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Development of an Advanced, Continuous Mild Gasification Process for the Production of Co-Products
Task 4.6: Economic Evaluation

Topical Report

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REVIEW OF MILD GASIFICATION TOPICAL REPORT

The principal finding of this study was the high capital cost and poor financial performance predicted for the size and configuration of the plant design presented. The XBi financial assessment gave a disappointingly low base-case discounted cash flow rate of return (DCFRR) of only 8.1% based on a unit capital cost of $900 per ton year (tpy) for their 129,000 tpy design. This plant cost is in reasonable agreement with the preliminary estimates developed by J.E. Sinor Associates for a 117,000 tpy plant based on the FMC process with similar auxiliaries (Sinor, 1989), for which a unit capital costs of $938 tpy was predicted for a design that included char beneficiation and coal liquids upgrading--or about $779 tpy without the liquid upgrading facilities. The XBi assessment points out that a unit plant cost of $900 tpy is about three times the cost for a conventional coke oven, and therefore, outside the competitive range for commercialization. Modifications to improve process economics could involve increasing plant size, expanding the product slate that XBi has restricted to form coke and electricity, and simplifying the plant flow sheet by eliminating marginally effective cleaning steps and changing other key design parameters.

Improving the financial performance of the proposed formed coke design to the level of a 20% DCFRR based on increased plant size alone would require a twenty-fold increase to a coal input of 20,000 tpd and a coke production of about 2.6 million tpy--a scaling exponent of 0.70 to correct plant cost in relation to plant size.

Other avenues for improving profitability besides increasing plant size would involve changes in the design and product slate, including as the most important possibilities:

1. Liquid Products--Additional quenching of off-gas from the carbonizer to obtain salable liquid products, which in Sinor's preliminary assessment more than doubled the revenue obtained from char and electricity while increasing capital cost by only about 20%, could substantially improve process economics. Questions concerning liquid quality and marketability still need to be answered, particularly the lower level of oxygenates reported by Merichem compared to the EERC analyses. The EERC analyses showed high levels of phenolics which, if stabilized and separated, could yield valuable cresyllic acids. The lower levels reported by Merichem could have resulted from polymerization that reduced the chromatographable oxygenates due to sample aging. A mild stabilization step could be important to improving coal liquids economics. The EERC tests have established that the 720°F (382°C) distillation residue is an excellent binder for char briquettes. A value for the heavy tar as a binder could be established by comparison with the cost of asphalt emulsion. The available test data on other liquids uses should be summarized, including the use of polymerized heavy tar as a chemical feedstock for electrode production and the use of the light liquid fraction as diesel fuel blending stock.

2. Coal and Char Cleaning--Elimination of marginally effective solids cleaning steps would simplify the process and improve char yield. Unit processes that could be removed include the gravity separation tables for cleaning feed coal, the magnetic separation on char between the carbonizer and calciner, and the gravity separation on calcinate fines. The char cooling step between the carbonizer and calciner would also be eliminated.

3. Carbonizer--Reduction in char residence time in the carbonizer from 3 hours to the 20 or 30 minutes used in EERC tests would correspondingly reduce the volume of gas needed to maintain fluidization. Less heat input would be required in relation to coal flow, and more gas/liquids should therefore be available for liquid product and electricity revenue streams.

4. Calciner--Changes to be considered in the calcination step should include a reduction in char residence time from 3 hours to on the order of 1 hour or less, the substitution of a rotary-hearth or kiln design to greatly reduce the gas flow rate requirement of the bubbling-bed design, provision for heating the calciner both by firing quenched carbonizer off-gas and injecting air and possibly steam for internal oxidation and gasification, and the use of the hot off-gas from calcining with a suitably augmented heating value as the main heat source for the carbonzier--without cooling or compression. The only gas requiring compression would be the cool quench gas from the carbonizer.

Other questions on the design report not related to economic performance are concerned with:

1. The feasibility of compressing partially quenched gas realizing that some condensation may occur during compression;

2. The feasibility of discharging hot briquettes into air;

3. The relatively low 50% efficiency for 10 micron and 4 micron solids in cyclones;

4. Any comment that can be offered on bed support in a commercial carbonizer based on scaling up the EERC/Boley design;

5. The need for an explanation of the XBi changes in the EERC material balances for the carbonizer and calciner.

Additional comments and corrections have been marked on the attached copy of the subject report.

EXECUTIVE SUMMARY

Under DOE/METC Contract No. DE-AC21-87MC24267, Amax Research & Development Center (AMAX) of Golden, Colorado, Xytel-Bechtel, Inc. (XBi) of Houston, Texas, and J.E. Sinor Consultants, Inc. (Sinor) of Niwot, Colorado, worked with the University of North Dakota Energy & Environmental Research Center (EERC) of Grand Forks, North Dakota, to develop an advanced continuous mild coal gasification (MCG) process for the production of co-products. This topical report presents the technical and economic evaluation of the process at the 1000-tpd commercial demonstration plant scale (Task 4.6).

Based on the results obtained during bench-scale studies with a continuous fluidized-bed reactor (CFBR) and operation of a 100-pound/hour mild gasification process research unit (PRU) and companion studies on coal and char cleaning, char calcining, and calcinate briquetting at various scales between bench scale and PRU scale, a commercial process flowsheet was developed for a 1,000 tpd coal processing plant to produce a formed coke product and electrical power. The plant will be located at an Amax coal mine near Terre Haute, Indiana.

Feed coal for the MCG process was a typical high-sulfur midwestern bituminous coal (Indiana No. 3) (4.2 wt%) that contained a relatively high percentage of organic sulfur species (1.8%). This coal proved to be difficult to process, and sulfur rejection ultimately turned out to be lower in the PRU than projected based on earlier bench-scale studies. Project timing dictated that the design for the 1000-tpd plant be frozen before final bench-scale and PRU results were available. Input to the Task 4.6 topical report was distributed as follows:

1. EERC

Equipment specifications, design criteria, and performance and yield data for mild gasification, liquid collection, and char calcining, plus updating formed coke technology.

2. AMAX

Commercialization potential, coal supply, coal physical beneficiation, char beneficiation, operating costs, process review, plant site infrastructure, and selection of final products.

3. XBi

Process simulation for material and energy balance, detailed design, flowsheet development, equipment list and capital cost estimate, plus a critique on the technical aspects of the process.

4. Sinor

Marketing assessment, product revenues, and economic analysis.

The process plant will consist of six major unit operations, which include coal preparation, mild gasification (carbonization), liquid and gas quenching, char

beneficiation and calcining, formed coke briquetting and curing, and electrical power generation from reject solids and noncondensable volatiles.

Preparation consists of storage, crushing, surface moisture drying in a fluidized-bed reactor, coal sizing, and physical beneficiation to reject ash and sulfur using air tables. The mild gasification, or carbonization, step is done in spouted fluidized-bed reactors under nonoxidizing conditions to produce a devolatilized char and off-gas stream containing the volatiles. High boiling point volatiles are quenched and collected in a scrubber tower as a pitch product that is used as a binder in the formed coke process.

Hot char is cooled and then screened into three size fractions prior to physical beneficiation by high-intensity magnetic separation to remove pyritic sulfur. The cleaned char is then calcined in a bubbling fluidized-bed reactor to eliminate additional volatiles. A final physical cleaning step using air tables removes additional ash and sulfur from the calcinate. This cleaned calcinate material is briquetted using the pitch product as a binder. The briquettes are cured at high temperature, which carbonizes some of the pitch and volatilizes the rest. After cooling, the briquettes are sold as a formed coke product with a targeted specification of less than 10% ash, 1% sulfur, and 2% volatiles.

When all of the rejected coal, char, and calcinate solids plus noncondensed volatiles are burned for their fuel value, excess energy over that required for the process is generated. This thermal energy is converted into steam and used to produce electric power as a product. The solid materials are burned in an atmospheric fluidized-bed combustor to produce steam, while the volatiles are burned in direct-fired burners to produce the hot, low-oxygen-content, fluidizing gases required for drying, carbonization, calcining, and coke curing.

Capital cost of the 1000-ton coal/day commercial demonstration plant is estimated at $116.4 million with an accuracy of minus 5% to plus 20% and includes a contingency factor of 20%. Using 1992 as the base case, operating costs are estimated at $15 million. The plant will produce about 129,000 tons/year of formed coke product valued at $150 per ton. In addition, the plant will produce 19.2 net MW of electricity valued at $0.05 per kWh. Using these base-case values, the DCFRR at $0 NPV for the plant is 8.1%, assuming a 3-year construction period and 20-year operating life. Sensitivity analysis on capital cost, operating cost, and revenue gave a DCFRR of 0% to 12%.

ACKNOWLEDGMENTS

The authors would like to acknowledge and show our appreciation and thanks to a number of organizations and people for their support and effort, which was a prerequisite for the successful completion of this task and topical report.

Project funding was provided by the Department of Energy's Morgantown Energy Technical Center under Contract Number DE-AC21-87MC24267 to the EERC as prime contractor and then to AMAX, XBi, and Sinor under various subcontracts. Project managers at METC were Sophie Lai and Jagdish Malhotra during the initial phases of the project and James Westhoff during the final phase.

The project manager at the EERC was initially Robert O. Ness, Jr. and was completed under the direction of Brian Runge. During the Task 4.6 study, Mr. Runge also provided the principal interface and liaison with the three subcontractors and worked closely with XBi on mild gasification and calcining technology and general day-to-day activities. Additional assistance was provided by Laura Sharp for material balance input data and Brian Young on formed coke briquetting and curing technology. A special thanks to Julie Entzminger, Don Cox, Ann Olson, the graphics and office services for the support and involvement in the project.

In addition to being the principal author of the XBi sections of this report, Les R. Cohen also served as project manager during the last half of the XBi subcontract. Project management during the first half of the project was provided by Scott McFeely. Process and/or discipline engineers working on the project were Jeanette Fong, Sam Cheng, Mahendra Dave, and Gobind Gidvani.

At Sinor, associates Robert E. Pressey and Trevor Ellis provided input and analysis in support of Jerry E. Sinor on the marketing and economic analysis tasks.

Within the internal AMAX organization, Mahesh C. Jha served as the project manager at Amax R&D. R. Frank Hogsett authored sections of the report, oversaw preparation of all input data for the economic evaluation, and provided general liaison among the task participants, in addition to process and project engineering functions. Mark H. Berggren and Robert L. McCormick supervised the coal and char physical beneficiation activities.

Special thanks go to Ms. Wendy Kennedy of Amax R&D who over the past few years has provided virtually all of the secretarial skills and word processing duties required for the AMAX involvement in the project.

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1.0 INTRODUCTION

To expand the use of coal, our primary indigenous resource for energy, in an environmentally acceptable and economically feasible manner, the United States Department of Energy (DOE) has been sponsoring research and development of new, promising coal conversion technologies. The conversion of coal to liquid and gaseous products can expand the markets for coal into transportation and other sectors of the energy market, as well as in large chemical markets. The enormous costs of liquefaction and gasification processes requiring hydrogen or oxygen plants and high-temperature, high-pressure operations have hampered the commercialization of these processes aimed at producing a single product.

As an alternative approach, Morgantown Energy Technology Center (METC) of DOE has sponsored, and continues to sponsor, programs for the development of technology and market strategies which will lead to the commercialization of processes for the production of co-products from mild gasification of coal. It has been recognized by DOE and industry that mild gasification is a promising technology with potential to economically convert coal into marketable products, thereby increasing domestic coal utilization.

In a typical mild gasification process, coal is devolatilized under nonoxidizing conditions at mild temperature (900° - 1100°F (482° - 593°C)) and pressure (1-15 psig). Condensation of the vapor will yield a liquid product that can be upgraded to a petroleum substitute, and the remaining gas can provide the fuel for the process. The residual char can be burned in a power plant as a premium fuel. Thus, in a long-term national scenario, implementation of this process will result in significant decrease of imported oil and increase in coal utilization.

However, before the technology can be made economic for large-scale utilization, it has to be developed and demonstrated on a commercial scale. With eventual commercial demonstration as a goal, DOE/METC awarded several contracts in October 1987 to different project teams (consisting of research organizations, coal companies, engineering companies, and potential product users) to develop advanced mild gasification and product upgrading processes for the production of marketable co-products.

Under one of these contracts, No. DE-AC21-87MC24267, "Development of an Advanced, Continuous Mild Gasification Process for the Production of Co-products", the University of North Dakota Energy & Environmental Research Center (EERC) of Grand Forks, North Dakota, worked with Amax Research & Development Center (AMAX) of Golden, Colorado, Xytel-Bechtel, Inc. (XBi) of Houston, Texas, and J. E. Sinor Consultants, Inc. (Sinor) of Niwot, Colorado, to develop a process using a high-sulfur-content midwestern coal, Indiana No. 3, as the feedstock.

The DOE project consisted of the following four tasks:

Task 1. Literature Survey and Market Assessment
Task 2. Bench-Scale Mild Gasification Study
Task 3. Bench-Scale Char Upgrading Study
Task 4. System Integration Studies

1.1 Project Organization

The EERC was the prime contractor and had the primary responsibility for development of the spouted fluidized-bed mild gasification process, first at the bench scale under Task 2 and later in a 100-pound/hour process research unit (PRU) under Task 4. AMAX had the primary responsibility for selection of a product slate that would enhance the commercialization potential of the technology (Task 1) and development of a char upgrading process at both the bench scale (Task 3) and in a 50-pound/hour PRU (Task 4).

Task 1 was completed in January 1988 and the findings were published in topical and summary reports.[56-57] It was concluded that economic viability of the mild gasification technology, at least for a few initial smaller plants, will critically depend upon upgrading of char to a higher-value product. A number of options were identified to enhance the value of the char. In order to enhance commercialization potential and properly focus project activities, AMAX had Sinor perform a preliminary commercialization and economic analysis in February 1989 that evaluated the different char upgrading processes.[58] A formed coke product for use in the steel industry produced from Indiana bituminous coal was chosen as the preferred product.

Since then, all of the tasks of the project have been completed. Results from Task 2 were submitted as a summary report by the EERC in December 1989.[59] Results from Task 3 by AMAX were presented in quarterly technical progress reports submitted by the EERC to METC during the July 1989 to December 1991 time period.[1-10] Likewise, the Task 4 results of the 100-pound/hour mild gasification PRU operation were presented in the same quarterly technical progress reports.[1-10] Information contained in these quarterly reports will be summarized in a final project report to be issued by the EERC.

In late 1990, DOE modified the the EERC contract and added Task 4.7 to perform a preliminary design and cost estimate for a 24-tpd mild gasification and product-upgrading process development unit (PDU). the EERC solicited combined proposals for both Tasks 4.6 and 4.7 and awarded the contract to XBi in early 1991. The bulk of the XBi contract was to be spent on Task 4.7 with only a minor amount of the effort devoted to Task 4.6. However, in May 1991, DOE/METC redirected the scope of work and withdrew the requirement for Task 4.7. The scope of work for the XBi contract was down-scaled in the overall effort, but the final effort for the remaining Task 4.6 was actually increased in scope over the original proposal.

1.2 Scope of Work

The XBi scope of work was broken down into two main tasks. One was to prepare a conceptual plant design for the 1000-tpd commercial scale mild gasification and product-upgrading facility, including a technical appraisal of the process flowsheet, and the second was to provide an estimate of the capital cost of the 1000-tpd plant. Specific subtasks in the XBi scope of work, plus the AMAX and Sinor tasks, are as follows:

1.2.1 Evaluation of Existing Pilot Plant Data

XBi assimilated the process information received from the EERC, AMAX, and others (as far as applicable) into a format suitable for the computer simulation effort. The mass and energy balance developed by XBi incorporates the physical characteristics of feeds, intermediates, and products as provided.

1.2.2 Heat and Material Balances

After preliminary data screening and evaluation of several alternate flow schemes, an optimum configuration was selected. XBi computer-modeled a mass and energy balance by 1) assimilating data received from the EERC and AMAX, 2) prorating the pilot-scale material flows and yields up to the 1000-tpd commercial-scale feed rate, and 3) applying other factors needed to complete the simulation. Commercial software (HYSIM™, Hyprotech, Ltd.) was used for the simulation.

1.2.3 Conceptual Flow Diagrams

Conceptual process flow diagrams were developed by XBi in conjunction with the mass and energy balance. These diagrams identify all major processing equipment within the facility, as well as all major process piping and conveyances. Equipment sizes, capacities, materials of construction, and major control loops are also indicated.

1.2.4 Mechanical Design

XBi developed a technical (sized) equipment list for all major equipment within the facility. This list is intended to communicate equipment requirements to mechanical engineers and will be used for equipment pricing for the basis of the capital cost estimate. Physical size and configuration of major pieces, as indicated in the equipment list, was used for layout and planning purposes. A considerable amount of equipment data was solicited from specific equipment and system designers and manufacturers.

1.2.5 Plot Plan

A plot plan and conceptual plant arrangement was developed. These drawings depict all major structures which house process and utility units and auxiliary buildings, stand-alone equipment, and interconnecting conveyances. Approximate plot space requirements and dimensions of the overall facility are indicated.

1.2.6 Utility Summary

A utility summary (user list) was generated in order to establish total facility power and steam demand and cooling load. The summary indicates maximum and normal utility loads. Operating labor requirements are also provided.

1.2.7 Capital and Operating Costs

In addition to providing input data and technical information for the Task 4.6 report, AMAX reviewed the 1000-tpd XBi capital cost estimate, compared the equipment and installation costs to other recent mild gasification-type and mineral processing projects, and determined that the capital cost estimate was in-line with the other studies. AMAX also supplied the unit cost factors and estimated the consumption rates and yearly operating costs for the plant.

1.2.8 Economic Analysis

All of the cost information, plus the yearly production rates for the formed coke and electricity products, was given to Sinor who estimated yearly revenues and performed the economic assessment and sensitivity analysis.

1.2.9 Topical Report

The topical report for Task 4.6, herein presented, describes the results of work performed by XBi, AMAX, and Sinor regarding all of the above-named project "subtasks."

2.0 PROCESS OVERVIEW AND CRITIQUE

2.1 Discussion of the EERC, XBi, AMAX and Sinor Contributions

Basic mild gasification (MG) concepts and design parameters were developed by the EERC in their pilot facilities at Grand Forks, North Dakota. Similar information on coal and char beneficiation was developed by AMAX at their facilities in Golden, Colorado. This information was transmitted to XBi throughout the project in letters, facsimiles, telephone conversations, and meetings (documentation listed in Appendix A). In order to integrate these essential concepts and design data into a plan for a grass-roots 1000-tpd commercial MG facility, XBi and the other project team members capitalized on a number of other information sources, including:

1. Data provided by AMAX, as required, based on their coal handling/processing experience and commercial-scale testing of specific operations related to various unit operations used in the process flowsheet.

2. Extensive coal handling and previous coal mild gasification experience of Bechtel Power Corporation.

3. The experience of Bechtel Power Corporation in providing the design criteria, process flowsheet, and equipment specifications for the waste heat atmospheric fluidized-bed combustor (AFBC) and steam and electric power generating facilities.

4. The experience of the cost-estimating department of the Bechtel office in Houston, Texas.

5. A substantial amount of practical data solicited and received from many equipment and system manufacturers and vendors, as suitable to specific areas of the facility.

In addition to the unit operations required for the mild gasification and calcining steps, XBi's scope of work also included the conceptual design of all auxiliary plant operations. This activity included the development of systems for coal and char handling, product upgrading (coke agglomeration, briquetting), and coal liquids recovery and conditioning, as well as the definition of all utilities and support systems required to sustain day-to-day plant operation.

Two key elements of the MG process design are the process flow diagrams and the mathematical computer model developed by XBi. These define the mass and energy balance around the MG process. The model provided stream flows and physical properties which supported the subsequent activity of estimating process and auxiliary equipment capacities and duties. The resultant equipment and system data were then developed into a definition package upon which the capital and operating cost estimate is based.

J. E. Sinor Consultants, Inc. has provided consulting services to the coal, oil and gas, and synfuels industries for about the last 15 years. The company has been involved with this project since inception and completed the first task in the project, which was market assessment (Task 1). They were particularly well-suited to estimate the product revenues and perform the economic and sensitivity analysis for Task 4.6.

2.2 Process Overview

Figure 1 is a block flow diagram of the 1000-tpd coal mild gasification process evaluated in Task 4.6. The block flow diagram of the process plant consists of 16 unit operations, which include coal preparation, mild gasification (carbonization), fines removal from the carbonizer off-gas, liquid and gas quenching, liquid storage, gas compression, char cooling, char magnetic separation, calcining, fines removal from the calciner off-gas, a second stage of gas compression, gravity separation of the calcinate, calcinate storage, formed coke briquetting and curing, and electrical power generation from reject solids and noncondensable volatiles burned in an AFBC to produce steam.

A brief summary of major unit operations follows with emphasis on process temperatures and solids composition. The process description section of this report gives a much more complete explanation of the process flowsheet.

2.2.1 Coal Preparation

Preparation consists of storage, crushing, surface moisture drying in a fluidized-bed reactor, coal sizing, and physical beneficiation to reject ash and sulfur using air tables. The coal is crushed from minus 2 inches to minus 6 mesh and then dried from about 13% moisture down to 8% moisture to eliminate surface moisture. Hot fluidizing gas to the dryer at 400°F (204°C) heats the dried product to about 200°F (93°C) and results in an off-gas temperature of about 250°F (121°C).

The dried product is screened into three size fractions (6 to 10 mesh, 10 to 24 mesh, and minus 24 mesh). Each size fraction is processed on a dedicated air table with the float material passed on as feed to the next step. The gravity or reject material is burned for its waste heat value in the AFBC. Feed coal at 4.2% moisture (as-received basis at 8% moisture) and 12% ash is cleaned to 3.9% sulfur and 9.9% ash with a weight recovery of 77%.

2.2.2 Carbonization

The mild gasification, or carbonization, step is done in a spouted fluidized-bed reactor under nonoxidizing conditions to produce a devolatilized char and off-gas stream containing the volatiles and some fines carryover. Part of the noncondensable volatiles from mild gasification (gas) are burned to provide hot fluidizing gas at 2480°F (1360°C) with minimal oxygen content. The char product is discharged at 1000°F (538°C).

Weight recovery from feed to char is 65% (45% overall). Product char analysis is 2.4% sulfur and 15.3% ash. Obviously no ash is eliminated during mild gasification, so the concentration increases proportionally to the weight loss during this processing step.

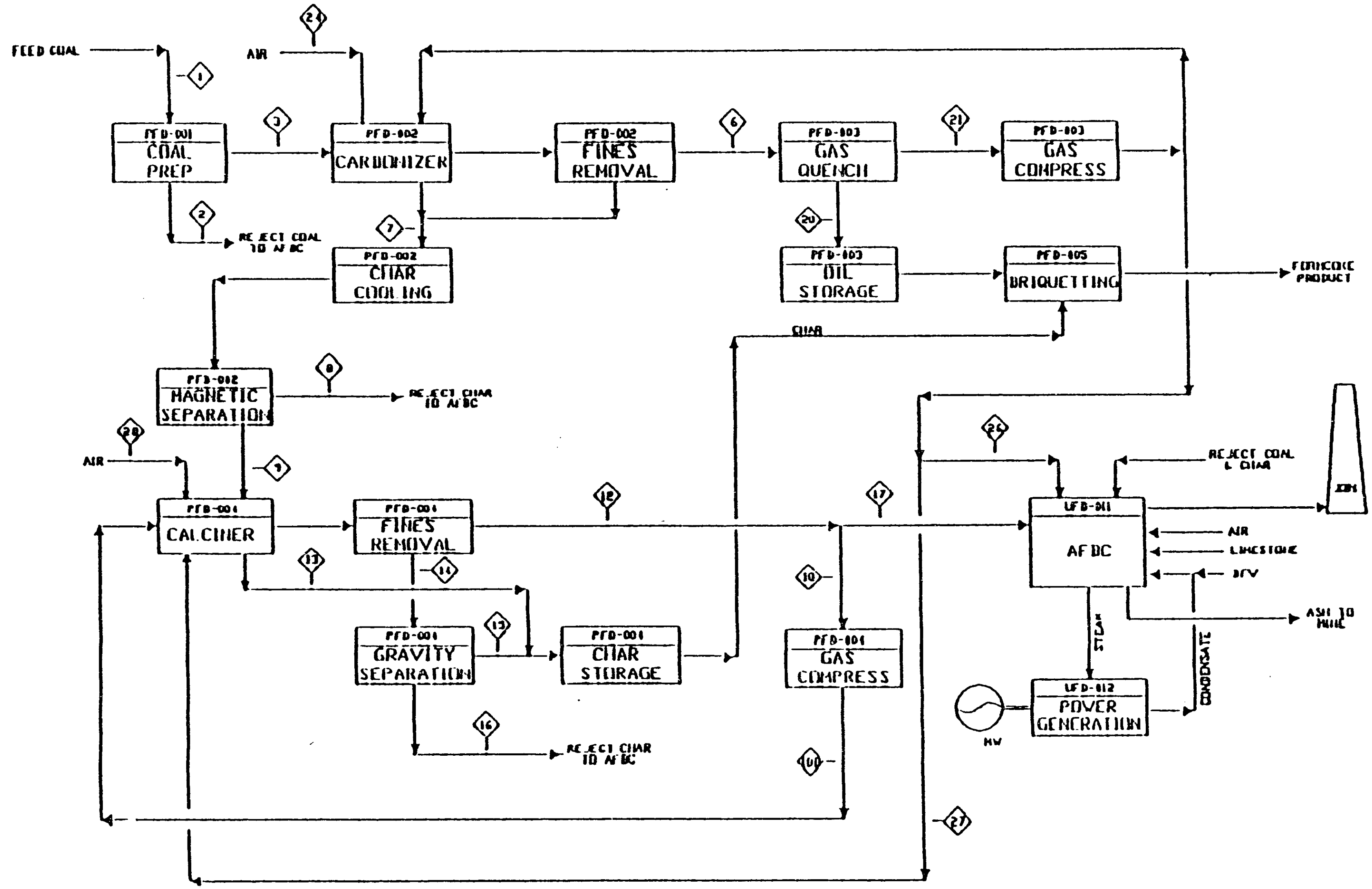

Figure 1. Mild coal gasification 1000-tpd plant block flow diagram.

