification plant. Downstream of this cut the remaining gas is fractionated into lighter products of propane, butane, light naphtha, and heavy naphtha.

The pretreatment section includes two absorbers that treat the gas in series by washing with butane in the first absorber and with propane in the second. This washing removes hydrocarbon compounds such as benzene that might freeze in the cryogenic exchangers. After washing, the hydrogen-rich gas from the propane wash column overhead is sent to the Cryogenic Hydrogen Purification plant. The bottoms from the two absorbers are sent to the deethanizer along with dry unstabilized naphtha from the drying section.

The deethanizer produces a sour, ethane-rich overhead product which is sent to the low-pressure acid gas scrubbing section, where, after sweetening, it is sent to the fuel gas system. The deethanized bottoms flow to a debutanizer tower that produces a propane-butane overhead and a debutanized bottoms. The overhead stream is sent to the LPG sweetening section, and the bottoms to the naphtha splitter column. After splitting, the heavy naphtha is sent to the Naphtha Hydrotreating and Reforming plant, while the light naphtha is sent to the naphtha sweetening section. The sweetened debutanizer overhead is returned to a depropanizer. The overhead from this column is split into two streams: one stream is sent to the upstream propane wash column as wash liquor; the second stream is sent to storage as LPG propane final product. Similarly, the bottoms stream is split into a wash liquor for the upstream butane wash column and a stream to storage as LPG butane final product.

The LPG sweetening section is fed by the debutanizer overhead stream of mixed propane and butane. This stream is sweetened in molecular sieve beds to remove hydrogen sulfide and mercaptans. The sweetened LPG is then sent to the depropanizer in the product fractionation section. In the product naphtha sweetening section, the light naphtha product from the naphtha splitter is treated in a caustic column and a Merox reactor and is then filtered before being sent to storage as LSR gasoline final product.

The refrigeration section provides coolant for the product fractionation section and for the Gasification and Purification plant. Use of this low-level cooling allows for a design which improves operational efficiency of the plants. The low temperatures are achieved by expanding propane in exchanger shells while the stream to be cooled is traveling through the tubes. The vaporized propane from these refrigeration exchangers is recompressed and liquefied, and the liquefied propane is returned to the exchangers. The three-stage propane compressors allow three refrigeration levels: a low-temperature stage of -41°F, an intermediate temperature of -3°F, and a high-temperature stage of 45°F. The three stages of refrigerant are circulated in separate systems.

4.11 CRYOGENIC HYDROGEN PURIFICATION - PLANT 8

The single train Cryogenic Hydrogen Purification plant is fed by the overhead stream from the propane wash tower in the Gas Plant. This feed stream is at 29°F and 645 psi. It contains about 73% hydrogen mixed with gaseous hydrocarbons, low-boiling hydrocarbons, nitrogen, carbon monoxide, and other inerts. The compounds removed from the crude hydrogen stream are methane, ethane, heavier hydrocarbons, nitrogen, and carbon monoxide. The products from the plant are a purified recycle hydrogen stream containing 93% hydrogen, a pipeline gas stream as a final product, a medium Btu fuel gas stream, and a low-boiling hydrocarbon stream which is returned to the Gas Plant for further processing. The plant is designed to recover 98% of the hydrogen contained in the feed stream.

The plant consists of a warm section with gas adsorber beds, a cryogenic section with a cold box, and compressors. The cold box is a confined, well insulated box containing process equipment such as exchangers and separators that purify the hydrogen feed gas by stagewise condensation of impurities at progressively lower temperatures, from 95°F to about -295°F.

The Cryogenic Hydrogen Purification plant is located between the Gas Plant and the Naphtha Hydrotreating and Reforming plant. The plant occupies an area of about 670 feet by 350 feet and is divided by a piperack extending through the equipment area. In a line on the right are the liquid hydrocarbon, inert gas, pipeline gas, and nitrogen compressors. Beyond the compressors is the separator-exchanger cold box. On the other side of the piperack are the three mol sieve dryer units and the regeneration and other equipment associated with their operation.

The feed stream entering the warm end of the plant is first dried in mol sieves to remove residual traces of water, carbon dioxide, mercaptans, and any other materials with high freezing points that might form solid deposits in the cold exchangers and necessitate frequent deriming. There are three of these mol sieve dryers with two in operation while the third is being regenerated.

The cryogenic section separates the impure components from the crude hydrogen stream. This is a simple but practical method of upgrading a hydrogen rich stream. A sharp hydrogen separation is possible because of its extremely low liquefaction temperature, compared to the higher boiling points of the impurities.

The feed stream from the warm section is fed to the cold box heat exchanger which cools the gas to -140°F. The gas is then separated from the heavier hydrocarbons in a heavy hydrocarbon separator. The condensate leaves the separator, is flashed to 30 psi, and enters a liquid-vapor separator. The separated streams are returned to the exchanger, heated, and then recombined after the warm end of the exchanger, which minimizes problems of distributing two phases inside exchanger passages. The mixed stream then leaves the cold box and is sent to a three stage 2000 HP compressor, elevated in pressure, and sent to the deethanizer in the Gas Plant for recovery and separation.

The gas stream from the heavy hydrocarbon separator flows to three heat exchangers in series that cool the stream to -288°F. The stream is then separated in a light hydrogen separator. The overhead gas is a purified hydrogen gas containing at least 93% hydrogen. It is first sent back through the exchangers in reverse flow to rewarm it and then leaves the cold box and is sent, at 575 psi and 23°F, to the make-up hydrogen compressor in the Gasification and Purification plant for use as hydrogen feed for the H-Coal® reactors.

The plant has a nitrogen refrigeration system to supply its refrigerant. This system consists of a six-stage, 5,000 HP compressor, intercoolers, aftercoolers, and similar equipment. The nitrogen is circulated to the various heat exchangers in the cold box.

4.12 GASIFICATION AND PURIFICATION - PLANT 12

The Gasification and Purification plant is a large and complex unit in which hydrogen and a medium-Btu fuel gas are generated, purified, and compressed. It contains the following five major sections:

- Gasification
- Shift
- Gas purification
- Hydrogen compression
- Fuel gas cooling and treating

The gasification section has five trains, four operating and one spare; the shift and acid gas removal sections each have three trains; the hydrogen compressor sections has five trains; and the fuel gas cooling and treating section consists of a single train. The vacuum tower bottoms and oxygen are the principal raw materials fed to the plant. Compressed hydrogen and fuel gas are the plant's principal product streams.

The Gasification and Purification plant is located between the H-Coal® Recycle Slurry Preparation and the H-Coal® Recycle Hydrogen Compression plants. It occupies an area about 915 feet by 600 feet. A main piperack extends through the center of the area with several branch piperacks on either side. The fuel gas cooling and treating section and the gasification and shift sections are located on one side of the central piperack; the gas purification and hydrogen compression sections are located on the other.

Starting at the central piperack at the shift section end, the first equipment items on the right side are the three shift section trains. Each train is oriented perpendicular to the rack and consists of five vertical vessels with the associated exchangers between them. The first three vessels are converters followed by the hot and cold shifted gas knockout drums. A branch piperack runs on one side of each train and the air-cooled exchanger for cooling the hot gas is mounted above it. The three shift trains are followed by the drums and exchangers that cool the syngas and fuel gas streams in waste heat boilers.

The next equipment is a conveyor belt and loading system for the collection and loading of the solid waste from the gasifier trains into trucks for disposal. The five gasifier trains are next. They are oriented perpendicular to the central piperack. The soot scrubber and lock hopper sludge drum are between the piperack and the gasifier; the slurry feed tanks and slurry booster and feed pumps are on the other side of the piperack. The balance of the fuel gas cooling and treating section is next. This consists of the H_2S absorber and lean solvent cooler along with the turboexpander and related exchangers.

The three gas purification trains are located in rows on the other side of and perpendicular to the central piperack. The equipment in each of these trains occupies both sides of a branch piperack. On one side are four vertical vessels consisting of the H_2S absorption tower, the CO_2 absorption tower and two parallel CO_2 strippers. Between the first two towers is a large, horizontal, rich solvent flash drum. The second tower is followed by the lean solvent hydraulic turbine, the lean solvent charge pump, and the hydrogen flash drum. Related shell-and-tube exchangers are mounted adjacent to each tower. On the other side of the branch piperack are the recycle vapor compressor and turbine with three related knockout drums followed by the horizontal, lean solvent presaturator and the large vertical H_2S stripper. The small vertical vessels next in line are the stripper overhead knockout drum and the sulfur filter. Related shell-and-tube exchangers are interspersed among the equipment. The air-cooled H_2S stripper condenser is mounted above the piperack.

Most of the remaining area is occupied by five hydrogen compressors and their associated knockout drums and interstage coolers. The compressors are aligned in a row parallel to the piperack near the plant's battery limits. The Selexol solvent sump and the solvent make-up storage tank are located on the other side of the compressors. The slurry equipment is between the rack and the compressors.

Slurry from the vacuum tower in the H-Coal® Recycle Slurry Preparation plant is fed to two agitated feed tanks in the gasification section. Centrifugal pumps circulate this slurry to the reactor feed pumps' suction and back to the tank to prevent the solids from settling out. There are eight of these high-pressure reciprocating reactor feed pumps, one for each reactor and three commom spares. The slurry is mixed with high-pressure steam and gasified with pure oxygen in a burner on top of the reactor. The combustion gases from the combustion chamber of the reactor are immediately quenched with water in a quench chamber below the combustion chamber. The gases collect in the upper part of the quench chamber and flow to a scrubbing tower where they are scrubbed with condensate from the downstream shift section. The raw syngas from the scrubber is sent to the shift section.

The solids resulting from the combustion are removed from the bottom of the quench chamber as a water slurry through a lock hopper arrangement. The larger solids are removed from the slurry by screening. The slurry passing through the screen is pumped to a clarifier. Two of these clarifiers serve the five trains in the section. The solids from screening and the sludge from the clarifier are sent offsite for disposal. The clarified water is recirculated to the lower section of the scrubber.

The water from the bottom section of the scrubber is pumped to the quench chamber of the reactor. A blowdown stream from above the bottom of the quench chamber is cooled by exchange with the clarified water and returned to the bottom section of the scrubber. This sidestream is then flashed to about 10 psi and the condensate further cooled in an air-cooled exchanger and sent to the clarifier. The vapor stream is also cooled in an air-cooled exchanger and the resulting condensate fed to the clarifier. Flashed vapor is vented to the acid gas header.

In the shift section, the raw syngas is split into two streams with about 20% being sent to the fuel gas cooling and treating section. The remainder is treated in three identical trains consisting of three catalytic shift converters. In normal operation, the raw syngas which is already at relatively high temperature and pressure is further heated by exchange with the hot gas from the bottom of the first shift converter. A gas-fired start-up heater, common to all three trains, is provided to heat the raw syngas feed during start-up. The heated gas is fed to the top of the converter and, in flowing down through the catalyst beds, the carbon monoxide is converted to hydrogen and carbon dioxide by reaction with the water vapor in the syngas stream. This reaction continues to occur in each of the two succeeding converters, but to a lesser degree as the carbon monoxide concentration is depleted. The reaction is exothermic and the heat of reaction must be removed between the successive stages.

Between the first and second converters, the shifted gas from the bottom of the first converter is cooled by heat exchange with the incoming raw syngas. It is then cooled further in the tubes of a waste heat boiler which generates 900 psi steam. A final cooling is effected by exchange with the feedwater to the boiler. Before the cooled gas is fed to the second stage converter, a sidestream is taken, raised to a higher pressure in a gas blower, and then recycled to the feed stream entering the top of the first converter. This stream is utilized to moderate and control the exit temperature from the first reactor. Between the second and third converters, the shifted gas is cooled in a waste heat boiler where 150 psi steam is generated. After leaving the bottom of the third converter, the shifted gas is cooled by exchange with utility water which has been partially preheated in the fuel gas cooling and treating section. Further cooling is effected in a waste heat boiler. The gas then passes through a hot knockout drum and is then cooled by exchange with condensate from the boiler system. It is cooled further by exchange with condensate from the downstream cold knockout drum, and then enters an air cooler. Trim cooling is by exchange with cooling water. The gas then enters a cold knockout drum.

The gas from the knockout drum is sent to the gas purification section as its principal feed. This section has three identical trains in which the shifted syngas is scrubbed with Selexol solution in two stages. In the first stage hydrogen sulfide is removed, and in the second stage carbon dioxide is removed. The shifted syngas is fed beneath the bottom tray of an H_2S absorption tower. As it passes up the column, it is contacted with lean Selexol solution which is fed above the top tray and the H_2S is absorbed from the gas stream. The H_2S-free gas from the top of the absorber is then mixed with incoming lean Selexol to presaturate the solvent with CO_2. A portion of the hot, lean Selexol and gas mixture is cooled by a water exchanger and the mixture is fed to the saturator drum. The gas is separated from the lean Selexol in the saturator drum and is fed to the CO_2 absorption tower. The lean solvent is sent to the top of the H_2S absorption tower.

The rich Selexol solution from the bottom of the H_2S absorption tower is let down in pressure in three stages. The first let-down is through a hydraulic turbine which drives the Selexol circulating pump. The stream is then flashed in a flash drum. The separated solution is let down for the second time through a let-down valve, and flashed in a second flash drum. The solution is let down for the third time through a let-down valve and, after heating in two exchangers, is fed to the top of the H_2S stripper tower. The gases removed from the two let-down flash drums are recompressed in a three-stage, turbine-driven compressor and recycled back to the shifted syngas stream feeding the H_2S absorber.

The rich solvent is stripped in the H_2S stripping tower by heating at low pressure. Heating is provided by a steam-heated reboiler. The H_2S passing overhead from this tower is cooled by an air-cooled exchanger. The condensate is refluxed to the tower and the H_2S-rich gas stream is reheated by steam in an exchanger before being sent to the Sulfur Plant. The lean solvent from the bottom of the H_2S stripper is cooled and pumped to the lean solvent presaturator. A side stream is fed to the H_2S absorber in the fuel gas cooling and treating section.

The shifted syngas from the lean solvent presaturator is fed to the CO_2 absorption tower. Before entering the tower, the gas is cooled by exchange with colder gas from the top of the downstream CO_2 stripper. Further cooling is effected in a reboiler-type exchanger which vaporizes propane. The gas enters the CO_2 absorption tower below a packed section. From the top of the CO_2 absorber the gas is fed to a knockout drum.

The rich Selexol solvent from the bottom of the CO_2 absorber is let down in pressure in two steps through a two-stage hydraulic turbine which drives the lean solvent feed pumps. The exhaust stream from the first stage of the turbine flows to the hydrogen flash drum. The vapors are fed to the fuel gas cooling and treating section. The rich Selexol solution from the hydrogen flash drum is cooled by propane in a reboiler-type exchanger and then flows to the second stage of the hydraulic turbine. It is next fed to a low-pressure flash drum on top of the CO_2 stripper and then to the top of the CO_2 stripper tower. The CO_2 stripper tower contains packing and one bottom tray. The CO_2 is stripped out of the Selexol solution by air which is fed to the bottom of the stripper by a blower. The air is cooled by exchange with cooling water before entering the tower. The air, carbon dioxide from the top of the tower, and the gas stream from the flash drum are combined, used to exchange heat with the incoming feed gas to the CO_2 absorber, and then vented to a stack. The lean solvent is returned to the top of the CO_2 absorber by the turbine driven pumps. A side stream is removed before the pumps and pumped through an exchanger and a filter to the H_2S stripper.

The hydrogen compression section contains five two-stage reciprocal compressors, four operating and one spare. Each compressor is driven by an 18,000 HP motor and protected by a knockout drum. An intercooler is located between each pair of stages. The hydrogen-rich gas is fed to the compressors from a knockout drum downstream of the CO_2 absorber. Hydrogen-rich gases from the Cryogenic Hydrogen Purification plant and from the Naphtha Hydrotreating and Reforming plant are also fed into this knockout drum. These combined streams are the make-up hydrogen feed.

