SECTION 3

DESIGN PARAMETERS

3.1 GENERAL DESIGN CHARACTERISTICS

The purpose of the Oil/Gas plant design is the production of clean boiler fuel plus significant quantities of SNG using SRC-based hydroliquefaction technology to best advantage. Related hydroliquefaction technology was used earlier in the Clean Boiler Fuel from Coal - Demonstration Plant design published by Parsons in 1973 as OCR R&D Report No. 82, Interim Report No. 1, Vols. I, II, and III. The present design uses SRC-II teachings at a high hydroliquefaction severity in order to obtain low-sulfur fuel oil and practices recovery of methane and light hydrocarbons to produce a high ratio of gaseous to liquid products. The facility operation and its products are to be ecologically acceptable.

A high priority was given to the development of a design to yield a high thermal efficiency in conversion of coal to saleable fuel products.

3.2 PLANT LOCATION

The plant is considered to be located in the eastern region of the U.S. Interior Coal province, which includes portions of the states of Illinois, Indiana, and Kentucky. The site conditions used for equipment design are summarized in the Basic Design Criteria document presented as Appendix A of this report. The plant complex is conceived to be close to the coal mines and a river.

3.3 SCOPE

The coal conversion complex is a grassroots facility with a captive coal mine to supply the necessary feed coal. Supply items include water and air. All utilities, including electricity and steam, are generated within the complex.

3.4 PLANT AVAILABILITY

The complex is considered to operate at capacity 330 stream days per year, resulting in an availability factor of 90.4%.

3.5 RAW MATERIALS

The following raw materials are used:

(1) Coal

(a) ROM coal is produced in a captive mine. The design is based on supply of a uniform coal composition to the process plant.

(b) The coal fed to the process plant has the following proximate analysis, expressed as weight percent:

Item	Wt %
Moisture	2.7
Ash	11.8
Volatile matter	39.7
Fixed carbon	45.8
Total	100.0

Heating value = 12,125 Btu/lb

The ultimate analysis, as weight percent composition, is as follows:

Item	Wt %
Carbon	67.2
Hydrogen	4.6
Nitrogen	1.3
Sulfur	3.7
Oxygen	8.7
Ash	11.8
Moisture	2.7
Total	100.0

(2) Oxygen - 99.5% purity, produced captively by air separation.

(3) Water

(a) Process water from river.

(b) Potable water from wells.

3.6 PRODUCTS

An objective of the design is the production of an economically competitive product slate with a high gas-to-oil ratio. Investigation of various process alternatives showed that the following approximate major product slate can be produced using 20,000 TPD dried coal as feed to the SRC dissolvers:

Product	Tons/Stream Day	MM SCF or Bbl per Stream Day	Characteristics
SNG	4,000	166 MM SCF	1,050 Btu/SCF at 1,000 psig
LPG	900	10,100 bbl	C_3 LPG and C_4 LPG
Naphtha	1,300	9,380 bbl	IBP to 380°F, 50° °API
Fuel oil	11,300	56,350 bbl	400°F$^+$, -8 °API

Elemental sulfur and anhydrous ammonia will be coproduced.

3.7 PRIMARY PROCESS STEPS: DESIGN BASIS

To produce the above product slate, the design incorporates the following key process steps:

(1) Coal Liquefaction - Data developed in the SRC program as reported by the process development contractor, Pittsburg and Midway Coal Mining Co. (P&M), were used. The SRC-II mode of operation was used as a basis for the design. This mode uses the recycle of dissolver effluent slurry as part of the coal slurry solvent, thereby permitting a high hydrogen uptake.

The major product of this process mode, after suitable treatment, is a low-sulfur fuel oil. Twenty thousand TPD of washed and dried coal will be fed to the hydroliquefaction process dissolvers.

(2) Product Gasification - High-pressure steam-oxygen gasification of feed coal will be used to produce methane and a hydrogen-rich synthesis gas (syngas) product. The raw gasifier product stream will be treated to produce the hydrogen required as feed for the dissolvers and for naphtha hydrogenation. The methane will be recovered as part of the product SNG.

The gasifier will be an entrained, slagging, two-stage design. It will take advantage of data published by the Bituminous Coal Research Inc. (BCR) during the ERDA-sponsored Bi-Gas development program.

(3) Low-Btu Gasification - The fuel gas required for process furnaces and power plant boilers will be generated in a low-pressure, air-blown, slagging, two-stage gasifier. This gasifier will be designed to operate at a pressure of 45 psig in order to move the gas through the downstream H_2S removal system and to the point of use.

(4) Supporting Processes - The complex will contain units to remove acid gases consisting primarily of H_2S and CO_2 from the various streams and to convert the H_2S to elemental sulfur and ecologically acceptable tail gases. Process steps will be included to separate the gas streams into SNG, LPG, and hydrogen. Liquid product treatment will be provided to produce 0.4 wt % sulfur fuel oil containing a maximum of 0.15 wt % solids plus commercially saleable naphtha.