2.2.3 Char Cooling and Screening

The hot char has to be cooled from 1000°F (538°C) down to 200°F (93°C) prior to magnetic separation. This is done indirectly in a Holo-Flite type unit using cooling water as the heat transfer media. Enthalpy loss from hot to cooled char is about 15 million Btu/hr (22.9 MM to 7.7 MM). The cooled char is then screened into three size fractions of plus 20 mesh, 20 by 40 mesh, and minus 40 mesh.

2.2.4 Magnetic Separation

Due to the rare earth permanent magnets used in the high-intensity separation process, the feed char has to be cooled to 200°F (93°C) to extend magnet life. A magnetic separator is dedicated to each size fraction to improve the efficiency of sulfur and ash rejection. Weight recovery in the nonmagnetic product is 87% (44% overall). The product analysis is 2.1% sulfur and 13.5% ash.

2.2.5 Calcining

Calcining at 1800°F (982°C) lowers the volatile content of the char from about the 14%-16% range down to about the 2%-4% range. Weight recovery during calcination is 85% (38% overall). The calcinate analysis is 1.7% sulfur and 15.8% ash. Although the ash composition increases, the weight of ash in the calcinate actually decreases due to some ash constituents being volatilized (limestone to lime and carbon dioxide as an example). As in the mild gasification reactor, part of the gas from mild gasification, plus the off-gas from the calciner, is burned at stoichiometric conditions to provide hot fluidizing gas to the conventional fluidized-bed reactor at 2394°F (1312°C). Heat input to the reactor in fluidizing gas is approximately 81 million Btu/hr, so the heat lost in cooling the char prior to magnetic separation (15 MM) accounts for about 19% of the heat input to the calcination step.

2.2.6 Gravity Separation

At this point in the process, there has been some attrition of calcinate particles as they have progressed through the various process steps. This has liberated some of the sulfur and, more particularly, the ash, so additional cleaning is effective on the finer fractions. The calcinate is cooled from 1800°F (982°C) down to 200°F (93°C) in another indirectly water-cooled unit. Fines elutriated out of the calciner are also water cooled and go through a final air table cleaning step. Recovery of final calcinate is 98% (37% overall). Cleaned calcinate analysis is 1.5% sulfur and 15% ash. Cooling the calcinate is required prior to briquetting and is not done solely for the purpose of the cleaning step.

2.2.7 Fines Removal and Gas Quenching

Off-gas from both the carbonizer and calciner passes through primary and secondary cyclones to remove particulates down to 4μm in size. Cyclone underflows are combined with the product discharged from each of the reactors and go through the respective cooling, sizing, and beneficiation steps associated with the carbonizer and calciner operations. Ultimately, most of the cyclone underflow materials are burned for the fuel value in the AFBC.

The off-gas from the calciner is burned for its fuel value, but the gas from the carbonizer is quenched to recover high boiling point volatiles. Quenching is done in a disc- and donut-scrubber tower using recirculating condensate as the scrubbing liquor. Operating temperature of the scrubber liquor is 175°F (79°C) which results in an exit gas temperature of 190°F (88°C) and a recovered condensate temperature of 370°F (188°C). At these conditions, about 65% of the total condensable volatiles are collected as a pitch-type material, which is used as the formed coke binder. The rest remains in the gas phase as uncondensed volatiles and adds to the fuel value of the gas.

2.2.8 Briquetting and Curing

Pitch from oil storage and calcinate material are blended to uniformly mix the pitch for use as a binder. Briquetting is done in a roll-type press that forms about 2-inch pillow shapes. The green briquettes are screened to eliminate fines and then cured at 450°F (232°C), which volatilizes some of the lower boiling point species in the pitch and initiates polymerization in the binder. The briquettes are then coked at 1600°F (871°C) which carbonizes about 60% of the remaining binder and volatilizes the rest. Volatiles from the coking step supply enough heat to autogenously fuel this process step; however, natural gas is required to supply heat on start-up. Hot briquettes are then cooled and transferred to the product silo prior to rail shipment as product which is sold as a formed coke product with a targeted specification of less than 10% ash, 1% sulfur, and 2% volatiles.

2.2.9 Gas Compression

Uncondensed volatiles from both the carbonizer and calciner are cooled and compressed for distribution back to the burners supplying heat to the fluidizing gas in the carbonizer and calciner fluidized-bed reactors. There is more fuel value in these gases than required to supply the heat requirement for the reactors, so the excess gas is burned in the AFBC to make steam. Since air is used as the oxidizer in the burners, the recirculating gas streams would become saturated with nitrogen unless nitrogen was continuously bled out of the system. The excess gas burned in the AFBC performs this function and holds the nitrogen and other noncondensables and nonburnables to an acceptable equilibrium value.

2.2.10 AFBC

All of the waste solid streams from the various physical beneficiation cleaning steps, plus the excess gases from the carbonization, calcining, and briquetting steps, are burned in an AFBC to generate steam. Limestone is added to the bed of the AFBC for sulfur capture. Excess limestone and sulfur compounds, plus ash from the coal/char/calcine solids, are hauled back to the mine for disposal. Prior to disposal, bottom ash is cooled with water, and fly ash is collected in a baghouse. Steam capacity of the AFBC is 280,000 pounds/hour at 1200 psig and 960°F (516°C).

2.2.11 Power Generation

Steam from the AFBC is converted to electric power in a 24-MW unit. The turbine generator is an extracting/condensing, nonreheat, 3600-rpm unit rated at 37,000 kVa at 13.8 kV. Approximately 5 MW of the power output is consumed in the mild gasification and supporting processes, which leaves 19 MW for export.

2.3 Technical Critique and Recommendations

Conceptual design of the gasification (carbonizing and calcining) and briquetting portions of the MG facility is based largely on experimental and somewhat speculative data, given the degree of scale-up and extrapolation. The design strategy for all other operations in the plant, including support facilities, is based on commercial-scale operating data and experience. The following describes what XBi and AMAX consider to be areas of moderate-to-high technical risk, which should be further investigated prior to commencement of detailed design:

- A centrifugal-type dewatering device to remove the bulk of free (surface) water prior to the fluid-bed coal dryer should be considered. This could significantly lower the cost of the fluid-bed dryer and the volume of hot air required for drying.

- Recent beneficiation tests on the subject coal do not support gravity table separation efficiencies used in this report. An investigation should be carried out to determine whether or not further testing or a change in design is justified (Topical Report for Task 4.6, Technical Evaluation).

- The efficiency of the magnetic separation step between mild gasification (carbonizer) and calcining is questionable. Performance on sulfur removal was marginal, considering the thermal energy required to cool the char from 1100 to 200°F (93°C) and then to heat it back to 1800°F (982°C). Either the step should be eliminated or the mild gasification temperature should be lowered so that less pyritic sulfur is converted to organic forms during gasification. Recent tests indicated there is more magnetic material produced at 1000°F (538°C) than 1100°F (593°C) (Topical Report for Task 4.6, Technical Evaluation).

- Midwestern coals with high organic sulfur content such as the Indiana No. 3 tested at the PRU scale may not be the appropriate feedstock for this process where low sulfur values are required in the formed coke product. Alternative coals should be evaluated for this process, particularly those coals that are more amenable to physical beneficiation for removal of sulfur and ash. Even with aggressive recoveries and efficiencies used in the beneficiation steps, the final product did not meet the targeted product specifications of less than 1% sulfur and 10% ash (Topical Report for Task 4.6, Technical Evaluation).

- The pressure profiles of all gas, liquid, and pneumatic conveying systems need to be confirmed during the detailed design, based on actual plant layout. The pressure drop for each piece of equipment should be verified.

- Scale-up from gasification pilot test data to the commercial plant is based on superficial velocity and residence time requirements only. Specification of actual reactor geometry requires more definitive verification. Specifically, carbonizer pilot test results are based on a residence time of about 20 minutes, whereas residence time in the commercial-scale carbonizer will be about 3 hours. This was done in order to duplicate the test run fluidizing gas-to-solid weight ratio and the superficial gas velocity and still have a reasonable reactor L/D ratio. Scale-up of the calciner is a similar situation. The effects of longer residence time on coal/char in the carbonizer and calciner require further study.

- Several simplifying assumptions (see Section 6.2) were made in order to complete the process simulation. As these hypotheses effect some uncertainties in the mass and energy balance, they must be resolved in the final design.

- Carbonizer and calciner bed supports have not been designed and specified. Operating temperatures preclude the use of metals. The use of ceramic balls may be a workable solution for both support and gas distribution, but this method may not be proven in commercial operation. Further investigation is required.

- Minimum freeboard space requirement in both the carbonizer and calciner should be verified. This will ensure that there is adequate solids separation from the gas, thus preventing excessive carryover to the cyclones.

- The potential hazards associated with hot char (1100°F [593°C]) and calcinate (1800°F [982°C]) contacting atmospheric oxygen at several transfer points in the process have not been addressed. These need to be investigated to determine whether or not nitrogen/inert blanketing is required.

- In the present design, the calciner recycle gas compressor operates at an inlet temperature of 375°F (191°C) to prevent oil condensation. Depending upon commercial compressor limitations, the gas may have to be cooled to below the oil dew point, which would necessitate a change in the design in order to handle this condensation.

- The present design assumes complete burning of off-gas combustibles, with no excess oxygen in the burners. If complete combustion is not attainable, off-gas may not be able to provide sufficient heat to maintain carbonization at about 1100°F (593°C) while meeting the total fixed fluidizing gas rate. Fluidizing gas includes cooler conveying gas used to transport the coal into the carbonizer.

- The formed coke system presented in this report is a preliminary scheme. Further investigation and testing should be made into the specific requirements of briquetting and curing the subject material. Disposition of tars driven off in the curing kiln is another concern.

- The material balance calls for about 14-wt% oil to be used as binder in the calcinate briquettes. Recent tests indicated the binder level can be as low as 10 wt%. (Topical Report for Task 4.6, Technical Evaluation). Also, depending on heat losses from the process and exact operating conditions, combustion of the noncondensables provides more heat than the process requires. This extra heat is eventually converted to electrical energy product. The recovery of more condensables by using a lower quench temperature and the use of less oil as binder will result in excess oil that can be sold as an additional product. This will improve the economics to some extent and should be investigated before proceeding to a detailed design for a commercial-size plant.

- Due to a number of uncertainties in the coal-cleaning steps, heat balance, and condensable yield data, the process will have to be piloted at the 10- to 30-tpd scale before proceeding to a commercial-size plant.

3.0 PROJECT DESIGN BASIS

3.1 General

The mild coal gasification plant is intended to produce metallurgical-grade formed coke briquettes from a feedstock of Indiana No. 3 coal. Production capacity is based on a nominal coal feed rate of 1000 tpd (dry basis). The conceptual plant design comprises of the following major processing steps and auxiliaries:

- Coal Receiving/Storage
- Coal Preparation
- Coal Beneficiation
- Coal Carbonization
- Char Calcining
- Gas Quench/Liquid Separation
- Waste Treatment
- Calcinate Beneficiation
- Calcinate Agglomeration
- Coke Storage
- Power Generation
- Other Required Utility Systems

The facility will be sited at Amax Coal Company's Chinook mine in Clay County, Indiana. Overall plant configuration is based upon carbonizer and calciner unit material balance/yield data provided by the EERC, based on previous pilot plant tests. Material balance and yield data for the physical beneficiation cleaning steps on coal, char, and calcine were provided by AMAX.

3.2 Site-Specific Data

3.2.1 Site Conditions

The plant will be located approximately 20 miles east of Terre Haute, Indiana, at the Chinook mine in Clay County.

The following climatological data apply:

Elevation, feet above Mean Sea Level	700
Ambient Temperature Outdoor, °F	
Maximum	100
Minimum	-20
Annual Snowfall, inches	30
Average Annual Relative Humidity, %	72
Average Temperature, °F[29]	
January	27
February	32
March	42
April	54
May	64

June	73
July	76
August	74
September	67
October	56
November	43
December	33
Average Precipitation, inches[29]	
January	2.9
February	2.4
March	3.5
April	3.6
May	5.0
June	5.3
July	3.4
August	3.2
September	3.1
October	3.0
November	3.1
December	2.6
Wind Loading, mph	80
Direction of Prevailing Wind	NW
Snow Loading, psf	20
Live Load, Platforms, psf	100
Dead Load, Platforms, psf	200
Seismic Zone (uniform building code)	No. 2

3.2.2 Utilities Available at Site

3.2.2.1 Fuel Gas

Natural gas is available at the plant battery limits.

A high-pressure natural gas pipeline crosses the plant property. Gas can be taken out of this line at any pressure desired. At present, the mine does not use any natural gas.

Natural gas composition:[29]

Component	Volume %
Carbon Dioxide	1.12
Nitrogen	0.44
Methane	95.28
Ethane	2.53
Propane	0.38
i-Butane	0.07
n-Butane	0.09
i-Pentane	0.03
n-Pentane	0.02

Hexanes	0.04
Specific Gravity, gm/cm^3	0.587
Lower Heating Value, Btu/scf	929

3.2.2.2 Electricity

Power is available at plant battery limits at 13.8 kV.[21]

3.2.2.3 Steam

Steam is not available from an outside source.

3.2.2.4 Raw Water

Raw water is available at plant battery limits.[21]

Battery Limits Pressure, psig	85
Battery Limits Temperature, °F	50

Raw water analysis (in ppm) is:[29]

Hardness	400
g/gal	23.6
Ca (as $CaCO_3$)	300
Mg	160
Fe	<0.3
Mn	0.16
Cl	0.30
F	1
Si	Not Available
Na	Not Available
pH	7

3.2.2.5 Potable Water

The existing Chinook mine potable water system will be extended to the MG facility via one supply line. This line will provide drinking water and water for domestic use, as well as for safety showers and eyewashes.

3.2.2.6 Instrument/Plant Air

Not available, to be supplied by new system.

3.2.3 Facility Service Requirements

The following services will be required at/in the plant site:

Railroad:	ISBL spur for limestone receiving, product shipping, ash disposal, and large equipment/parts delivery
Roadways:	Exterior service, interior plant roads to be minimum 30 feet wide
Storm Drainage:	Surface slope of 0.5%, open trench slope of 1%
Fire Protection:	Hydrant loop system
Freeze Protection:	Electric heat tracing
Utilities:	Site-generated, except as stated above

3.3 Feed and Product Specifications, Process Wastes

3.3.1 Feed Specifications

3.3.1.1 Coal

The plant is designed to utilize Indiana No. 3 coal from Amax's Chinook mine. Feed coal has the following characteristics:[34]

Coal Rank	Bituminous
Mine	Chinook, Brazil, Indiana
Proximate Analysis, wt% as-received	
Moisture	8.20
Ash	12.12
Volatile Matter	34.79
Fixed Carbon (by difference)	44.89
Total	100.00
Sulfur (total)	4.20
Sulfur (pyritic)	2.25
Sulfur (organic)	1.81
Sulfur (sulfate)	0.14
Specific Gravity	1.32
Apparent Density, -6 mesh, lb/ft^3	47.4
Feed Coal Size	2 inch x 0 mesh

3.3.1.2 Limestone (for AFBC)

Crushed limestone will be delivered to the plant site via truck/rail. The following specifications are required:

Size 1/4 inch x 0 mesh

3.3.2 Product Specifications

3.3.2.1 Formed Coke

Formed coke product (briquettes) is expected to meet quality specifications as determined by the following standard test procedures:

- Drop Strength Test for Shatter Resistance
- Tumble Test for Abrasion Resistance
- Compressive Strength Test for Crush Resistance
- Immersion Test and Shower Test for Resistance to Water Penetration
- Weight Loss Test under Reducing Conditions
- Ash, μm, S

3.3.3 Process Wastes

The following process wastes are generated at the MG plant and are subject to disposal in accordance with existing local and federal EPA regulations:

3.3.3.1 AFBC Ash

Fly ash and bottom ash from the AFBC are collected and sent by truck/rail to the Chinook mine for underground disposal.

3.4 Plant Capacity and Product Slate

The facility is designed to process feed coal at a rate of 1000 standard tons/day (dry basis) from the mine, received via off-site feed conveyor from the Amax Chinook mine washing plant.

The primary plant product is formed coke consisting of briquetted and cured calcinate/binder mix. Recovered coal liquids from the gasification process are used as a binder material for the formed coke. Only sufficient liquid for binding is recovered; no excess liquid product will be produced at this facility at the assumed 14% binder level.[18]

Electrical power is generated on-site for plant consumption. It is intended that the quantity of power generated will be commensurate with the utilization of the combined chemical heat content of all reject solid material and gaseous effluents from the various coal/char beneficiation steps. Excess power generated from waste materials only may be sold into the grid. Should the burning of wastes not provide sufficient power, supplementary fresh coal may be utilized to meet on-site power demand. However, fresh coal may not be used to generate merchant power.

3.5 Process Model

Process simulation software, HYSIM™ (Hyprotech, Calgary), was used to model the process in conjunction with the Peng-Robinson equation of state for estimating physical properties and vapor-liquid equilibria. In the simulation, feed coal is represented by moisture- and ash-free material (maf), ash, and water. Ash is treated as inert. No heat of formation is included for the solids.

Product oils were characterized for input to HYSIM™ using an approximate ASTM D2887 assay with 10 boiling point fractions. As the nature of the oil components is hypothetical, heats of formation and heats of combustion for these are not available from HYSIM™ and had to be estimated by approximating standard components. The carbonizer and calciner were modeled as stoichometric reactors.

Sulfur was not included in the simulation, as 1) modeling the transformation of sulfur compounds as they pass through the carbonizer and calciner is not practical and 2) sulfur is relatively insignificant in the energy balances. Instead, the sulfur balance was performed externally to the model. As a result, gas streams in the mass balance (Section 6.0) showed somewhat higher sulfur contents than was found in the simulation output (Appendix B).

3.6 Design Parameters from the EERC and AMAX

Data in this section constitute the basis for the mass and energy balance and are used as design criteria for specific plant systems and equipment. General arrangement of design data herein is presented according to the order of process flow.

3.6.1 Coal Beneficiation

The following separation parameters were provided by AMAX for coal separation by gravity tables:[34]

Component	Weight % Rejected
maf	7.75
Ash	25.0
Water	9.99
Sulfur	15.01
Volatile Matter	7.0

3.6.2 Carbonization

3.6.2.1 Carbonizer Feed

AMAX provided the following carbonizer feed composition:[34]

	lb/hr	% by Weight
Coal (-6 mesh, as-received)	64,505	
maf	52,778	
Ash	6,438	10.9

Water	5,290	8.9
Sulfur	2,514	4.2
Volatile Matter	23,191	39.2

3.6.2.2 Carbonizer Conversion

Coal conversion in the carbonizer is based on the EERC's initial material balance.[34] Fluidizing gas rate to the carbonizer was maintained at 91,833 lb/hr in accordance with the EERC's balance. However, with regard to char formation, a change has been made from the EERC's basic balance. The EERC's data show a significant quantity of oxygen in the fluidizing gas, based on runs performed in their test facility. In the commercial plant, oxygen will not be present in the carbonizer. This difference is reflected by the suppression of CO_2 and a corresponding increase in char yield. Accordingly, XBi established the following changes in coal/char composition (conversion) in the carbonizer:

Component	Yield, lb/100 lb Feed maf	Weight % in Overhead Gas
maf	+67.52	10.0
Ash	0.00	10.0
Oxygen	0.00	100.0
Nitrogen	0.00	100.0
Carbon Dioxide	0.00	100.0
Methane	+2.49	100.0
Hydrogen	+0.78	100.0
Carbon Monoxide	+2.09	100.0
Hydrogen Sulfide	+2.33	100.0
Ethane	+0.53	100.0
Ethylene	+0.13	100.0
Propane	+5.98	100.0
Propylene	+0.15	100.0
Water	0.00	100.0
Condensable Hydrocarbon	+18.00	100.0
	100.00	

3.6.2.3 Carbonizer Effluents

The quantities and compositions of carbonizer char and effluent gas are based on conversion parameters derived by XBi from the EERC data (see table above). The following data regarding hydrocarbon and sulfur in the exit gas were also given by the EERC:

- CARBONIZER GAS
  - Condensable hydrocarbon: 9500 lb/hr (fixed).
  - Simulated ASTM distillation:[28]

ABP, °F	Weight %
320	0.0
392	24.0
482	66.0
572	90.0
662	97.5
752	99.0
842	100.0

- Includes 345 lb/hr total sulfur.

- CARBONIZER CHAR

Based on the XBi conversion parameters above, the following total char (bed + fines) is produced in the carbonizer:

	lb/hr
Total Char	42,090
maf	35,652
Ash	6,438
Sulfur	1,011
Volatile Matter	5,557

3.6.2.4 Carbonizer - Other Design Parameters

- Superficial Gas Velocity: 4 fps.[43]

- Residence Time: 3 hours,[17] minimum is 30 minutes.[18]

- Carbonizer Geometry:[10] Bed L/D = 1, Freeboard (Top) L/D = 1, Overall L/D = 2.

- Heat loss: 7 MM Btu/hr (approximately 10% of heat load).[18]

3.6.3 Char Beneficiation

The following separation parameters were given by AMAX for char magnetic separation:[34]

	Weight % Rejected
maf	11.11
Ash	22.76
Sulfur*	23.80
Volatile Matter	13.44

* Adjusted value in order to maintain char sulfur at 2.1 wt% to calciner.

3.6.4 Calcination

3.6.4.1 Calciner Feed

Quantity and composition of feed to the calciner are derived from 1) the carbonizer effluent given above and 2) beneficiation of the carbonizer char by magnetic separation according to the above separation factors. The following calciner feed composition was used:

	lb/hr
Total Char	36,363
maf	31,691
Ash	4,972
Sulfur*	770
Volatile Matter	4,810

* Adjusted value in order to maintain char sulfur at 2.1 wt%.

3.6.4.2 Calciner Conversion

Char conversion in the calciner is based on the EERC's initial material balance.[34] Fluidizing gas rate to the calciner was maintained at 100,000 lb/hr in accordance with the EERC's balance. However, with regard to calcinate formation, an adjustment has been made from the EERC's basic balance. Accordingly, XBi established the following changes in coal/char composition (conversion) in the carbonizer:

Component	Yield, lb/100 lb Feed maf	Weight % in Overhead Gas
maf	+83.0	20.0
Ash	0.0	20.0
Oxygen	0.0	100.0
Nitrogen	0.0	100.0
Carbon Dioxide	+9.05	100.0
Methane	+1.86	100.0
Hydrogen	+0.56	100.0
Carbon Monoxide	+1.86	100.0
Hydrogen Sulfide	+0.83	100.0
Ethane	+0.06	100.0
Ethylene	+0.01	100.0
Propane	+0.66	100.0
Propylene	+0.02	100.0
Water	+1.68	100.0
Condensable Hydrocarbon	+0.19	100.0
	100.00	

3.6.4.3 Calciner Effluents

The quantities and compositions of calcinate and effluent gas are based on conversion parameters derived by XBi from the EERC data (see table above). The following data regarding hydrocarbon and sulfur in the exit gas were also given by the EERC:[34]

- CALCINER GAS

  - Condensable hydrocarbon: 59 lb/hr (fixed).
  - Simulated ASTM distillation:[35]

ABP, °F	Weight %
176	0.0
392	32.0
572	68.0
752	86.0
932	98.0
950	100.0

  - Includes 1-lb/hr sulfur.

- CALCINATE

Based on the XBi conversion parameters above, the following total calcinate (bed + fines) is produced in the calciner:

	lb/hr
Total Calcinate	31,372
maf	26,400
Ash	4,972
Sulfur	521
Volatile Matter	1,336

3.6.4.3 Calciner - Other Design Parameters

- Superficial Gas Velocity: 2 fps.[10]

- Residence Time: 3 hours,[17] minimum is 30 minutes.

- Calciner Geometry:[17] Bed L/D = 0.5, Freeboard (Top) L/D = 1, Overall L/D = 1.5.

- Heat loss: 7 MM Btu/hr (approximately 10% of heat load).[18]

3.6.5 Calcinate Beneficiation

The following separation parameters for calcinate fines (cyclone underflow) by gravity table were derived from data given by AMAX for coal gravity table separation:[34]

Component	Weight % Rejected
maf	7.75
Ash	25.0
Sulfur*	24.4
Volatile Matter	7.0

* Adjusted value in order to maintain calcinate fines sulfur at 1.6 wt%.

3.6.6 Briquetting (Formed Coke)

Formed coke contains 6 - 10 wt% recovered liquids for binder.

3.7 Design Factors Applied by XBi

3.7.1 On-Stream Factor

- Operation 330 days per year (approximately 90% on stream).

3.7.2 Minimum Storage Capacities

- Coal feed: 48-hour reserve at 1000 tpd (8% moisture by weight).
- Formed coke product: 48-hour capacity.
- Intermediate coal/char surge hoppers: 2-hour capacity.
- Calcinate storage: 48-hour capacity.
- Reject coal/char storage: 24-hour capacity.
- Reject calcinate storage: 24-hour capacity.

3.7.3 Bulk Solids Belt Conveying

- Belt conveyors are generally used for bulk conveying cool solids.
- Conveying design capacity is approximately twice normal (continuous) requirement for feeding downstream equipment.
- Maximum incline for belt conveyors: 15°.
- Belt conveyors are enclosed.

3.7.4 Pneumatic Conveying

- Maximum 8:1 solids-to-air ratio.
- Piping is sized for 6000 to 7000 fpm.
- All bends are sweeps; no ells are used.

3.7.5 Cyclones

- Primary cyclones remove particles >10μm with 50% efficiency.
- Secondary cyclones remove particles >4μm with 50% efficiency.

3.7.6 Baghouses

- Maximum 3:1 air-to-cloth ratio.
- Maximum solids discharge to atmosphere is 0.002 grain/scf.