The fuel gas portion of the syngas stream that was taken ahead of the shift section is sent to the fuel gas cooling and treating section. It is cooled, washed with Selexol to remove H_2S, expanded to drive an electric generator, and finally delivered to the plant fuel gas header. This section consists of only one train. The feed syngas is first cooled by a waste heat boiler that generates 150 psi steam and is then further cooled in a second waste heat boiler that generates 50 psi steam. The cooled gas is fed to a knockout drum. The condensate material is sent to the quench water surge drum in the shift section. The gases are cooled further and fed to a cold fuel gas knockout drum. The condensate from this drum is sent to the cold shifted gas knockout drum in the shift section. The gas is fed to the bottom of the fuel gas H_2S absorber and contacted with Selexol solution from the bottom stream of the H_2S stripper in the gas purification section. The rich solvent removed from the bottom of the fuel gas H_2S absorber is sent back to join the feed stream at the top of the H_2S stripper.

The desulfurized gas is heated in an exchanger, let down through the first stage of a turboexpander and joined by the stream from the hydrogen flash drum in the gas purification section. The combined gases are heated in an exchanger and expanded through the second stage of the turboexpander. The exhaust stream from the expander is fed to the fuel gas header. The turboexpander drives a generator which generates 5128 KW of electricity to supplement the plant's electric power system.

4.13 OXYGEN PLANT - PLANT 15

The Oxygen Plant produces the oxygen required for production of hydrogen in the Gasification and Purification plant. The plant also produces nitrogen which is required for blanketing, purging, and other uses. The capacity of the plant is somewhat greater than the normal operating requirements. The excess products will be liquefied and stored to provide capacity for abnormal demands and to store products for sale. When oxygen or nitrogen is required at a rate in excess of the immediate capacity at which the plant is operating, either or both materials can be withdrawn from the liquefied storage and vaporized to meet the extra demand. In normal operation both materials are supplied directly from the cold boxes as gases. Oxygen is produced by three independent trains. A single train of facilities is provided for storage of liquid oxygen, liquid nitrogen and by-product argon with equipment for vaporizing the liquid oxygen and nitrogen.

The Oxygen Plant is located between the Steam Generation and Boiler Feedwater Treating plant and the Naphtha Hydrotreating and Reforming plant. It is located in an area measuring 850 feet by 450 feet. Entering the area from the air intake side, the air intakes are lined up in a row and followed by a row of three air compressors alternating with three oxygen compressors and the freon unit. The next row of equipment consists of the direct coolers, cycle nitrogen compressors, and the liquid nitrogen tank. Following this is a piperack, with the three air separation units in a row parallel with the rack. Each of these units has a 150-foot-high central tower section, with separate sections on each side containing the reversing exchangers. The argon purification unit and the liquid oxygen tank are adjacent to the towers.

The Oxygen Plant is a standard commercial unit and only a brief description of its functioning and equipment is provided in this report. Each of the three trains has a three-stage axial centrifugal air compressor which takes in ambient air through an inlet filter and discharges it through a direct contact cooler to the air separation unit. The compressor in one train is driven by a 30,000 HP motor, while the other compressors are steam driven. The direct contact cooler is a tower which contains three trays where cooling water delivered to the top contacts the air countercurrently, cools, and washes it.

The air separation unit contains reversing heat exchangers in which the air is cooled to cryogenic temperatures by cold outgoing streams. It also contains a high-pressure and a low-pressure distillation column, a crude argon column, other exchangers and separators, a nitrogen expander, liquid oxygen pumps, and hydrocarbon guard absorbers. The reversing heat exchangers have channels for air, nitrogen, and oxygen with provision for interchanging the air and nitrogen channels on a timed cycle basis. As the compressed and cooled air enters the exchangers and is cooled down, water and carbon dioxide freeze out on the exchanger surfaces, building up a rime which must be removed periodically. Reversing the air and nitrogen stream at intervals causes the waste nitrogen from the top of the low-pressure column to pass through the rimed sections, melting the rime, and the water and carbon dioxide is exhausted through the vent stack. Air leaves the reversing exchangers as a saturated vapor and enters the high-pressure column in which the separation into oxygen-rich liquid (at the bottom) and pure nitrogen vapor (at the top) is made.

The pure nitrogen vapor condenses in a condenser/reboiler surrounded by a pool of liquid oxygen located in the bottom of the low-pressure column. The condensing liquid nitrogen transfers heat to the liquid oxygen which vaporizes to form vapor boil-up for the low-pressure column. The liquid nitrogen stream splits into a reflux stream for the high-pressure column and a liquid nitrogen product stream which is flashed before proceeding to storage.

Two oxygen-lean streams are removed from the middle sections of the high-pressure column and subcooled to form reflux for the top of the low-pressure column. The oxygen-rich bottom liquid product from the high-pressure column is subcooled in the rich liquid subcooler, purified in the rich liquid adsorbers, and sent to the low-pressure column. A portion of this stream is diverted after the adsorbers to the crude argon condenser, where part of it is vapororized by condensing argon.

Liquid oxygen is taken from the bottom of the low-pressure column and subcooled before being sent to storage. Oxygen vapor is also taken from the low-pressure column, reheated in the reversing exchangers, and sent to the oxygen compressors as the primary oxygen make-up gas.

The bulk of the nitrogen gas stream is vented up the stack but required quantities are sent to other plants for purging, blanketing, and refrigeration. A crude argon liquid stream is sent to the pure argon unit for refining to the pure liquid argon product. Medium-pressure nitrogen warm and cold gas streams are sent to the nitrogen liquefying unit and returned to the air separation unit as a liquid stream.

The nitrogen refrigeration unit contains a six-stage nitrogen cycle compressor driven by a 10,000 HP motor, two compressor/expanders, a freon unit, and a cold box containing multicompartment exchangers with associated intercoolers and aftercoolers. This unit provides refrigeration for the air separation unit by expansion of compressed nitrogen with assistance from the freon precooling unit. This permits the production of liquid oxygen and liquid nitrogen when the cold box production exceeds the gasification requirements.

4.14 NAPHTHA HYDROTREATING AND REFORMING - PLANT 18

The Naphtha Hydrotreating and Reforming plant consists of a single train with a hydrotreating and reforming section. The heavy naphtha from the H Coal® Distillate Separation plant and the Gas Plant is hydrotreated and reformed in this plant to produce a stabilized high-grade gasoline blending stock with a RONC of 105. UOP process and technologies are used in both the hydrotreating section and the reforming section.

The Naphtha Hydrotreating and Reforming plant is located between the Oxygen Plant and Cryogenic Hydrogen Purification plant. It occupies an area about 350 feet by 200 feet. A piperack extends down the center of the area. On the right side of the feed end are the fired heaters of the hydrotreating section, followed by the two hydrotreater reactors with their exchangers, separators, and pumps. The hydrotreater recycle compressors are near the center of the area and beyond them is a high structure containing the reforming reactor and the catalyst regeneration tower. The platformer fired heaters are at the far end of the area. The hydrotreater stripper and the reformate stabilizing equipment and their exchangers, separators, and pumps are on the other side of the piperack. The platformer recycle compressor and its exchangers, separators, and pumps are located beyond this equipment.

The heavy naphtha is catalytically treated with hydrogen in two stages in the hydrotreating section. The first-stage reactor is operated at the relatively modest temperature of 350°F and serves to saturate the unstable diolefins present in the charge stock. The freshly fractionated naphtha feed flows to a surge drum which is gas blanketed to minimize gum formation. The stream is then mixed with hydrogen, preheated to reaction temperature by exchange with the products from the final second-stage reactor, and fed to the first-stage reactor of the hydrotreating section. This reactor contains a catalyst and the hydrogen reacts with the unsaturated compounds to saturate them.

The conditions in the second-stage reactors are more typical of hydrotreating as the nitrogen, oxygen, and sulfur are split off and converted to ammonia, water, and hydrogen sulfide, respectively. The resulting organics are partially hydrogenated to naphthenes. The saturated product from the first-stage hydrotreater, along with added make-up hydrogen, is heated by exchange with products from the final second-stage reactor and then further heated in a fired heater and fed to the first of two second-stage reactors. The products from this reactor are then cooled by passage through a steam generator which produces 600 psi steam. The partially cooled stream, along with added hydrogen make-up, then flows to the final second-stage reactor. Further cooling of products from this reactor is obtained by exchange with upstream feed streams.

The product stream is further cooled in an air-cooled condensor and flows to the reactor products separator. The separated hydrogen-rich gas joins a make-up hydrogen gas stream which is compressed, and becomes make-up hydrogen gas feed for the various reactors.

The separated liquid stream is fed to a stripping column after heat exchange with the bottoms stream from the stripper. The stripping column has a fired reboiler to provide additional heat. The sour light gases stripped in this column are sent to the Gas Plant for additional treatment. The stripped liquid is sent to the reforming section.

In the reforming section, the saturated and stripped product from the hydrotreating section is reformed over a platinum catalyst in a three-stage reactor. The feed stream from the hydrotreating section, along with recycle hydrogen, is first heated by exchange with the bottom product from the reforming reactor and then further heated in the first stage of a three-stage, direct-fired heater. It then enters the first stage of the reactor and passes through the three stages, being reheated in the second and third stages of the fired heater before passing to the second and third stages of the reactor. Freshly regenerated catalyst is fed to the top of the reactor and passes through the three reactor catalyst beds in essentially plug flow. It is removed from the bottom of the third stage of the reactor and sent to the catalyst regeneration system.

The product from the bottom of the third stage of the reforming reactor, after cooling by heat exchange with the entering feed stock, is further cooled in air or water exchangers and separated in a low-pressure separator. The separated hydrogen-rich gases are compressed and part is recycled to the entering feed stock stream, while the remainder is sent to the high-pressure separator along with the liquids from the low-pressure separator.

The gas and liquid feeds to the stabilization facilities are cooled in exchangers upstream from the high-pressure separator. Separator overhead gas is sent to the hydrotreating unit and to the Gasification and Purification plant. The separator liquid is heated by exchange with the bottoms stream from the debutanizer column and then flows to the debutanizer. The bottoms stream from the debutanizer is split, with the platformate stream being cooled and sent to stabilized reformate product storage. The other stream is pumped to a reboiler heater and sent back to the debutanizer. Debutanizer overhead gas is cooled in an air exchanger and then separated in an overhead reliever. The separated gas and a portion of the liquid are sent to the Gas Plant. The remaining liquid is refluxed to the debutanizer column.

A controlled quantity of catalyst is continuously withdrawn from the bottom of the platforming reactor through a lock hopper arrangement. The catalyst is lifted to a regeneration tower and returned to the reactor.

4.15 SOUR WATER TREATING - PLANT 9

The Sour Water Treating plant consists of a stripping and ammonia recovery section and a dephenolization section. The stripping and ammonia recovery section has two identical trains. The dephenolization section consists of a single train, although the first four towers operate in parallel. Sour water from throughout the project is treated in this plant to remove H_2S, ammonia, and phenolic compounds. Ammonia and the phenolic compounds are recovered as marketable products. The water, after stripping and dephenolization, is sent to the Sewers and Wastewater Treatment plant. The sour gases from the stripping operation are first treated to remove ammonia and then sent to the Sulfur Plant. United States Steel's PHOSAM® process for recovery of ammonia is used in the stripping and ammonia recovery section. The technology developed by Jones & Laughlin Steel is used in the dephenolization section for recovery of the phenolic compounds.

The Sour Water Treating plant is adjacent to the Sulfur Plant. It occupies an area about 130 feet by 490 feet. A piperack extends down the center of the plant. Entering the area from the feed end, the two trains of the stripping and ammonia recovery section extend along both sides of the piperack. The two trains are mirror images of each other. The dephenolization section occupies both sides of the piperack beyond these trains.

The four towers of each train of the stripping and ammonia section are located perpendicular to the central piperack. The stripping tower is first, followed by the ammonia tower, the PHOSAM® ammonia stripper, and the ammonia fractionator. The related exchangers and drums are located adjacent to the towers.

In the dephenolization section, the four extraction columns form a line parallel to the piperack. These are followed by the solvent recovery column and the solvent stripping column. The phenol column is located opposite the solvent stripping column. The related exchangers and drums are near their respective columns and the pumps are located in a line parallel to the piperack.

Sour water is pumped to the stripping and ammonia recovery section. The feed stream is split and heated by exchange with bottoms from the H_2S stripper tower of the PHOSAM® NH_3 stripper tower. The stream is then joined by a sour steam from the Gasification and Purification plant and fed to the H_2S stripping tower. Acid gases, ammonia, and H_2S are stripped from the sour water by 50 psi steam and the stripped water is sent to the dephenolization section for further processing.

The ammonia and H_2S overhead vapor stream stripped from the sour water in the first tower is sent to the ammonia absorber, where the vapor is contacted countercurrently by a lean PHOSAM® solution stream fed in at the top of the tower. The ammonia in the feed gas is absorbed by the PHOSAM® solution. Make-up phosphoric acid is fed to the bottom of the tower. The H_2S-rich acid gas passes overhead and, after cooling by exchange, is sent to the Sulfur Plant. The ammonia-rich PHOSAM® solution stream from the bottom of the absorber is pumped through an exchanger which recovers heat from the bottoms stream from the PHOSAM® contactor and then is flashed in the PHOSAM® contactor. Vapors released are returned to the feed of the NH_3 absorber.

The rich solution is pumped through a PHOSAM® NH_3 stripper-condenser, and the preheated solution then flows to the PHOSAM® NH_3 stripper tower, which operates at elevated pressure. This stripper removes ammonia and generates lean solution for recycling to the NH_3 absorber. Stripping is by means of 600 psi steam. The aqueous ammonia vapor passes back through the PHOSAM® NH_3 stripper-condenser where it is partially condensed and cooled. The stream then passes through a drum into which a small stream of caustic is metered. This caustic combines with trace amounts of acid gases to form salts which will pass through the ammonia fractionator.

The aqueous ammonia is pumped to the ammonia fractionator where it is fractionated into an overhead anhydrous ammonia product and a bottoms stream. The bottoms stream is recycled to the H_2S stripper. The overhead stream is condensed in the ammonia fractionator condenser. Part of the condensate is returned to the fractionator as reflux; the balance goes to storage as ammonia product.

The water that was stripped of H_2S and ammonia in the upstream H_2S stripper is fed to four extraction columns operating in parallel in the dephenolization section. The water is contacted countercurrently by a proprietary solvent that extracts the phenolic compounds. The raffinate (dephenolized water) from the extractor columns is fed to a solvent stipping column where solvent is removed by distillation. The overhead solvent is condensed and decanted. The water stream is pumped back to the column while the recovered solvent is returned to the extractors. The bottoms stream is sent to the Sewers and Wastewater Treatment plant.

The extract streams from the extraction columns are fed to a solvent recovery column in which the solvent and extracted phenols are separated. The overheads are condensed and returned to the extractors as recycle solvent or pumped back to the column as reflux. The bottoms are sent to the phenols column where the solvent content is further reduced under vacuum. The overheads are condensed and returned to the solvent recovery column and to the phenols column as reflux. The phenols product stream is cooled and sent to storage.

4.16 SULFUR PLANT - PLANT 10

The Sulfur Plant has three parallel and independently operating trains. Two trains will accommodate the full demand of the project; however, all three trains will operate at reduced capacity under normal operation. Sour gases from the Gas Plant, the Sour Water Treating plant, the Gasification and Purification plant, and the Stack Gas Scrubbing plant are treated in this plant to remove about 95% of the sulfur as a liquid product. The tail gases contain the remaining sulfur and are sent to the Steam Generation and Boiler Feedwater Treating plant and incinerated in the boilers. The boiler flue gas is then processed in the Stack Gas Scrubbing plant, which recovers about 95% of the sulfur from the tail gas, bringing the total sulfur recovery to about 99%. The design production rate of the Sulfur Plant is about 700 tons per day of molten sulfur.

The Sulfur Plant is located between the Gas Plant and the Sour Water Treating plant. It occupies an area about 275 feet by 170 feet. Beginning at the feed end, the four knockout drums and associated pumps are grouped to the right adjacent to a piperack. The three trains are arranged side-by-side along the piperack and occupy most of the remaining area.

The first equipment in each train is the large air blower that furnishes combustion air to the reaction furnaces. There are four of these blowers, one for each line and a common spare. The three reaction furnaces and their coupled waste heat boilers are next, followed by the feed preheaters mounted adjacent to the reaction furnaces. Beyond the reaction furnace and waste heat boiler equipment is a structure supporting the converters which are mounted side-by-side beneath the converters. Beyond the structure are three vertical reheat exchangers and the vertical tail gas superheater. The sulfur pit is located in a corner of the plant.