3.8 EFFLUENT TREATMENT AND NOISE CONTROL

All effluent streams will be treated to meet environmental standards. Disposal of solid wastes will be integrated with coal mining to provide haul-away and proper disposal. Equipment will be designed to meet OSHA noise level requirements.

3.9 RAW MATERIAL AND PRODUCT STORAGE

Facilities are provided for storage of a 14-day feed coal inventory and a 30-day product storage inventory.

3.10 ANCILLARY FACILITIES

Ancillary facilities adequate to service the industrial complex and its personnel population of approximately 2,350 are included.

3.11 SPARING PHILOSOPHY

Except for a few instances in which equipment size considerations forced the use of multiple units, this design uses spares only for critical rotating equipment. A critical piece of equipment was defined as one that would shut down a process unit in case of failure; exceptions occur when its cost is excessive and it has a sufficiently reliable performance history. All spares are shown as such in the equipment lists and on the flow diagrams.

For example, all process pumps whose failure would shut down a unit are spared. In cases in which two pumps are required to meet the service duty, one additional pump is provided as spare. Major compressors and blowers are not spared, following the philosophy used successfully in ammonia and similar plant practice for many years.

Pressure letdown turbines are not spared. In case of failure of these machines, the flow will be diverted to lines equipped with chokes and pressure-reducing control valves, temporarily wasting the energy while restoring the turbines to service. Slurry pressure-reducing valves are provided with by-passes and spares to allow maintenance of these devices.

Because of size limitation of commercially available equipment, the coal drying area is equipped with three dryers. In order to take the best advantage of this requirement, the dryers are interconnected by conveyors so that two dryers can feed the three units fed by dried coal.

Because of the limitation of vessel wall thickness, the dissolver train was designed using three dissolvers. Operating considerations resulted in the provision of three sets of slurry feed pumps, preheaters, high-pressure separators, and pressure letdown turbines. Thus, the shutdown of one set of this critical equipment will allow the plant to continue operation at a minimum of two-thirds of normal capacity. In all probability, the operation under these conditions can be forced and can approach capacity operation with two dissolver trains.

Feed to the gasifiers is required at multiple points around their periphery to provide satisfactory feed distribution. Therefore, four feeders are shown for each gasifier. They are sized to permit full throughput with one feeder out of operation for maintenance.

The power plant consists of two half-size units allowing operation of the plant at a reduced rate in case of boiler or turbine/generator outage. Normal preventive maintenance will be carried out on these units when the process plant is shut down for similar purposes.

The remainder of the process plant is of single-train design per normal refinery practice.

3.12 PRIMARY PROCESS UNITS

The complex contains the following primary units:

(1) A unit to wash and crush the coal to minus 3-in. size.

(2) A unit to grind and dry the coal to 5% plus 20-mesh size and 2.7% inherent moisture.

(3) A unit to slurry the coal with recycle solvent, heat it in the presence of hydrogen, and react it at high temperature and pressure. The unit will then reduce the pressure and collect the resultant gases and liquids.

(4) An atmospheric fractionation unit to separate the dissolver liquids into gas and various liquid cuts.

(5) A unit to separate the solids from the liquid in the fractionator bottoms by vacuum filtration and solvent washing, and further to recover the wash oil and to dry the filter cake.

(6) A unit to produce gas containing a significant amount of hydrogen and methane in a high-pressure, steam/oxygen slagging gasifier.

(7) A sour shift conversion unit to increase the hydrogen-to-carbon monoxide ratio in the gasifier product to the level required for further processing.

(8) A physical solvent selective acid gas removal unit separating the H_2S and CO_2 from the process gasifier gas stream. The purified effluent gas stream is used as part of the dissolver reducing gas feed.

(9) An acid gas removal unit to separate H_2S and CO_2 from gas from gas streams evolved in the dissolving and fractionation units.

(10) A gas treatment facility using primarily cryogenic methods to separate hydrogen-rich, methane-rich gases and heavier fractions, to purify the methane-rich stream to SNG product quality, and to fractionate the heavier fraction into LPG and naphtha products. Part of the resulting recovered hydrogen-rich gas is recycled as dissolver feed.

(11) A unit to methanate the remaining CO in the above-mentioned hydrogen-rich stream to produce high-purity hydrogen for naphtha treatment.

(12) A unit to hydrotreat naphtha cuts from liquid and LNG fractionation to produce saleable naphtha.

(13) A unit to separate ammonia and H_2S from the sour water streams generated in the process, producing saleable anhydrous ammonia.

(14) A unit treating all H_2S streams generated in the process to produce elemental sulfur and an ecologically acceptable tail gas.

(15) A unit producing a low-Btu fuel gas for use in process furnaces and the boiler plant. The low-pressure, air-blown, slagging gasifier will utilize as fuel the dry filter cake and char produced in the hydroliquefaction section together with feed coal makeup, as required, to produce the necessary quantity of fuel gas.

(16) A unit to remove H_2S from the fuel gas stream producing low-sulfur gas and elemental sulfur.