3.7.7 Dusty Vent Lines

- Minimum incline/decline: 60°.

3.7.8 Solids cooling

- Design duty is 115% of the normal rate.

3.7.9 Compressors

- Carbonizer gas: design capacity is 110% of normal flow.
- Calciner makeup gas: design capacity is 120% of normal flow.

3.7.10 Heat Exchangers

- Design duties are 120% of normal rate.

3.7.11 Carbonizer Off-gas In-line Burners

- 10:1 carbon-to-hydrogen weight ratio for condensables in off-gas.
- Air compressors: design capacity is 120% of normal flow.
- Heat loss not included in duty.

3.7.12 Gas Quenching/Oil Recovery

- Oil circulating pump and cooler: design capacity is 130% of normal rate.
- Oil storage tank: 48-hour reserve at 5,278 lb/hr.
- Heat loss is 0.65 MM Btu/hr.
- Oil transfer pump: design capacity is about three times the normal flow.

3.8 Safety and Environmental Constraints and Compliance

3.8.1 General

The MG facility is to be detail designed in accordance with all applicable national safety codes and standards. These include, but are not limited to:

ASME Sections I, II, V, VIII, and IX	RMA
ASTM	AWS
ANSI B31.1	OSHA

HI Standards	MSHA
ASHRAE	AFBMA
SMACNA	NFPA
AMCA	AGMA
TEMA	FM
ASME Performance Test Codes	UL
HEI	NFPA
CEMA	

Design, construction, and operation of the plant is also governed by applicable federal, state, and local environmental and health regulations which include CAA, CWA, HSWA, and SARA.

3.8.2 Safety Considerations

3.8.2.1 MSHA and OSHA

AMAX's existing Chinook mine is currently regulated by the Mining Safety and Health Act (MSHA). The new MG facility, considered to be an addition to the mining operation, will thus be regulated by MSHA as far as applicable. For industrial safety and health concerns beyond those administered by MSHA, the Occupational Safety and Health Act (OSHA) will apply.

3.8.2.2 Fire and Explosion Protection

National Fire Protection Administration (NFPA) codes and guidelines as applicable to coal processing/handling will govern. State-of-the-art fire and explosion prevention technology will be applied; e.g., all coal, coke, and dust-laden conveyances and handling equipment are to be protected by venting, explosion-suppression devices, and/or water sprays, as applicable.

3.8.3 Safety Design Features

3.8.3.1 Fire Water System

A fire water loop is provided to supply water to hydrants, hose stations, and fixed automatic water suppression systems. Fire water is supplied by an electric motor-driven primary pump and backup diesel engine-driven pump. The system is continuously pressurized by one partial capacity jockey pump. The pumps take suction from a single, above ground raw water tank. In the event the jockey pump cannot maintain the system pressure, the main fire pumps will start sequentially.

The following equipment and areas are protected by fixed automatic water suppression systems:

- Coal/char conveyors, galleries, and solids handling structures.
- Main and auxiliary transformers.
- Turbine lube oil reservoir.
- Areas under the turbine generator operating floor.

- Cooling tower.
- Warehouse and other facilities, as required.

3.8.3.2 Fire/Explosion Detection and Prevention

An alarm system utilizing ionization detectors is provided for the electrical cable spreading room and electronic rooms. Fixed-temperature detectors and rate-of-rise detectors are provided in the coal and char handling areas, cooling tower, and main and auxiliary transformer areas. These are protected by deluge water spraying systems.

UV/IR flame detectors are provided for the boiler in the AFBC firing aisles. A permanent Halon extinguishing system is provided for the electronic/computer room. Permanently installed Fike or Fenwall flooding systems are provided for the protection of each dust-collection system.

Permanently installed fire protection systems are augmented by the following portable equipment:

- Manual carbon dioxide and/or Halon extinguishers for electrical equipment and switchgear in confined areas where this type of extinguisher is effective.

- Multipurpose ABC dry chemical extinguishers throughout the plant.

- A carriage-mounted 150-pound dry chemical unit on each level of the turbine bay.

- A fire truck with 3500-gallon capacity and 250 gpm pump capable of passing a 3-hour National Board of Fire Underwriters Class A acceptance test.

- Hose stations with 1-1/2-inch fire hose in areas not readily accessible by hydrants.

3.8.3.3 Fire/Safety Around Specific Areas or Equipment

Coal Storage: A fire water loop is not provided around inactive coal storage areas. Enclosed storage areas are ventilated to prevent the accumulation of explosive or combustible gas and dust mixtures. Continuous venting of the space at the top of coal storage silos is provided.

Conveyors: Bureau of Mines fire retardant conveyor belt material is standard. Conveyor galleries are provided with bulkheads or draft curtains to inhibit potential spread of fire by drafts or natural air convection. Conveyors are further protected by fixed water spray systems.

Transformer Areas: A dry-pipe, open-head deluge water spray system is provided for the main and auxiliary transformers. The deluge system will comprise of an automatic deluge valve interlocked with the transformer protective relays.

3.8.4 Enivronmental Regulations

3.8.4.1 Air Emissions

Atmospheric airborne discharges from the MG facility are regulated by USEPA, Indiana EPA, and applicable local air quality regulatory agencies under the 1990 Amendments to the Clean Air Act (CAA), the Hazardous and Solid Waste Amendments (HSWA), and the Superfund Amendments and Reauthorization Act Community Right-to-Know Act (SARA Title III).

3.8.4.2 Water Discharge Quality

Aqueous discharges from the MG facility must meet all pollution criteria as prescribed by the Water Quality Act (WQA), National Emissions Standards for Hazardous Air Pollutants (NESHAP), the Hazardous and Solid Waste Amendments (HSWA), the Toxic Characteristic Leaching Procedure (TCLP, effective 1994), and the Superfund Amendments and Reauthorization Act Community Right-to-Know Act (SARA Title III). These regulations are enforced by USEPA, Indiana EPA, and applicable local regulatory water quality agencies.

3.8.4.3 Sanitary Discharge

Sanitary wastes will be sent to the existing Chinook mine waste disposal facilities. It is assumed that the existing facility is in compliance with current regulations.

3.8.4.4 FAA

The height limitation and visibility of facility structures and equipment are governed by FAA regulations, Obstruction Marking and Lighting, A.C. 70/7460-1C.

3.8.4.5 Noise

Noise levels within the plant boundaries are not to exceed MSHA standards for Occupational Noise Exposure as stated in the Federal Register, Section 1910.95.

3.8.4.6 HVAC

Design of HVAC and HV systems are based on ASHRAE guides and AMCA standards. Heat load calculations and equipment selection are based on outdoor conditions listed in the ASHRAE Handbook of Fundamentals.

3.8.5 Environmental Compliance Design Features

3.8.5.1 Air Emissions

Emission species which are controlled to meet environmental requirements include sulfur compounds (H_2S, SO_2, COS, and complex organic sulfur compounds), nitrogen oxides (NO_x), particulates, carbon monoxide (CO), hydrocarbons, and others (NH_3, HCN, alkali metals, etc.). In the MG facility, some of these are generated in both the gasification process and from the combustion of coal and char in the AFBC. Those produced during gasification, however, are sent with the process off-gases to the AFBC, where they are burned. Thus emission of the controlled species, with the exception of particulate matter (see below), is limited to AFBC flue gas.

AFBC: Design of the AFBC is predicated on compliance with Federal EPA and local agency air quality requirements. Emissions of SO_2, NO_x, CO, and particulate matter (fly ash) from the AFBC will not exceed these standards. The boiler stack is designed to comply with Good Engineering Stack Height as defined by Federal Register 40 CFR 51.

Particulates: All coal and char in the MG facility is conveyed and processed in closed systems. Prior to atmospheric discharge, each gas stream which has been used in the process and/or for solids conveying is passed through a dedicated, suitably designed baghouse. Baghouses reduce the discharge particulate level of these vents to 0.002 grains/scf in order to meet current federal and local air emissions standards.

3.8.5.2 Wastewater

The process normally uses no water and does not generate aqueous process wastes. Coal, char, and ash are not stored in open piles on-site. Thus process runoff or leachate from these need not be considered.

Oil-lubricated equipment or equipment which contains regulated materials (e.g., transformer oil) are located in diked areas. Runoff from these is collected and pumped to the Chinook mine wastewater handling system for further treatment. Cooling tower blowdown, boiler blowdown, and water treatment backflush are also collected and pumped to the mine wastewater treatment facility. Domestic wastewater is pumped to the existing Chinook mine area sanitary waste disposal system.

3.8.5.3 Solid Wastes

All reject process solids (coal and char) are burned as fuel in the AFBC. Fine solids (particulates) which are collected in baghouses throughout the processing facilities are either returned to the process or burned in the AFBC. Fly ash and bottom ash from the AFBC are collected in closed hoppers and transported by truck/rail to the Chinook mine for underground disposal. The need for the routine disposal of other solid/hazardous wastes is not anticipated.

4.0 PROCESS DESCRIPTION AND PHILOSOPHY

4.1 General

The mild coal gasification plant flow scheme is divided into five main processing areas. These are:

- Coal storage and preparation (Appendix B, PFD-001) which comprises:
  - Receiving and storage.
  - Preparation (crushing and drying).
  - Coal beneficiation (screening and gravity separation).
- Coal carbonization (Appendix B, PFD-002) which comprises:
  - Carbonization and char cooling.
  - Carbonizer char beneficiation (screening and magnetic separation).
- Carbonizer liquids recovery (Appendix B, PFD-003) which comprises:
  - Gas quench and liquids storage.
  - Carbonizer gas recompression and burning.
- Char calcination (Appendix B, PFD-004) which comprises:
  - Calcination and calcinate cooling.
  - Fines recovery and beneficiation (gravity separation).
  - Calciner gas recompression.
- Coke briquetting (Appendix B, PFD-005) which comprises:
  - Char and binder feed mixing.
  - Briquetting.
  - Briquette curing and coking.
  - Gas handling.

In addition to the coal handling and processing units, facility on-sites also incorporate all equipment and utility systems required to support and maintain continuous independent operation. These include:

- AFBC and auxiliaries (Appendix B, UFD-011).
- Steam/power generation (Appendix B, UFD-012).
- Water treatment and storage (Appendix B, UFD-013).
- Plant cooling water, fire water, and brine facilities.

As in the previous section, several references to sources of information are cited. A list of these references is given in Appendix A.

4.2 Coal Storage and Preparation Area (Appendix B, PFD-001)

4.2.1 Coal Receiving and Storage

Coal enters the plant battery limits via a belt conveyor from the mine. From the plant boundary, feed coal is transferred by the Coal Receiving Conveyor F-101, to the Coal Silo, T-101. A belt scale (an accessory to F-101) records the quantity of coal which crosses the plant boundary. Air vented from the Silo is passed through Baghouse G-101 to eliminate fugitive coal dust emissions, then discharged by the Baghouse Blower K-101.

The Coal Silo has twin bottom discharge cones, each feeding one of two equal and parallel process trains. All equipment from this point (except as noted otherwise) is identified by suffixes "A" and "B" for respective trains on flow diagrams, the equipment list, etc. For clarity in the process description, however, suffixes are not used, and the description refers to each train.

Feed coal from T-101 is first carried a short distance by Belt Feeder F-102 to the main Belt Conveyor F-103, which lifts the coal to Surge Bin T-102. As coal is conveyed on F-103, it encounters a scale, magnetic separator, and metal detector. These auxiliaries verify the mass of coal to be processed and ensure that no large metallic debris is passed through to possibly damage downstream equipment.

Bin T-102 provides feed surge and consistent flow for the Coal Crusher J-101. Both F-103 Conveyors discharge to only one T-102. As with the T-101 bin, air from T-102 is vented through a baghouse and discharged to the atmosphere via a blower (G-102 and K-102, respectively, single-train). T-102 also has twin bottom discharge cones; from here the process again splits to two parallel trains.

4.2.2 Coal Preparation

Feed coal received at the site is approximately 2 inch x 0 mesh and wet. In order to facilitate downstream processing, the coal is first crushed,[16] then screened and surface-dried to no more than 8% moisture.[15] Crushing the coal prior to drying permits fluidization in the dryer, thus enhancing the dryer's effectiveness.

From each discharge cone of T-102, Belt Feeder F-104 carries feed coal into Crusher J-101. J-101 is a double roll-type crusher which reduces the coal to approximately 1/4-inch mesh. Crushed coal from J-101 falls onto the belt-type Dryer Feed Conveyor F-105, which carries the coal up to the feed chute of Coal Dryer H-101 above the 5th level (approximately 90 feet above grade). The dryer is a fluid-bed type in which the coal is dried with hot air from the AFBC air preheater. Air enters the dryer at 400°F (204°C). Dryer capacity is based on drying 45 tph (dry basis) of coal containing 13% to 8% moisture maximum.

Exhaust air from the dryer is discharged to the Coal Cyclones C-101 (two cyclones in parallel). Here the larger coal particles still entrained in the air are removed. Cyclone overflow is sent to Baghouse G-103, where the remaining fine coal particles are eliminated by the cloth filter bags. Air leaves the dryer at approximately 250°F (121°C), suitably above the water dew point to prevent downstream condensation and sticking of char fines in the cyclones and baghouse. Coal fines collected in the cyclones and baghouse are discharged by rotary valves to the Reject Hopper T-103.[14]

4.2.3 Coal Beneficiation

Feed coal typically contains three types of sulfur compounds, viz., organic, pyritic, and sulfates (inorganic). Pyritic sulfur occurs in distinct particles and is approximately three times the density as the coal itself.[50] This allows some amount of physical rejection of pyritic sulfur to be achieved. Furthermore, reducing the amount of pyrite fed to the carbonizer decreases the degree of gravity separation required downstream and reduces the conversion of pyritic sulfur to organic sulfur during carbonization.[23]

Coal from the dryer flows by gravity into the Coal Screener C-102. The Screener has two vibrating screens in series which separate the coal into three fractions: 10 mesh and over, 10 to 24 mesh, and <24 mesh (fines). The purpose of this operation is to facilitate the next step, beneficiation by gravity separation, by limiting the size distribution range of coal to each of the gravity tables.[23]

Crushed, dried, and segregated coal from the screener is fed by gravity to three gravity tables (C-103, C-104, and C-105), which operate in parallel. In the gravity tables, air from blowers (K-103, K-104, and K-105, respectively) is blown upward through a sloped vibrating deck, fluidizing the lighter coal particles. Heavier particles (containing pyrite and ash) are not fluidized and thus are carried upward by the motion of the deck toward the high end. The lighter particles, disengaged from the deck, "float" downslope and are discharged from the low end.

The denser fraction from each gravity table is fed by gravity to the Reject Hopper T-103. This fraction contains a higher concentration of pyrites than the coal in the light fraction. Reject coal from T-103 is pneumatically conveyed to the AFBC reject coal hopper[14] with air from Blower K-106.

The lighter fraction from each gravity table, now somewhat reduced in pyritic sulfur and ash content, is gravity fed to Surge Hopper T-104 through the Carbonizer Feed Mixer M-101. M-101 is a vertical static mixer which ensures that the varying particle sizes from all three gravity tables are well blended before feeding to the carbonizer.

4.3 Carbonizer Area (Appendix B, PFD-002)

4.3.1 Coal Carbonization

Processed feed coal from Hopper T-104 is carried by belt-type Feed Conveyor F-106 to the Carbonizer Feed Hopper T-301. Coal is pneumatically conveyed[15] from T-301 into the bottom feed section of the Carbonizer R-301. Fresh coal is fed at a constant rate to the carbonizer. Recycled and reheated gas at 2800°F (1538°C) is simultaneously injected into the bottom of the carbonizer. A portion of the recycled carbonizer gas stream is used for conveying feed into the carbonizer. Temperature of the conveying gas is maintained at approximately 600°F (316°C) by mixing reheated and cold recycle gas.[16] Total gas to the carbonizer (feed gas plus conveying gas) is maintained at a constant rate.

The carbonizer operates at approximately 1100°F (593°C).[1] A range of 1050° to 1125°F (566° to 607°C) is optimum.[18] High-temperature carbonization is recognized as the principal carbonization technique for the production of metallurgical coke as 1) coke produced in this manner is less porous and less reactive, and 2) recovered liquids coproduction is not as essential for commercial viability.[50]

Hot gas is fed into the carbonizer char bed through a distribution device.[18] Coal is fed to the carbonizer through multiple ports, creating a spouted-bed operation. During a residence time of 3 hours in the carbonizer, char (enriched coal) is formed as volatile compounds are driven out of the coal. The spouted-bed design was chosen based on favorable results with caking coals in other gasifier systems. In this carbonizer configuration, the internal recycle of char back to the bottom of the bed reduces agglomeration.[1]

Volatiles from the carbonizer are carried off by the exit gas. Gas exits the top of the carbonizer at about 1100°F (593°C). Char particulate matter is separated from the gas by passing it through a two-stage (series) cyclone system. Each of the primary and secondary carbonizer cyclones, C-301 and C-302, is comprised of two units in parallel (four cyclones in all) for capacity considerations. Primary cyclones are designed to separate 10μm particles with 50% efficiency; secondaries are designed for 4μm particle separation at 50% efficiency.[1] Underflow solids are discharged by rotary air locks from the bottom of the four cyclones and cooled prior to further processing (see below). Gas from the cyclones is sent to the quench section for cooling, condensation of volatiles, and liquids recovery.

Devolatilized char is discharged from the top of the char bed of the carbonizer via a chute and rotary air lock into the Char Cooler H-301. Separated char fines from the cyclones (see above) are combined with the carbonizer char into H-301. H-301 is a screw-type cooler with hollow flights filled with circulated cooling brine.[16] Char enters the cooler at the carbonizer temperature of 1100°F (593°C) and exits at about 200°F (93°C). Cooling the char prior to calcining is not energy efficient, but the char must be cooled to less than 250°F (121°C) in order to protect the permanent magnets in the magnetic separators which are used prior to calcining.[23] Cooled char drops by gravity from the discharge end of the cooler into the Screener Feed Hopper T-302.

4.3.2 Char Beneficiation

Although coal beneficiation reduces the pyritic sulfur content (see above), carbonizer char still contains significant pyritic sulfur in the form of pyrrhotite. During carbonization, pyrite (FeS_2) is converted to pyrrhotite (FeS_x) with the extra sulfur either reporting to the off-gas or remaining in the char as elemental sulfur. Where the sulfur goes is influenced by reducing conditions and other factors that cannot be fully explained. Pyrrhotite is magnetic, while pyrite is paramagnetic and elemental sulfur has very little magnetic susceptibility. At temperatures of 800° to 1100°F (427° to 593°C), the conversion of pyrite to pyrrhotite is maximized, and there should be a good opportunity to use magnetic separation to remove sulfur from the char, assuming the pyrrhotite mineralization is liberated from the other constituents in the char. At temperatures below 800°F (427°C), conversion to pyrrhotite is not possible, and at temperatures above 1100°F (593°C), the pyrite converts completely to iron compounds and elemental sulfur. Magnetic separation may remove the iron compounds and improve the ash content, but it is not effective on elemental sulfur.

Char is transferred by belt-type Conveyor F-301 from grade level (under Hopper T-302) to the top of the Char Screener C-307 at approximately 90 feet above grade. The screener has two vibrating screens in series which separate the char into three fractions: 20 mesh and larger, 20 to 40 mesh, and <40 mesh (fines). The purpose of this operation is to limit the particle-size distribution range of char to each magnetic separator in order to enhance separation efficiency.[23]

Char is fed by gravity from the screener to three magnetic separators (C-304, C-305, and C-306), which operate in parallel. High-strength magnetic elements on a rotating drum in each magnetic separator draw away char particles which have a high pyrrhotite content. The high-pyrrhotite char is then discharged to one side of the separator (reject magnetic discharge), while the nonmagnetic char (product) is discharged from the other side. Reject char is discharged from the three separators gravity flows to the Reject Char Hopper T-303. Reject char from T-303 is then pneumatically conveyed to the AFBC reject char hopper[14] with air from Blower K-302.

Nonmagnetic (product) char from each magnetic separator, now somewhat further reduced in pyritic sulfur content, is gravity fed to Surge Hopper T-304 through the Calciner Feed Mixer M-301. M-301 is a vertical static mixer[16] which ensures that the varying particle sizes from all three separators are well blended before being fed to the calciner.

Atmospheric discharge of coal and char dust is prevented by feeding the vent lines from all carbonizer area equipment (i.e., hoppers, screeners, gravity tables, and conveyors) to Baghouse G-301. The baghouse filter medium ensures that discharge gas does not exceed the EPA airborne dust criterion of 0.002 grain/scf.[18] Vent draft is induced through the baghouse by Exhaust Blower K-301.

4.4 Carbonizer Gas Quench System (Appendix B, PFD-003)

4.4.1 Gas Quench and Liquids Recovery

Recovered coal liquids are not intended to be a discrete product of this plant.[16] Thus the liquids recovery system is operated at conditions which limit the amount of liquid recovered to only that required as binder in the formed coke process (see Section 3.6).[42] Surplus condensable components which evolve during carbonization are allowed to exit with the make gas to be burned in the AFBC.[14]

Hot gas at 1100°F (593°C) from the carbonizer cyclones enters the bottom section of the Quench Tower Q-501 and flows upward through a series of disc-and-donut trays. Recirculating recovered coal liquids at 175°F (79°C) are introduced onto the top tray in Q-501 and flow downward, contacting the gas. The gas is thus quenched, and higher boiling fractions in the gas are condensed into the liquid. Gas leaves the top of the tower at 190°F (88°C); liquid exits the bottom of the tower at 370°F (188°C). The tower operates at a top pressure of 1.5 psig. At these operating conditions, water will not condense from the carbonizer gas stream in the quench tower.[1,5]

Liquid from the bottom of Q-501 is pumped by the Circulating Pump P-501 (spared by P-502) to the Oil Cooler H-501 where it is cooled by brine to 175°F (79°C), then recirculated to the top of the tower. The return rate to the tower is manually set at about 520 gpm. Level control for the tower bottom determines the portion of the cooled stream that is removed. Net bottoms liquid is thus equivalent to the amount of material which condenses from the gas as it passes through the tower.

Net bottoms liquid from the quench operation is stored in Storage Tank T-501. This tank is split-range pressure controlled; i.e, it is nitrogen-padded to eliminate air when operating below atmospheric pressure and evacuated by the Off-gas Compressor K-504 (spared by K-505) to prevent overpressure.[16] The Compressor discharges off-gas to the AFBC where it is burned. Liquid temperature in the tank is maintained at 175°F (79°C) by the self-regulating electric bayonet Tank Heater H-502. This temperature is warm enough to prevent the liquid from setting up like asphalt, yet not high enough to significantly weather the liquids by boiling off lighter components.[16] Furthermore, tank contents are stirred by the paddle-type Mixer M-501, which also reduces the tendency of the oil to set up, stratify, or polymerize.[16] The Oil Transfer Pump P-503 (spared by P-504) delivers liquid from T-501 to T-603 in the briquetting area as required. All equipment in the liquid storage system (i.e., T-501, H-502, M-501, K-504/505, and P-503/504) is common to both trains.

4.4.2 Gas Recompression and Reheat

Gas from the top of the quench tower is sent to the Compressor Suction Drum T-502, where entrained liquid droplets are removed prior to compression of the gas. Liquid recovered in T-502 is returned to the tower by Pump P-505. Scrubbed gas, at approximately 0.5 psig, from T-502 is then compressed to 18 psig by the Carbonizer Gas Compressor K-501. K-501 is a steam turbine-driven centrifugal machine. Quench tower operating pressure (compressor suction) is maintained by controlling the steam rate to the K-501 turbine driver.

A sidestream is taken from K-501 at 10 psig and approximately 300°F (149°C). Part of this stream is returned directly to the carbonizer area where it is used to convey feed coal from the feed hopper into the carbonizer (see above), the remainder of the sidestream is flow-controlled to the Carbonizer Recycle Gas Burner B-501. Here combustibles in the quenched, recompressed gas are burned with air. Combustion air is supplied to the burner by Compressor K-502. Air rate to the burner is set by ratio control to the combustibles content of the quench tower overhead stream. Compressor output is regulated by controlling the steam rate to its steam turbine drive. Reheated gas from the burner at approximately 2800°F (1538°C) is then recycled to the bottom of the carbonizer.

The final stage of K-501 discharges at 18 psig and approximately 400°F (204°C). Part of this gas is vented off to maintain pressure in the recycle gas system. This vent gas is sent to the AFBC where it is burned. The remainder of the high-pressure discharge from K-501 is flow-controlled to the Calciner Makeup Gas Burner B-502, where combustibles in the gas are burned with air, as in B-501 above. Combustion air is supplied to the burner by Compressor K-503. Again, air rate to the burner is set by ratio control to the combustibles content of the gas stream, and air compressor output is regulated by controlling steam rate to the turbine drive. Reheated gas from B-502 at approximately 2800°F (1538°C) is then sent to the calciner area where it is mixed with recycle gas before entering the bottom of the calciner.

4.5 Calciner Area (Appendix B, PFD-004)

4.5.1 Calciner Operation

Product char from magnetic separation is transferred by belt-type Conveyor F-302 from grade level (under Hopper T-304) into the top of the Calciner Feed Hopper T-401 at approximately 120 feet above grade. From T-401, char is gravity fed by rotary air lock into a pneumatic conveying line which transports it into the bottom of the char bed in Calciner R-401.

Calciner feed rate is dependent upon the char production rate of the carbonizer. Residence time of the char in the calciner is approximately 3 hours.[17] Calciner bed temperature is maintained at 1800°F (982°C) by the circulation of reheated gas into the bottom of the bed which exits the top of the calciner. Total gas to the calciner (feed gas plus conveying gas) is maintained at a constant rate, sufficient to affect fluidization.[1] Calcinate (enriched char) is formed under these conditions as the hot fluidizing gas drives off an additional amount of volatile compounds (compared with the Carbonizer) from the char.