Each of the feed gases to the Sulfur Plant is fed to a separate knockout drum. The liquid separated in these drums is pumped back to its originating plant. The gas is divided and fed to the three trains. Gas flow to two of the trains is by flow control while flow to the third is by pressure control to adjust for feed fluctuations. The gas fed to each train is sent to a feed preheater where its temperature is raised to about 460°F by 600 psi steam.

The sour gases are burned in a reaction furnace at high temperatures. The exit gases from the furnace are cooled in a waste heat boiler which generates 600 psi steam. The cooled gases then join bypass gases from the Stack Gas Scrubbing and the Gasification and Purification plants. The amount of gas which bypasses the reaction furnace is controlled to achieve optimum conditions in the downstream converters.

The combined stream is fed through a sequence of condensers, reheat exchangers, and converters. The converters are horizontal, cylindrical vessels containing catalyst beds. The sulfur compounds in the gases are converted to sulfur vapors in the converters and then condensed and removed as molten sulfur. Each condenser is cooled by preheated boiler feedwater which is converted to 500 psi steam. Molten sulfur is condensed and drained through a seal pot. The preheaters are heated by 600 psi steam. Each train has two condensers with two passes, three reheaters and three converters. Each of the condensers has a seal pot that drains into a sulfur pit common to all three trains. Molten sulfur is pumped to storage. The exit vapor from the final pass of the last condenser is superheated with 600 psi steam and sent to the boilers for burning.

Offsite Plants

5.0 OFFSITE PLANTS

5.1 FLARE SYSTEM - PLANT 19

The Flare System plant consists of primary and auxiliary flare systems. The plant provides for safe collection and disposal of overpressure relief discharges, and for operational and emergency venting of flammable vapors and liquids from the various process plants and loading facilities.

Each individual process plant is provided with the necessary flare headers to collect overpressure relief valve discharges, operational vents (start-up and shut-down), and emergency vents. These unit headers tie into the appropriate main flare headers which run down the central pipe-rack corridor and combine in the primary flare knockout drum. The relieving fluid is separated in the knockout drum into a vapor stream that is directed to the flare where it is burned, and a liquid stream that is collected and pumped back to slop tanks in the Tankage Plant. The two pumps (one spare) are automatically controlled by level controls. The primary flare system knockout drum is equipped with steam heating lances. These lances are used to prevent material from freezing during winter.

The primary flare collection system consists of three flare headers: high-pressure, low-pressure, and low-temperature. The high-pressure header is connected to relief valves with a set pressure of 300 psig or more, while the low-pressure flare is connected to relief valves with a set pressure under 300 psig. The low-temperature flare header is connected to relief valves that relieve liquids with a temperature below -20°F. The high-pressure header has a diameter of 42 inches and the low-pressure header is 30 inches. The low-temperature header has a diameter of 8 inches and is fabricated of stainless steel. It handles only the cryogenic liquids from relief valves in the Gas Plant and the Cryogenic Hydrogen Purification plant.

Two primary flares measuring 42 inches in diameter and 360 feet high are provided. Each stack has a refractory-lined tip, conventional pilot, a flame-front generator that provides ignition to the pilot gas burner located at the top of each flare stack, and molecular seals that prevent air from entering the system. In addition, each primary flare system header is purged with fuel gas. The flares operate in parallel from the common knockout drum, but normally only one flare is on line at any given time. The flares feature smokeless operation achieved by automatically controlled injection of steam that provides smoke suppression by promoting a more complete combustion from intimate mixing of the flared material and the oxygen in the air. The two primary flares are located on the east side of Town Creek near the base of the hills.

The auxiliary flare system consists of separate collection systems and flare stacks at the rail, truck, and barge loading facilities. Separate flare stacks are also provided for hydrogen sulfide and sulfur dioxide releases from the Sour Water Treating plant and the Sulfur Plant.

The auxiliary flare stacks for the Sour Water Treating plant and the Sulfur Plant are 6 inches in diameter and 150 feet high. They are provided with conventional pilots and flame-front generators but require no knockout drums. The H_2S and SO_2 flares are located in the vicinity of the plants they serve. The two flare stacks for the loading station are each 12 inches in diameter, 150 feet tall, and are equipped with pilots and flame-front generators. Each has a knockout drum with the separated liquids pumped to slop tanks. Both of the loading area flares are smokeless type. The truck and rail loading vent flare is located between the two loading stations. The barge loading vent flare is located onshore near the barge loading dock.

5.2 TANKAGE - PLANT 20

The Tankage plant performs three functions:

- Storage of finished products awaiting shipment
- Storage of intermediate products for further processing
- Storage of purchased liquids to be used in operations

The plant contains 46 tanks and spheres of various sizes, not including the potable water and fire water tanks. The tanks in the processing units, some of which are quite large, are not included in this plant.

Standard size API tanks were selected whenever possible. Two tanks are provided for each finished product in order to avoid having to run down and ship from the same tank simultaneously. The storage tanks have diameters of up to 200 feet. A general height limitation of 40 feet was imposed due to the available soil bearing loading conditions. Large spheres will be supported by piles.

Individual tanks are generally surrounded by dikes with sufficient volume within the dike to safely contain the entire contents of the tank. However, the five spheres and two refrigerated storage tanks are contained in a common diked area. The caustic and acid tank areas are curbed.

The tankage area is irregular in configuration. Its maximum dimensions are about 2,500 feet in either direction. Total area devoted to tankage is about 90 acres. Several pipeways traverse the area.

Product tankage is sized for 30 days' production except for anhydrous ammonia tankage, which is sized for 60 days' production. Thirty days' storage was selected to even out variations in production and shipping rates. More storage was provided for ammonia due to its seasonal demand. Five days of pressure storage for propane and ammonia is provided since both of these products are shipped in pressurized containers at ambient temperature. The remaining storage is in refrigerated vessels maintained at atmospheric pressure, as this is a more economic mode of storage. Space for five days of solid sulfur storage has been allowed in the plot plan.

The final products for which tankage is provided are:

- Propane LPG
- Butane LPG
- LSR gasoline
- Gasoline reformate
- Middle distillate
- Heavy distillate
- Anhydrous ammonia
- Liquid sulfur
- Phenols
- Liquid oxygen
- Liquid argon

The liquid oxygen and liquid argon are stored adjacent to the Oxygen Plant and are not located in the Tankage plant area.

Propane LPG enters the plant battery limits at -30°F from the Gas Plant and is cooled in a refrigeration unit to -48°F before storage in refrigerated tanks at atmospheric pressure. Two 80,000-barrel cone roof tanks provide 25 days of refrigerated storage. The tanks are equipped with a refrigeration unit and a product heater. Propane may also enter the plant at 100°F, bypassing the refrigeration unit in the Gas Plant. In this case, the propane is sent directly to pressurized storage and shipping. Product in excess of shipments is refrigerated and sent to the refrigerated storage. Product propane taken from the refrigerated tanks is heated to a shipping temperature of 100°F and sent to pressurized storage. Two 16,000-barrel spheres provide five days of nonrefrigerated storage. Propane product loading pumps are designed for 2,000 GPM.

Butane LPG is received at the battery limits at 100°F from the Gas Plant. Product butane is then stored in three 43,000-barrel pressurized spheres providing 30 days' storage. Loading pumps are designed for 2,000 GPM of butane product.

LSR gasoline from the Gas Plant is received at 100°F and stored in two 61,000-barrel spheroids which provide the 30 days' storage. Two 3,500 GPM pumps are provided for product loading.

Gasoline reformate is delivered from the Naphtha Hydrotreating and Reforming plant at 100°F and stored in three 118,000-barrel tanks which provide 30 days' storage. Each tank is equipped with a floating roof inside a cone roof. Product loading pumps are designed for 3,500 GPM.

Middle distillate from the H-Coal® Distillate Separation plant enters the tankage battery limits at 130°F and is stored in three 208,000-barrel cone roof tanks providing the 30 days' storage. Loading pumps are designed for 3,500 GPM. Steam coils are provided in these tanks to maintain the product at a pumpable temperature.

Heavy distillate from the H-Coal® Distillate Separation plant enters the tankage battery limits at 180°F and is stored in two 89,000-barrel cone-roof tanks providing the 30 days' storage. Loading pumps are designed for

3,500 GPM. Tank bottom steam coils are provided to maintain the product at a pumpable temperature.

Anhydrous ammonia from the Sour Water Treating plant reaches the battery limits at 100°F. The product ammonia is stored in two 4,000-barrel spheres providing five days of storage. Additional storage consists of two 45,000-barrel cone-roof refrigerated tanks with a storage capacity of 55 days. These tanks are equipped with both a refrigeration unit to cool the ammonia from 100°F to -28°F and product heating equipment. Loading pumps are designed for 2,000 GPM.

Molten sulfur is received and stored at 300°F. Two 33,000-barrel cone roof tanks provide the 30 days' storage. Tank temperatures are maintained by heating with steam coils which include four coils located at the bottom, two roof coils, and two suction heaters. Pumps provide 3,500 GPM loading capacity.

Phenols from the Sour Water Treating plant reach the battery limits at 100°F. Two 8,000-barrel vertical tanks provide 30 days of storage. Each tank has a floating roof inside a cone roof. Loading pumps are designed for 2,000 GPM.

Intermediate tankage provides temporary storage for intermediate products that require additional processing or will be used in the Process Plants. This tankage provides for the uncoupling of some of the process units so that variations in the rate of production or temporary stoppage in one unit does not upset the operation of related units. It also provides for storage of materials produced in the units and is used intermittently or at widely varying rates such as the purge and flush oils. Tank sizes were based on projections from pilot plant operations or standard refinery practice. Intermediate tankage is provided for the following materials:

- Raw heavy naphtha
- Vacuum tower bottoms
- Vacuum tower side draw
- Sour water
- Dilute sour water
- Distillate flush oil
- Heavy flush oil
- Light slop oil
- Heavy slop oil
- Wet slop oil

To allow for turnaround in other plants, ten days' intermediate storage is provided in two 65,000-barrel tanks for feed to the Naphtha Hydrotreating and Reforming plant. This feed is made up of a bottoms stream from the naphtha splitter in the Gas Plant and a sidedraw from the main tower in the H-Coal® Distillate Separation plant. The tanks are cone roofed with an interior floating roof. Plant feed normally bypasses these tanks. Two pumps are provided.

Vacuum tower bottoms from the H-Coal® Recycle Slurry Preparation plant normally flow to the Gasification and Purification plant. Intermediate storage is provided for emergency operation. The stored material from the vacuum bottoms stream is cut with heavy flush oil to maintain a lower viscosity. The mixture is then stored at 300-400°F in two 80,000-barrel agitated tanks with cone roofs. The tanks are heated by steam coils located at the top and bottom of each tank and fin-tube heaters located at the suction nozzles. Pumps are provided to feed the vacuum tower bottoms to the process area.

Intermediate storage is provided for concentrated sour water fed to the Sour Water Treating plant. The concentrated sour water from the H-Coal® Primary Separation plant is stored at 100°F. Three 80,000-barrel tanks provide seven days of storage to allow for turnaround or unscheduled interruption of operations. Each tank has an oil skimmer and floating roof inside a cone roof. Two pumps are provided and a compressor is included to recover vapors escaping from the tanks and to send the recovered vapors to the Steam Generation and Boiler Feedwater Treating plant for incineration.

Dilute sour water is collected from the Gas Plant, Naphtha Hydrotreating and Reforming plant, and the filtered grey water tank in the Solid Waste Management plant. Intermediate storage is provided for dilute sour water prior to use in the H-Coal® Primary Separation plant. Two 70,000-barrel tanks provide seven days' storage of the dilute sour water at 100°F to allow for turnaround time. Each tank has an oil skimmer and a floating roof inside a cone roof. Pumps feed the diluted sour water to the process area.

Distillate flush oil from the main tower in the H-Coal® Distillate Separation plant is stored in two 50,000-barrel cone roof tanks at 130°F. The tanks are provided with bottom steam coil heaters to maintain pumping temperature. Three pumps are provided for feeding low evaporator flush valve flush oil to process plants for instrument purging and other uses.

Heavy distillate from the H-Coal® Distillate Separation plant is used for flush oil, pump warming, and catalyst transfer. A 50,000-barrel cone roof tank is provided to store the heavy distillate. A bottom steam coil heater maintains pumping temperature. Two pumps supply heavy oil for pump warming in Process Plants and provide catalyst transfer oil to handle the heavy flush oil demands. A jockey pump is provided to pressurize the system.

A sidedraw from the vacuum tower in the H-Coal® Distillate Separation plant is used for the flush oil services requiring oil with a high boiling point. A 10,000-barrel cone roof tank provides storage capacity. A bottom steam coil is provided to maintain storage temperature. Three pumps transfer vacuum tower sidedraw to the process area.

The light slop tank and heavy slop tank provide storage capacity for emergency operations. Each cone roof tank stores 25,000 barrels. The light and heavy slops are returned to the H-Coal® Distillate Separation plant after normal plant operation is established. Four pumps are provided for pumping light and heavy slop, two for each service.

The wet slop tank provides 10,000 barrels' storage in a cone roof tank that is supplied with an oil skimmer and a heating steam coil. The wet slop is sent to the process area by two pumps for further processing.

The tankage provided for storage of purchased liquids used in the processing units is comparatively small. Sizing was based on facilities with similar throughput volumes. Storage is provided for:

- 50% caustic
- 20% caustic
- 98% sulfuric acid
- 20% sulfuric acid
- Neutral oil

Storage for glycol, Selexol, DEA, and other materials is located in the Process Plants and is not discussed in this section.

Storage tanks for caustic include a 1,000-barrel cone roof tank for concentrated (50 wt%) caustic solution. This is pumped to another cone roof tank for dilution to 20%. The dilute tank has a capacity of 400 barrels and uses a steam coil to maintain storage temperature. Four pumps are used, two for tank transfer and two for transfer to the process area.

Concentrated sulfuric acid and dilute sulfuric acid are stored in a 1,000- and a 400-barrel vertical cone roof tank, respectively. Four pumps are used to transfer the acid to other tanks or to the process area.

A 10,000-barrel cone roof tank is provided for storage of neutral oil. Two pumps transfer the oil to the process area.

5.3 INTERCONNECTING PIPING - PLANT 21

The Interconnecting Piping plant includes the fuel gas blending and distribution, interconnecting process, and utility piping as well as most of the piping outside the battery limits of other plants. The fire water and the flare system piping is not included in this plant. Generally, all piping is located aboveground on racks or sleepers except for the water distribution piping, which is underground.

The utility systems include the following:

- High-Btu fuel gas
- Medium-Btu fuel gas
- High solids cooling water supply and return
- Low solids cooling water supply and return
- Closed loop cooling water supply and return
- 50 psi steam
- 150 psi steam

- 600 psi steam
- 900 psi steam
- 50 psi condensate
- 150 psi condensate
- 600 psi condensate
- Instrument air
- Utility air
- Potable water
- Utility water
- Nitrogen
- 50/150 psi boiler feedwater
- 600 psi boiler feedwater

The greatest density of piping is in the main pipeway which runs through the center of the processing area. It is a multitiered structure and is approximately 3,200 feet long. At one end it intersects with a second major pipeway. This pipeway is smaller but much longer, as it runs from the loading dock to the flare area, or about 6,300 feet. Secondary pipe-racks run to the cooling tower area, the Coal Washing plant and the coal handling area.

The largest utility pipelines are the underground lines running to and from the cooling towers. Lines from the low solids tower are 54-inch, while those from the high solids tower are 60-inch diameter. The 54-inch lines run to the vicinity of the Steam Generation and Boiler Feedwater Treating plant. The 60-inch lines run along and under the main pipeway until reduced in size beyond the Gas Plant. The largest line on the piperacks is the 42-inch steam header. The fuel gas mains are as large as 36 inches; however, the process liquid lines are all 12-inch or smaller.

This plant also includes the fuel gas blending system. Plant fuel gas is available from four sources, two of which are classed as high-Btu gas while two are medium-Btu gas. Most users will not tolerate quality variations which might result if all four streams were combined, so the distribution system has been split into a medium- and a high-Btu system. Gas-fired equipment generally has two sets of burners connected to each system to allow maximum flexibility.