Calcinate is discharged from the top of the char bed of the calciner via a chute and rotary air lock into the Bed Calcinate Cooler H-401, a screw-type cooler with hollow flights filled with circulated cooling brine. Calcinate enters the cooler at the calciner temperature of 1800°F (982°C) and exits at about 200°F (93°C). The cooled calcinate drops by gravity from the discharge end of the cooler into the Calcinate Product Storage Hopper T-402. From T-402, calcinate is pneumatically conveyed to the Product Calcinate Formed Coke Feed Hopper T-601 with air from Blower K-402.

4.5.2 Calciner Gas Recycle System

Gas exits the top of the calciner at about 1800°F (982°C) and enters a two-stage cyclone system to remove entrained calcinate particles. The system comprises the Primary Cyclone C-401 and Secondary Cyclones C-402 and C-403. Each of the primary and secondary carbonizer cyclone services require two units in parallel (four cyclones in all) for capacity considerations. Primary Cyclones are designed to separate 10μm particles with 50% efficiency; secondaries are designed for 4μm particle separation at 50% efficiency.[1] Underflow solids are discharged by rotary air locks from the bottom of the four cyclones and cooled prior to further processing (see below).

Pressure of the deentrained gas from the secondary cyclones is boosted by the Calciner Recycle Gas Compressor K-406 and recycled to the bottom of the calciner. Prior to recompression, the gas is cooled first to 1200°F (649°C) by heat exchange with the compressor discharge stream in Heat Exchanger H-403. The temperature of the gas is further reduced to 375°F (191°C) in Gas Cooler H-404 with cooling brine. The gas is then passed through the Suction Drum T-405 in order to deentrain any liquids which may condense as the gas is cooled. Liquids from T-405 are returned to the tower by Pump P-402. As the compressor suction gas is cooled in H-403, the compressor discharge stream is preheated from 450° to 1150°F (232° to 621°C).

Recycle Compressor K-406 is a steam turbine-driven centrifugal machine. Calciner operating pressure is maintained by controlling the steam rate to the K-406 turbine driver. Recompressed gas at 21 psig and 500°F (260°C) from K-406 is reheated in Exchanger H-403 (see paragraph above), then recycled to the calciner. A flow-controlled portion of this preheated recycle calciner gas stream is used to convey feed into the calciner. The remainder of the recycled gas is mixed with makeup gas from Burner B-502 and fed to the bottom of the calciner.

4.5.3 Calcinate Beneficiation

Separated calcinate fines from the cyclones (see above) are cooled from 1800 to 200°F (982° to 93°C) with brine coolant in the Calcinate Fines Cooler H-402. The design and operation of H-402 is similar to H-401 above. Cooled calcinate from H-402 is discharged by gravity into Gravity Table C-405. C-405 operates in the same manner as the coal gravity tables (see above). Heavier calcinate particles are discharged to the Reject Calcinate Hopper T-403, while lighter material is collected in the Calcinate Fines Product Hopper T-404. It was decided to gravity table only calcinate fines, as these particles have been newly generated by attrition, whereas the coarser particles are probably separated as well as possible.[23]

4.6 Formed Coke (Appendix B, PFD-005)

4.6.1 Briquetting

Calcinate and calcinate fines from Feed Hoppers T-601 and T-602, respectively, together with recovered coal liquids (oil) via Metering Pump P-601 from Tank T-603, are fed simultaneously into Feed Mixer M-601. Calcinate and oil are both fed to M-601 at constant rates and in correct proportion. M-601 is a paddle-type blender which thoroughly commingles the calcinate and oil (binder) prior to briquetting.

The homogeneous mixture from M-601 is gravity-fed to the charge hopper of the Briquette Press J-601. J-601 is a roll-type briquetter in which matching pockets on the rolls squeeze and compact the feed mixture into dense, cohesive shapes (briquettes). Freshly formed, "green", briquettes are discharged by gravity from the briquetter into Screener C-602, where fines are separated from the soft, green, briquettes. Fines from the bottom of C-602 are lifted by the bucket-type Briquette Conveyor F-602 and recycled back to the briquetter feed hopper.

4.6.2 Briquette Curing and Coking

Green briquettes are relatively soft and crumble easily. Initial briquetting is thus followed by a two-step curing process which sets the binder and hardens the briquettes (formed coke).

Briquettes from the screener are transferred by the belt-type Green Briquette Conveyor F-601 to the Curing Oven H-601. Hot air from the AFBC air preheater is used in the oven to heat the briquettes to 450°F (232°C). At this temperature, some of the lighter volatiles in the binder are driven off and burned in the oven and some polymerization occurs in the binder. Exhaust gas from the oven is passed through

Cyclone C-602 to remove entrained coke fines and then sent to the AFBC to ensure incineration of unburned organics which may be present.

Cured briquettes are gravity-discharged from the oven onto belt-type Conveyor F-603 which, in turn, drops the briquettes into the feed hopper of Briquette Elevator F-604. F-604 lifts the briquettes, discharging them into the top of the Coking Kiln B-602. The kiln is a shaft-type roaster in which the briquettes are coked at 1500° - 1600°F (816° to 871°C). Heat to B-602 is provided by burning volatilized organics from the binder and natural gas via its own fired heater. During coking some high boiling volatiles are evolved from the briquette binder. These are burned in the kiln atmosphere, providing most of the heat for coking.

Hot briquettes are discharged from the bottom of the kiln onto the Cooling Conveyor F-606. F-606 has an open-mesh belt through which cooling air is blown from Blower K-604. The cooled briquettes are then transferred from the cooling conveyor by the Product Conveyor F-605 to the Product Silo T-604. Product formed coke is loaded into railcars from this silo.

Dusty vents from the briquetting operation are discharged through Cyclone C-601 and Baghouse G-602. Hot vent gas containing tars from the curing oven and kiln are scrubbed in Cyclone C-602 and then sent to the AFBC. Cool dusty vents from the cooling conveyor and product silo are cleaned in Baghouse G-601 before discharging to the atmosphere.

4.7 Site-Generated Utility Support Facilities

The MG plant is a stand-alone facility, and all utilities essential for continuous operation are generated on-site. The plant is tied into the local power grid for start-up and for support of basic services while the plant is shut down. The plant receives raw well water for makeup to all process and utility services; potable water is obtained from the local domestic water supply. Natural gas is available from a local pipeline.

Site-generated/distributed utilities include:

- AFBC and auxiliaries for steam generation.
- Power generation.
- Water treatment and storage.
- Cooling water facilities.
- Plant and instrument air systems.
- Fuel gas receiver.
- Fire protection system.

4.8 Steam and Power Generation

The generation of steam and power at the mild coal gasification facility is based on a single unit 24-MW reject coal- and char-fired power plant using one atmospheric fluidized-bed combustor/boiler (AFBC) and common facilities. The design of associated equipment and systems is based on utilizing all reject coal and char and other waste products generated by the two-train mild coal gasification process. Fresh feed coal is to be used in the boiler only during start-up or during an upset condition.

4.8.1 AFBC, Boiler, and Steam Systems (Appendix B, UFD-011 and UFD-012)

4.8.1.1 Fluid-Bed Combustor (AFBC) and Accessories

An AFBC is provided to generate steam for the turbine-generator. The boiler is a drum type with a balanced draft furnace equipped for firing reject coal and char. Sulfur dioxide emissions are controlled by limestone injection in the furnace. The design includes natural gas as the start-up/ignition fuel. The AFBC (Appendix B, PFD-011) includes:

- Atmospheric fluidized-bed combustor (AFBC).
- AFBC feed (reject coal/char and limestone) storage and handling.
- Fly ash and bottom ash storage and handling.
- Flue gas system with stack.

Guaranteed maximum evaporation capacity for the boiler is approximately 280,000 lb/hr at 1200 psig and 960°F (516°C). These output conditions were chosen as suitable for subsequent use in the turbogenerators.

Provision is made in the system for obtaining the required soot-blowing steam at essentially all loads. The boiler is designed to achieve a stable operating load range without auxiliary fuel firing from 30% load to maximum continuous rating (MCR) when firing the designated fuel. The main steam temperature control range will be 50% to MCR. The following is the predicted performance of the boiler, using designated fuel, and calculated for 20% excess air:

Evaporation, lb/hr	280,000
Temperature at superheater outlet, °F (°C)	960 (516)
Pressure at superheater outlet, psig	1,200
Feed water temperature entering Economizer, °F (°C)	380 (193)
Ambient air temperature, °F (°C)	80 (27)
Process air heating, scfm	87,000
Process air temperature, °F (°C)	450 (232)

The boiler is furnished as a complete package with the following accessories:

- Induced-draft (ID) and forced-draft (FD) fans.
- Primary air (PA) fan.
- Soot blowing system, including controls.
- Tubular air heater for process air.
- All necessary boiler trims and appurtenances, including safety relief valves.
- Support steel, insulation, and legging.
- Cyclone ash reinjection and sealing systems.
- Two fuel silos, one for reject char and the other for reject coal.
- One limestone silo.
- System for fuel handling from silo to boiler.
- System for limestone injection.
- Baghouse for emissions control.

4.8.1.2 Fuel and Limestone Handling

The conveying capacity of the fuel handling system from the reject coal and char storage bins to the boiler silos will be 12.5 tph. The conveying capacity of the feed coal is 4.6 tph for start-up purposes and upset condition. Two fuel silos are provided, one for reject coal and the other for reject char. The feed coal, when required, will be conveyed to the reject-coal silo.

The unloading capacity of the limestone handling system is 21 tph. Reclaim conveying capability is twice the limestone feed rate required by the AFBC at full load. Two 100% capacity limestone pneumatic transport systems are provided to feed prepared limestone to the AFBC silo. Limestone conveyor capacity is sized on a limestone density of 90 pounds/cubic foot.

4.8.1.3 Boiler Emissions Control and Ash Handling

A reverse-air cleaning-type baghouse, equipped with multiple compartments, is provided for controlling particulate emissions from the boiler. Baghouse design is based on collecting 85% of the total ash generated in the boiler. The total fly ash generated is the sum total of the ash in the waste fuel and unreacted lime and calcium sulfate from the limestone reaction. The baghouse will have a minimum collection efficiency of 99.99% and an outlet grain loading not exceeding 0.002 grain/scf. The baghouse is sized assuming one compartment is out of service for maintenance and one compartment is out of service for cleaning. Two reverse-air cleaning fans are provided for the entire installation, each fan rated at 100% of total required capacity.

The ash handling system is sized to accommodate fuel ash and the unreacted lime and calcium sulfate from the limestone reaction; 35% of this amount will be bed ash, 5% will be economizer ash, and 60% will be fly ash. Two separate ash handling systems are provided; one system will be for bed ash and the other for fly ash and air preheater ash. The conveying and removal rate for the fly ash handling systems is approximately twice the design ash production rate. Both fly ash and bed ash silos are provided with 24 hours storage capacity.

The bed ash system consists of two 100% capacity flight chain enclosed mechanical conveyors that will collect cooled bed ash from the boiler and convey it to the bed ash silo by means of silo feed conveyors. The fly ash system will consist of a pressure transfer system. Fly ash is transported from the baghouse, economizer, and air preheater hoppers to the fly ash silo. Two 100% pressure blowers are provided. Each ash storage silo is equipped with two truck unloading spouts complete with ash conditioners.

4.8.1.4 Steam and Condensate Systems

A single line from the AFBC boiler will transport the main steam to the turbine generator. Medium pressure steam, extracted from the main turbine at 400 psig, is sent to the distribution system for use in several turbine drivers of equipment in process and utility service. Low pressure steam, extracted from the main turbine at 65 psig, is distributed for used in deaerating boiler feed water and for several miscellaneous heating services. Exhaust steam which exits the turbine at 3- to 5-in

HgAbs. is condensed in the surface condenser. Excess low pressure steam at 50 psig is reinjected into the main turbine to increase power output from the generator.

Two, full-capacity, motor-driven, vertical can-type, multistage, condensate pumps are provided. A full-flow condensate polishing system is provided to maintain condensate water quality. The system includes two 50% capacity vessels and are of the precoat type, with disposable ion-exchange media.

4.8.1.5 Boiler Feed Water System

Feed water is pumped from the deaerator by the boiler feed water pumps through one high-pressure feed water heater to the boiler economizer inlet. The feed water system will also provide spray water for both superheater attemperator and medium-pressure steam header temperature control. The major equipment in the feed water system consists of one deaerator, two boiler feed water pumps, and a high-pressure (HP) feed water heater.

The deaerator provides the first stage of feed water heating. It is a tray-type deaerating heater consisting of a heater and storage tank. The design will comply with requirements of the ASME B&PV Code, Section VIII, Division 1, and HEI standards for deaerators. The deaerator storage tank is sized to supply feed water to the boiler feed water pumps for approximately 10 minutes at full load. The deaerator is designed to deliver feed water with a dissolved oxygen content of 0.005 cc/L or less at all loads. The deaerator will have no free carbon dioxide.

One auxiliary turbine-driven, 100% capacity boiler feed water pump and one 40% capacity electric motor-driven start-up boiler feed water pump are provided. The pumps are multistage horizontal, centrifugal, split-case-type construction. The HP feed water heater is horizontal, single-train, shell and tube type with integral drain coolers. The heater is designed in accordance with HEI standards for closed feed water heaters. The HP feed water heater shell and ends are constructed of carbon steel. The HP feed water heater tubes will be seamless. Tube material will be SA-688 Type 304 stainless steel.

4.8.2 Power Generating Facilities (Appendix B, UFD-012)

4.8.2.1 Turbine Generator

The turbine generator is an extracting/condensing, nonreheat type, 3600 rpm unit. The turbine operates at design main steam conditions of 1200 psig, 940°F (504°C) from the AFBC at the throttle, one controlled extraction at 400 psig and one additional admission at 50 psig, 3.5-in HgAbs at the exhaust, 1-1/2% makeup, and with one high-pressure feed water heating while supplying steam for the boiler feed pump turbine and compressor drive turbines.

The generator is air cooled with water-cooled stator windings. The generator will be rated at approximately 37,000 kVA, 0.90 power factor when operating at 3600 rpm. The generator is a 3-phase, 60-cycle, 0.58-scr machine. All stop and intercept valves are hydraulically operated for automatic tripping.

4.8.2.2 Auxiliary Turbines

An individual auxiliary turbine drive is provided for the main boiler feed water pump. Driver brake horsepower satisfies the maximum boiler feed pump design rating power requirements when using the medium-pressure steam, exhausting to the main condenser at an auxiliary turbine exhaust pressure, which is 0.50-in HgAbs greater than the condenser pressure. This power requirement determines the auxiliary turbine rating.

Process gas recompressors are also steam turbine-driven and supplied with medium-pressure steam.

4.8.2.3 Power Distribution (Figure 2, One-Line Diagram)

Figure 2 is a one-line sketch showing conceptual electrical service distribution inside the MG facility. A dual-buss concept is shown to provide critical electrical service redundancy.

4.9 Water Systems (Appendix B, UFD-013)

Raw well water is supplied to the plant by the raw water well pumps. On-site raw water is stored in a 5000-barrel tank. This tank supplies water to the water treating system and also contains the required fire water reserve. Water from the raw water tank is used directly for makeup to the cooling tower and supply to the treatment (demineralized) system.

4.9.1 Cooling Water

The circulating water system will dissipate waste heat from the unit thermal cycle and plant equipment coolers. A cooling tower is used as the heat sink. The cooling tower is a field-erected, wooden construction designed to cool circulating water from 105° to 88°F (41° to 31°C). The ambient wet bulb temperature is assumed to be 77°F (25°C). The cooling tower is provided with one extra cell. Each cell will require a 200-HP air fan. The cooling tower will be erected on a 162- x 52-foot concrete basin.

Three 50% capacity, vertical, mixed-flow-type, wet pit, pull-out pumps will be provided. The pumps will be located in the cooling tower basin, discharging into a common circulating water line to the main condenser and the auxiliary cooling water heat exchanger, and returning to the distribution header of the cooling tower.

4.9.2 Water Treatment

Raw water must be treated (demineralized) in order to be suitable for makeup to the boiler. The boiler feed water makeup (water treatment) system consists of:

- Two full-capacity activated-carbon filters.
- Two full-capacity zeolite softeners.
- Acid and antiscaling chemical dosing systems.
- Two full-capacity cartridge filters.
- Two 60% capacity reverse osmosis systems.

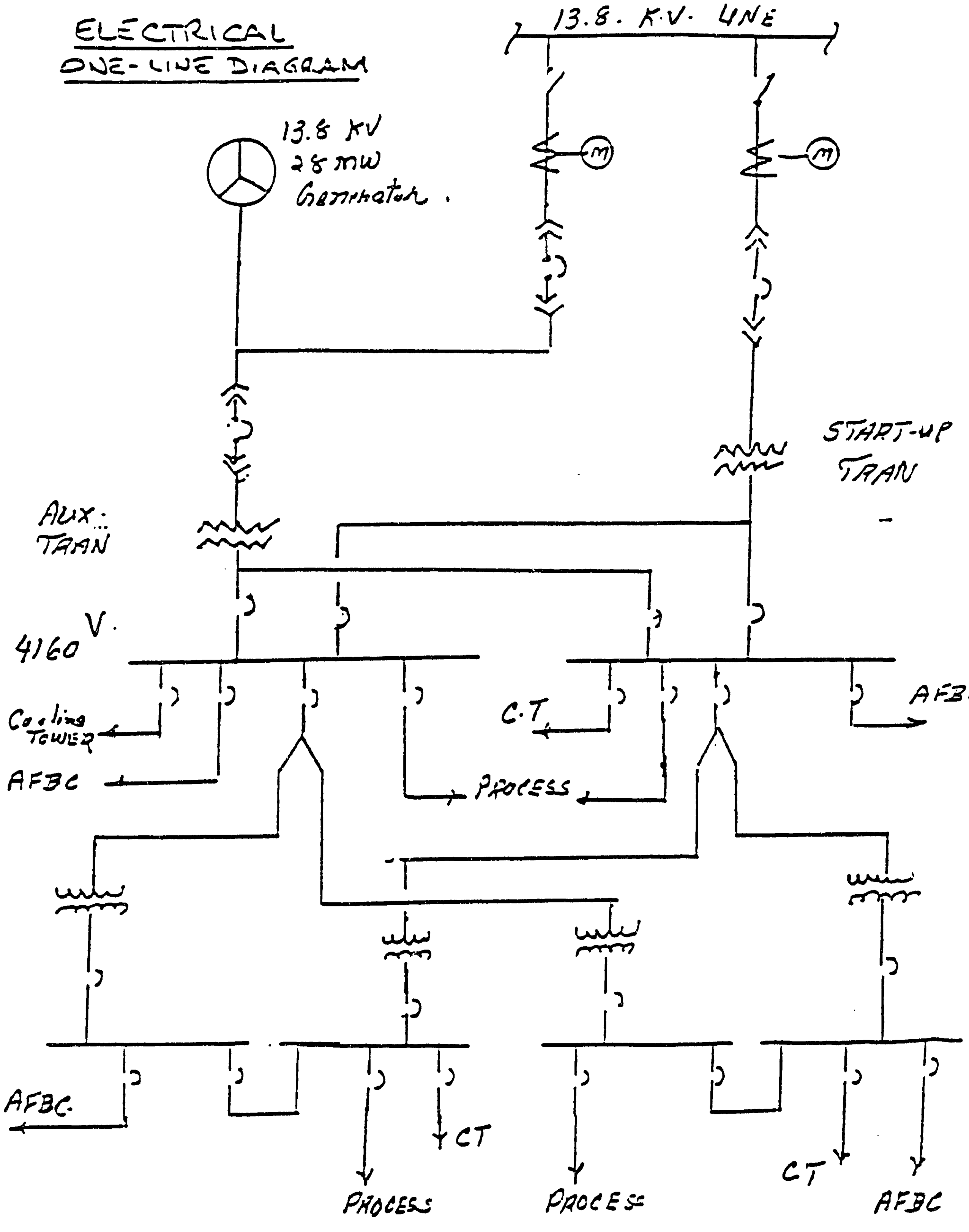

Figure 2. Electric power one-line distribution.

- Two 60% capacity mixed-bed units.
- One full-capacity demineralized water storage tank.

The treatment system is sized to provide 200% of the feed water makeup flow required for the boiler.

4.9.3 Cooling Brine

A 50/50 mixture of ethylene glycol and water in the closed-loop system is pumped through the shell side of the auxiliary cooling water heat exchangers for heat rejection to the circulating water; the cooled media of 50/50 mixture of glycol and water is circulated to the various equipment and returned to the heat exchanger. Two 100% capacity cooling media pumps are provided.

4.9.4 Fire Water

A fire loop is provided to supply fire protection water to fire hydrants, hose stations, and fixed automatic water suppression systems.

The fire protection water supply is provided by means of an electric motor-driven fire pump and a backup diesel engine-driven fire pump. The system will be continuously pressurized by one partial-capacity jockey pump. The pumps shall take suction from a single, above-ground, 5000-barrel raw water tank. In the event the jockey pump cannot maintain the system pressure, the main fire pumps will start sequentially.

4.10 Other Utility Systems

4.10.1 Instrument/Plant Air

Instrument and plant air are provided by a single air compressor/dryer system. Filtered air is compressed to 150 psig, then cooled and dried. Both instrument and plant air are dried to a dew point of -40°F (40°C) in order to prevent condensation and icing during cold weather. The dryer is a desiccant type with prefilters and afterfilters. Separate receiver for instrument air and plant air maintains system supply pressures during compressor cycling. Combined air capacity is 1000 scfm; the compressor is fully spared.

4.10.2 Fuel Gas Supply

The fuel gas system will supply the main boiler gas ignitors and warmup gas nozzles during start-up. The system will be sized to carry 25% of main boiler load.

4.10.3 Backup Power Supply

Backup power is supplied in the form of Uninterruptible Power Supplies (UPS) for the computer control, instruments, safety, and electrical control systems in the plant. Standby generators are used to supply power to critical circuits such as some of the blowers, vent fans, and condensate pumps. A diesel-driven pump is used to supply fire water in the event of electrical power failure.

4.11 Process Control System

4.11.1 Control Philosophy

A distributive control system (DCS) provides hierarchical control of the MG complex. All major operating unit programmed logic controllers (PLC) are connected to the DCS by a plant-wide data highway. The DCS is to use Iconics' Genesis™ software, or equivalent, as its operating system.

Instrument and control systems are designed with safety interlocks to ensure the safety of plant personnel and provide protection for plant equipment. Redundancy is provided as necessary for critical process measurements and safety features. Equipment with local and remote control capability are designed in a manner so that only one has control over the equipment at any given time. Equipment with local control systems are interfaced with the central control room for operation and status.

4.11.2 Control Room

The central control room houses the main system which primarily 1) controls alarm/shutdowns, and 2) monitors and provides supervisory data. It is also the engineering interface point. Each operating unit, generally contained within a physical unit structure, contains its own PLC system and has a local operator interface and monitoring station.

The control room is situated strategically so operators can keep a vigil on the surrounding equipment in operation and quickly attend to the critical systems in the event of an emergency. The control room is a controlled environment-type designed for human comfort and equipment protection. Typical equipment resident in the control room includes:

- Operator consoles with CRTs and keyboards for the operation of boiler, turbine/generator, and other auxiliary equipment.

- Printers.

- Auxiliary consoles containing CRTs to monitor support units and provide historical trending, production scheduling, and plant status updates.

5.0 PROCESS FLOW DIAGRAMS

5.1 General

The process flow diagrams (PFDs) illustrate the flow of process materials through the mild coal gasification facility as described in Section 4.0 Process Description and Philosophy. The PFDs show all major process equipment, process lines/conveyances, and key process control functions. Operating conditions are also indicated where necessary for process understanding. For many process systems, the relative vertical position of adjacent equipment is represented on the PFDs for increased comprehension of the operation, especially where flow is by gravity.

The following PFDs are contained in this section of the report:

PFD-001	Coal Receiving and Preparation
PFD-002	Carbonizer
PFD-003	Gas Quench and Recompression
PFD-004	Calciner
PFD-005	Coke Briquetting and Curing

In addition, the following utility flow diagrams are also contained in this section of the report:

UFD-011	Atmospheric Fluid-Bed Combustor
UFD-012	Boiler-Feed Water (BFW), Steam, Condensate, and Turbine Generator
UFD-013	Water Treatment, Cooling Water, and Brine System

6.0 MASS AND ENERGY BALANCE

6.1 General

The mass and energy balance contained in this section is a summary of the process simulation model (see Section 3.5 and Appendix B). The balance indicates total flow for both process trains, based on 330 operating days per year. Provided are stream-by-stream flow rates and operating conditions, as well as stream-average molecular weights, densities, heat contents, and component analyses. Total sulfur is also shown for each stream; sulfur characterization (e.g., organic, pyritic), however, is not indicated.

Stream numbers indicated in the mass and energy balance are keyed to stream numbers on the PFDs (see Section 5.0). For process comprehension, discrete stream numbers have been used whenever there is a change in stream composition (reaction) or a significant change in operating conditions or phase change.

6.2 Discussion

The simulation is based on empirical, practical, and experimental data provided by the EERC and AMAX (see Section 3.6). Much of the experimental data was derived from the EERC's pilot units and required scaleup to the 1000 tpd production level. Data received from these sources were supplemented by XBi in order to develop a complete balance for the MG plant. Among the assumptions and uncertainties associated with completing the mass and energy balance were:

- Mass and energy balances around the carbonizer and calciner are based on pilot test yield data. Elemental balances or thermodynamic balances have not been attempted within the scope of this study. These should be performed to provide at least some confirmation of the experimental data.

- Carbonizer pilot tests were run using direct combustion of natural gas to provide the heat for the devolatilization process. The commercial plant uses no auxiliary combustion in the carbonizer or calciner, but instead uses the combustion of off-gas in the in-line burners external to the carbonizer and calciner. Therefore, the coal/char will be exposed to a somewhat different devolatilizing environment. Although several pilot tests have shown that this change in environment has little effect on carbonizing/calcining, this may not be true in a large scale unit.

- Although reasonable sulfur contents are represented in the mass balance, sulfur and the transition of its forms through carbonizing and calcining were not included in the simulation. As a result, combustion gases and recycle gases represented in the balance generally have a higher sulfur content than that shown in the simulation output. The actual effect of this sulfur on carbonization or calcination is uncertain. This may be demonstrated by pilot tests using a lower-sulfur coal or coal which has been desulfurized.

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UND/EERC MILD COAL GASIFICATION PROJECT
1000 T/D COAL FEED – MATERIAL BALANCE

(Flows shown are total for both trains)

Stream No.		1	2	3	4	5	6	7	7A	8	9
Description	Units	Feed Coal	Reject Coal from Cleaning	Carbonizer Feed Coal	Conveying Gas to Carbonizer	Hot Gas to Carbonizer	Hot Gas from Carbonizer	Total Carbonizer Char	Cooled Carbonizer Char	Carbonizer Reject Char	Carbonizer Char to Calciner
Vapor Fraction		0	0	0.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000
Temperature	°F	60	60	60	600	2,480	1,101	1,101	200	200	200
Pressure	psia	14.7	14.7	14.7	21.9	21.9	16.4	14.7	14.7	14.7	14.7
Molar Flow	lb•mol/h			491.2	400.2	2,911.9	4,107.6	270.2	270.2	40.7	229.5
Mass Flow	lb/h	83,340	18,835	64,506	10,751	81,082	114,251	42,090	42,090	5,427	36,663
Enthalpy	MMBtu/h			6.45	3.40	73.48	59.07	22.93	7.66	1.03	6.63
Mole Weight				131.3	26.86	27.85	27.81	155.8	155.8	133.2	159.8
Density	lb/ft³	83.4		81.3	0.051	0.019	0.028	56.1	56.1	58.8	55.8
Component:											
Indiana Coal	lb/h	66,407	13,629	52,778	0	0	0	0	0	0	0
Ash	lb/h	10,099	3,661	6,438	0	0	0	6,438	6,438	1,466	4,972
Nitrogen	lb/h			0	6,182	54,730	60,913	0	0	0	0
Oxygen	lb/h			0	0	0	0	0	0	0	0
Carbon Monoxide	lb/h			0	118	137	1,356	0	0	0	0
Carbon Dioxide	lb/h			0	1,518	13,437	14,954	0	0	0	0
Methane	lb/h			0	139	162	1,605	0	0	0	0
Ethane	lb/h			0	30	35	342	0	0	0	0
Ethylene	lb/h			0	7	8	83	0	0	0	0
Propane	lb/h			0	338	393	3,889	0	0	0	0
Propene	lb/h			0	8	10	95	0	0	0	0
Hydrogen Sulfide	lb/h			0	132	153	1,516	0	0	0	0
Sulfur Dioxide	lb/h			0	117	1,033	1,150	0	0	0	0
Water	lb/h	6,834	1,545	5,290	1,667	10,406	17,363	0	0	0	0
Hydrogen	lb/h			0	44	51	509	0	0	0	0
Oil	lb/h			0	452	526	10,478	0	0	0	0
Carbonizer Char	lb/h			0	0	0	0	35,652	35,652	3,961	31,691
Calciner Char	lb/h			0	0	0	0	0	0	0	0
Total Sulfur	lb/h	3,500	986	2,514				1,011	1,011	241	770

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UND/EERC MILD COAL GASIFICATION PROJECT
1000 T/D COAL FEED – MATERIAL BALANCE
(Flows shown are total for both trains)

01-Apr-92

Stream No.		10	11	12	13	13A	14	14A	15	16	17
Description	Units	Conveying Gas to Calciner	Hot Gas to Calciner	Hot Gas from Calciner	Bed Calcinate	Cooled Bed Calcinate	Calciner Cyclone Char Fines	Cooled Calc. Cyclone Char Fines	Calcinate Fines Product	Calciner Reject Char	Calciner Off-gas to AFBC
Vapor Fraction		1.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
Temperature	°F	1,150	2,394	1,800	1,800	200	1,800	200	200	200	1,800
Pressure	psia	33.7	33.7	28.2	14.7	14.7	14.7	14.7	14.7	14.7	28.2
Molar Flow	lb•mol/h	191.6	3,407.0	3,851.1	584.9	584.9	146.1	146.1	132.4	13.8	2,584.8
Mass Flow	lb/h	5,238	94,762	105,288	25,100	25,100	6,272	6,272	5,614	657	70,669
Enthalpy	MMBtu/h	2.41	81.59	71.53	23.03	4.49	5.75	1.12	0.99	0.13	48.01
Mole Weight		27.34	27.81	27.34	42.9	42.9	42.9	42.9	42.4	47.7	27.34
Density	lb/ft³	0.052	0.031	0.033	56.2	56.2	56.2	56.2	55.7	61.5	0.033
Component:											
Indiana Coal	lb/h	0	0	0	0	0	0	0	0	0	0
Ash	lb/h	0	0	0	3,978	3,978	994	994	745	248	0
Nitrogen	lb/h	3,360	64,170	67,529	0	0	0	0	0	0	45,325
Oxygen	lb/h	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	lb/h	44	244	876	0	0	0	0	0	0	588
Carbon Dioxide	lb/h	1,036	16,940	20,827	0	0	0	0	0	0	13,979
Methane	lb/h	44	244	876	0	0	0	0	0	0	588
Ethane	lb/h	1	8	27	0	0	0	0	0	0	18
Ethylene	lb/h	0	2	7	0	0	0	0	0	0	4
Propane	lb/h	15	86	308	0	0	0	0	0	0	207
Propene	lb/h	0	2	7	0	0	0	0	0	0	5
Hydrogen Sulfide	lb/h	19	109	391	0	0	0	0	0	0	263
Sulfur Dioxide	lb/h	63	1,211	1,275	0	0	0	0	0	0	855
Water	lb/h	638	11,648	12,815	0	0	0	0	0	0	8,601
Hydrogen	lb/h	13	73	262	0	0	0	0	0	0	176
Oil	lb/h	4	24	87	0	0	0	0	0	0	59
Carbonizer Char	lb/h	0	0	0	0	0	0	0	0	0	0
Calciner Char	lb/h	0	0	0	21,122	21,122	5,278	5,278	4,869	409	0
Total Sulfur	lb/h				402	402	119	119	90	29	735

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UND/EERC MILD COAL GASIFICATION PROJECT
1000 T/D COAL FEED – MATERIAL BALANCE

01-Apr-92

(Flows shown are total for both trains)

Stream No.		18	18A	18B	18C	18D	19	19A	20	21	22
Description	Units	LP Calciner Recycle Gas	LP Calciner Recycle Gas ex. H-403	LP Calciner Recycle Gas ex. H-404	HP Calciner Recycle Gas ex. K-406	HP Calciner Recycle Gas ex. H-403	Quench Tower Bottoms	Cooled Quench Tower Btms	Recovered Oil	Quench Tower O/H Gas	Conveying Recycle Gas to Carbonizer
Vapor Fraction		1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	1.000	1.000
Temperature	°F	1,800	1,210	375	503	1,150	357	170	170	191	305
Pressure	psia	28.2	25.7	23.2	35.7	33.7	16.4	40.0	14.7	16.2	24.9
Molar Flow	lb-mol/h	1,266.3	1,266.3	1,266.3	1,266.3	1,266.3	1,933.2	1,933.2	27.8	4,079.9	346.8
Mass Flow	lb/h	34,619	34,619	34,619	34,619	34,619	367,136	367,136	5,278	108,975	9,263
Enthalpy	MMBtu/h	23.52	16.63	7.79	9.07	15.96	32.77	(6.14	(0.09	20.25	2.06
Mole Weight		27.34	27.34	27.34	27.34	27.34	189.9	189.9	189.9	26.71	26.71
Density	lb/ft³	0.033	0.038	0.071	0.096	0.052	44.0	48.9	48.9	0.061	0.080
Component:											
Indiana Coal	lb/h	0	0	0	0	0	0	0	0	0	0
Ash	lb/h	0	0	0	0	0	0	0	0	0	0
Nitrogen	lb/h	22,204	22,204	22,204	22,204	22,204	43	43	1	60,912	5,178
Oxygen	lb/h	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	lb/h	288	288	288	288	288	1	1	0	1,356	115
Carbon Dioxide	lb/h	6,848	6,848	6,848	6,848	6,848	30	30	0	14,954	1,271
Methane	lb/h	288	288	288	288	288	2	2	0	1,605	136
Ethane	lb/h	9	9	9	9	9	1	1	0	342	29
Ethylene	lb/h	2	2	2	2	2	0	0	0	83	7
Propane	lb/h	101	101	101	101	101	23	23	0	3,889	331
Propene	lb/h	2	2	2	2	2	1	1	0	95	8
Hydrogen Sulfide	lb/h	129	129	129	129	129	6	6	0	1,516	129
Sulfur Dioxide	lb/h	419	419	419	419	419	9	9	0	1,150	98
Water	lb/h	4,213	4,213	4,213	4,213	4,213	40	40	1	17,362	1,476
Hydrogen	lb/h	86	86	86	86	86	0	0	0	509	43
Oil	lb/h	29	29	29	29	29	366,980	366,980	5,276	5,205	442
Carbonizer Char	lb/h	0	0	0	0	0	0	0	0	0	0
Calciner Char	lb/h	0	0	0	0	0	0	0	0	0	0
Total Sulfur	lb/h								192		

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UND/EERC MILD COAL GASIFICATION PROJECT
1000 T/D COAL FEED – MATERIAL BALANCE
(Flows shown are total for both trains)

Stream No.		23	24	25	26	27	28	29	22A	25A	
Description	Units	Compr. Gas to Carbonizer Burner	Compr. Air to Carbonizer Burner	Carbonizer Burner Effluent	Carbonizer Off-gas to AFBC	Compr. Gas to Calciner Burner	Compr. Air to Calciner Burner	Hot Makeup Gas to Calciner	Carbonizer Burner Bypass	Recycled Hot Gas to Carbonizer	
Vapor Fraction		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
Temperature	°F	305	172	2,887	402	402	273	2,968	305	2,480	
Pressure	psia	24.9	24.9	21.9	37.7	37.7	37.7	33.7	24.9	21.9	
Molar Flow	lb•mol/h	952.3	1,591.5	2,545.2	1,487.9	872.7	1,458.4	2,332.3	420.1	2,965.3	
Mass Flow	lb/h	25,437	45,911	71,348	39,743	23,310	42,071	65,381	11,222	82,570	
Enthalpy	MMBtu/h	5.65	6.98	72.33	10.08	5.91	7.42	68.05	2.49	74.83	
Mole Weight		26.71	28.85	28.03	26.71	26.71	28.85	28.03	26.71	27.85	
Density	lb/ft³	0.080	0.107	0.017	0.110	0.110	0.138	0.025	0.080	0.019	
Component:											
Indiana Coal	lb/h	0	0	0	0	0	0	0	0	0	
Ash	lb/h	0	0	0	0	0	0	0	0	0	
Nitrogen	lb/h	14,218	35,244	49,462	22,214	13,029	32,296	45,325	6,273	55,735	
Oxygen	lb/h	0	10,667	0	0	0	9,775	0	0	0	
Carbon Monoxide	lb/h	316	0	0	494	290	0	0	140	140	
Carbon Dioxide	lb/h	3,491	0	12,144	5,454	3,199	0	11,128	1,540	13,683	
Methane	lb/h	375	0	0	585	343	0	0	165	165	
Ethane	lb/h	80	0	0	125	73	0	0	35	35	
Ethylene	lb/h	19	0	0	30	18	0	0	8	8	
Propane	lb/h	908	0	0	1,418	832	0	0	400	400	
Propene	lb/h	22	0	0	35	20	0	0	10	10	
Hydrogen Sulfide	lb/h	354	0	0	553	324	0	0	156	156	
Sulfur Dioxide	lb/h	268	0	934	419	246	0	855	118	1,052	
Water	lb/h	4,053	0	8,809	6,332	3,714	0	8,072	1,788	10,597	
Hydrogen	lb/h	119	0	0	185	109	0	0	52	52	
Oil	lb/h	1,215	0	0	1,898	1,113	0	0	536	536	
Carbonizer Char	lb/h	0	0	0	0	0	0	0	0	0	
Calciner Char	lb/h	0	0	0	0	0	0	0	0	0	
Total Sulfur	lb/h				826						

7.0 FACILITY PLAN AND LAYOUT

7.1 General

A preliminary facility layout was developed in order to establish a general physical perception of the operating plant and its auxiliaries and to approximate the size of the overall plot space required. The following drawings are included in this section:

- Figure 3. Plot plan, showing approximate plot projections of structure and stand-alone equipment, with relative distances and proximities.

- Figure 4. Conceptual 3-D layout, indicating functional "blocks" and major interconnecting conveyances within the facility.

It should be noted that these are conceptual arrangements only. These drawings do not represent exact dimensional requirements, nor has the arrangement shown been optimized. The following are approximate sizes of facility structures and buildings which house specific plant operations:

Coal Crushers, Feed Bins	50' x 50' x 60'
Coal Dryers, Screeners, etc.	100' x 75' x 125'
Carbonizers	100' x 50' x 100'
Char Screeners, Mag Separators, etc.	60' x 60' x 70'
Calciners, Coolers, etc.	100' x 50' x 60'
Formcoke	125' x 75' x 50'
Control Room, Lab	80' x 40' x 20'
Compressor Building	100' x 50' x 30'
AFBC, Generators	75' x 50' x 110'
Maintenance Shop	60' x 40' x 40'

Principal plant administration, maintenance, and warehousing functions required for the MG plant are to be added to, and integrated with, corresponding facilities of the existing Chinook mine operation.[18] A small local maintenance shop is shown, but no other physical representation for the remainder of these functions is included in the layout.

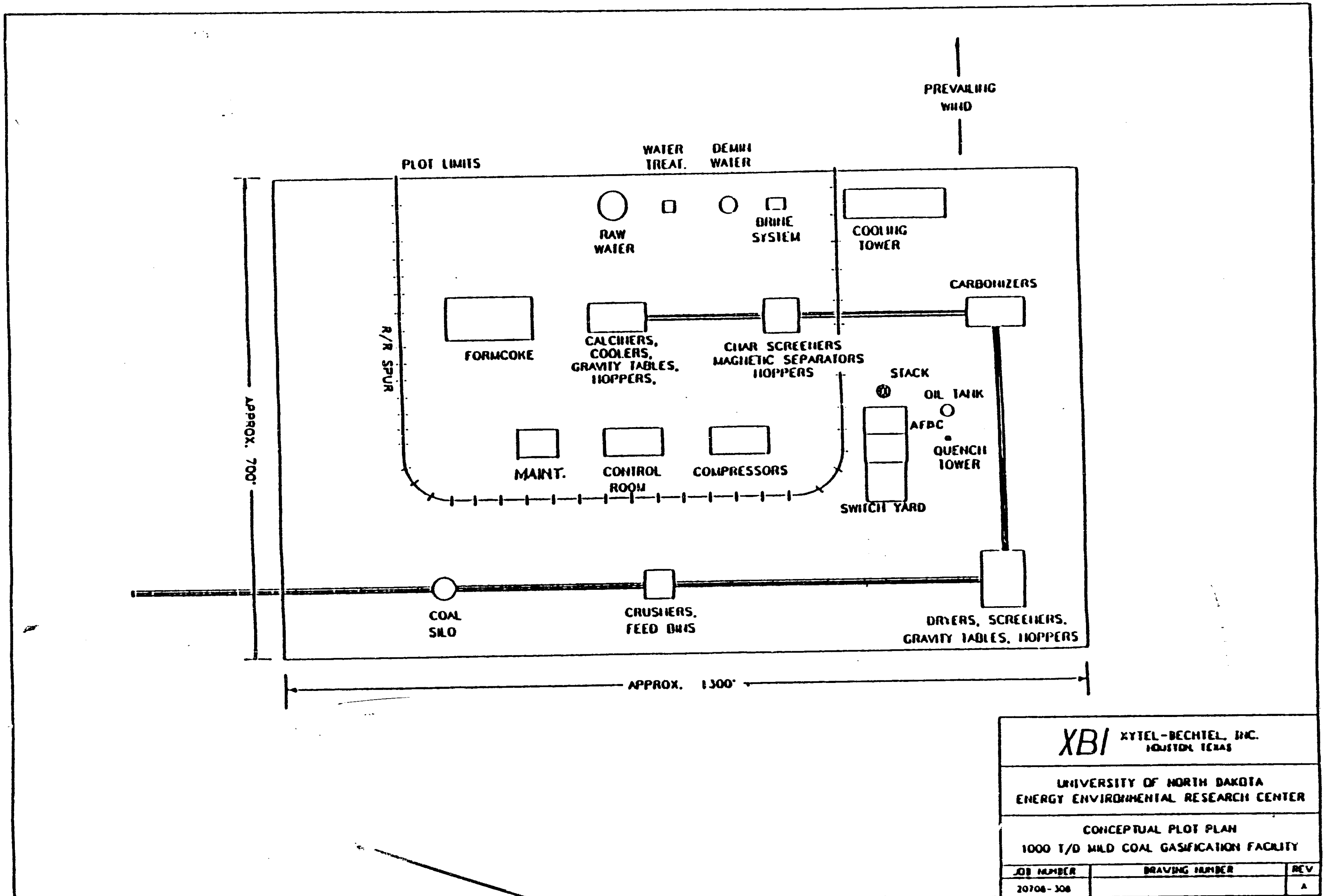

Figure 3. Plot plan, showing approximate plot projections or structure and stand-alone equipment, with relative distances and proximities.

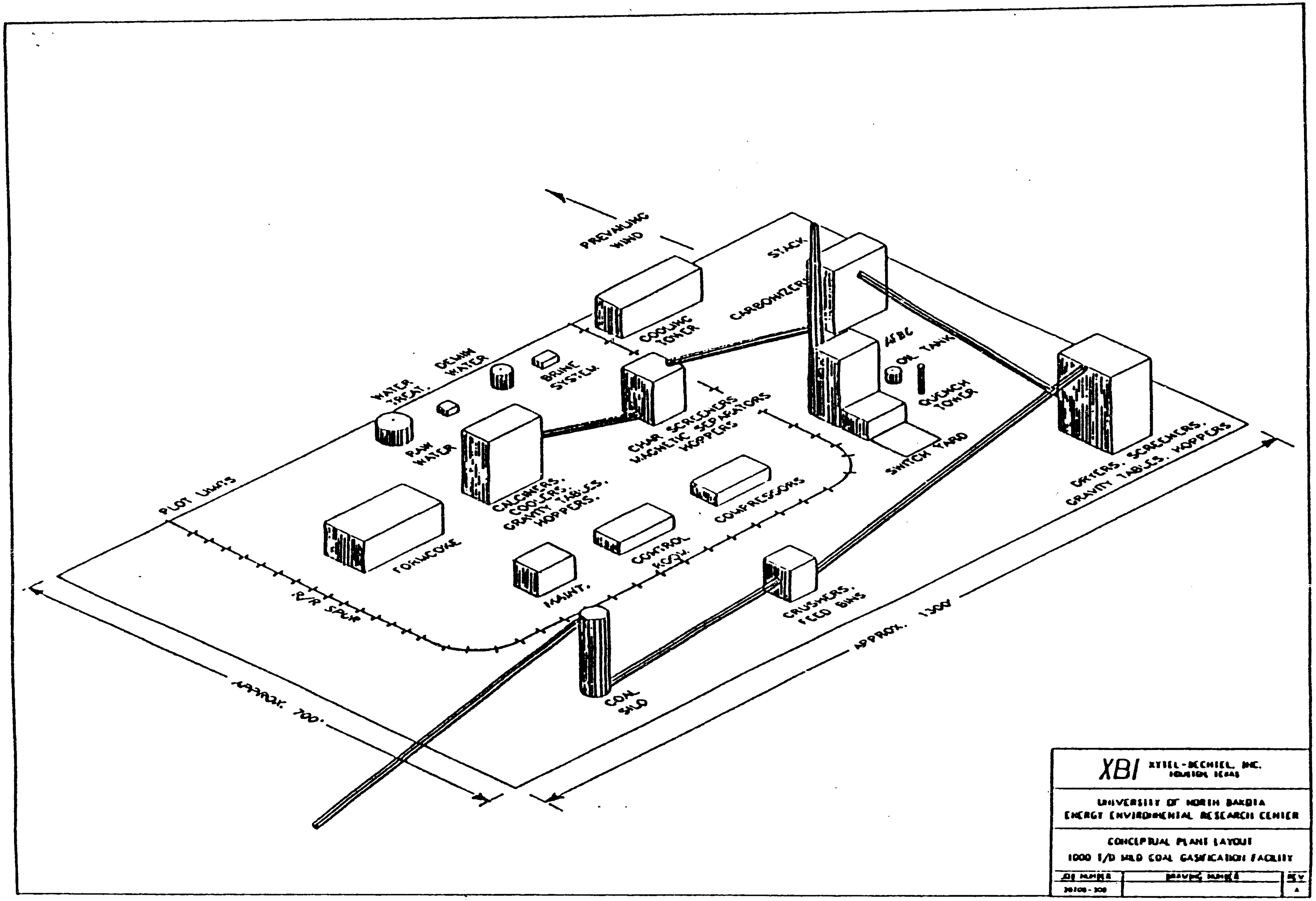

Figure 4. Conceptual 3-D layout, indicating functional "blocks" and major interconnecting conveyances within the facility.

8.0 TECHNICAL EQUIPMENT LIST

8.1 General

The equipment list included in this section of the report provides a description for each item of process and support equipment required in the operation of the MG facility. As a minimum, the level of detail of equipment descriptions is adequate as input to a plant budget estimate. In many cases, especially for relatively expensive and/or "nontypical" items, manufacturer names and model numbers are included. As added support for the selections of these types of equipment, confirmations of suitability to specific service and written price quotations were requested from appropriate suppliers.

While the equipment list provides data for all process and utility equipment, it should be noted that the following is not included:

- Buildings and structures.
- Laboratory facilities.
- Stationary maintenance equipment such as hoists and monorails or mobile equipment such as forklifts, cranes, etc.
- Stationary safety/fire equipment (other than primary fire water supply) and mobile safety/emergency equipment.

The instrument list is contained in Appendix C.

Client: UND/EERC Unit: 1,000 T/D MILD COAL GASIFICATION
Location: CLAY COUNTY, INDIANA

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A	07-Apr-92	CLIENT APPROVAL/BUDGET ESTIMATE			

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FIRED EQUIPMENT

Item No.	Name	Fuel Type / Duty MMBtu/h	OA Dimensions	Op. Press / Des. Press. psig	Op. Temp. / Des. Temp. °F	Materials: Housing	Materials: Elements	Wt lb	Mfr. Model No.	Req. No. P&I No.	Remarks
B-501A/B	CARBONIZER RECYCLE GAS BURNER	Off-gas 35.8		10	2,800	Steel				PFD-003	Incl. 20% design margin Refractory lined
B-502A/B	CALCINER MAKEUP GAS BURNER	Off-gas 32.8		23	2,800	Steel				PFD-003	Incl. 20% design margin Refractory lined
B-602A/B	BRIQUET KILN	Natural gas			1,500	Steel				PFD-005	Refractory lined

NOTES:

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CLASSIFIERS, VIBRATING SCREENS

Item No.	Name	Screen Area, ft² / Mesh	Housing LxW, ft-in / H, in	Op'g Temp. °F	Materials: Housing	Materials: Liner	Materials: Screen	Motor HP / rpm	Wt lb	Mfr. / Model No.	Req. No. / P&I No.	Remarks
C-102A/B	COAL SCREENER	10 & 24*		250	CS		SS	10			PFD-001	30 t/h capacity, ea. * Double deck
C-307A/B	CARBONIZER CHAR SCREENER	20 & 40*		250	CS		SS	10			PFD-002	15 t/h capacity, ea. * Double deck
C-603A/B	BRIQUET SCREENER			200	CS		SS	10			PFD-005	

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BELT CONVEYORS

Item No.	Name	Capacity t/h	Width, in / OAL, ft	Lift, ft	Lin. Vel. fpm	Max. Op. Temp., °F	Materials Housing	Materials Belt	Motor HP/rpm	Wt lb	Conveyor Mfr.	Req. No. / P&I No.	Remarks
F-101	COAL RECEIVING CONVEYOR	250	24 / 500	125	500				75			PFD-001	Bulk density: 83.4 lb/ft³
F-102A/B	FEED TRANSFER CONVEYOR	50	30 / 10	0	100				7.5			PFD-001	Bulk density: 83.4 lb/ft³
F-103A/B	CRUSHER FEED BIN CONVEYOR	50	24 / 300	75	200				15			PFD-001	Bulk density: 83.4 lb/ft³
F-104A/B	CRUSHER FEED CONVEYOR	50	30 / 10	0	100				7.5			PFD-001	Bulk density: 83.4 lb/ft³
F-105A/B	DRYER FEED CONVEYOR	50	24 / 500	125	200				20			PFD-001	Bulk density: 83.4 lb/ft³
F-106A/B	CARBONIZER FEED CONVEYOR	50	24 / 200	50	200				15			PFD-001	Bulk density: 83.4 lb/ft³
F-107A/B	AFBC FRESH COAL CONVEYOR	15							15			PFD-001	Bulk density: 83.4 lb/ft³
F-301A/B	CARBONIZER CHAR CONVEYOR	50	24 / 300	75	200				15			PFD-002	Bulk density: 53 lb/ft³
F-302A/B	CALCINER FEED CONVEYOR	50	24 / 200	50	200				15			PFD-002	Bulk density: 53 lb/ft³
F-601A/B	GREEN BRIQUET CONVEYOR	20	24						10			PFD-005	Bulk density: 55 lb/ft³
F-603A/B	CURED BRIQUET CONVEYOR	20	24						10			PFD-005	Bulk density: 55 lb/ft³
F-605A/B	FORMCOKE PRODUCT CONVEYOR	20	24	75	100				10			PFD-005	Bulk density: 55 lb/ft³
F-606A/B	FORMCOKE COOLING CONVEYOR	20	24						10			PFD-005	Bulk density: 55 lb/ft³

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BUCKET ELEVATORS

Item No.	Name	Capacity ft³/h	Elevator LxW, in H, ft	Bucket LxW, in H, in	Linear Velocity fps	Op. Temp. °F	Materials Housing	Materials Buckets	Wt lb	Mfr. Model No.	Req. No. P&I No.	Remarks
F-602A/B	GREEN BRIQUET RECYCLE ELEVATOR										PFD-005	Bulk density: 55 lb/ft³, 7 t/h
F-604A/B	KILN FEED ELEVATOR										PFD-005	Bulk density: 55 lb/ft³, 7 t/h

NOTES:

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DUST COLLECTORS, BAGHOUSES

Item No.	Name	Retention Area, ft² Part. Size	Elements No.	Elements D/L, in	Housing Diameter, in OAL, ft	Op. Press Des. Press. psig	Op. Temp. Des. Temp. °F	Materials Housing	Materials Elements	Wt lb	Mfr. Model No.	Req. No. P&I No.	Remarks
G-101	COAL SILO BAGHOUSE	113 10 µ			30 11.6	Atm ±17in. WG	100 150	CS	Felted Polyester	850	Mikropul 12-8-160	PFD-001	Notes 1, 2 For Blower, see K-101
G-102	CRUSHER FEED BIN BAGHOUSE	113 10 µ			30 11.6	Atm ±17in. WG	100 150	CS	Felted Polyester	850	Mikropul 12-8-160	PFD-001	Notes 1, 2 For Blower, see K-102
G-103A/B	COAL DRYER BAGHOUSE	7,540 10 µ			30.5'Lx10.5'W 23	Atm ±17in. WG	250 300	CS	Felted Nomex	35,000	Mikropul 640K-10	PFD-001	Notes 1, 2 For Blower, see K-107A/B
G-301A/B	CARBONIZER BAGHOUSE	113 10 µ			30 11.6	Atm ±17in. WG	200 300	CS	Felted Nomex	850	Mikropul 12-8-160	PFD-002	Notes 1, 2 For Blower, see K-301A/B
G-401A/B	CALCINER BAGHOUSE	113 10 µ			30 11.6	Atm ±17in. WG	200 300	CS	Felted Nomex	850	Mikropul 12-8-160	PFD-004	Notes 1, 2 For Blower, see K-401A/B
G-601A/B	FORMCOKE FINES BAGHOUSE	113 10 µ			30 11.6	Atm ±17in. WG	100 150	CS	Felted Nomex	850	Mikropul 12-8-160	PFD-005	Notes 1, 2 For Blower, see K-601A/B
G-602A/B	BRIQUET FEED BAGHOUSE	113 10 µ			30 11.6	Atm ±17in. WG	100 150	CS	Felted Nomex	850	Mikropul 12-8-160	PFD-005	Notes 1, 2 For Blower, see K-602A/B

NOTES:
1. Pulse-jet type, complete with air header and timer/controller, exhaust blower.
2. Equip with Fike or Fenwall explosion suppression system.