The separate systems pass through their respective mixing drums for blending. The medium-Btu mixing drum has a draw-off connection to remove liquids. The gas is then sent to its distribution header. The high-Btu gas drum is connected to offsite natural gas for use during start-up or to adjust for supply fluctuations.

The Interconnecting Piping plant contains a minimum number of valves and fittings since the battery limits of the isolating valves, blinds, and the like are classified as intraplant piping.

5.4 RIVER FACILITIES - PLANT 22

The River Facilities provide equipment for unloading coal barges and loading product barges. The coal unloading facilities are at the upriver end of the plant site while the product loading facilities are downstream near the tank farm. Provisions are made for docking both loaded and unloaded barges. A work boat moves the barges as required.

The coal unloading dock is located near the center of the coal barge unloading facilities and extends along the riverfront for some 5,300 feet. The coal unloading equipment is mounted on a platform 32 feet above the river's normal pool level in order to accommodate the 26-foot variation that can occur during flooding. The platform is supported by two 36-foot diameter cell dolphins inshore and two 28-foot diameter dolphins offshore. The loaded barges are moved between the inshore and offshore dolphins while being unloaded by an overhead barge unloader. Three 28-foot diameter cell dolphins are also provided at 120-foot intervals on each side and in line with the platform. These dolphins serve to breast the barges and provide mounting points for the winches and sheaves used in moving the barges back and forth along the dolphins. The work boat moves the barges in and out of position.

Beyond each end of the dolphins, pile clusters are provided at 120-foot intervals for temporary tie-off of empty and loaded barges. Fifteen tie-off pile clusters are provided upstream for the unloaded barges and twenty-two tie-off pile clusters are provided downstream to accommodate the loaded barges. Space is thereby provided for four tows (12 barges to a tow) of unloaded barges and five tows of loaded barges.

A 15-foot-wide trestle extends from the onshore road to the unloading platform and also provides access to the dock. A separate trestle supports the conveyor belt from the unloader to the transfer house. A lighted walkway connects the tops of the dolphins with the platform and provides access to the barge hauling winch, cable, and sheaves. Rubber fenders protect the faces of the dolphins where the barges come in contact with them. Mooring bitts are provided for tying up the barges. The river bank will be lined with stone blocks as necessary to protect the facilities from erosion.

The liquids product loading facility is some 4,300 feet downstream from the coal unloading dock. The dock is supported by two 28-foot diameter cell dolphins on 42-foot centers. A series of guide piles extend away from the dock on both sides followed by two 28-foot dolphins, a pile cluster, and a single pile at various intervals. A 15-foot wide road connects the loading dock to shore. The trestle supporting the road also supports piperacks for product and utility piping.

Two loading barges are held captive between the center dolphins and first outboard dolphins as permanent floating sections of the dock. A cable and fender system secures the barges and protects them. These barges support the loading arms and are provided with guides to ensure proper positioning if the river level changes. Firefighting and other equipment is also mounted on the barges. Gangways with self-leveling steps provide access from the twin cell structure to the barges. A horizontal gangway with handrailing is installed between the two captive barges. A control house is located on the platform and contains communication equipment, an alarm panel, and control board. Motor-operated jib cranes are installed on each side of the platform to facilitate cargo handling and maintenance operations.

The dock arrangement permits the loading of two different products into separate barges at a time. Two or more barges abreast can also be loaded with the same or different products.

The product loading system includes piping from the tankage area to the marine loading facilities. This piping is provided with safety shut-off valves that are part of the safety system. Loading is accomplished by pumping to the marine loading arms at a maximum controlled rate of 5,000 BPH. The design provides a dedicated loading line for each product. The product flow from the fixed dock structure to the floating loading barges is accomplished by the use of articulated joints in the loading lines. These joints allow free vertical and horizontal movement of the loading barges with fluctuating draft and water levels. One free-standing manually operated loading arm is provided for each product. The inboard and outboard arms are counter-weighted and balanced. Insulating flanges are provided in the loading arms to electrically isolate the barges from the loading structure.

Propane and butane are transported by pontoon-type barges that have pressurized storage tanks mounted on them. The barge capacity is 10,000 barrels. Light straight-run (LSR) gasoline, gasoline reformate, light distillate, and heavy distillate are loaded into double-skin barges ranging from 10,000 to 30,000 barrels in capacity. Molten sulfur is loaded into double-skin barges provided with a hot oil heat exchange system. Barge capacities are 2000-2500 tons. Berth analysis indicates an arrival frequency of 1.4 barge tows per day. Two berths are provided to limit waiting time for the barges to an acceptable level. Barge tows consist of two large or four small barges.

Utility and vapor return systems include: steam for heat tracing; nitrogen for purging and instruments; potable water; utility water; waste water; vapor recovery for propane, butane and LSR gasoline; and vapor return for gasoline reformate. A local blower pressures the LSR gasoline vapor back to the plant. Blowers for recovery of propane and butane vapors are located in the Rail, Truck, and Pipeline plant. The gasoline reformate vapor is piped to a low-pressure flare with a knockout drum and condensate pump. Any spillage is recovered by vacuum trucks and returned to the plant site for disposal. Storm water is collected in a sump on the loading barges and pumped to a collection sump on shore. A 1,000-gallon fuel storage tank is provided on the twin cell structure for fuel supply to the support vessel. A floating boom and skimmers are provided to contain and remove any liquids spilled into the river.

The fire fighting system is a wet system using river water. It is automatically activated by fire detectors located at critical points. One main fire water pump and one jockey pump maintain minimum pressure on the system. The fire protection system is supplemented with portable liquid foam units located on the loading barges. Fire water monitors are located on the central platform and on the mooring dolphins.

Area lighting and power distribution are provided. An electrostatic grounding system on the captive barges grounds the static electricity from the loading barges. Flow rate and storage tank level indicators for each product are provided in the dock control room. Product custody transfer is monitored by plant control room instruments. The control and alarm panel in the dock control room contains fire detection instruments, fire pump controls, and emergency shut-down controls. Local dock security and loose barge alarms and controls are repeated on the control panel. The dock sentry and loose barge safety shut-down system closes product line shoreside valves and also shuts down the plant loading pumps. Automatic shut-down is initiated by any low-pressure signal from pressure switches installed at strategic locations on the product loading lines.

5.5 RAIL, TRUCK, AND PIPELINE - PLANT 23

This plant provides shipping and receiving capability and contains the equipment, facilities, and piping needed to receive or transport products by rail, truck, or pipeline.

Products handled by the truck facilities include propane, anhydrous ammonia, molten sulfur, and phenols. The rail facilities handle these plus butane, LSR gasoline, gasoline reformate, middle and heavy distillates.

The products are generally pumped from the storage tank to the loading point. One pump delivers the required rate with the exception of propane and butane, which can be simultaneously loaded into two tank cars or to a barge. All pumps are spared. Each product is piped by a separate line to the loading racks, then branched to different loading nozzles so that the product can be loaded from two or more bays. A 15-minute loading time is scheduled for 30,000-gallon tank cars and 10,000-gallon tank trucks. Middle and heavy distillates are loaded at 130°F, molten sulfur at 300°F, and the remaining products at ambient temperature.

The design and operation of the equipment requires special attention to assure compliance with safety and environmental regulations. Hydraulic shock absorbers are provided for sudden shutoffs and static neutralizing devices are provided for gasoline reformate, middle distillate, heavy distillate, liquid sulfur, and phenols. Heat tracing and insulation are provided for the heavy distillate and molten sulfur. Vapor recovery lines are provided from the tank trucks and tank car loading racks. The loading nozzles have connections for bleeds and drains. Hand-operated block valves are provided just upstream of the loading nozzles and are accessible from the platforms. Connections for nitrogen purge are provided at the loading nozzles for certain products.

Railroad facilities provide for the operation of the rail tank car unloading, coal unloading, and receipt of construction materials and commodities. The rail tank car loading facility is capable of loading 23 tank cars per day during two shifts. Rail trackage is sufficient to store an additional 23 tank cars. Trackage for coal cars can accommodate one unit train of 100 cars being unloaded while another unit train is waiting to be unloaded. Total length for the railroad spurs is approximately 41,000 feet.

The rail tank car loading platforms consist of a structural steel frame with grating and walkways. Swing-down catwalks with counter-weights are used for each loading spot for operator accessibility. The loading platform is 340 feet long, 4 feet wide, and 12 feet high. The products are piped to six loading bays. Stairs are provided at both ends of the platform and at 110-foot intervals. Standard loading arms with telescopic nozzles and swivel joints are provided for top-loading facilities. Loading arms with bottom-loading hose connections are used for volatile products such as propane, butane, LSR gasoline, and anhydrous ammonia. The materials for the loading systems are such that the equipment is compatible with the shutoff pressures of the pumps.

The tank truck loading facility is capable of loading four products and metering or weighing the products being shipped. The main tank truck loading facility consists of a steel structure that shelters and contains a loading platform which is 10 feet long, 8 feet wide, and 10 feet high. One set of stairs is provided for accessibility. A truck scale is provided for weighing the empty or loaded trucks. The products are loaded to the level marker provided in tank cars and by set stop meters for tank trucks. All trucks are weighed in and out. Top-loading nozzles are used for phenols and molten sulfur. Nozzles with bottom-loading hose connections are used for anhydrous ammonia and propane. A separate truck loading station is provided at the Oxygen Plant to handle the cryogenic products. Another loading station is provided near the boilers to load solid sodium sulfate.

Support facilities include a fire water system, instrumentation and a vapor recovery system. A sprinkler fire water system is provided for the tank truck loading rack which is automatically energized in case of fire, covering the entire loading rack area with water. Fire hydrants, portable dry chemical fire extinguishers and monitors are provided for the tank car loading rack.

Pressure indicators are provided at each loading nozzle location. Automatic excess flow shutoff control valves for emergency shut-down in case of a broken hose in the loading nozzles are used for volatile products. Positive displacement meters with totalizers are provided for each product. Digital counters with printout capability are installed at the loading locations.

Vapor lines from loading facilities provide separate vapor recovery systems for propane, butane, anhydrous ammonia, and LSR gasoline. The vapors are piped to a compressor for each service and pressured back to the tankage area. Vapors from gasoline reformate and phenols are piped to a local flare system.

The main loading facilities are located adjacent to the highway near the tank farm.

The design of a pipeline for exporting synthetic natural gas (SNG) will be developed at a later date in cooperation with local gas pipeline operators. This pipeline will be about 10 miles long.

5.6 SITE DEVELOPMENT AND ROADS - PLANT 40

The development of the site involves the grading of approximately three square miles and the addition of basic improvements such as roads, fencing, drainage, load-bearing fills, piling, and foundations.

The general site will be graded to an average elevation of about 420 feet above mean sea level. The surface soils at the site are highly organic. Beneath this, topsoil is a 6 to 18 feet layer of silty alluvial soils that is underlaid by a sandy layer some 100 to 130 feet thick. The topsoil will be stripped from the site and stockpiled for later reuse in landscaping or disposal. The silty soils will be removed and compacted as structural fill, or stockpiled for other use if their moisture content is too high. The sandy soils will be consolidated through dynamic consolidation or other techniques as necessary to support the various structures of the facility.

As site development proceeds, drainage facilities will be developed. This starts with rough grading during the site work to keep runoff from ponding in the working area, and progresses to excavation of drainage channels and installation of culverts, ponds, headwalls, and underground storm sewers.

Spread footings and mat foundations will be used to support nominal loads; however, piling will be used for heavy or settlement-sensitive structures and equipment. Both 50- and 100-ton capacity endbearing piles will be used for foundations.

As the rough grading, installation of foundations, and underground piping work is completed, the area will be fine graded. This consists of: providing the correct finish slope for surface drainage; final shaping and sloping of drainage ditches; and bringing the roads, parking lots and other paved areas to their final elevation for paving.

Containment dikes for the tank farm area and water storage ponds with 3-to-1 side slopes will be constructed from the material that was excavated and not reused in the engineered fill.

Plant roads are asphaltic concrete on a crushed limestone base course placed on a compacted subgrade. Main plant roads are 24 feet wide with 3-foot shoulders. Secondary roads have similar cross sections with widths appropriate to their usage. Parking lot construction is similar to the roads.

A highway overpass and a bridge are required. The overpass crosses the existing highway and railroad and provides access from the main plant area to the wastewater collection and treatment area and the river facilities on the west side of the highway. It has a length of approximately 500 feet and has a reinforced concrete deck supported by steel girders.

The overpass abutments and piers are supported on piles. The bridge provides access across Town Creek, and has a total length of approximately 520 feet. It is designed to carry the solid waste disposal trucks and is of similar construction to the highway overpass structure.

Perimeter fencing and gates are provided to restrict access. In addition, certain areas within the plants are protected by fencing.

5.7 BUILDINGS - PLANT 41

The type of construction selected for each building considers its location with respect to potential hazards, importance to plant operations, and its function. The buildings are classified as types A, B, C, D, or administrative according to their major construction features. A total floor space of about 480,000 square feet will be provided.

Type A buildings house critical equipment or instrumentation used for the continuous operation of the plant. The structures are blast resistant, designed for 3 to 3-1/2 psi overpressure and are provided with air lock entrances/exits. Interiors are pressurized to 0.1 to 0.2 inches of water. Type A buildings are steel framed with concrete walls and metal roof decking. The structural frame is fireproofed with three-hour-rated material. Interior walls are fire coded plasterboard on metal studs or concrete block. Ceilings are provided in all rooms except the mechanical equipment rooms. Type A buildings are provided with heating, air conditioning, lighting, electrical, plumbing, and sanitary systems.

Type B buildings include the plant laboratory, wet air oxidation laboratory, reverse osmosis laboratory, cafeteria, medical building, and the change house. The supporting structure is steel framed with masonry walls and metal roof decking. Structural framing is fireproofed with three-hour-rated materials. Interior walls are fire coded plaster board on metal studs or concrete block. Ceilings are installed in all rooms except the mechanical equipment rooms. Type B buildings are provided with heating, air conditioning, lighting, electrical, plumbing, and sanitary systems.

Type C buildings serve a number of diverse functions that are generally related to operation or maintenance. These buildings are steel framed structures with metal siding and roofing. When required, the building frame is designed to support cranes and monorails. Roofing and siding are factory finished. The sides of compressor shelters are only partially covered. Metal sandwich panels are used where buildings require insulation. Office areas are heated and air conditioned by package units. Type C buildings are provided with lighting, electrical, and plumbing systems. Sanitary facilities are provided only when required.

Type D buildings include transformer houses and storage buildings. They have masonry walls and structural steel framed roofs with metal decking. Interior partitions and walls are concrete block. Finished ceilings are not required. These buildings are provided with lighting, electrical, and plumbing systems. Sanitary facilities are provided only when required.

The administration building, which also contains the computer room, is identical in construction to that of Type B buildings except that the exterior is finished with brick veneer.

5.8 SOLID WASTE MANAGEMENT - PLANT 42

The project will produce an estimated 8,700 tons of a variety of solid wastes each day. The management plan calls for identifying, characterizing, segregating, and transporting the various types of solid wastes to either outside sales or to disposal sites. Major types of waste solids include: coal refuse; slag, ash, and soot; filter cake; and sludge. Most of the solid wastes produced in plants within the complex are dewatered within the battery limits of the plant. Wastes will be transported by trucks. The Solid Waste Management plant includes gasifier slag and ash dewatering equipment, as well as incinerators for sludge, emulsion, and oily water.

Four incinerators are provided to meet a maximum charge rate of sludge from the complex. During normal conditions three will be in operation and one on standby. Each incinerator is designed to have a heat release rate of 10 million Btu per hour which allows for a water evaporation capacity of 2,600 to 2,900 pounds per hour. The charge rate will be a function of the characteristics of the sludge feed. Auxiliary fuel is medium-Btu fuel gas.

Oily and chemical sludges from various operations throughout the complex are incinerated. Typical sources of waste sludges include the API separator bottoms, DAF bottoms and float, desalter emulsion cuff, storage tank bottom residues, oily sewer manhole residues, and skimmings and dredgings from ponds.

Sludges and emulsions are pumped to one of two incinerator feed tanks. Miscellaneous sludges that develop as a result of maintenance, housekeeping, or special clean-up operations are delivered to the incineration site by vacuum truck and dumped into a below ground concrete sump. Positive displacement sludge pumps periodically transfer the contents of the sump to one of the incinerator feed tanks. The tanks are equipped with mixers to produce a homogeneous mixture that minimizes abrupt variations in incinerator feed composition.

The incineration is a batch operation and has built-in flexibility by virtue of the two feed tanks and four incinerators. Normally, all sludge streams are routed to one of the tanks. The thoroughly mixed contents are analyzed for physical, chemical, and heating value characteristics. After determining that the sludge is suitable for incineration, a predetermined quantity is transferred to the second tank from which a number of incinerators are charged, depending on the inventory of sludge on hand.

The fluidized-bed incinerators are capable of burning miscellaneous sludges, emulsions and suspensions of oil, ash, soot, and coal dust in water. Each incinerator unit includes all associated equipment, such as the sludge feed pumps, air preheat and fluidizing combustion air blowers, intake air filters, incinerator reactor, sand storage bin, and material handling equipment. Combustion gas from each incinerator is fed directly into the firebox of the coal fired boilers.

The gasifier plant normally produces about 1,500 tons of slag and soot per day. About 80% of this waste material is coarse slag that is screened from the rest of the solid waste as it is transferred as water slurry to clarifiers. The solids in the underflow from the clarifiers are referred to as "ash" and the overflow as "grey water". (The water has a characteristic gray color derived from the fine ash and soot in suspension.) The underflow solids from the clarifier are dewatered by a vacuum filter system into filter cake which is then delivered to the dewatered slag/soot bin by a conveyor. The dewatered ash is mixed with coarse slag in the bin before being trucked to disposal in a landfill.

A portion of the clarifier overflow, called grey water blowdown, is filtered in media and cartridge filters in series. The treated water is recycled to the hydrocarbon desalting process in the H Coal® Distillate Separation plant. The filter backwash containing fine ash is sent back to the clarifier on an intermittent basis.

5.9 LANDFILL - PLANT 44

The Landfill plant provides for the collection, transportation, and disposal of solid wastes generated by the project. Dewatering, storage, and loading facilities are provided in the appropriate Process and Offsite Plants. The following paragraphs briefly characterize the wastes and describe the landfill techniques and disposal locations.

Solid waste includes ash, solid residue, dewatered sludge, trash, and garbage from the operation and maintenance of the facility. Moisture content is generally low enough for the waste to be handled as a solid material. Most of the waste is nonhazardous, including the coal refuse, gasifier ash and slag, boiler ash, water treatment waste, and miscellaneous facility trash and garbage. A small portion is hazardous, such as the flue gas desulfurization by-product waste and the wastewater treatment's filter cake and salts. Approximately 8570 tons per day (TPD) of nonhazardous and 130 TPD of hazardous waste are produced. Some nonhazardous waste is mixed with the hazardous waste to improve the compaction properties of the hazardous waste. Consequently, the quantities of dry solids disposed at the nonhazardous and hazardous waste disposal sites are 8450 TPD and 250 TPD, respectively. Solid waste is collected daily to minimize onsite waste storage. All solid waste except miscellaneous plant trash and garbage is stored in elevated bins and hoppers.

The disposal sites will be prepared by clearing, grubbing, and removal of the soil layers having a high organic content. Steep areas will be benched to provide stability. Fill operations will begin at the upstream end of the hollows and move downstream. A soil-cement starter dike will be constructed at the toe of each fill stage to provide stability and access and to act as part of the water retention system.

Waste material is placed and compacted in layers. As the area is filled, gentle face slopes and construction of benches on the face will provide erosion control. As finish grade is reached, the areas are capped with clay, covered with top soil, graded for proper drainage, and revegetated. The disposal areas selected have forty years of storage capacity. Capacity of the area is designed to fill the watershed, avoid visibility problems from adjacent lands, and maintain stable slopes for erosion control.

The construction of the two disposal areas differs in several aspects. The hazardous waste disposal area has more gentle slopes, more frequent benches, and the final clay cap will be thicker. It also uses intermediate cover material to minimize leaching. The non-hazardous area uses an impervious compacted clay liner on the bottom and sides of the fill area. A thick graded gravel layer will be placed on top of this to provide drainage to the low point of the area with its collection pipes. The hazardous waste area uses a double-walled or sandwich impervious liner with a leakage detection layer at the bottom consisting of a gravel layer and collection pipes. Over this is a clean sand layer, then a synthetic membrane liner overlaid by another sand layer, then a thick clay layer, and finally a leachate collection system consisting of a graded sand and gravel layer with collection pipes.

Leachate management consists of collection of the leachate in ponds and returning the leachate to the wastewater treatment unit through a pipeline. Depending on location, the transport of leachate is by either pump or gravity. The ponds have impermeable liners and are constructed in cells to allow for maintenance. The hazardous area has several monitoring wells which monitor the groundwater quality.

Runoff control during construction of the landfill is primarily by perimeter drainage ditches that divert runoff from adjacent areas away from the disposal area. Runoff from the working area is sent to the collection ponds. As construction is completed and the areas capped, surface runoff from the landfill is diverted to the permanent drains. These drains are a combination of permanent channels, downcomer pipes on steep slopes, and energy dissipation structures.

Forty- to eighty-five-ton trucks haul the waste to the various sites. The material is spread by the trucks and compacted by wheeled loaders. Tracked dozers will assist with spreading and compacting the waste. Motor graders maintain the roads and perform the fine grading.

Access roads are provided to both sites, and both sites are fenced. A common equipment service and maintenance area is provided at the non-hazardous site.

5.10 TRANSPORTATION PLANT

The Transportation Plant provides the mobile equipment used in plant operations. Over 140 items of equipment are required, including light trucks, welders, fork lifts, cranes, fire trucks, ambulance, trailers, bulldozers, compactors, and front-end loaders. Landfill equipment is included in the Landfill plant.

Utility Plants

6.0 UTILITY PLANTS

6.1 ELECTRICAL DISTRIBUTION - PLANT 30

The project requires 186 mW of electric power when operating at rated capacity. About 50 mW is generated in the Steam Generation and Boiler Feedwater Treating plant and some 15 mW is generated by pressure let-down expanders in the Process Plants. The remaining electrical requirements are supplied by the Big River Electric Corporation from two separate power systems, each of which is capable of supplying the entire project requirements of 186 mW at 161 kV. Each incoming power line from the two power systems will be tied to the two main substations in order to provide each main substation with two sources of feed. The main substations are located at opposite corners of the processing area. Generally, each of the main substations feeds the plants on its side of the main piperack. However, some of the multiple equipment items in particular plants are split between two substations to minimize the effect of failure of one source.

Each main substation will deliver power to three satellite substations. The first main substation delivers to satellites located at the Gasification and Purification plant, adjacent to the H-Coal® Recycle Slurry Preparation and H-Coal® Recycle Hydrogen Compression plants, and near the Coal Drying and Pulverizing plant. The other main substation delivers power to satellites at the Oxygen, Steam Generation and Boiler Feedwater Treating, and Sulfur plants.

Each satellite substation has two 34.5 kV transformers. One transformer in each satellite is connected to a separate incoming main. The secondary of each of these transformers is connected to a bus system that connects to the bus system of the other transformer through a manually operated tie-breaker. In the event of failure of either power source or a transformer, the load on that transformer can be transferred to the other transformer and power source by closing the breaker. Each transformer is sized to carry the full load.

At each voltage step-down the secondary of the two transformers involved are similarly tied together with busses and a manually operated tie-breaker to provide reliability.

One of the main substation's feed transformers is rated at 100 mVA and is connected to a metal clad 34.5 kV switch gear through vacuum-type breakers in its three satellite substations. The power supplied at this 34.5 kV level to the individual plants is stepped down to 4,160 and 480 voltage as required. Large drives are fed at 13.8 kV through individual breakers and dedicated transformers from the 34.5 kV source. The other main substation feeds 50 mVA rated transformers with 13.8 kV secondaries connected to 15 kV metal-clad switchgear utilizing vacuum-type breakers. This 13.8 kV level current is fed to the individual plants where it is further stepped down to 4, 160, and 480 volt levels as required. Large horsepower motors are fed at 13.8 kV through individual breakers and dedicated transformers.

6.2 STEAM GENERATION AND BOILER FEEDWATER TREATING - PLANT 31

The Steam Generation and Boiler Feedwater Treating plant is more complex than typical boiler plants since the plant also provides for the disposal of the Sulfur Plant tail gases, provides boiler feedwater for the steam generating units in the Process Plants, and is the electric generating facility for the essential electric supply. The four main boilers are each rated at a continuous flow of 400,000 pounds per hour of 900 psi, 750°F steam. When all four boilers are onstream, each will be operating at only three-quarters capacity. When one boiler is down the other three are sized to meet the requirements of the project. The essential power is produced by two 26.8 megawatt turbine generators.

The Steam Generation and Boiler Feedwater Treating plant is located between the Oxygen Plant and the coal storage yard. The Stack Gas Scrubbing plant occupies part of the area between the main plant piperack and the boiler facilities. The combined plants occupy an area about 850 feet by 800 feet.

The coal feed conveyors enter a 190-foot high structure that houses the coal surge bin, gravimetric feeders, bin feed conveyors, coal storage bins, and pulverizer feeders. The pulverizers are mounted at grade beneath the bins. This structure is several hundred feet long. To the north is a line of fly ash handling equipment, including the ash storage bin, dewatering bins, ash loading area, settling tank and surge tank. The four boiler trains consisting of the boiler, precipitator, and induced-draft fan are located perpendicular to the structure. The boiler trains are followed by the Wellman-Lord absorbers in the Stack Gas Scrubbing plant. Common stacks are centered beyond each pair of the absorbers. Each stack is about 400 feet high and is followed by the blowdown tanks, a piperack, part of the water treatment system, the suspect condensate tank, associated pumps, receivers, filters, and coolers, the boiler feedwater storage area, the sodium zeolite equipment, instrument air compressors, and a control building.

To the south of the structure is a piperack and a row of equipment, both parallel with the structure. This row contains the demineralized water storage tank, the ion exchange units with their associated caustic and acid tanks, and the demineralized water feed tank. The superheaters, turbine generators, switchgear building, boiler feed pumps, and deaerators complete the area's equipment.

The primary boiler fuel consists of middlings, which is an intermediate grade of coal produced in the Coal Washing plant. Alternate boiler fuel is a blended coal. The middlings can be delivered directly from the Coal

Washing plant, as well as from the storage piles. Coal is delivered to the plant by one of two full capacity belt conveyors that operate intermittently as required to keep the bins full.

Each boiler unit has two operating and one spare feed train consisting of a bin, gravimetric feeder, and a pulverizer. The equipment is housed in a gallery to control fugitive dust. The bins are sized to hold a minimum of four hours' storage which allows each boiler to operate for at least eight hours without additional feed. The pulverizers grind the coal to 200 mesh. The coal is conveyed to the furnace combustion chamber pneumatically.

The furnaces are a conventional balanced-draft design which includes induced-draft and forced-draft fans, a preheater, superheater, economizer and an electrostatic precipitator. Preheaters remove heat from the flue gas and heat the incoming primary air and the secondary combustion air. The combustion heat is transferred through the boiler tube walls to generate high-pressure steam. Hot flue gases pass through the primary and secondary superheaters, and the economizers before exiting through the air preheater. The flue gas then passes through an electrostatic precipitator in which particulate removal efficiency exceeds 99.8%. The flue gas is then sent to the Stack Gas Scrubbing plant for desulfurization and then to one of the two 400-foot double flue stacks. Tail gas from the Sulfur Plant is also incinerated in the furnaces. Pipeline gas is provided for plant start-up.

The boiler feedwater make-up and treatment system consists of three major subsystems, which include those for treated boiler feedwater, suspect condensate, and demineralized water.

Treated river water is routed to a sodium zeolite softening system consisting of three softeners with one operating, one on standby, and the other regenerating. Softened water is combined in a tank with condensate from the Sewers and Wastewater Treatment plant. If condensate is not available, the standby softener is used to provide additional capacity. The mixed stream is sent to the demineralizer, with a side stream to the suspect condensate subsystem when make-up is required.

The suspect condensate system is fed by various 50 and 150 psi condensate streams from process users, steam traps, and such. The condensate is cooled and placed in a storage tank where it is joined by condensate streams from blowoff tanks that are fed from various gland condensate and steam piping low point drains.

The combined stream passes through a system of three filters of the pre-coated leaf-type which use solka floc to remove trace hydrocarbons. Two filters operate normally, while the third is on regeneration or standby. The stream is then sent to the low-pressure deaerators. However, the filtered stream is monitored for hydrocarbons and high conductivity and is recycled to the filters or diverted to the low-solids cooling tower if necessary. Softened make-up water from the sodium zeolite system can be added as make-up.

The demineralizer subsystem is fed by softened water, condensate from various process plants, and steam turbine exhaust condensate. The mixed feed stream is then treated in ion exchange demineralizers consisting of four cation and four anion exchangers regenerated with sodium hydroxide and sulfuric acid. The demineralized water is stored for use as feedwater for the high-pressure deaerator.

The plant has three deaerators that use 50 psi steam to strip and deaerate the water. One of the deaerators serves the high-pressure feedwater system, a second the low-pressure system, while the third is a swing unit. The stream from the low-pressure system is split into 600 psi and 150 psi streams, pumped to system pressure and distributed to various users. The stream from the high-pressure system is pumped to 900 psi and used as boiler feedwater or distributed to other users.

The boilers operate at a nominal 900 psi and 750°F. Temperature control is by a combination of intermediate superheater attemperation, tilting main burners, regulation of excess air, and combustion controls. Pressure is regulated by a load-following control system which maintains 900 psi throttle pressure to the turbines. Flow of water in the boiler is by natural circulation to and from the steam drum. Saturated steam from the drum flows through the primary superheater, the superheater attemperator and, finally, through the secondary superheater. During low-load operation a bypass circulates water through the economizer to prevent steaming.

The 900 psig steam drives the turbine generators or is sent to process users. A backup supply of 900 psig saturated steam and a supply to the 600 psig steam system is provided by use of a desuperheater or a let-down station and desuperheater, respectively. The 600 psig steam system normally receives extractor steam from the turbines and excess saturated waste heat steam which has been superheated in a gas fired superheater. The 600 psig steam supplies throttle steam to equipment drive turbines in the boiler plant and to other process heaters and turbine drives as well as supplying the 150 psig system through a let-down station. The 50 psig steam system receives steam from drive turbine exhausts, flash drum vents, and the 150 psig system and distributes it to various users.

Boiler blowdown and blowdown from other sources is routed to various flash drums, and flashed. Flash steam is vented to the 600 psig header, and the liquid is sent to waste treatment.

The ash handling system is composed of the fly ash and bottom ash systems. The fly ash handling system handles ash collected in the air preheater and electrostatic precipitator hoppers. The ash is conveyed pneumatically to a silo, and is then loaded in a truck for disposal. The bottom ash system handles ash from the bottom ash hopper, the economizer, and pulverizer rejects. The material is sluiced by ejector pumps to transfer tanks and is then pumped to one of two dewatering bins. Most of the ash settles to the bottom of the bin and the water is decanted and recirculated. The sludge is loaded into trucks and hauled to disposal.

6.3 STACK GAS SCRUBBING - PLANT 35

The boiler flue gases from the electrostatic precipitators and the tail gas from the Sulfur Plant are treated in the Stack Gas Scrubbing plant to remove sulfur dioxide before being released to the atmosphere through the stacks. The plant uses the Wellman-Lord process and has three sections: an absorption section, a crystallization section, and a regeneration section. The absorption section has four trains, one for each boiler; the regeneration section has two trains; and the crystallization section consists of a single train.

As mentioned previously, the Stack Gas Scrubbing plant shares a portion of the area occupied by the Steam Generation and Boiler Feedwater Treating plant. The four trains of the absorption section are located between the electrostic precipitators of the boilers and the flue gas stacks. In effect these units are a part of the individual boiler trains. The venturi scrubber, mist eliminator, and absorber are located in a line past the electrostatic precipitators of the regeneration section. The four evaporators are in a row parallel to the boiler trains and the stripper is just beyond the evaporators. The dissolving tank and the evaporator tank are on one side of the evaporators, and the air-cooled condensers are mounted on a rack over the top of the tanks. The sodium sulfate crystallizing, centrifuging, and drying equipment is grouped towards the piperack which runs along the evaporator-stripper line. The SO_2 compressors and related equipment are contained in a building.