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HEAT EXCHANGERS

Item No.	Name	TEMA Type Size	Design Duty MMBtu/h	Transfer Surface ft²	Tubes OD, in Pitch, in	Shellside/Tubeside DP psi	Shellside/Tubeside DT °F	Shellside/Tubeside Material	Shellside/Tubeside CA in	Total Wt lb	Mfr. Model No.	Req. No. P&I No.	Remarks
H-403A/B	CALCINER GAS HEAT EXCHANGER		4.13	610 (finned)		35 35	1300 2000		none none			PFD-004	20% design margin
H-404A/B	CALCINER GAS COOLER		5.3	650 (finned)		35 100	1400 250	CS	none 1/8			PFD-004	20% design margin
H-501A/B	OIL COOLER		25.3	5,900		50	250	304SS	none			PFD-003	30% design margin
H-903	HP BOILER FEEDWATER HEATER		30			500 1500	750 500					UFD-012	
H-905	MAIN SURFACE CONDENSER		250	30,000		15 15	120 120	CS 304SS	3/8 none			UFD-012	
H-906	BRINE COOLER	Plate	137.4	13,900		100	250	304SS plates	none none	30,000	Alfa-Laval M30-FG	UFD-013	10% design margin Requires two parallel units

NOTES:

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COMPRESSORS, BLOWERS, FANS

Item No.	Name	Cap'y SCFM ICFM	ΔP psi	Rotor Dia., in rpm	Material Case Rotor	Driver Type	Driver HP rpm	Total Wt. lb	Seal Type Material	Compr./Blwr. Mfr. Model No.	Coupling Mfr. Model No.	Req. No. P&I No.	Remarks
K-101	BLOWER FOR BAGHOUSE G-101	600	18"SP		CS		3			Robinson 12MH		PFD-001	Vendor package with G-101
K-102	BLOWER FOR BAGHOUSE G-102	600	18"SP		CS		3			Robinson 12MH		PFD-001	Vendor package with G-102
K-103A/B	AIR BLOWER FOR GRAVITY TABLE C-103A/B	7,000					20					PFD-001	Vendor package with C-103
K-104A/B	AIR BLOWER FOR GRAVITY TABLE C-104A/B	7,000					20					PFD-001	Vendor package with C-104
K-105A/B	AIR BLOWER FOR GRAVITY TABLE C-105A/B	12,000					30					PFD-001	Vendor package with C-105
K-106A/B	REJECT COAL BLOWER	410	6.5				20					PFD-001	Solid: 18,835 lb/h @ 84 lb/ft³ 30% design margin
K-107A/B	BLOWER FOR BAGHOUSE G-103A/B	42,000	10"SP		CS		125			Robinson		PFD-001	Vendor package with G-103
K-301A/B	BLOWER FOR BAGHOUSE G-301A/B	600	10"SP		CS		3			Robinson		PFD-002	Vendor package with G-301
K-302A/B	CARBONIZER REJECT CHAR BLOWER	175	5.5				10					PFD-002	Solid: 5,427 lb/h @ 58.8 lb/ft³ 30% design margin
K-401A/B	BLOWER FOR BAGHOUSE G-401A/B	600	10"SP		CS		3			Robinson		PFD-004	Vendor package with G-401
K-402A/B	CALCINATE PRODUCT BLOWER	620	6				25					PFD-004	Solid: 25,100 lb/h @ 56.2 lb/ft³ 30% design margin
K-403A/B	REJECT CALCINATE BLOWER	30	7				1.5					PFD-004	Solid: 657 lb/h @ 61.5 lb/ft³ 30% design margin
K-404A/B	CALCINATE FINES PRODUCT BLOWER	170	5.5				7.5					PFD-004	Solid: 5,614 lb/h @ 55.7 lb/ft³ 30% design margin
K-405A/B	AIR BLOWER FOR GRAVITY TABLE C-405A/B	5,000					15					PFD-004	Vendor package with C-405
K-406A/B	CALCINER RECYCLE GAS COMPRESSOR	4,870	12.5				300 bhp					PFD-004	Steam turbine driven 20% design margin

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COMPRESSORS, BLOWERS, FANS

Item No.	Name	Cap'y SCFM ICFM	ΔP psi	Rotor Dia., in rpm	Material Case Rotor	Driver Type	Driver HP rpm	Total Wt. lb	Seal Type Material	Compr./Blwr. Mf. Model No.	Coupling Mf. Model No.	Req. No. P&I No.	Remarks
K-501A/B	CARBONIZER GAS COMPRESSOR	17,810	23				1455 bhp					PFD-003	Steam turbine driven 10% design margin
K-502A/B	CARBONIZER BURNER AIR COMPRESSOR	6,120	10.2				295 bhp					PFD-003	Steam turbine driven 20% design margin
K-503A/B	CALCINER BURNER AIR COMPRESSOR	5,610	23				510 bhp					PFD-003	Steam turbine driven 20% design margin
K-504 -1,2	OIL TANK OFF-GAS COMPRESSOR & SPARE	2.4	14				0.5					PFD-003	30% design margin
K-601A/B	BLOWER FOR BAGHOUSE G-601A/B	600	18"SP				3					PFD-005	Vendor package; see G-601
K-602A/B	BLOWER FOR BAGHOUSE G-602A/B	600	18"SP				3					PFD-005	Vendor package; see G-602
K-603A/B	FORMCOKE FINES BLOWER	30	5				1.5					PFD-005	
K-604A/B	FORMCOKE COOLING AIR BLOWER						7.5					PFD-005	
k-605A/B	CURING OVEN EXHAUST BLOWER						7.5					PFD-005	

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CENTRIFUGAL PUMPS

Item No.	Name	Rated Cap'y gpm	TDH, ft ΔP, psi	Impeller Dia., in Act./Max.	Rated Pump rpm	Material Case Impeller	Seal Type Material	Motor HP rpm	Baseplate L/W in	Total Wt lb	Pump Mfr. Model No.	Coupling Mfr. Model No.	Req. No. P&I No.	Remarks
P-401A/B	V-401A/B SUCTION DRUM PUMP	10	23			CI CS		0.5 1800					PFD-004	
P-501A/B -1,2	QUENCH TOWER CIRCULAT. PUMP & SPARE	680	29			CI CS		25 1800					PFD-003	Viking type, thermal jacket 30% design margin
P-503 -1,2	OIL TRANSFER PUMP & SPARE	40	30			CI CS		1.5 1800					PFD-003	Viking type, thermal jacket 30% design margin
P-505A/B	V-501A/B SUCTION DRUM PUMP	10	22			CI CS		0.5 1800					PFD-003	
P-901	MAIN BOILER FEED WATER PUMP	560	1500			CI 316SS		N/A					UFD-012	Multistage Steam turbine drive
P-902	STARTUP BOILER FEED WATER PUMP	220	1500			CI 316SS		900 3600					UFD-012	Multistage
P-903 -1,2	CONDENSATE RECYCLE PUMP & SPARE	560	50			CI 316SS		50 3600					UFD-012	Canned pump 100% spare
P-904	FLASH TANK WATER PUMP	10	30			CI CS		5 1800					UFD-012	
P-905 -1,2,3	COOLING WATER PUMPS & SPARE	35,000	30			CI CS		1000 600					UFD-013	Vertical Three 50% pumps
P-906 -1,2,3	BRINE PUMPS & SPARE	3,500	35			CI CS		150 1800					UFD-013	Three 50% pumps
P-907 -1,2	RAW WATER PUMP & SPARE	3,500	35			CI CS		150 1800					UFD-013	Vertical well pump
P-908 -1,2	WATER TREATMENT FEED PUMP & SPARE	50	80			CI CS		5 3600					UFD-013	

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CENTRIFUGAL PUMPS

Item No.	Name	Rated Cap'y gpm	TDH, ft ΔP, psi	Impeller Dia., in Act./Max.	Rated Pump rpm	Material Case Impeller	Seal Type Material	Motor HP rpm	Baseplate L/W in	Total Wt lb	Pump Mfr. Model No.	Coupling Mfr. Model No.	Req. No. P&I No.	Remarks
P-909-1	FIRE WATER PUMP	1,000	50			CI CS		40 3600					UFD-013	
P-909-2	BACKUP FIRE WATER PUMP	1,000	50			CI CS		N/A					UFD-013	Diesel engine drive
P-910	FIRE WATER JOCKEY PUMP	100	50			CI CS		5 3600					UFD-013	
P-911 -1,2	BOILER MAKEUP PUMP & SPARE	50	60			CI 316SS		5 3600					UFD-013	

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POSITIVE DISPLACEMENT PUMPS

Item No.	Name	Type	Rated Cap'y gpm	ΔP psi	Strokes per min.	Material Case Internals	Seal Type Material	Motor HP rpm	Baseplate L/W in	Total Wt lb	Pump Mfr. Model No.	Coupling Mfr. Model No.	Req. No. P&I No.	Remarks
P-601A/B	BINDER FEED PUMP	Metering				CI CS							PFD-005	

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STORAGE TANKS (ATMOSPHERIC, API), BINS & SILOS

Item No.	Name	Type	Wkg Vol ft³	Diameter Height	Des. Press. Positive Vacuum	Op. Temp. Des. Temp. °F	Materials Vessel	Materials CA in	Materials Lining	Total Wt lb	Fabricator Shop/Field?	Req. No. P&I No.	Remarks
T-101	COAL SILO		80,000	40' 100' OAH			CS					PFD-001	48h capacity
T-102	CRUSHER FEED BIN		4,675	20' Sq 25' OAH			CS					PFD-001	
T-103A/B	REJECT COAL HOPPER		2,700	11'-0" 29'-0"			CS					PFD-001	24h capacity
T-104A/B	COAL SURGE HOPPER		780	9'-0" 13'-0"			CS					PFD-001	2h capacity
T-301A/B	CARBONIZER FEED HOPPER		780	9'-0" 13'-0"			CS					PFD-002	2h capacity
T-302A/B	CARBONIZER SCREENER FEED HOPPER		750	9'-0" 12'-0"			CS					PFD-002	2h capacity
T-303A/B	CARBONIZER REJECT CHAR HOPPER		1,100	10'-0" 15'-0"			CS					PFD-002	24h capacity
T-304A/B	CARBONIZER CHAR SURGE HOPPER		660	9'-0" 11'-0"			CS					PFD-002	2h capacity
T-401A/B	CALCINER FEED HOPPER		660	9'-0" 11'-0"			CS					PFD-004	2h capacity
T-402A/B	CALCINATE PRODUCT STORAGE HOPPER		11,000	24'-0" 25'-0"			CS					PFD-004	48h capacity
T-403A/B	CALCINATE REJECT HOPPER		260	6'-0" 10'-0"			CS					PFD-004	24h capacity
T-404A/B	CALCINATE FINES PRODUCT HOPPER		2,400	12'-0" 22'-0"			CS					PFD-004	48h capacity

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STORAGE TANKS (ATMOSPHERIC, API), BINS & SILOS

Item No.	Name	Type	Wkg Vol ft³	Diameter / Height	Des. Press. Positive / Vacuum	Op. Temp. / Des. Temp. °F	Materials: Vessel	Materials: CA in	Materials: Lining	Total Wt lb	Fabricator Shop/Field?	Req. No. / P&I No.	Remarks
T-501	OIL STORAGE TANK	API 12D	1,000 bbl	21'-6" / 16'-0"	8 oz/in² / ½ oz/in²		CS	1/8	---			PFD-003	48h capacity
T-601A/B	BRIQUETTING FEED HOPPER		410	7'-6" / 11'-0"			CS					PFD-005	2h capacity
T-602A/B	BRIQUETTING FINES FEED HOPPER		90	4'-6" / 8'-6"			CS					PFD-005	2h capacity
T-603A/B	BINDER FEED TANK		20 bbl	4'-6" / 7'-0"			CS					PFD-005	2h capacity
T-604A/B	FORMCOKE PRODUCT SILO						CS					PFD-005	
T-903	BRINE TANK	API 12D	1,000 bbl	21'-6" / 16'-0"	8 oz/in² / ½ oz/in²		CS	1/8	---			UFD-013	6min holdup, full
T-904	RAW WATER TANK	API 12D	5,000 bbl	55'-0" / 24'-0"	3 oz/in² / ½ oz/in²		CS	1/8	---			UFD-013	
T-905	DEMIN WATER TANK	API 12D	3,000 bbl	29'-9" / 24'-0"	4 oz/in² / ½ oz/in²		CS	0	Epoxy-coated			UFD-013	

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PRESSURE VESSELS

Item No.	Name	H V	Total Wkg Vol ft³	Diameter Tan-Tan	Op. Press Des. Press. psig	Op. Temp. Des. Temp. °F	Materials Vessel	CA In	Lining	Wt lb	Vessel Mfr.	Req. No. P&I No.	Remarks
V-401A/B	CALCINER RECYCLE GAS COMP. SUCTION DRUM	V	125	4'-0" 11'-0"	8.5 25	375 500	CS					PFD-004	Incl. demister pad
V-501A/B	CARBONIZER GAS COMP. SUCTION DRUM	V	310	6'-0" 12'-0"	1.5 15	190 1400	CS					PFD-003	
V-901	DEAERATOR	V	110	4'-6" 7'-6"	30 75		CS 516-70	3/8	---	8,000		UFD-012	
V-902	BOILER BLOWDOWN DRUM	V	280	6'-0" 8'-0"	50 75		CS	1/4	---	3,000		UFD-012	
V-903	CONDENSATE FLASH TANK	V	100	4'-0" 6'-0"	Atm 15		CS	1/4	---	1,500		UFD-012	
V-904	DEAERATOR STORAGE TANK	H	1,700	8'-0" 17'-0"	30 75		CS 516-70	1/2	---	17,000		UFD-012	
V-905	FUEL GAS DRUM	V					CS						

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PACKAGED EQUIPMENT & SYSTEMS

Item No	Name	Description	Wt lb	Equip. Mfr. Model No.	Req. No. P&I No.	Remarks
Z-901	ATMOSPHERIC FLUIDIZED BED COMBUSTER (AFBC)	Complete boiler system (B1) to generate 280,000 lb/h steam @ 1200psia & 950°F, with superheaters (H6,H8), economizer (H5), air heaters (H1,H2,H3, & H4), steam drum (T4), attemperator (H7), waterwalls, mud drums, boiler trims, and soot blowers The package includes: 1. Dual fuel silos for reject coal (T1) & reject char (T2) 2. Fuel weighing and feed equipment (F1 & F2) 3 Limestone silo (T3), limestone feed equipment (F3), and limestone blower (K4) 4. Baghouse (G5) with eight ash discharge outlets 5 Primary blower with 300 HP motor (K6) 6. Induced draft fan with 1000 HP motor (K5) 7. Secondary air blower with 1000 HP motor (K7) 8. All ducts and breechings 9. Boiler support steel 10. Soot blower control system, 20 HP connected total 11. Burner management system 12. Boiler trim consists of: a. Boiler non-return valve (motor operated) b. Steam drum and superheater safety relief valves c. Electromatic relief valve with 2 HP motor d. Continuous blowdown valves (2 in tandem) e. Mud drum and lower header blowdown valves f. All vent and drain valves g. Steam drum level gauges and remote level indicators h Steam drum and superheater temperature indicators i Superheater temperature control spray assembly 13 Cyclone separator (C1) and ash reinjection system 14. Natural gas startup burner 15. Fuel hopper baghouses (G1 & G2) & vent blowers (K1 & K2), each with 3 HP motor 16 Limestone hopper baghouse (G3) and vent blower (K3) with 3 HP motor 17. Steam coil air heaters for primary and secondary airheaters (H2 & H3) 18 Fly ash blower (K6) and steam coil airheater (H4) 19 Seal pot blower with 150 HP motor (K9)		Tampella Power Co.	UFD-011	
Z-902	TURBOGENERATOR SYSTEM	Double automatic extraction/condensing steam turbine complete with 3600 rpm, 19,620 kVa totally-enclosed synchronous generator and brushless excitation system, including: 1. Complete combined hydraulic and lube oil system with reservoir, two full capacity AC motor-driven pumps, one DC emergency oil pump, two lube oil coolers, filters, etc. 2. Steam seal system 3 Woodward 50 SE governor and selected instruments and controls 4. Four fin-tube surface air coolers for generator heat sink (water to air coolers) 5. Lube oil, control oil, steam seal and leak-off piping 6 AC motor-driven turning gear, 5 HP 7. Gland steam condenser (H1)		GE	UFD-012	

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EQUIPMENT LIST

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PACKAGED EQUIPMENT & SYSTEMS

Item No.	Name	Description	Wt lb	Equip. Mfr. Model No.	Req. No. P&I No.	Remarks
Z-903	WATER TREATMENT SYSTEM	50 gpm treatment system to provide demin water to the AFBC. System includes: 1. Two full capacity carbon filters (X1 & X2) 2. Two full capacity zeolite softeners (X3 & X4) 3. Two full capacity cartridge filters (X5 & X6) 4. Two full capacity reverse osmosis (RO) units (X7 & X8) 5. Two full capacity mixed bed demineralizers (X9 & X10) 6. Three 50% capacity RO feed pumps (P1, P2 & P3) 7. Three 50% capacity demineralizer feed pumps (P4, P5 & P6) 8. Chemical injection systems for acid and anti-scaling (T2 & P7, T3 & P8) 9. RO product storage tank (T1) 10. Interconnecting piping and valves, PLC-based controller		Glegg Water Cond. Co.	UFD-013	
Z-904	COOLING TOWER	Five-cell (including spare) field erected, wooden, counter-flow, cooling tower with the following features and accessories: 1. 65,000 gpm cooling water capacity from 105°F to 88°F with 77°F wet bulb 2. 240'L x 48'W framework with 240'x54' concrete basin 3. Five (5) fans, each with 200 HP 460 V motor and gear reducer 4. Deluge type fire protection system			UFD-013	
Z-905	ASH HANDLING SYSTEM	Bottom ash and fly ash removal system to handle ashes generated at the fluidized bed combustor. System includes: 1. Bottom ash hopper (T1) & fly ash hopper (T2) 2. Water cooled drag chain for bottom ash (F1) 3. Bottom ash fluid bed air blower (K3) & air heater (H1) 4. Fly ash fluid bed air blower (K4) & air heater (H2) 5. Bottom ash baghouse (G1) and vent blower (K1) 6. Fly ash baghouse (G2) and vent blower (K2)			UFD-011	
Z-906	CHEMICAL INJECTION SYSTEM	Chemical injection tank and six pumps each with 2 HP motor			UFD-013	
Z-907	PLANT & INSTRUMENT AIR SYSTEM	1000 SCFM air system to supply plant and instrument air to the entire plant System includes: 1. Compressor and spare equipped with inlet filter, intercooler and aftercooler to produce 150 psig 2. Complete automatic dryer unit to provide -40°F dew point 3 Instrument air receiver 4. Plant air receiver				

NOTES:

XBi XYTEL-BECHTEL, INC.

EQUIPMENT LIST

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MAJOR ELECTRICAL & CONTROL SYSTEM COMPONENTS

Item No.	Name	Description	Wt lb	Equip. Mfr. Model No.	Reg. No. P&I No.	Remarks
2 Required	METER	13.8kV				
1 Required	SWITCH GEAR	24MVa, 13.8kV				
2 Required	SWITCH GEAR	6MVa, 13.8kV				
2 Required	TRANSFORMER	6MVa, 13.8kV Primary; 4160V Secondary				
2 Required	TRANSFER SWITCH	6MVa				
8 Required	DISCONNECT	4160V				
4 Required	TRANSFORMER	1MVa, 4160V Primary; 480V Secondary				
20 Required	TRANSFORMER	30kVa, 480V Primary; 120V Secondary				
1 Required	DCS SYSTEM & ASSOCIATED COMPONENTS					
1 Required	UPS SYSTEM	50kVa Static converter type				

NOTES:

XBi XYTEL-BECHTEL, INC.

EQUIPMENT LIST

Client: UND/EERC
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MISCELLANEOUS EQUIPMENT

Item No.	Name	Description	Wt lb	Equip. Mfr. Model No.	Reg. No. P&I No.	Remarks
C-101 A/B-1,2	COAL CYCLONE	113" Dia X 30' Ht ea, Des. ±17" WG @ 300°F, CS	3,400	Sprout Hi-spin	PFD-001	2 cyclones in parallel, each train
C-103A/B	FINE COAL GRAVITY TABLE	25 ft² deck area, 2 HP deck drive motor, 20 HP blower motor, -24 mesh	6,000	Triple/S Dyn. S-25 Stoner	PFD-001	15 t/h ea with K-103
C-104A/B	INTERMEDIATE COAL GRAVITY TABLE	25 ft² deck area, 2 HP deck drive motor, 20 HP blower motor, 10 X 24 mesh	6,000	Triple/S Dyn. S-25 Stoner	PFD-001	15 t/h ea with K-104
C-105A/B	LARGE COAL GRAVITY TABLE	25 ft² deck area, 2 HP deck drive motor, 20 HP blower motor, ¼" X 10 mesh	6,000	Triple/S Dyn. S-25 Stoner	PFD-001	15 t/h ea with K-105
C-301 A/B-1,2	PRIMARY CARBONIZER CYCLONE	113" Dia X 30' Ht ea, Des. 20 psig @ 1400°F, refractory-lined CS	3,400 + Ing	Sprout Hi-spin	PFD-002	2 cyclones in parallel, each train
C-302 A/B-1,2	SECONDARY CARBONIZER CYCLONE	113" Dia X 30' Ht ea, Des. 20 psig @ 1400°F, refractory-lined CS	3,400 + Ing	Sprout Hi-spin	PFD-002	2 cyclones in parallel, each train
C-304A/B	FINES MAGNETIC SEPARATOR	36"Dia X 12"W Drum, 300 fpm drum speed, 3 HP motor, -40 mesh	2,700	Eriez DF-R	PFD-002	15 t/h ea
C-305A/B	INTERMED. MAGNETIC SEPARATOR	36"Dia X 12"W Drum, 300 fpm drum speed, 3 HP motor, 40 x 20 mesh	2,700	Eriez DF-R	PFD-002	15 t/h ea
C-306A/B	LARGE PARTICLE MAG. SEPARATOR	36"Dia X 12"W Drum, 300 fpm drum speed, 3 HP motor, +20 mesh	2,700	Eriez DF-R	PFD-002	15 t/h ea
C-401 A/B-1,2	PRIMARY CALCINER CYCLONE	113" Dia X 30' Ht ea, Des 30 psig @ 1900°F, refractory-lined CS	3,400 + Ing	Sprout Hi-spin	PFD-004	2 cyclones in parallel, each train
C-402 A/B-1,2	SECONDARY CALCINER CYCLONE	113" Dia X 30' Ht ea, Des. 30 psig @ 1900°F, refractory-lined CS	3,400 + Ing	Sprout Hi-spin	PFD-004	2 cyclones in parallel, each train
C-405A/B	CALCINER GRAVITY TABLE	25 ft² deck area, 2 HP deck drive motor, 10 HP blower motor, -40 mesh	6,000	Triple/S Dyn. S-25 Stoner	PFD-004	2 t/h ea With K-405
C-601A/B	BRIQUET FINES CYCLONE				PFD-005	

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MISCELLANEOUS EQUIPMENT

Item No.	Name	Description	Wt lb	Equip. Mfr. Model No.	Req. No. P&I No.	Remarks
C-602A/B	FORMCOKE FINES CYCLONE				PFD-006	
H-101A/B	COAL DRYER	Fluid bed type, 45 t/h ea, moisture reduction from 13% to 8%			PFD-001	? hp
H-301A/B	CARBONIZER CHAR COOLER	Cooled screw type, 6.8 MMBtu/h ea, Design: Screw 150 psig Jacket 30 psig CS 30 HP motor	44,860	Holo-Flite Q-2424-6	PFD-002	15% design margin
H-401A/B	BED CALCINATE COOLER	Cooled screw type, 10.7 MMBtu/h ea, Design: Screw 150 psig Jacket 30 psig CS 30 HP motor	44,860	Holo-Flite Q-2424-6	PFD-004	15% design margin
H-402A/B	CALCINATE FINES COOLER	Cooled screw type, 2.7 MMBtu/h ea, Design: Screw 150 psig Jacket 30 psig CS 3 HP motor	19,690	Holo-Flite D-2420-6	PFD-004	15% design margin
H-502	OIL STORAGE TANK HEATER	Electric bayonet; 650,000 Btu/h			PFD-003	191 KW @ 90% efficiency
H-601A/B	BRIQUET CURING OVEN				PFD-005	
J-101A/B	COAL CRUSHER	6'L x 4'W x 6'H double-roll type, 60t/h capacity, size reduction fr 2"x0 to ½"x0 4 motors ea: 2 @ 15HP, 2 @ 30HP	11,000	Pennsylvania PDR	PFD-001	
J-601A/B	BRIQUET PRESS				PFD-005	

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XBi XYTEL-BECHTEL, INC.