Each train of the absorption section treats the flue gas from its boiler to remove the sulfur dioxide before the flue gas is sent to the stack. A safety bypass line is provided from the incoming flue gas line to the outgoing flue gas line so the absorption unit can be bypassed in case of damper or blower failure. In normal operation, the incoming flue gases are boosted in pressure by a blower before entering a venturi-type scrubber for cooling and residual fly ash removal. The flue gases then pass through a mist eliminator to remove entrained liquid. The gases are further washed and cooled with water sprays and then pass through mist-eliminator pads before entering the absorber.

In the absorber the gases are contacted countercurrently by a lean sodium sulfite solution fed to the topmost of seven trays. Liquor is recirculated over each of the bottom four trays. The sulfur dioxide in the gases reacts with the sulfite to form bisulfite. The scrubbed flue gases from the top of the absorber are reheated by the combustion products from a gas-fired heater before being vented to the boiler flue gas stack.

The bisulfite-rich solution from the bottom of the absorbers is pumped to a common precoated filter where particulates are removed. A second filter is provided to allow for precoating while the other is operating. The filtered liquor is fed to the absorber product tank which is sized for 3 days' storage. The liquor is pumped from this tank to the evaporator feed preheaters in the regeneration section. A side stream is sent to the crystallization section as a purge to prevent build-up of sodium sulfate in the system.

The filtered liquor is split into two streams. The first stream is evenly distributed to each first-effect evaporator where water and SO_2 are evaporated using low-pressure steam. The second stream is evenly distributed to the second-effect evaporators which are heated by overhead vapor from the first-effect evaporator and the sulfate crystallizer. The slurry product is discharged from the evaporators to an agitated dissolving tank. A side stream of mother liquor is decanted from one of the first-effect evaporators and sent to the downstream sulfate dryer. Slurry in the tank is mixed with cooled stripped condensate from the condenser system to redissolve sulfite crystals. Soda ash solution is added to replace sodium lost to the sulfate purge stream. Regenerated solution from the dissolving tank is pumped to the absorber feed tank as absorbing solution which is also used in the vent gas scrubber to recover SO_2.

The vapors from the top of the second-effect evaporator are combined with other vapors and condensed in air-cooled exchangers. The condensate is fed to the condensate stripper which handles condensate from both sets of evaporators as well as other condensates from about the facility. In the condensate stripper the condensate is steam stripped to remove SO_2. The SO_2-rich overhead from the stripper is cooled in an exchanger by cooling water. The cooled vapor flows to the suction of the primary compressors, while condensate is returned to the stripper. Stripper bottoms are cooled and returned to the dissolving tank.

The four primary compressors operate in parallel and serve to keep the evaporators and the strippers under vacuum. The SO_2-rich gases from the primary compressors flow to a common suction drum and SO_2 superheater and then to three secondary SO_2 compressors. These single-stage machines operate in parallel and deliver the SO_2-rich gases to the Sulfur Plant.

In the absorbers, the primary reaction is that of SO_2 reacting with the sodium sulfite in the lean absorption solutions to form sodium bisulfite. In a secondary reaction, some of the sodium sulfite is oxidized to sodium sulfate which must be continuously removed to avoid build-up in the system. This is accomplished by taking a side stream from the absorber product liquor, after filtration, and concentrating it in an evaporator crystallizer.

The sodium sulfate crystals and mother liquor are withdrawn from the crystallizer and separated in a centrifuge. The crystals are dried in a dryer heated by the combustion products from a fuel gas-fired heater. The dried sodium sulfate crystals are stored in an elevated bin for loading into trucks as a marketable product. The mother liquor, together with a mother liquor stream drawn from a special separator in the evaporator, are collected in an agitated storage tank and pumped back to the absorber product tank for recirculation.

6.4 WATER SYSTEMS: RAW, POTABLE, COOLING - PLANT 32

This plant includes the river water treating and the cooling tower systems. A comprehensive project-wide water management plan has been developed based on total reuse of water and zero discharge to public water during normal operation. This zero discharge plan is not cost effective and various discharge scenarios will be evaluated by the Operator prior to the Engineering Phase. The water management plan and its objectives are covered in detail in Report VII and will not be discussed here further. It is important to note that the plant is virtually inseparable from the Sewers and Wastewater Treatment plant. Practically all of the treated effluent from the wastewater system is used as make-up in the water system.

The treating, filtering, and pumping facilities are located next to the raw water pond and between the river and railroad near the corner of the site, while the cooling towers and associated facilities are near the Coal Washing plant.

The main elements of the plant are the:

- River water treatment system
- Cooling water system
- Cooling water sidestream treatment system

The principal source of fresh water for the plant is the Ohio River. The river water treatment system prepares the river water for some of its direct-end uses (cooling, firefighting, housekeeping) and for secondary water treatment processes (boiler feedwater, process water). Water used for drinking and sanitary facilities is obtained from onsite wells or river water that is treated in a package potable water treating plant.

The treatment of river water consists of screening, cold lime softening, sedimentation, clarification, pH adjustment, and filtration. The system is designed to treat up to 10,000 GPM of river water. Normal flow rate through the system will vary between about 5,700 and 7,000 GPM depending on rainfall. Rain runoff from building roofs and uncontaminated plant areas as well as certain treated process wastewaters will be used to supplement river water.

The river water intake includes six 2500 GPM pumps (four operating and two spares) that are used to pump water from the river to the reactor clarifier in the cold lime softening and sedimentation section. Controlled quantities of slaked dolomitic lime, soda ash, sodium aluminate, and a polymer are added, in liquid form, to the reactor clarifier. Dolomitic lime is used in the softening process to raise the pH of the water and precipitate calcium and magnesium present as carbonate hardness. It is expected that some of the silica will also coprecipitate as a magnesium silicate complex. Soda ash is added to precipitate calcium as noncarbonate hardness. Sodium aluminate and a polymer are added to aid settling of the suspended solids along with the chemical precipitate generated by the softening reactions. The clarifier effluent passes through a neutralizing basin where sulfuric acid is added to lower the pH to approximately 7.0 in order to preclude post precipitation in the filter media downstream of the softener. Sulfuric rather than hydrochloric acid is used to minimize chloride build-up in the cooling water system.

About 600 GPM of clarified river water is filtered using anthracite filters and pumped as make-up to boiler feedwater treatment. Sand is not used in these filters in order to avoid dissolution of silica which would be undesirable in boiler feedwater. The balance of the clarified river water is filtered using five anthracite/garnet dual media filters. This water flows to the water storage pond where it is blended with clean or treated storm runoff. The filters are backwashed with water from the utility water/fire water storage pond. The backwash water, containing the filtered solids, is returned to the reactor clarifier.

Reactor clarifier underflow is sent to a sump where it is pumped to two rotary vacuum filters for dewatering. Filtrate is returned to the reactor clarifier for reuse. Sludge produced from treating coal storage pile storm runoff is dewatered with the clarifier reactor underflow. A conveyor system delivers the filter cake to a bin where it is periodically loaded onto trucks that transport it to the landfill.

Two conventional cooling water systems with mechanical induced-draft cooling towers are provided. One system circulates water with a relatively low dissolved solids content and serves the Oxygen and Steam Generation and Boiler Feedwater Treating plants. The other system circulates water with relatively high dissolved solids content (4,000 ppm TDS) and serves the other Process Plants. The low-solids cooling tower is designed to provide 1,507 MM Btu/hr cooling requirement at a circulation rate of 124,000 GPM. The high-solids cooling tower is designed to supply the 1,335 MM Btu/hr cooling requirement of the Process Plants at a circulation rate of 150,000 GPM.

The make-up water to the cooling towers is a variable mix of treated river water and treated process wastewater. The make-up to the low-solids cooling tower is treated river water plus treated wastewater. The total make-up requirement to this tower is 4,520 GPM. Treated wastewater will provide 2,050 GPM in dry weather and 3,300 GPM in wet weather. The make-up to the high-solids cooling tower consists of approximately 1,500 GPM of blowdown from the low-solids cooling tower and treated river water to make up the total requirement of about 3,130 GPM.

The cooling water treatment requires the use of additives such as chlorine, inhibitors, acids, and dispersing agents. Chlorine is added intermittently for bacteria and algae control. A sidestream of the low-solids cooling water supply is used to carry the chlorine to the tower basins. The chlorine is introduced into the cooling water system by a water ejector that aspirates the chlorine and dissolves it in the water. Dosage control is by periodic wet analysis of the cooling water.

A chromate-based corrosion inhibitor is used in both circulating cooling water systems. It is introduced into the low-solids system in the make-up water and is carried over to the high-solids system in the blowdown which constitutes the bulk of the make-up to the high-solids system. Control is by automatic corrosivity control. Sulfuric acid is added to control pH and a dispersing agent is required to minimize fouling in both cooling water systems. The agents are added as an aqueous solution by metering pumps.

A sidestream from the high-solids cooling water system is treated to remove suspended and dissolved solids from the circulating cooling water. This permits operating the tower at high cycles of concentration and reduces the cooling tower make-up and blowdown rates. The flow is diverted from the high-solids cooling water tower return header and fed to the sidestream reactor clarifier along with recycle streams from the vacuum filters and sidestream gravity filter backwash sump. The reactor clarifier precipitates calcium and silica and partically removes suspended solids. Dolomitic lime is added to raise the pH and cause precipitation of magnesium. Additionally, silica is coprecipitated with magnesium hydroxide as a magnesium silicate complex. Sodium aluminate and polymer are added as coagulants, allowing colloidal particles to agglomerate and settle out.

The overflow is gravity-fed to the sidestream gravity filters. A system of five gravity sand filters operating in parallel is used. The filters automatically backwash on differential pressure mode; however, controls limit backwashing to one filter at a time. Filter backwash water is collected in a below-grade sump and pumped back to the reactor clarifier at a steady rate. An agitating system in the sump keeps the solid particles suspended. The filtered water is collected and pumped to the high-solids cooling tower.

An underflow containing about 5% solids by weight is drawn from the bottom of the reactor clarifier into a below-grade sludge pit. The tank is sized for two hours of sludge retention and is equipped with a water jet sludge breaker. Abrasion-resistant progressing cavity pumps transport the sludge to the vacuum filters. Three filters are provided, two operating and one spare. Filtrate is pumped back to the reactor clarifier. A filter cake, estimated to contain 48% solids by weight, is discharged onto the sludge cake conveyor and transported to an elevated sludge cake storage bin sized to contain one day's production of sludge cake. Trucks transport the solid waste to landfill.

The distribution system consists of underground piping for potable, utility, high-solids, and low-solids cooling water systems. Potable water is pumped to drinking fountains, cafeteria facilities, showers, and sanitary facilities from a storage tank. Pumps circulate the cooling water through separate high-solids and low-solids underground piping systems to and from their points of usage. Utility water is pumped from the raw water pond to a header that extends throughout the plants. Branch lines from this header to each plant carry the water to its use points.

6.5 FIRE SYSTEMS - PLANT 33

A comprehensive fire water system is provided for the general fire protection of the entire facility, including steam blanketing and chemical fire suppression systems for selected facilities and equipment. Fire Systems provide:

- Fire water to Process Plants, coal handling, water and waste treatment, and tankage
- Fireproofing for vessel supports, pipe racks, and such
- Sprinkler systems for buildings, for part of the process equipment such as pumps or heat exchangers (depending on the location), and for the tank filling rack
- Blanketing steam for compressor buildings and fired heaters
- Halogen systems for computer room and laboratory
- Nitrogen system for sulfur storage tanks

Separate fire control systems for the liquids loading and coal unloading docks are included in the River Facilities plant.

Fire protection and control systems for all facilities, structures, and equipment of the project are designed in compliance with all federal, state, and local laws. They are also designed to comply with all applicable codes and standards, recommendations of the National Fire Protection Associations, and the guidelines of the Industrial Risk Insurers.

The fire water system is supplied from a fire water storage tank located near the tank farm and from the main raw water pond. Either source can supply 60,000 barrels, which is 150 percent of the system's four-hour demand.

Four main fire water pumps, each rated for 3,500 GPM at 192 psi, deliver the water to the distribution system. Two vertical pumps are located at the new water pond. One is dual-driven by electric motor or turbine and the other is driven by a diesel engine. Two horizontal pumps powered by similar drivers deliver water from the fire water tank.

Two vertical electric-drive fire water jockey pumps, each rated for 275 GPM at 192 psi discharge pressure, are installed at the raw water pond to maintain the pressure in the fire water system. Either pump is capable of producing 150% rated capacity at 65 percent rated head, thereby allowing the second pump to serve as a spare.

Independent fire water supply loops are provided around the coal handling area, the process plant area, and the tankage area. Each loop can be cut off without affecting the others. Branch headers extend from the main loops through the areas surrounded by each loop. The fire water mains are coated and wrapped steel pipe and are installed underground. Fire water is supplied to fire hydrants and/or fixed monitors spaced at a maximum of 150 feet around each plant. The monitors are 500 GPM units with adjustable fog/straight stream tips and locking devices for both horizontal and vertical adjustment. Fire hydrants have flanged connections with outside independent shutoff valves for hose connections. All fire hydrants are self draining. Each individual Process Plant has accessibility to at least four firehose stations complete with hose stored on reels and preconnected to the fire water system.

Water deluge systems are provided for the propane, butane, LSR gasoline, and anhydrous ammonia tankage, as well as for all areas of piperacks within 25 feet of heaters, pump batteries, towers, and other major vessels containing flammable materials. Sprinkler systems are provided as necessary in buildings, at the tank truck loading rack, coal unloading dock, silos, bins, and the coal conveyors. They are also installed at air-cooled exchangers on piperacks if flammable material is contained in equipment immediately adjacent to the piperacks.

Dry chemical facilities include hand extinguishers in the offices, warehouse, change house, laboratory, cafeteria, and like buildings on the basis of at least one extinguisher for every 2,500 square feet of floor area. An average of four wheeled dry chemical extinguishers will be provided for each process plant.

Low-pressure (50 psig) blanketing steam for fire fighting is available in the compressor buildings, at exchanger and pump rows, heater fire boxes, and accumulator decks. Steam valves and 50-foot hoses are located at 50-foot intervals along equipment rows and at 100-foot intervals along piperacks.

Storage tanks with bottom injection foam systems are provided for products with less than 140°F flash points. This includes a 1,000-gallon system for light and heavy slop tanks and a 3,000-gallon system for gasoline reformate, phenols, and raw heavy naphtha tanks. Mobile foam equipment includes a pumper equipped with a balanced pressure foam proportioning system that has a solution pumping capacity of 1,500 GPM and a trailer equipped with a 500-gallon tank, hose bed, portable monitors, and a balanced-pressure foam proportioning system.

The chemical laboratory and the computer room are protected by Halon 1301 fire extinguishing systems. The systems are fully automatic, energized by thermal detectors, and equipped with personnel alarms.

A nitrogen fire extinguishing system is provided for the two sulfur tanks in the tank farm. The system is fully automatic and energized by thermal detectors.

Other equipment for fire fighting includes air paks, flame resistant fire fighter suits, foam eductors, fire hose, hydrant monitors, ladders, axes, and walkie-talkie sets. Detectors and alarms are installed in all buildings occupied by personnel.

6.6 SEWERS AND WASTEWATER TREATMENT - PLANT 34

The goal of minimizing both water consumption and effluent discharge is achieved by segregating wastewater streams and treating them to the degree necessary for reuse. Most of the water used in the project goes to atmosphere in the form of harmless water vapor. A very small fraction of the water is associated with solid wastes that are disposed of in the landfill operations.

Individual systems included in the Sewers and Wastewater Treatment Plant include:

- Coal storage pile runoff treatment
- Oily wastewater treatment
- Deoiled wastewater treatment
- Stripped/dephenolated wastewater treatment
- Reverse osmosis for process wastewater
- Brine concentration and drying for process wastewater
- Reverse osmosis, brine concentration and evaporation wastewater from boiler feedwater treating and boiler cooling tower blowdown
- Sanitary sewage treatment

The design of the coal storage pile runoff treatment system is based on acidic water in which bicarbonate alkalinity is insignificant and hardness is noncarbonate. Soda ash is used in treatment and will raise the pH and precipitate calcium and magnesium as carbonates. If it is determined later that the runoff contains appreciable bicarbonate alkalinity, lime addition may be required. The treatment system consists of clarification, neutralization and filtration.

The runoff from the coal storage piles is routed to a storm surge pond that acts as a flow and composition equalizer and feeds the treatment equipment. Some of the heavier suspended solids settle out at this point. From the surge pond the runoff is pumped to a reactor clarifier where it is neutralized with soda ash and clarified with the aid of a polyelectrolyte. Settled solids are withdrawn as sludge from the bottom of the clarifier and pumped to the sludge dewatering facilites at the river water treatment plant. Liquid effluent is pumped through two downflow, pressure-type, dual-media filters to remove residual suspended solids. Filter backwash water is returned to the clarifier reactor inlet. The surge pond size is based on a 10-year frequency storm lasting 48 hours that results in an estimated 7 million gallons of runoff water. This will be processed at the 500 GPM design rate in about 10 days. Provision is made for overflow to the river in case the storm runoff exceeds the 10-year design storm. The surge pond will be dredged periodically.

The oily wastewater treatment system consists of API gravity separation followed by dissolved air floatation (DAF). Sludges generated by the API separator and DAF units are disposed of by incineration. Oil contaminated wastewaters from throughout the plant, including contaminated surface runoff, are collected by an underground sewer system. Normally, oily wastewaters flow directly to the API separator. When design flow rates are exceeded the flow is diverted to an oily water surge pond. When direct flow to the API separator falls below design, surge water is pumped from a pond using non-emulsifying pumps. The pond has a working volume of 25 million gallons. It is equipped with baffles, and floating booms are located near the inlet end to retain free surface oil within a relatively small area. Floating oil skimmers and vacuum-equipped trucks will be used to skim off oil before emptying the pond. The emergency overflow to the river is located under a baffle and at the opposite end of this pond to ensure no loss of oil to the river.

Unemulsified oil is floated to the surface and skimmed off in the API separator while the heavier oils and oil-coated solids settle to the bottom. Skimmed oil is pumped to a slop oil tank prior to reuse while settled sludges are removed from the API separator and collected in a sump prior to being incinerated. Separator effluent is pumped to the flash mix tank where the pH is adjusted by either sulfuric acid or caustic soda and it is dosed with polyelectrolyte flocculants. Effluent from the flash mix tank flows to the flocculation tank where gentle agitation speeds the coagulation of solids.

From the flocculation tank, the wastewater flows by gravity to two parallel DAF units. Additional suspended solids and fine oil droplets are removed in these units by their attachment to rising air bubbles. The air bubbles are created by introducing a recycle stream into the DAF tanks which has been saturated with air under pressure. Effluent from the DAF units flows by gravity to the biological treatment system while both skimmed and settled sludges are pumped to a local sump for transfer to incineration.

The deoiled wastewater treatment system consists of an oxygen-activated sludge treatment to remove biodegradable organics, followed by dual-media filtration to remove suspended solids. Effluent from the oily water treatment system is sent to the oxygen-activated sludge system which consists of three aeration basins, each with two Merox aerators, three clarifiers, and one sludge thickener. Effluent is fed into the aeration basins in which organic contaminants are contacted with recycled microorganisms and oxygen. The organisms use the biodegradable organic matter as a source of energy and as food for cell growth. The suspension of organisms and wastewater is passed through a clarifier where most solids settle out. The bulk of these settled solids or sludge is recycled to the front of the aeration basins. The remaining sludge is removed to maintain a constant microorganism concentration in the basin and is thickened to 3 percent solids in the sludge thickener. The concentrated sludge is sent to the Zimpro wet oxidation unit. Thickener overflow is recycled to the front of the aeration basin.

Effluent from the clarifier is filtered in a anthracite garnet dual-media pressure-type filter to remove the last traces of suspended solids. The filter feed is first chlorinated to prevent biological growth in the filters, and a polymer is added to improve performance. The filtered effluent is routed to the low-solids cooling tower make-up system.

Following treatment in the Sour Water Treating plant, the stripped and extracted process wastewater will contain large quantities of dissolved organics and inorganic salts. These organics are those which are not removed by the extraction process for phenolics. This waste stream is treated in a system consisting of wet oxidation and biophysical treatment (powdered activated carbon, or PAC) using activated sludge to remove the organic matter.

The waste stream is collected in an equalization tank and sent to a Zimpro wet oxidation unit where dissolved and suspended organics are oxidized. Three identical parallel trains are used. Wastewater is first pumped to system pressure (1500 psi) by a positive displacement pump and then passed through a heat exchanger where it is preheated by the hot, oxidized effluent. The temperature of the feed is raised to a point where the oxidation reaction will proceed autogenously in the reaction vessel. Oxygen required to support the oxidation reaction is compressed to system pressure and bubbled through the liquid phase in the reactor.

As oxidation progresses within the reactor, the heat of combustion raises the temperature of the reaction products to 530-540°F. The hot reactor effluent is passed through a waste heat boiler generating about 50,000 lb/hr of 150 psig steam. The partially cooled effluent is then passed through the feed preheater for further cooling. The stream is depressurized to atmospheric pressure after cooling. The resultant vapors contain most of the hydrocarbons and are scrubbed with cold water to condense as much of the water vapor as possible and then vented to the flare.

In addition to the stripped-extracted sour water, the Zimpro wet oxidation system will receive waste-activated sludge from the deoiled wastewater biological treatment system, the spent PAC and waste-activated sludge mixture from the PAC-activated sludge system, and digested waste-activated sludge from the sanitary sewage treatment unit. The spent PAC is treated for removal of inert solids in the reactor and the regenerated carbon is returned to the PAC-activated sludge system.

The effluent from the Zimpro system is sent to the PAC-activated sludge system where the partially oxidized wastewater is treated by an activated sludge process in the presence of activated carbon. The presence of powdered carbon allows operation of the activated sludge system with high concentrations of easily settleable mixed liquor suspended solids.

The Zimpro effluent, returning sludge, and regenerated PAC is fed into five aeration basins equipped with a total of 30 pure oxygen aeration systems of the Merox rotating active diffusers type. Organics are biologically degraded in the aeration basins. The effluent overflows from the aeration basins into three clarifiers where spent PAC and waste sludge settle out. The clarifier overflow drains to the filter feed tank. Most of the settled solids are recycled to the aeration basin. A small portion, which constitutes the net microorganism production, is pumped to the wet oxidation system. This stream also contains the spent PAC which is regenerated in the wet oxidation system.

A reverse osmosis sytem is used to separate an aqueous salt solution into two portions, one more dilute and the other more concentrated than the starting solution. The separation is effected by special non-porous membranes which permit the water to pass through the membrane more easily than the salt. Pressure is used as the driving force. The feedwater must be free of suspended solids that might damage the membrane. Preparing the feed for reverse osmosis consists of filtration followed by chemical treatment.

The effluent from the PAC-activated sludge system is split and pumped to two filters. When a filter is on backwash, the entire load is carried by the other filter. The wastewater is dosed with chlorine and polymer to destroy any remaining microorganisms and to act as a filtration aid.

The effluent from the two media filters is pumped through four cartridge filters. When a cartridge is loaded with solids as indicated by a high pressure drop, it is isolated and the cartridges replaced. Backwash from the media filter is discharged to the PAC-activated sludge system where the solids utimately leave the system with the clarifier underflow. The effluent pH from the cartridge filters is adjusted to 5 or 6 using sulfuric acid. Following pH adjustment, the wastewater is dosed with a predetermined amount of sodium bisulfite and a polyphosphate solution.

The chemically conditioned reverse osmosis (RO) feed is pressurized to an operating pressure of 400 to 600 psi by high-pressure pumps and fed into the RO membrane units that are arranged in an inverted pyramid array. Relatively pure water permeates through the membranes, while the brine becomes more concentrated. A number of parallel units and stages in series are designed to meet the flow and concentration requirements. The permeate or clean water from the system is sent as make-up to the low-solids cooling tower basin, while the concentrated brine is sent to the brine evaporation system. A brine concentration and drying system is used to process stripped and dephenolized wastewater which has been treated by reverse osmosis.

Concentrated stripped and dephenolized water from reverse osmosis units flows to a feed tank that provides surge capacity. Wastewater is pumped to the vapor recompression evaporators through a series of feed preheaters. The feed is then deaerated and injected into the body of the evaporator.

Brine in the body of the evaporator is continuously circulated by pumps through the respective heaters in the evaporators. The vapors are compressed in vapor compressors to a pressure sufficient to raise the saturation temperature about 8 degrees above the boiling temperature of the brine. The hot vapors condense on the steam side of the heaters providing heat of vaporization for the brine. The condensate is collected and constitutes the recovered water.

Brine is continuously drawn from the evaporator and pumped to the brine crystallizer. The crystallizer is essentially identical to the evaporator except that it uses steam instead of compressed vapors as the heating medium. Generated vapors are condensed and collected for recycle to the boiler feedwater storage tank. Noncondensibles are removed from the system by a vacuum pump.

Slurry is continuously drawn from the crystallizer and pumped to the solid bowl centrifuge, which separates the liquid from the solid phase. Granular salt product is continuously discharged from one end of the solid bowl centrifuge and stored, while the filtrate with some solids is discharged from the other end. The filtrate is received in a liquor tank and pumped back to the crystallizer.

The brine concentration and drying systems for blowdown water are designed to process high total dissolved solids (TDS) wastewaters and produce solids for land disposal and water for reuse in the plant. Wastewater containing dissolved salts is evaporated using vapor recompression evaporators. The resultant condensate is reusable water. The concentrated salts are processed in a spray dryer to produce dry solids for easier disposal.

There are two types of feedwater to the evaporator, high TDS and low TDS. The high solids are fed directly to the evaporator. The low solids are first concentrated using reverse osmosis. The permeate or dilute portion is recycled to the low-solids cooling tower while the concentrate is fed to the evaporator. The wastewater must be treated before reverse osmosis. The pretreatment consists of filtration and chemical treatment to assure no solids formation in the reverse osmosis units.

Cooling tower blowdown and boiler blowdown is collected in a tank. The combined stream is pumped to two parallel filters. Chlorine and polymer is added to the filter feed to control biological growth and promote flocculation of suspended solids for better capture in the filter beds. Filtered water flows to a surge tank upstream of the RO system. Spent backwash from the filters is returned to the high-solids cooling tower's side stream softener.

The RO system is used to concentrate the dissolved salts in the filtered blowdown stream by a factor of about four. Liquid from the RO feed tank is pumped through cartridge filter units prior to entering the suction side of the high-pressure RO feed pumps. Sulfuric acid for pH reduction, sodium bisulfite for dechlorination and sodium hexamethaphosphate as an anti-precipitant is added to condition the RO feed. Four multi-stage centrifugal pumps feed the two-stage RO modules. Each module consists of 16 pressure vessels in the first stage and 8 in the second stage. Water recovery in permeate is about 75 percent. Recovered water is routed to the low-solids cooling tower as partial make-up.

Sodium zeolite waste and demineralizer waste are combined with the RO concentrate in a tank upstream of the two vapor recompression evaporators. The two evaporator units further concentrate the wastes to a brine slurry by evaporation and recover a high-quality distillate water product. The wastewater feed is pumped through three plate-type heat exchangers to preheat the stream above its boiling point. Dissolved CO_2 and oxygen are released in deaerators and the hot waste stream discharges into the evaporator sump. Brine is circulated to the top of the heat transfer plates and spread in a thin film. Water evaporates from the brine film and the resultant vapor is compressed to raise its saturation temperature 6 to 8°F above the brine boiling point. The compressed vapor is introduced into the internal section of the heat transfer plates and condenses, thereby providing the heat required for evaporation. The condensate is collected and pumped through the feed product exchanger to the condensate storage tank in the Steam Generation and Boiler Feedwater Treating plant. Concentrated brine from the recirculation line is sent to the spray dryer feed tank. Water recovery is about 92 percent.

Concentrated brine from the two evaporators is pumped from a common agitated tank to a spray dryer tower and introduced into a hot air stream by an atomizing wheel. The hot air contacting the droplets evaporates the water, leaving dry solid particles that are collected in a product cyclone. Residual particulates in the cyclone exhaust go through an induced-draft fan and into the fabric filter collector. Collected particulates are periodically discharged to the products solids line for disposal. The solids are conveyed to a storage hopper from which they are loaded onto trucks for transport to the disposal site.

Sanitary sewage from the various sanitary facilities throughout the complex is collected in an underground sewer network terminating at the central sewage treatment facility located between the railroad tracks and the river bank. Sewage lift stations are used to avoid excessively deep excavations.

At the terminal end of the sewer network is a final lift station that delivers the sewage to the aboveground treatment plant.

The sanitary sewage treatment plant is a pre-engineered package unit, which is shop-fabricated, knocked down, and reassembled in the field; it is a standard installation used in many industrial plants and small communities. It is simple to operate and maintain and has three operating modes including step aeration, contact stabilization, or extended aeration. The package unit is capable of handling considerable variations in incoming flow and waste strength without causing upsets or off-test effluent. The unit has two aboveground concentric circular tanks. One is divided into three compartments to form an aeration tank, an aerobic digester, and an effluent chlorine contact tank, while the other serves as the settling tank. The settled effluent from the treatment plant is chlorinated and pumped to the inlet of the aeration basins of the deoiled wastewater treatment system for additional treatment.

Sanitary sewage treatment facilities are located near of the oily water surge pond. The evaporator system is located near the cooling towers. Other treatment facilities are located near the river.

6.7 INSTRUMENT AND PLANT AIR SYSTEMS - PLANT 36

The Instrument and Plant Air Systems plant includes all equipment and piping necessary to supply instrument and utility air to the plants. Air is delivered at 100 psig, 100°F, and a dew point of -40°F. The equipment is located in a portion of the Steam Generation and Boiler Feedwater Treating plant near the plant control house.

Three 4,000 cfm packaged air compressors supply both the instrument and plant air systems at 125 psi. One of the compressors is a spare. Air filters on the compressor suctions remove dirt and debris from the incoming air. Interstage coolers, knockout drums and after coolers are included in the compressor packages.

The two sets of packaged air dryers are provided with the dryers in each set alternating at being on line or regenerated. The air dryers employ heatless desiccant beds. Two air filters, one a spare, are installed after the dryers to guard against dessicant breakthrough.

The compressors and air dryers are fully automatic and incorporate surge control, dewpoint control, automatic regeneration, and automatic start-up of standby units if low pressure occurs in the header.

After compression, drying, and filtration, the air is split into two streams. One stream feeds the plant utility air header while the other feeds the instrument air header. The maximum utilization in each system is about 4,000 cfm but the piping after the dryers and filters permits either system to utilize a greater quantity if the other system is not loaded.

Independent 10-inch headers for instrument air and utility air run from the plant to the pipeway. From the main headers, smaller subheaders are run to the battery limit of each plant and the air is further distributed, within the battery limits, to the individual users. The headers are part of the Interconnecting Piping plant.

6.8 TELECOMMUNICATION SYSTEMS - PLANT 37

The Telecommunication Systems plant includes the equipment and wiring for internal plant communication, linking plant data processing systems with offsite computing facilities, and for communication with transportation carriers. The plant will initially serve the telecommunications requirements during the construction effort and is designed with sufficient flexibility to allow for conversion to final facility operation. Master communications control and monitoring of all subsystems are provided for the facility operation phase.

Reliability is a prime factor in the design of the plant and is achieved through the use of solid-state components, factory burn-in of assemblies, use of redundant assemblies, alternative traffic flow routing and, where possible, automatic operation. Maintainability is achieved through modular organization of hardware assemblies, automatic fault detection and alarm systems, standardization of components and procurement sources, and a spare inventory based upon mean-time-between-failure data and repair cycle time. Flexibility is achieved through the usage of central electronic switching, shelterized (transportable) facilities, commonality of subassemblies where possible, and adequate system capacity.