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Item No.	Name	Description	Wt lb	Equip. Mfr. Model No.	Req. No. P&I No.	Remarks
M-101A/B	CARBONIZER FEED MIXER	Vertical static type, 20 t/h ea		Koflo	PFD-001	
M-301A/B	CALCINER FEED MIXER	Vertical static type, 10 t/h ea		Koflo	PFD-002	
M-501	OIL STORAGE TANK MIXER	Paddle-type, roof-mounted agitator, CS shaft, 316SS blades 7.5 HP with gear reducer			PFD-003	
M-601A/B	BRIQUETTING FEED MIXER				PFD-005	
N-901	BOILER STACK	Steel, 300' ht. with 6'dia. @ top and 12'dia. @ bottom			UFD-011	
Q-501A/B	QUENCH TOWER	Vertical vessel: 9'-0" Dia x 37' T-T, Des. 20 psig/FV @ 1400'F, CS w/1/8"CA, 10' skirt Trays: 9 discs/8 donuts @ 20" spacing, 410SS			PFD-003	
R-301A/B	CARBONIZER	Spouted bed type, multiple coal injection, 14'-3"dia X 28'-6"ea, 4500 ft³ ea Design 20 psig @ 1400'F, refractory-lined CS, w/ceramic distribution medium			PFD-002	4 ft/sec superficial gas vel., L/D=2 3 hrs residence time
R-401A/B	CALCINER	Bubbling bed type, 17'-3"dia X 26'ea, 6000 ft³ ea Design 30 psig @ 1900'F, refractory-lined CS, w/ceramic distribution medium			PFD-004	2 ft/sec superficial gas vel., L/D=1.5 3 hrs residence time

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Item No.	Name	Description	Wt lb	Equip. Mfr. Model No.	Req. No. P&I No.	Remarks
MISC.	48 AIRLOCKS	CS, 1 HP motor ea.		Sprout or Mikropul		
	2 SCREWFEEDERS	CS, 2 HP motor ea.		Mikropul		
	2 SLIDE GATES			Pebco BD-48/60		
	METAL DETECTORS	50 t/h capacity		Erlez MD-1260		
	2 OVERHEAD ELECTRO-MAGNETIC SEPARATORS	50 t/h capacity, 1 HP motor ea.		Erlez SE-7325		
	2 BELT SCALES	One with ± ½% accuracy, 250 t/h capacity, Ramsey model 10-14 The other with ± ½% accuracy, 50 t/h capacity, Ramsey model 10-20-2	800 400	Ramsey		

NOTES:

9.0 ON-SITE UTILITY CONSUMPTION

9.1 General

This section provides a tabulation of all consumers of electrical power (motor list), steam, cooling water, brine coolant, and fuel gas. Estimates of individual user consumption and total consumption of each utility/service is listed.

9.2 Consumption Basis and Use Factors

The following definitions/clarifications are provided to facilitate interpretation of the tabulated data:

9.2.1 Electrical Power Consumers

Connected horsepower = installed motor horsepower.
Operating horsepower is assumed at 65% (average) of motor horsepower.
Operating kW = .75 x operating horsepower.

Spare equipment and equipment not used in normal operation is shown at 0 operating horsepower.

Values in italics are estimates with no support data for confirmation.

9.2.1.1 Cooling Water Users

Design duties/flows are approximately 10% over normal requirement.

Temperature rise is that across user at design conditions; bulk temperature rise is weighted average for all users.

9.2.1.2 Cooling Brine Users

Design duties/flows are 15% to 30% over normal requirement, depending upon service.

Brine is 50/50 ethylene glycol/water; average heat capacity is 0.85 Btu/lb-°F.

Temperature rise is that across user at design conditions; bulk temperature rise is weighted average for all users.

9.2.1.3 Steam Consumers

Pressure shown is required supply pressure at user inlet.

Design duties/flows are approximately 20% over normal requirement.

Total condensate return rate assumes all condensate is collected.

9.2.1.4 Natural Gas Consumers

Lower heating value of natural gas is 929 Btu/scf.

XBi XYTEL-BECHTEL, INC.

UND/EERC - MILD COAL GASIFICATION FACILITY

UTILITY SUMMARY

ELECTRICAL POWER CONSUMERS

ITEM NO.	DESCRIPTION	EST'D POWER REQUIREMENT CONN. HP	OP'G HP	OP'G kW
C-102A	Coal Screener	10	6.5	5.4
C-102B	Coal Screener	10	6.5	5.4
C-103A	Fine Coal Gravity Table	2	1.3	1.1
C-103B	Fine Coal Gravity Table	2	1.3	1.1
C-104A	Intermediate Coal Gravity Table	2	1.3	1.1
C-104B	Intermediate Coal Gravity Table	2	1.3	1.1
C-105A	Large Coal Gravity Table	2	1.3	1.1
C-105B	Large Coal Gravity Table	2	1.3	1.1
C-304A	Fines Magnetic Separator	3	2.0	1.6
C-304B	Fines Magnetic Separator	3	2.0	1.6
C-305A	Intermediate Magnetic Separator	3	2.0	1.6
C-305B	Intermediate Magnetic Separator	3	2.0	1.6
C-306A	Large Particle Magnetic Separator	3	2.0	1.6
C-306B	Large Particle Magnetic Separator	3	2.0	1.6
C-307A	Carbonizer Char Screener	10	6.5	5.4
C-307B	Carbonizer Char Screener	10	6.5	5.4
C-405A	Calciner Gravity Table	2	1.3	1.1
C-405B	Calciner Gravity Table	2	1.3	1.1
C-603A	Briquette Screener	*7.5*	*4.9*	*4.0*
C-603B	Briquette Screener	*7.5*	*4.9*	*4.0*
F-101	Coal Receiving Conveyor	75	48.8	40.4
F-102A	Feed Transfer Conveyor	7.5	4.9	4.0
F-102B	Feed Transfer Conveyor	7.5	4.9	4.0
F-103A	Crusher Feed Bin Conveyor	15	9.8	8.1
F-103B	Crusher Feed Bin Conveyor	15	9.8	8.1
F-104A	Crusher Feed Conveyor	7.5	4.9	4.0
F-104B	Crusher Feed Conveyor	7.5	4.9	4.0
F-105A	Dryer Feed Conveyor	20	13.0	10.8
F-105B	Dryer Feed Conveyor	20	13.0	10.8
F-106A	Carbonizer Feed Conveyor	15	9.8	8.1
F-106B	Carbonizer Feed Conveyor	15	9.8	8.1
F-107	AFBC Fresh Coal Conveyor	*15*	-	-
F-301A	Carbonizer Char Conveyor	15	9.8	8.1
F-301B	Carbonizer Char Conveyor	15	9.8	8.1
F-302A	Calciner Feed Conveyor	15	9.8	8.1
F-302B	Calciner Feed Conveyor	15	9.8	8.1
F-601A	Green Briquet Conveyor	*10*	*6.5*	*5.4*
F-601B	Green Briquet Conveyor	*10*	*6.5*	*5.4*
F-602A	Green Briquet Recycle Elevator	*10*	*6.5*	*5.4*
F-602B	Green Briquet Recycle Elevator	*10*	*6.5*	*5.4*
F-603A	Cured Briquet Conveyor	*10*	*6.5*	*5.4*
F-603B	Cured Briquet Conveyor	*10*	*6.5*	*5.4*

XBi XYTEL-BECHTEL, INC.

UND/EERC – MILD COAL GASIFICATION FACILITY

UTILITY SUMMARY

ELECTRICAL POWER CONSUMERS (Cont'd)

ITEM NO.	DESCRIPTION	EST'D POWER REQUIREMENT CONN. HP	OP'G HP	OP'G kW
F-604A	Kiln Feed Elevator	10	6.5	5.4
F-604B	Kiln Feed Elevator	10	6.5	5.4
F-605A	Formcoke Product Conveyor	10	6.5	5.4
F-605B	Formcoke Product Conveyor	10	6.5	5.4
F-606A	Formcoke Cooling Conveyor	10	6.5	5.4
F-606B	Formcoke Cooling Conveyor	10	6.5	5.4
H-101A	Coal Dryer	25	16.3	13.5
H-101B	Coal Dryer	25	16.3	13.5
H-301A	Carbonizer Char Cooler	30	19.5	16.2
H-301B	Carbonizer Char Cooler	30	19.5	16.2
H-401A	Bed Calcinate Cooler	30	19.5	16.2
H-401B	Bed Calcinate Cooler	30	19.5	16.2
H-402A	Calcinate Fines Cooler	3	2.0	1.6
H-402B	Calcinate Fines Cooler	3	2.0	1.6
H-502	Oil Storage Tank Heater	---	---	191
J-101A	Coal Crusher	90	58.5	48.5
J-101B	Coal Crusher	90	58.5	48.5
J-601A	Briquette Press	150	97.5	80.8
J-601B	Briquette Press	150	97.5	80.8
K-101	Blower for Baghouse G-101	3	2.0	1.6
K-102	Blower for Baghouse G-102	3	2.0	1.6
K-103A	Air Blower for Gravity Table C-103A	20	13.0	10.8
K-103B	Air Blower for Gravity Table C-103B	20	13.0	10.8
K-104A	Air Blower for Gravity Table C-104A	20	13.0	10.8
K-104B	Air Blower for Gravity Table C-104B	20	13.0	10.8
K-105A	Air Blower for Gravity Table C-105A	20	13.0	10.8
K-105B	Air Blower for Gravity Table C-105B	20	13.0	10.8
K-106A	Reject Coal Blower	20	13.0	10.8
K-106B	Reject Coal Blower	20	13.0	10.8
K-107A	Blower for Baghouse G-103A	125	81.3	67.3
K-107B	Blower for Baghouse G-103B	125	81.3	67.3
K-301A	Blower for Baghouse G-301A	3	2.0	1.6
K-301B	Blower for Baghouse G-301B	3	2.0	1.6
K-302A	Carbonizer Reject Char Blower	10	6.5	5.4
K-302B	Carbonizer Reject Char Blower	10	6.5	5.4
K-401A	Blower for Baghouse G-401A	3	2.0	1.6
K-401B	Blower for Baghouse G-401B	3	2.0	1.6
K-402A	Calcinate Product Blower	25	16.3	13.5
K-402B	Calcinate Product Blower	25	16.3	13.5

XBi XYTEL-BECHTEL, INC.

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UTILITY SUMMARY
ELECTRICAL POWER CONSUMERS (Cont'd)

ITEM NO.	DESCRIPTION	EST'D POWER REQUIREMENT CONN. HP	OP'G HP	OP'G kW
K-403A	Reject Calcinate Blower	1.5	1.0	0.8
K-403B	Reject Calcinate Blower	1.5	1.0	0.8
K-404A	Calcinate Fines Product Blower	7.5	4.9	4.0
K-404B	Calcinate Fines Product Blower	7.5	4.9	4.0
K-405A	Air Blower for Gravity Table C-405A	15	9.8	8.1
K-405B	Air Blower for Gravity Table C-405B	15	9.8	8.1
K-504-1	Oil Tank Off-gas Compressor	0.5	0.3	0.3
K-504-2	Spare Oil Tank Off-gas Compressor	0.5	0	0
K-601A	Blower for Baghouse G-601A	3	2.0	1.6
K-601B	Blower for Baghouse G-601B	3	2.0	1.6
K-602A	Blower for Baghouse G-602A	3	2.0	1.6
K-602B	Blower for Baghouse G-602B	3	2.0	1.6
K-603A	Formcoke Fines Blower	5	3.3	2.7
K-603B	Formcoke Fines Blower	5	3.3	2.7
K-604A	Formcoke Cooling Air Blower	7.5	4.9	4.0
K-604B	Formcoke Cooling Air Blower	7.5	4.9	4.0
K-605A	Curing Oven Exhaust Blower			
K-605B	Curing Oven Exhaust Blower			
M-501	Oil Storage Tank Mixer	7.5	4.9	4.0
M-601A	Briquetting Feed Mixer	15	9.8	8.1
M-601B	Briquetting Feed Mixer	15	9.8	8.1
P-401A	K-406A Suction Drum Pump	0.5	0.3	0.3
P-401B	K-406B Suction Drum Pump	0.5	0.3	0.3
P-501-A1	Quench Tower Circulating Pump	25	16.3	13.5
P-501-B1	Quench Tower Circulating Pump	25	16.3	13.5
P-501-A2	Spare Quench Tower Circulating Pump	30	0	0
P-501-B2	Spare Quench Tower Circulating Pump	30	0	0
P-503-1	Oil Transfer Pump	1.5	1.0	0.8
P-503-2	Spare Oil Transfer Pump	1.5	0	0
P-505A	V-501A Suction Drum Pump	0.5	0.3	0.3
P-505B	V-501B Suction Drum Pump	0.5	0.3	0.3
P-601A	Binder Feed Pump	1	0.7	0.5
P-601B	Binder Feed Pump	1	0.7	0.5
P-902	Startup Boiler Feed Pump	400	0	0
P-903-1	Condensate Recycle Pump	50	32.5	26.9
P-903-2	Spare Condensate Recycle Pump	50	0	0
P-904	Flash Tank Water Pump	5	0	0
P-905-1	Cooling Tower Pump	1000	650.0	538.6
P-905-2	Cooling Tower Pump	1000	650.0	538.6
P-905-3	Spare Cooling Tower Pump	1000	0	0

XBi XYTEL-BECHTEL INC.

UND/EERC – MILD COAL GASIFICATION FACILITY

UTILITY SUMMARY

ELECTRICAL POWER CONSUMERS (Cont'd)

ITEM NO.	DESCRIPTION	EST'D POWER REQUIREMENT CONN. HP	OP'G HP	OP'G kW
P-906-1	Brine Pump	150	97.5	80.8
P-906-2	Brine Pump	150	97.5	80.8
P-906-3	Spare Brine Pump	150	0	0
P-907-1	Raw Water Pump	150	97.5	80.8
P-907-2	Spare Raw Water Pump	150	0	0
P-908-1	Water Treatment Feed Pump	5	3.3	2.7
P-908-2	Spare Water Treatment Feed Pump	5	0	0
P-909-1	Fire Water Pump	40	26.0	21.5
P-910	Fire Water Jockey Pump	5	3.3	2.7
P-911-1	Boiler Makeup Pump	3	2.0	1.6
P-911-2	Spare Boiler Makeup Pump	3	0	.0
Packaged Equipment & Systems				
Z-901	ATMOSPHERIC FLUIDIZED BED COMBUSTER (AFBC)			
– F1	Reject Coal Feeder	*10*	*6.5*	*5.4*
– F2	Reject Char Feeder	*10*	*6.5*	*5.4*
– F3	Limestone Feeder	*10*	*6.5*	*5.4*
– K1	Blower for Baghouse G1	3	2.0	1.6
– K2	Blower for Baghouse G2	3	2.0	1.6
– K3	Blower for Baghouse G3	3	2.0	1.6
– K4	Limestone Blower	*20*	*13.0*	*10.8*
– K5	Induced Draft Fan	1000	650.0	538.6
– K6	Fly Ash Transfer Blower	*10*	*6.5*	*5.4*
– K7	Secondary Air Blower	1000	650.0	538.6
– K8	Primary Air Fan	300	195.0	161.6
– K9	Seal Pot Blower	150	97.5	80.8
	Electromagnetic Relief Valve	2	0	0
	Soot Blower Control System & Motors	20	13.0	10.8
Z-903	WATER TREATMENT SYSTEM			
– P1	RO Feed pump	*25*	*16.3*	*13.5*
– P2	RO Feed pump	*25*	*16.3*	*13.5*
– P3	RO Feed pump	*25*	*16.3*	*13.5*
– P4	Demineralizer Feed Pump	*5*	*3.3*	*2.7*
– P5	Demineralizer Feed Pump	*5*	*3.3*	*2.7*
– P6	Demineralizer Feed Pump	*5*	*3.3*	*2.7*
– P7	Sulfuric Acid Feed Pump	*0.5*	*0.3*	*0.3*
– P8	Anti-Scaling Feed Pump	*0.5*	*0.3*	*0.3*
Z-904	COOLING TOWER			
	5 Fans (5 @ 200 HP ea.. 4 op./1 spare)	1000	650.0	538.6
Z-905	ASH HANDLING SYSTEM			
– F1	Bottom Ash Drag Chain Conveyor	*5*	3.3	2.1
– K1	Blower for Baghouse G1	*3*	2.0	1.3
– K2	Blower for Baghouse G2	*3*	2.0	1.3
– K3	Bottom Ash Fluid Bed Air Blower	*5*	3.3	2.1
– K4	Fly Ash Fluid Bed Air Blower	*5*	3.3	2.1

XBi XYTEL-BECHTEL INC.

UND/EERC – MILD COAL GASIFICATION FACILITY

UTILITY SUMMARY

ELECTRICAL POWER CONSUMERS (Cont'd)

ITEM NO.	DESCRIPTION	EST'D POWER REQUIREMENT		
		CONN. HP	OP'G HP	OP'G kW
Z-906	CHEMICAL INJECTION SYSTEM			
	Chemical Injection Package (6 pumps @ 2HP ea.)	12	7.8	6.5
Z-907	PLANT & INSTRUMENT AIR SYSTEM			
– K1	Air Compressor	350	227.5	188.5
– K2	Spare Air Compressor	350	0	0
Miscellaneous Motors				
	Airlocks – 48 @ 1HP ea. (average)	48	31.2	25.9
	Screw Feeders – @ 2HP ea.	4	2.6	2.2
	Slide Gates – 2 @ 2HP ea.	4	0	0
????	2 Overhead Electromagnetic Separators			10.0
	with Belts	2	1.3	1.1
Other Users				
	Lighting			25
	Electric Tracing			10
	Heating & Ventillation			10
	Instruments & Control Systems			10

Summary:

Total Combined Connected Motor HP	10,623
Total Operating Motor HP	5,477
Total Operating kW Demand	4,791

XBi XYTEL-BECHTEL, INC.

UND/EERC - MILD COAL GASIFICATION FACILITY

UTILITY SUMMARY

COOLING WATER (TOWER) USERS

ITEM NO.	DESCRIPTION	TEMP. RISE °F	EST'D COOLING WATER USE DES. DUTY MMBtu/h	FLOWRATE, GPM NORMAL	DESIGN
H-905	Main Surface Condenser	17.0	250.0	26,460	29,400
H-906	Brine Cooler	17.0	137.4	14,535	16,150

Summary:

Total Combined Cooling Load, MMBtu/h	387.4	Bulk ΔT, °F	
Total Normal Flowrate, gpm	40,995	17.0	
Total Design Flowrate, gpm	45,550		

COOLING SYSTEM (BRINE) USERS

ITEM NO.	DESCRIPTION	TEMP. RISE °F	EST'D COOLING MEDIUM USE DUTY MMBtu/h	FLOWRATE, GPM NORMAL	MAX
H-301A	Carbonizer Char Cooler	50	7.6	342	394
H-301B	Carbonizer Char Cooler	50	7.6	342	394
H-401A	Bed Calcinate Cooler	50	9.3	416	478
H-401B	Bed Calcinate Cooler	50	9.3	416	478
H-402A	Calcinate Fines Cooler	50	2.3	104	119
H-402B	Calcinate Fines Cooler	50	2.3	104	119
H-404A	Calciner Gas Cooler	80	4.4	123	148
H-404B	Calciner Gas Cooler	80	4.4	123	148
H-501A	Oil Cooler	40	19.5	1,096	1,425
H-501B	Oil Cooler	40	19.5	1,096	1,425
Z-905-F1	Bottom Ash Drag Chain Conveyor	?	?	?	?
Z-907-H1	Air Compressor Intercooler	20	0.36	40	52
Z-907-H2	Air Compressor Aftercooler	20	0.27	30	39
Z-907-H3	Air Compressor Lube Oil Cooler	10	0.11	25	32

Summary:

Total Combined Cooling Load, MMBtu/h	86.9	Bulk ΔT, °F	
Total Normal Flowrate, gpm @ 120°F	4,258	47.2	
Total Maximum Flowrate, gpm @ 120°F	5,252		

XBi XYTEL-BECHTEL INC.

UND/EERC – MILD COAL GASIFICATION FACILITY

UTILITY SUMMARY

07-Apr-92
Page 7 of 7

STEAM CONSUMERS

ITEM NO.	DESCRIPTION	ESTIMATED STEAM USE PRESS PSIG	FLOWRATE, lb/h NORMAL	MAX
H-903	HP Boiler Feed Water Heater	400	38,608	46,330
K-406A-T	Calciner Recycle Gas Compressor (Turbine Drive)	400	7,504	9,004
K-406B-T	Calciner Recycle Gas Compressor (Turbine Drive)	400	7,504	9,004
K-501A-T	Carbonizer Gas Compressor (Turbine Drive)	400	34,980	43,564
K-501B-T	Carbonizer Gas Compressor (Turbine Drive)	400	34,980	43,564
K-502A-T	Carbonizer Burner Air Compressor (Turbine Drive)	400	7,333	8,800
K-502B-T	Carbonizer Burner Air Compressor (Turbine Drive)	400	7,333	8,800
K-503A-T	Calciner Burner Air Compressor (Turbine Drive)	400	12,769	15,322
K-503B-T	Calciner Burner Air Compressor (Turbine Drive)	400	12,769	15,322
P-901	Main Boiler Feed Water Pump	400	27,000	32,400
Z-901	ATMOSPHERIC FLUIDIZED BED COMBUSTER (AFBC)			
-H2	Steam Coil Primary Air Heater	50	9,200	11,040
-H3	Steam Coil Secondary Air Heater	50	3,900	4,680
-H4	Transfer Air Heater	50	2,000	2,400
Z-905	ASH HANDLING SYSTEM			
-H1	Bottom Ash Fluid Bed Air Heater	50	800	960
-H2	Fly Ash Fluid Bed Air Heater	50	800	960

Summary:

Total Normal Steam Flow, lb/h	207,480
Total Maximum Steam Flow, lb/h	252,150
Design Condensate Return Rate, gpm @ 60°F	504

NATURAL GAS CONSUMERS

ITEM NO.	DESCRIPTION	EST'D NATURAL GAS USE DES. DUTY MMBtu/h	FLOWRATE, ft³/h NORMAL	MAX
B-602A	Briquet Kiln	?	?	?
B-602B	Briquet Kiln	?	?	?

Summary:

Total Normal Natural Gas Flow, ft³/h	0
Total Maximum Natural Gasm Flow, ft³/h	0

10.0 CAPITAL COST ESTIMATE AND SCHEDULE

10.1 General

This capital cost estimate was done by the Estimating Department of the Bechtel Houston office for XBi. It is based on the technical equipment list provided in Section 8.0 and the instrument list provided in Appendix C. Factors were then applied to arrive at the final cost. The 1000-tpd mild coal gasification facility is estimated to cost $116.4 million dollars, including the cost of the 24-MW power generation facility. The engineering and construction schedule calls for 44 months from start of preliminary engineering to final commissioning.

10.2 Capital Cost Estimate

10.2.1 <u>Assumptions</u>

The following assumptions were used:

- Overall project schedule is 42 to 48 months.

- The project consists of:

  - 1000 tpd mild coal gasification.
  - Formed coke production.
  - Electric power generation at 24 MW.

- The plant battery limits start with a 500-foot-long conveyor from the mine. Coal feeding to the conveyor is by the mine operations. The battery limits stop at the 13.8-kV switchgear and the storage silos/hoppers for the formed coke product and solid waste products. Wiring from the 13.8-kV switchgear to the utility's service line is not included along with disconnect switches and any required voltage step-up or step-down transformers.

- Base date of the estimate is second quarter 1992. Escalation factors are not included in the estimate.

- Items specifically included in the estimate are:

  - Buildings and structures.
  - Lab facilities.
  - Stationary maintenance equipment (hoists, monorails, etc.).
  - Stationary fire/safety equipment.
  - Civil/structural/architectural (concrete), piping, electrical wiring and raceways, communications, cathodic protection, freeze protection, grounding, etc.

- Items specifically excluded from the estimate are:

  - All facilities outside the battery limits.
  - Laboratory equipment.

- Mobile equipment such as bulldozers, forklifts, cranes, trucks, etc.
- Electric power transmission lines.
- Taxes such as sales, local, and use.
- Land and land rights.
- Allowance for funds during construction (cost of money).
- Operation and maintenance costs during start-up and commissioning.
- The owners' organization costs.