The telecommunication subsystems in this plant are described below:

- Computer remote access terminal. The terminal is used for gathering data between the jobsite, the design office and fabrication yards, and the offices of the Operator. Computer data terminal circuits for 1200/2400/4800 baud rates are provided. The facilities for long distance transmission are required on a 24-hour basis during all phases of the project. The quality of transmission for the circuits is consistent with the requirements for interconnection with international circuits

- Facsimile terminal. The facsimile terminal is for transmitting drawings, graphics, and pictorial information between various locations

- Fire alarm and public address (PA) system. The system is integrated with the telephone and switching network. It serves only the administration building

- Medical emergency system and life-signs telemetry. These are provided in the ambulance, first aid stations and the medical building

- Intraplant page system and telephones. The multichannel page party system is installed in all control rooms, operating equipment rooms, storage, shipping, and receiving areas, flare areas, process areas, and substations. Permanently installed direct dial telephones will be placed in all operational areas

- Land mobile radio. The land mobile radio system includes communication between mobile units and hand held portable radios as well as with base stations. It includes or supplements other systems serving the mobile vehicle units, plant operations and maintenance, fire, safety, security, the medical emergency system, and communication with railroad operations. The radio telephone service is used on an urgent basis to provide automatically switched mobile radio telephone communications between site offices, residences, and vehicles

- Maritime mobile radio. The marine radio system operates between base, barges, and towboats

- Radio paging system. Pocket pager units are used for communication by the radio base station to selected personnel

- Security system. This system consists of status and alarm reporting systems connected by multipair cables and is supplemented by land mobile radio and by video monitoring systems

- Telephone service and PABX. The telephone facilities provide dial switching service to fill the mobilization requirements and later will be expanded to encompass the needs of the construction and operational efforts. Teleconferencing channels are included. The PABX system switches all interplant communications. In addition, the system switches construction and operation computer data traffic and telex and facsimile traffic. It also interconnects direct dial capability to the radio paging system

- Telex service. The telex facilities are used to transmit messages between jobsite, engineering design offices, and other office locations as required

- Emergency power, interconnecting cables, and grounding. The battery plant supplies standby emergency power to the telephone, security, land mobile radio, and maritime mobile radio systems and is maintained in readiness by dual battery chargers. The outside cable layout consists of all direct buried telephone cables and computer cables connecting the jobsite system with all work stations. Grounding is installed as required

6.9 INERT GAS SYSTEMS - PLANT 38

Nitrogen is used as the inert gas for the project. Both pure nitrogen and the waste nitrogen from the reversing exchangers is used. The nitrogen compressor in the Oxygen Plant supplies most of the nitrogen required for purging. Two auxiliary two-stage compressors are provided to compress the high-purity nitrogen required for intermittent use in the molecular sieve dryers and LPG sweetener. This partial relief of the load assures that the nitrogen compressor can meet the purge gas requirements of the project. The two auxiliary compressors operate independently of the nitrogen compressor.

The low-pressure nitrogen requirements for the air slides are met by a blower which raises the pressure of a portion of the waste nitrogen stream from the reversing exchangers to 12 psi.

Of the three nitrogen headers one low-pressure, low-purity header runs from the blower to the Coal Drying and Pulverizing plant and supplies nitrogen for the air slides. A second header runs from the two auxiliary nitrogen compressors to the sieve dryers in the Cryogenic Hydrogen Purification plant and the LPG sweetener in the Gas Plant. The third header runs from the nitrogen compressor of the Oxygen Plant to the main pipeway. Branch headers are run to the plants requiring purge gas. The headers are in the Interconnecting Piping plant.

6.10 PURGE AND FLUSH OIL SYSTEMS - PLANT 39

Purge and flush oils are used throughout the project for flushing, guard seals, instrument purging, equipment warming, casing cooling, and similar services. Different grades of oil are required for different services. This plant includes various drums, pumps, heaters, coolers, and filters, all of which are physically located within the battery limits of other plants in the complex.

There are five systems for handling the services which are as follows:

- High-volatility pump seal and instrument flush oil
- Low-volatility pump seal oil
- Glycol for cooling
- Neutral oil for seals
- Heavy flush oil for pump warming, flushing, purging, and quenching

The neutral oil and glycol are purchased from commercial sources. The vacuum distillate is supplied from the vacuum tower in the H-Coal® Recycle Slurry Preparation plant. The distillate and heavy flush oils are taken from fractionator towers in the H-Coal® Distillate Separation plant. Tanks are provided in intermediate storage for all the oil except glycol, which is stored in drums.

Oil from the distillate flush oil tank in the intermediate storage area is pumped through a precoat filter and distributed as high-volatility pump seal oil and instrument flush oil. The system has provision for heating and surge storage of the oil used in the ebullating pumps. The distillate flush oil piping downstream of filtration is stainless steel to avoid plugging the small valves used in metering and also to ensure a clean supply of flush for the ebullating and charge pump requirements.

The flush oil header design pressure is 250 psig so that only the high-pressure users require independent charge drums and pumps.

The low-volatility seal oil is stored in the vacuum tower side draw tank in the intermediate storage area. The oil is pumped through a precoat filter to all inboard seals of pumps requiring a low-volatility seal oil. The vacuum-distillate seal oil piping downstream of filtration is also stainless steel to ensure a clean supply of seal oil. Vacuum-distillate seal oil is used in applications where the lower boiling distillates would vaporize in the pump casing and cause cavitation.

Glycol cooling is furnished by two nearly identical systems. Each involves a storage tank located within the units, piping, circulating pumps, and an air-cooled exchanger. One system services the Slurry Preparation, H-Coal® Preheating and Reaction, and H-Coal® Primary Separation plants. The other system services the H-Coal® Recycle Slurry Preparation, Gasification and Purification, and H-Coal® Distillate Separation plants. These systems provide a cooling medium for slurry pump pedestals, seal housings, bearing casings, and lube oil cooling. The glycol is pumped from the storage tank to the air-cooled exchangers for cooling before its return to the tank. Glycol solution of 50 wt% is used. The glycol solution is brought to the plant site in 55-gallon drums and unloaded directly into the holding drums.

The neutral oil system utilizes oil stored in the intermediate tankage area. This oil is pumped to eight 3,000 gallon day tanks and is heated, raised to a higher pressure by a positive displacement pump, and fed to the ebullating pumps. The oil is also routed to a surge tank equipped with a heating coil in the Gasification and Purification plant. It is pumped from the surge tank to the seals of the vacuum bottom pumps that feed the gasifiers. The stream is filtered after the pumps, cooled in an air-cooled exchanger, and returned to the surge tank.

The heavy distillate flush oil for pump warming is pumped from the heavy flush oil tank in the intermediate tankage area to surge tanks in the H-Coal® Primary Separation, H-Coal® Recycle Slurry Preparation, and Gasification and Purification plants. The two surge tanks in the H-Coal® Primary Separation Plant each serve four of the eight processing trains. The oil is pumped from each of the tanks and heated in an exchanger. It then flows to the suction of the slurry pumps and back to the surge tank. Contaminated oil is pumped to the preflash drum in the H-Coal® Distillate Separation plant.

The heavy-distillate flush oil is also used for flushing, purging, and emergency temperature control; however, separate piping is provided for the various services. A header from the primary pumps in the intermediate product storage area delivers the heavy flush oil to all process areas that require the oil for low-volume, intermittent applications such as line flushing and reactor catalyst transfer. A second header is maintained at under 120 psi pressure by jockey pumps and provides oil to the Coal Slurry Preparation, H-Coal® Preheating and Reaction, H-Coal® Primary Separation, H-Coal® Recycle Slurry Preparation, and Gasification and Purification plants. The system is kept in a constant state of readiness. The oil is also used as a flushing stream for slurry lines during shut-down operations, diluting vacuum bottoms being pumped to storage, and as back-up coal reactor feed for instances in which normal reactor feed is interrupted.

Summary of Reports

7.0 SUMMARY OF REPORTS

Prior to execution of the Cooperative Agreement, ASFI developed a very comprehensive definition of the scope of work for the "Initial Effort" that included an itemized list of the engineering drawings, narratives, and other descriptive materials or "deliverables" that were anticipated as being required to document the effort. This scope of work was included in the Cooperative Agreement. The "deliverables" produced during the Initial Effort, are presented in twenty-eight volumes of eleven reports; this Breckinridge Project Design Basis is the second report. The contents of the other ten reports are briefly summarized below. An index of reports and volumes is also included with the Table of Contents of this report.

REPORT I - EXECUTIVE SUMMARY

This report presents an overview of the Breckinridge Project and summarizes the results achieved during the Initial Effort or Development Phase of the project.

REPORT III - SPECIFICATIONS

This report contains the design, engineered equipment, and material specifications prepared for the Initial Effort and is presented in two volumes. These specifications are grouped into: general specifications that cover basic procedures and other project wide matters; standard equipment specifications that establish basic design, fabrication, inspection, and certification standards for major equipment; and standard specifications for equipment, bulk materials, and services for the basic requirements. Unique specifications relating to a specific process or offsite plant are also included in this report.

The specifications are numbered and lettered. The letters describe the type of specification. The twenty one "A" specifications delineate project procedures and describe such matters as standards for P&ID's, responsibilities, document control and numbering, basic design standards, and procurement standards. Twenty-three standard equipment specifications cover pressure vessels, tanks, compressors and other equipment and are covered by the letter designations "C" through "K" and "Y." Fortyone standard service specifications cover piping, concrete, and other bulk accounts and are designated by letters "L" through "X." The standards define code requirements, material and workmanship standards, testing requirements, and similar items that can be applied to all equipment or services of the category. These specifications, in combination with data sheets for individual items of equipment or services, serve as the basis for quotations and estimating the cost of individual equipment items.

A section of unique specifications for three of the plants contains thirty specifications prepared due to the advanced state of design of the plants or the uniqueness of the equipment.

REPORT IV - PROCESS UNITS

The seven volumes of Report IV present the design and engineering data developed for the sixteen Process Plants. These volumes present information such as the design basis, detailed process description, a list of chemicals and catalysts, utility balances, process flow diagrams, and an equipment list. Data sheets describing equipment duty requirements, and sketches of vessels and tanks are presented as well as plot plans, electrical single line drawings, and process and instrumentation diagrams. Each volume contains an appendix with an overall site plan and a list of symbols used on P&ID's. Each volume has an introduction and reference section that lists all of the Initial Efforts reports, followed by a table of contents for the particular volume.

REPORT V - UTILITIES AND OFFSITES UNITS

Report V presents the design and engineering data for the Utility and Offsite Plants in a manner almost identical to that used for the Process Plants of Report IV. It contains four volumes.

REPORT VI - PROJECT MANAGEMENT PLAN

This report presents the management plan for execution of the engineering, procurement, construction, and operation of the Breckinridge Project. It presents a project overview and describes each phase of the work and its objectives. The project schedule is discussed in detail. The project's development phase is reviewed along with its interrelationship to subsequent work.

The work required to execute the project is discussed rather extensively including management concepts such as organization of the work; the planning required to perform the work in a logical and efficient manner; a description of the tasks that must be accomplished and the methods by which they will be achieved; and the techniques and programs which will be used to control the work. Manning levels for each segment of the work are also presented.

REPORT VII - ENVIRONMENTAL, SOCIOECONOMIC, SAFETY AND HEALTH

Report VII presents the results of activities in the environmental, socioeconomic, safety and health aspects of the Breckinridge Project. These efforts were the subject of major emphasis throughout the preparation of the design and engineering data. In addition, the environmental and socioeconomic aspects were the subject of extensive studies by independent consulting firms. The firm of Dames and Moore was engaged to establish baseline environmental data at the site. They were also commissioned to make an archaeological survey. Watkins and Associates was retained to survey the socioeconomic aspects of the surrounding area.

Report VII is presented in four volumes. The first volume contains an introduction and background section, a description of the site selection process, and an overview of regulatory requirements. This is followed by three sections that describe the plans for air quality management, water quality management, and solid waste management. The second volume contains the baseline data prepared by Dames & Moore. Cultural and socioeconomic information is presented in Volume 3. The safety and health aspects of the project are treated in the final volume and describe organization and administration, government and internal requirements, safety in design, fire and explosion protection and organization, hazardous controls and protection system, industrial health, training and motivation, safety compliance, accident investigation, and critical safety and health items requiring additional study,

REPORT VIII - CAPITAL COST ESTIMATE

Report VIII presents the Capital Cost Estimate. After an introduction and statement of objectives for the report, the estimate basis section describes the methodology used in the preparation of the estimate. This includes methods used for estimating major equipment, bulk material, and subcontract costs. The report describes the basis for determining direct labor manhours and the cost of that direct labor; the method of arriving at the costs of spare parts, sales taxes and field indirects; and the basis of determining home office manhours and the related costs. The determination of cost of engineering by others is also explained, as are the methods used in arriving at estimating allowances and fees.

The capital cost summary section contains tabulations of the overall cost of the project and a plant-by-plant summary of the costs. The plant sections include a brief description of the individual plants, a discussion of special estimating considerations and a detailed estimate on a plant-by-plant basis. Finally, the detailed estimate of major equipment costs is tabulated.

The accuracy of this estimate is considered to be well within the limits of the ± 20% specified in the Cooperative Agreement.

REPORT IX - OPERATING COST ESTIMATE

Report IX presents the Operating Cost Estimate. The introduction discusses the factors that determine these costs and is followed by a section that discusses the bases and methods used in preparing the estimate for operating costs. A section on annual operating costs presents the estimated costs of operations in the first, second, and third years when throughput is below rated capacity, and for the fourth and subsequent years of operation at full throughput. A section on organization for plant operations presents the overall organization chart for operation and maintenance, and contains detailed organization charts for the laboratory, operations, environmental-health-safety, administration, and maintenance groups of the operating staff. This report also contains the overall material balance, the annual catalyst and chemicals cost estimate, the estimated annual cost of fuel, lube oil, greases, etc. for rolling stock, and a tabulation of the estimated annual cost of local taxes and insurance.

REPORT X - ECONOMIC ANALYSIS AND FINANCIAL PLAN

Report X is divided into sections covering marketing analysis, an economic analysis and the financial plan. The forecasting methodology and key assumptions are first described in the marketing analysis section. The base case is then developed with a discussion of the world energy outlook and the energy demand, supply, and prices in the United States, followed by information on regional demand and supply. Marketing opportunities for the Breckinridge products are examined, citing the product characteristics, markets and potential customers and analyzing the possibilities as to market share and product values. The report then reviews the effect of natural gas decontrol or long-term disruption in supply of crude oil on project economics and the alternative of producing feedstocks for petrochemicals.

The economic analysis section sets forth the assumptions made in the analysis including product pricing, inflation, capital and operating costs, and tax issues. It presents a discounted cash flow analysis, required product pricing, and a sensitivity analysis. Supporting schedules, including product values, operating costs, and capital costs are presented.

The Financial Plan addresses the organization of the joint venture and the present status of negotiations with prospective participants. The requirement for funds and the sources of those funds is outlined followed by a discussion of plans for repayment of borrowed funds. Tabulations of cash flow and base case capital structure risk are presented.

REPORT XI - TECHNICAL AUDIT

Report XI is a technical review of the Initial Effort. It is presented in five volumes with three principal sections covering engineering comparisons, critical design areas, and supplementary design data requirements.

The first two volumes discuss the process trade-off and technical uncertainties studies that were made on a plant-by-plant basis. They present the basis for selection of processes, choice of operating conditions, and both general and specific decisions affecting design and engineering considerations. Some of the material is in the form of conference and trip reports and other portions are more formal reports of specific studies. The material is mostly limited to the basic Process Plants and does not include the standard offsite and utility plants.

The Critical Design Areas volume is a plant-by-plant compilation of design and engineering features that require further or more detailed study for safety considerations, unusual operation conditions, or for process or mechanical problems which might develop during start-up or emergency shutdown. It includes such things as materials of fabrication, coal particle size, pressure letdown valves, interfaces between units, and equipment design details. Detailed design of these features was not within the scope of the Phase Zero work. Nevertheless, many of the features were given some study and this section summarizes all such considerations and indicates factors to be included in further work.

The final two volumes of Report XI contain a plant-by-plant analysis of the adequacy of the data basis for the detailed design and engineering work. It sets forth the additional design data that is considered necessary for each plant and indicates how this data will be obtained, i.e., from pilot plant operations, other coal processing plants, or other commercial installations. Some subjects covered include coking of vacuum tower internals, CO conversion in the reactor, gasifier refractory life, NH_4Cl deposition, letdown valve service period extensions, quench cooling for temperature excursions, coking in hot separators, and materials of fabrication in areas of corrosion and erosion.