10.2.2 Elements of the Cost Estimate

The cost estimate of $116.4 million is presented in the tables at the end of this section, which comprise 21 sheets. The first sheet summarizes all of the inputs into the cost estimate including mechanical equipment, packaged systems, major electrical and instrumentation items, bulk materials, labor, subcontracts, freight, construction contractor's fee, engineering and home office fees, and contingency.

10.2.2.1 Mechanical Equipment

Equipment specifications and quantity are based on the equipment list presented in Section 8.0. Budget quotations from equipment vendors were used for most of the equipment and packaged systems except for the briquetting system. Bechtel in-house data was used for the remaining equipment. The vendor that supplied the quotation is listed on the estimating cost sheets. If no vendor is listed, then the information came from the in-house files. An allowance was made for miscellaneous equipment items such hoists, monorails, strainers, etc., that are not on the equipment list.

10.2.2.2 Electrical Equipment

The quantity of major electrical equipment is based on the single line electrical drawing and the equipment list. The smaller electrical items were factored from the major equipment list based on Bechtel experience with similar projects.

10.2.2.3 Instrumentation and Control

Instrumentation and control items were taken from the instrument list and from the process and utility flow diagrams.

10.2.2.4 Bulk Materials

Bulk material costs were factored from either the equipment or instrument lists.

10.2.2.5 Construction Manpower

Construction is based on a 40-hour work week at 8 hours per day, 5 days per week. Man-hours required for installation of all equipment, electrical, instruments, and bulk materials was estimated from Bechtels' in-house files. The average composite wage rate was estimated to be $45 per hour. Calculations showing how the composite wage rate was estimated are shown on page 89.

10.2.2.6 Indirect Field Costs

Indirect field costs such as temporary facilities, temporary construction services, construction equipment, tools, welders' certification, security, field supervision, project engineering, administration, safety, warehouse, and project insurance are included in the composite man-hour rate ($45/hr) at 120% ($24.22) of the direct field labor cost ($20.18).

10.2.2.7 Construction Management Fee

The construction management fee for overhead and profit is calculated at 2% of the total field cost excluding the cost of equipment materials and subcontracts.

10.2.2.8 Engineering and Home Office Fee

Architect, engineering and home office fees, including overhead and profit are estimated at 10% of the total installed cost, which includes the contingency allowance.

10.2.2.9 Contingency

The contingency factor consists of two values, which are 15% of equipment materials and subcontracts and 30% of installation man-hours.

10.2.2.10 Accuracy of the Estimate

The accuracy of the estimate as defined herein by the equipment list and the scaling factors discussed above is -5% and +20%.

10.3 Engineering and Construction Schedule

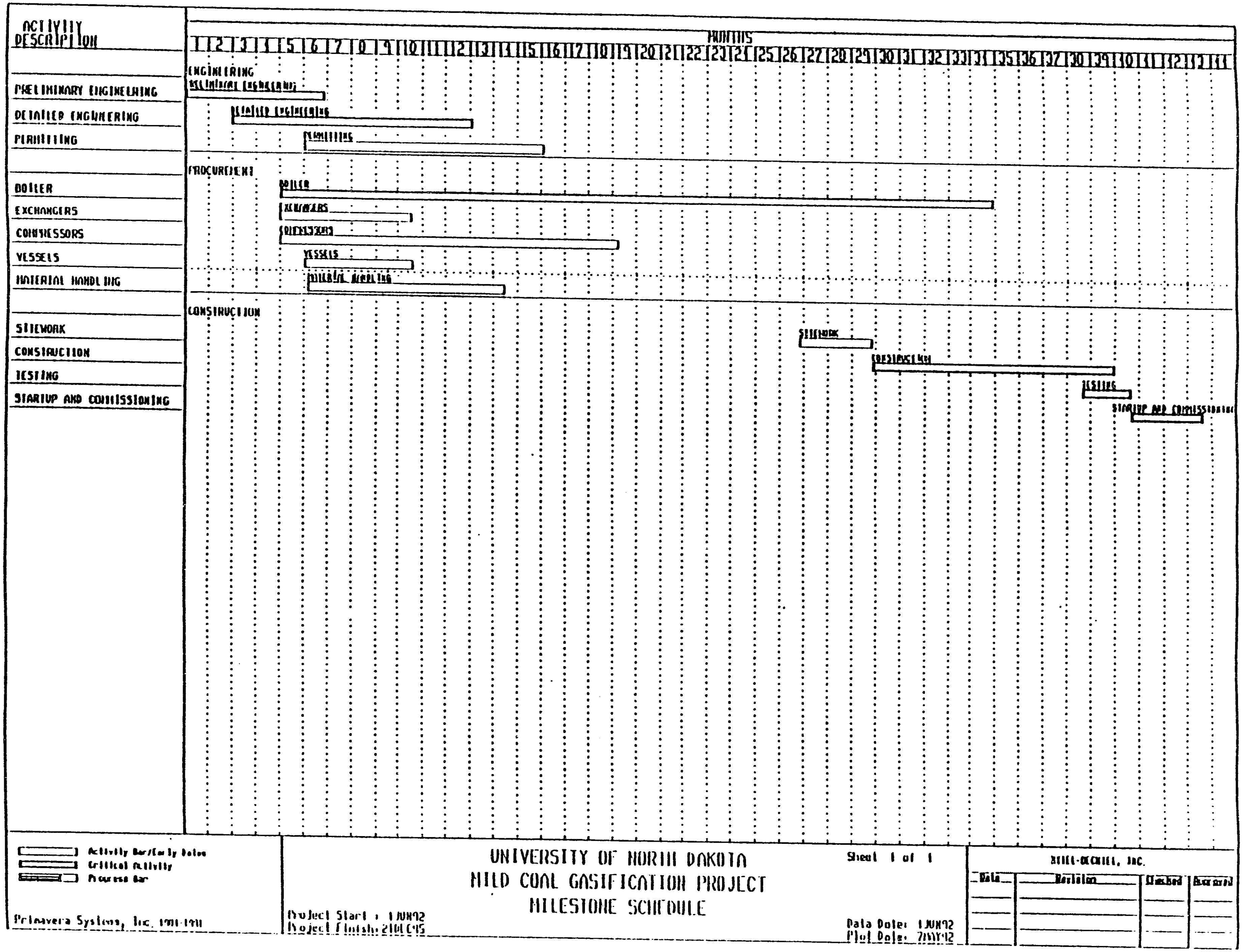
The engineering and construction schedule, shown on page 90, is based on Bechtel's (XBi) experience on similar gasification/fluid-bed boiler projects. The schedule is dictated, in large part, by lead time for environmental permitting and the long delivery time for the AFBC. The overall project activities and durations are:

	Months
Engineering, Licensing, Permitting	15 - 18
Procurement and Deliver	30
Construction (6-Month Overlap with Above)	14
Start-up, Commissioning	3 - 6
Overall Schedule, Planning to Full Production with Overlaps	42 - 48

20708-308 / UND/EERC AND AMAX
MILD COAL GASIFICATION PROJECT - 1000 T/D
CLAY COUNTY, INDIANA

FILE:\XYTEL\MCB-WR1

	CRAFT	DISTRIB-UTION	OPEN SHOP W RATE + PER DIEM		OPEN SHOP WEIGHTED	
		%	$/MH		$/MH	
	MECHANICAL	65.0%	18.12		11.78	
	CIVIL	35.0%	17.62		6.17	
	SUBTOTAL				17.95	
ALLOW	J'MAN:APP 45/55 % APP @ 70% JMAN RATE ADJUST	-16.5%			-2.96	
	SUBTOTAL				14.98	
ALLOW	FMAN DIFF	10.0%	3.97		0.40	
ALLOW	GFMAN DIF	3.0%	4.82		0.14	
ALLOW	P/R T+I INCLUDS WC	30.0%			4.66	
	SUBTOTAL				20.18	
ALLOW	DISTRIBS @	120.0%			24.22	
	TOTAL				44.40	
				USE	$45.00	INCLUDING ALLOWANCE FOR TURNOVER


ACTIVITY DESCRIPTION
MONTHS
ENGINEERING
PRELIMINARY ENGINEERING
DETAILED ENGINEERING
PERMITTING
PROCUREMENT
BOILER
EXCHANGERS
COMPRESSORS
VESSELS
MATERIAL HANDLING
CONSTRUCTION
SITEWORK
CONSTRUCTION
TESTING
STARTUP AND COMMISSIONING
UNIVERSITY OF NORTH DAKOTA
MILD COAL GASIFICATION PROJECT
MILESTONE SCHEDULE
Sheet 1 of 1
Project Start : 1JUN92
Data Date: 1JUN92
Primavera Systems, Inc.
BECHTEL, INC.
Date
Revision
Checked
Approved

BECHTEL CORPORATION
JOB NO. / CLIENT 20708-308 / UND/EERC AND AMAX
JOB TITLE MILD COAL GASIFICATION PROJECT - 1,000 T/D
JOB LOCATION CLAY COUNTY, INDIANA

PRELIMINARY
** CONCEPTUAL FACTORED BUDGET ESTIMATE **

TAKEOFF ________
PRICED ________
CHECKED ________

FILE: XYTEL\MCG-F1
DATE 07-May-92 02:40 PM
SHEET 1 OF 21

COST CODE	ITEM AND DESCRIPTION		QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	TOTAL COST SUB-CONT.	TOTAL COST TOTAL
	SUMMARY												
B	FIRED EQUIPMENT		6	EA				1,400		600,000			600,000
C	CLASSIFIERS, VIBRATING SCREENERS		6	EA				320		76,600			76,600
F	BELT CONVEYORS, BUCKET CONVEYORS		29	EA				7,260		4,840,000			4,840,000
G	DUST COLLECTORS, BAGHOUSES		12	EA				430		274,000			274,000
H	HEAT EXCHANGERS		9	EA				3,240		1,180,400			1,180,400
K	COMPRESSORS, BLOWERS, FANS		46	EA				6,940		6,234,400			6,234,400
P	CENTRIFUGAL PUMPS, POSITIVE DISPLACEMENT PUMPS		32	EA				3,330		1,151,800			1,151,800
T	STORAGE TANKS, BINS, SILOS		34	EA				4,550		585,800		868,200	1,454,000
V	PRESSURE VESSELS		9	EA				260		238,600			238,600
Z	PACKAGED EQUIPMENT & SYSTEMS		10	EA				18,050		8,780,000		17,300,000	26,080,000
C,H,J,M, N,Q,R	MAJOR ELECTRICAL, AND CONTROL SYSTEM COMPONENTS		47	EA				11,360		3,020,000		300,000	3,320,000
	MISCELLANEOUS EQUIPMENT		142	EA				29,280		10,042,400			10,042,400
	BULKS							309,650		9,122,400		4,717,000	13,839,400
	SUBTOTAL		382	EA				396,070		46,146,000		23,185,000	69,331,000
	FREIGHT	INCLUDED											INCLUDED
	SALES TAX	NOT INCLD											NOT INCLUDED
	TOTAL DIRECT COST							396,070		46,146,000		23,185,000	69,331,000
	FIELD INDIRECTS	INCLUDED											INCLUDED
	TOTAL FIELD COST							396,070	45	46,146,000	17,823,000	23,185,000	87,154,000
	CONTRACTOR'S FEE: (FR TOTL FLD COST MINUS EQP MAT & S/C)	2.0%											633,000
	TOTAL FIELD COST												87,787,000
	CONTINGENCY- EQUIP.: 15.0% BALANCE:	30.0%											18,012,000
	SUBTOTAL												105,799,000
	ENGINEERING & H.O.-	10.0%											10,580,000
	OWNERS' COST-	NOT INCLD											NOT INCLUDED
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992												116,400,000

BECHTEL CORPORATION
JOB NO. / CLIENT 20708-308 / UND/EERC AND AMAX
JOB TITLE MILD COAL GASIFICATION PROJECT- 1,000 T/D
JOB LOCATION CLAY COUNTY, INDIANA

PRELIMINARY
** CONCEPTUAL FACTORED BUDGET ESTIMATE**

TAKEOFF ______
PRICED ______
CHECKED ______

FILE: XYTEL\MCG-F1
DATE 07-May-92 02:40 PM
SHEET 2 OF 21

COST CODE	ITEM AND DESCRIPTION	FUEL, DUTY-MMBtu/h	Op Press psig	Op Temp F	Mat'l Housing	Mat'l Element	REFRCT LINED	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
B	FIRED EQUIPMENT																	
B-501A/B	CARBONIZER RECYCLE GAS BURNER	Off-GAS 35.8	10	2,800	Steel		Yes	2	EA	80,000		100	200		160,000			
B-502A/B	CALCINER MAKEUP GAS BURNER	Off-GAS 32.8	23	2,800	Steel		Yes	2	EA	80,000		100	200		160,000			
B-602A/B	BRIQUET KILN	Nat. Gas		1,500	Steel		Yes	2	EA	140,000		500	1,000		280,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							6	EA				1,400		600,000			

BECHTEL CORPORATION
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JOB LOCATION CLAY COUNTY, INDIANA

PRELIMINARY
** CONCEPTUAL FACTORED BUDGET ESTIMATE**

TAKEOFF ______
PRICED ______
CHECKED ______

FILE: XYTEL\MCG-F1
DATE 07-May-92 02:40 PM
SHEET 3 OF 21

COST CODE	ITEM AND DESCRIPTION	Screen Area-sf, Mesh	CAP. t/hr	Op Temp F	Mat'l Housing	Mat'l Screen	HP, RPM	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	TOTAL COST SUB-CONT.	TOTAL
C	CLASSIFIERS, VIBRATING SCREENERS																	
C-102A/B	COAL SCREENER, DOUBLE DECK	10 24	30	250	CS	SS	10	2	EA	13,700		60	120		27,400			
C-307A/B	CARBONIZER CHAR SCREENER, DOUBLE DECK	20 40	15	250	CS	SS	10	2	EA	12,300		50	100		24,600			
C-603A/B	BRIQUET SCREENER,			200	CS	SS	10	2	EA	12,300		50	100		24,600			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							6	EA				320		76,600			

BECHTEL CORPORATION
JOB NO. / CLIENT 20708-308 / UND/EERC AND AMAX
JOB TITLE MILO COAL GASIFICATION PROJECT- 1,000 T/D
JOB LOCATION CLAY COUNTY, INDIANA

PRELIMINARY
** CONCEPTUAL FACTORED BUDGET ESTIMATE**

TAKEOFF ____________
PRICED ____________
CHECKED ____________

FILE: XYTEL\MCG-F1
DATE 07-May-92 02:40 PM
SHEET 4 OF 21

COST CODE	ITEM AND DESCRIPTION							QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
F	BELT CONVEYORS, BUCKET CONVEYORS																	
		DENSITY LB/CF	CAPACITY t/hr	W-inch OAL-ft	LIFT ft	VEL. fpm	HP, RPM											
F-101	COAL RECEIVING CONVEYOR	83.4	250	24 500	125	500	75	1	EA	500,000		750	750		500,000			
F-102A/B	FEED TRANSFER CONVEYOR	83.4	50	30 10		100	7.5	2	EA	30,000		80	160		60,000			
F-103A/B	CRUSHER FEED BIN CONVEYOR	83.4	50	24 300	75	200	15	2	EA	300,000		450	900		600,000			
F-104A/B	CRUSHER FEED CONVEYOR	83.4	50	30 10		100	7.5	2	EA	30,000		80	160		60,000			
F-105A/B	DRYER FEED CONVEYOR	83.4	50	24 500	125	200	20	2	EA	500,000		625	1,250		1,000,000			
F-106A/B	CARBONIZER FEED CONVEYOR	83.4	50	24 200	50	200	15	2	EA	200,000		300	600		400,000			
F-107A/B	AFBC FRESH COAL CONVEYOR	83.4	15	?? 12 ?? 200	?? 0		15	2	EA	150,000		200	400		300,000			
F-301A/B	CARBONIZER CHAR CONVEYOR	83.4	50	24 300	75	200	15	2	EA	300,000		450	900		600,000			
F-302A/B	CALCINER FEED CONVEYOR	83.4	50	24 200	50	200	15	2	EA	200,000		300	600		400,000			
F-601A/B	GREEN BRIQUET CONVEYOR	83.4	20	24 ?? 100	?? 30		10	2	EA	100000		190	380		200,000			
F-603A/B	CURED BRIQUET CONVEYOR	83.4	20	24 ?? 30	?? 0		10	2	EA	80,000		80	160		160,000			
F-605A/B	FORMCOKE PRODUCT CONVEYOR	83.4	20	24 ?? 150	75	100	10	2	EA	150,000		260	520		300,000			
F-606A/B	FORMCOKE COOLING CONVEYOR	83.4	20	24 ?? 40	?? 0		10	2	EA	100,000		80	160		200,000			
		DENSITY LB/CF	CAP. cf/hr	ELEVATOR LxW, in H, ft	BUCKET LxW, in H, in	LINEAR VEL. ips	HP, RPM											
F-602A/B	GREEN BRIQUET RECYCLE ELEVATOR	55		?? 12 ?? 30			10	2	EA	15,000		80	160		30,000			
F-604A/B	KILN FEED ELEVATOR	55		?? 12 ?? 30			10	2	EA	15,000		80	160		30,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							29	EA				7,260		4,840,000			

BECHTEL CORPORATION
JOB NO. / CLIENT 20708-308 / UND/EERC AND AMAX
JOB TITLE MILD COAL GASIFICATION PROJECT- 1,000 T/D
JOB LOCATION CLAY COUNTY, INDIANA

PRELIMINARY
** CONCEPTUAL FACTORED BUDGET ESTIMATE**

TAKEOFF ______
PRICED ______
CHECKED ______

FILE: XYTEL\MCG-F1
DATE 07-May-92 02:40 PM
SHEET 5 OF 21

COST CODE	ITEM AND DESCRIPTION	Retentn. Area-sf, Particle Size-Micron	Design Press. in. WG	Design Temp. F	Mat'l Housing	Mat'l Element	Housng Dia-in, OAL-ft, Wt-lb	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
G	DUST COLLECTORS, BAGHOUSES																	
G-101	COAL SILO BAGHOUSE Vndr: Mikropul	113 10	+/-17	150	CS	Felted Polyster	30 11.6 850	1	EA	7,000		25	25		7,000			
G-102	CRUSHER FEED BIN BAGHOUSE Vndr: Mikropul	113 10	+/-17	150	CS	Felted Polyster	30 11.6 850	1	EA	7,000		25	25		7,000			
G-103A/B	COAL DRYER BAGHOUSE Vndr: Mikropul	7,540 10	+/-17	300	CS	Felted Nomex	30.5x10.5 23 35000	2	EA	90,000		90	180		180,000			
G-301A/B	CARBONIZER BAGHOUSE Vndr: Mikropul	113 10	+/-17	300	CS	Felted Nomex	30 11.6 850	2	EA	10,000		25	50		20,000			
G-401A/B	CALCINER BAGHOUSE Vndr: Mikropul	113 10	+/-17	300	CS	Felted Nomex	30 11.6 850	2	EA	10,000		25	50		20,000			
G-601A/B	FORMCOKE FINES BAGHOUSE Vndr: Mikropul	113 10	+/-17	150	CS	Felted Nomex	30 11.6 850	2	EA	10,000		25	50		20,000			
G-602A/B	BRIQUET FEED BAGHOUSE Vndr: Mikropul	113 10	+/-17	150	CS	Felted Nomex	30 11.6 850	2	EA	10,000		25	50		20,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							12	EA				430		274,000			

NOTE: PULSE JET TYPE, INCLUDES FIKE OR FENWALL EXPLOSION SUPPRESSION SYSTEM
BLOWERS ARE IN "K" ACCOUNT

BECHTEL CORPORATION
JOB NO. / CLIENT 20708-308 / UND/EERC AND AMAX
JOB TITLE MILD COAL GASIFICATION PROJECT- 1,000 T/D
JOB LOCATION CLAY COUNTY, INDIANA

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COST CODE	ITEM AND DESCRIPTION	Duty MMBtu/h	DP Shell, Tube psi	DT Shell, Tube F	Mat'l Shell, Tube	CA-in, Shell, Tube Wt- lb	Transfer Surface sf	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	TOTAL COST SUB-CONT.	TOTAL COST TOTAL
H	HEAT EXCHANGERS)																	
H-403A/B	CALCINER GAS HEAT EXCHANGER	4.13	35 35	1,300 2,000 (100 HIGH)	316 SS I 800	None None	610 Finned	2	EA	40,000		25	50		80,000			
H-404A/B	CALCINER GAS COOLER	5.3	35 100	1,400 250	316 SS	None 0.125	650 Finned	2	EA	18,700		25	50		37,400			
H-501A/B	OIL COOLER	25.3	50	250	304 SS	None	5,900	2	EA	226,000		50	100		452,000			
H-903	HP BOILER FEEDWATER HEATER	30	500 1,500	750 500				1	EA	96,000		80	80		96,000			
H-905	MAIN SURFACE CONDENSER	250	15 15	120 120	CS 304 SS	0.375 None	30,000	1	EA	390,000		2,880	2,880		390,000			
H-906	BRINE COOLER (Requires 2 parallel paths) Vndr: Alfa-Laval	137.4	100	250	304 SS PLATES	None None 30,000	13,900	1	EA	125,000		80	80		125,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							9	EA				3,240		1,180,400			

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COST CODE	ITEM AND DESCRIPTION	Cap'y SCFM ICFM	Delta P psi	Rotor Dia., in rpm	Mat'l Case, Rotor	Seal-Type, Mat'l	HP, RPM	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
K	COMPRESSORS, BLOWERS, FANS																	
K-101	BLOWER FOR BAGHOUSE G-101 Vndr: Robinson	600	18"SP		CS		3	1	EA	5,000		25	25		5,000			
K-102	BLOWER FOR BAGHOUSE G-102 Vndr: Robinson	600	18"SP		CS		3	1	EA	5,000		25	25		5,000			
K-103A/B	AIR BLOWR FR GRVTY TABLE C-103A/B	6,500					15	2	EA	W/C-103A/B		30	60		W/C-103A/B			
K-104A/B	AIR BLOWR FR GRVTY TABLE C-104A/B	8,000					20	2	EA	W/C-104A/B		40	80		W/C-103A/B			
K-105A/B	AIR BLOWR FR GRVTY TABLE C-105A/B	15,000					30	2	EA	W/C-105A/B		50	100		W/C-103A/B			
K-106A/B	REJECT COAL BLOWER Solids:18,835 lb/h, @ 84 lb/cf	410	6.5				20	2	EA	19,400		40	80		38,800			
K-107A/B	BLOWER FOR BAGHUSE G-103A/B Vndr: Robinson	42,000	10"SP		CS		125	2	EA	13,100		120	240		26,200			
K-301A/B	BLOWER FOR BAGHUSE G-301A/B Vndr: Robinson	600	10"SP		CS		3	2	EA	5,000		25	50		10,000			
K-302A/B	CARBONIZER REJECT CHAR BLOWER Solids: 5,427 lb/h, @ 58.8 lb/cf	175	5.5				10	2	EA	12,800		25	50		25,600			
K-401A/B	BLOWER FOR BAGHUSE G-401A/B Vndr: Robinson	600	10"SP		CS		3	2	EA	5,000		25	50		10,000			
K-402A/B	CALCINATE PRODUCT BLOWER Solids:25,100 lb/h, @ 56.2 lb/cf	620	5				25	2	EA	22,600		45	90		45,200			
K-403A/B	REJECT CALCINATE BLOWER Solids:657 lb/h, @ 61.5 lb/cf	30	7				5	2	EA	9,800		25	50		19,600			
K-404A/B	CALCINATE FINES PRODUCT BLOWER Solids:5,614 lb/h, @ 55.7 lb/cf	170	5.5				7.5	2	EA	12,500		25	50		25,000			
K-405A/B	AIR BLOWR FR GRVTY TABLE C-405A/B	5,000					25	2	EA	W/C-405A/B		45	90		W/C-405A/B			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							26	EA				1,040		210,400			

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COST CODE	ITEM AND DESCRIPTION	Cap'y SCFM ICFM	Delta P psi	Rotor Dia., in rpm	Mat'l Case, Rotor	Seal-Type Mat'l	HP, RPM	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
K	COMPRESSORS, BLOWERS, FANS (Contd)																	
K-406A/B	CALCINER RECYCLE GAS COMPRESSOR, STM TURBNE DRIVEN	4,870	12.5				300 bhp	2	EA	482,000		400	800		964,000			
K-501A/B	CARBONIZER GAS COMPRESSOR, STM TURBNE DRIVEN	17,810	23				1,455 bhp	2	EA	1,450,000		1,200	2,400		2,900,000			
K-502A/B	CARBONIZER BURNER AIR COMPRESSOR, STM TURBNE DRIVEN	6,120	10.2				295 bhp	2	EA	474000		400	800		948,000			
K-503A/B	CALCINER BURNER AIR COMPRESSOR, STM TURBNE DRIVEN	5,610	23				510 bhp	2	EA	555,000		800	1,600		1,110,000			
K-504-1,2	OIL TANK OFF-GAS COMPRESSOR,SPARE	2.4	14				7.5	2	EA	10,400		25	50		20,800			
K-601A/B	BLOWER FOR BAGHUSE G-601A/B	600	18"SP				3	2	EA	5,000		25	50		10,000			
K-602A/B	BLOWER FOR BAGHUSE G-602A/B	600	18"SP				3	2	EA	5,000		25	50		10,000			
K-603A/B	FORMCOKE FINES BLOWER	30	5				5	2	EA	9,800		25	50		19,600			
K-604A/B	FORMCOKE COOLING AIR BLOWER						7.5	2	EA	10,400		25	50		20,800			
K-605A/B	CURING OVEN EXHAUST BLOWER						7.5	2	EA	10,400		25	50		20,800			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							20	EA				5,900		6,024,000			

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COST CODE	ITEM AND DESCRIPTION	Cap'y gpm	TDH-ft, Delta P psi	Impeller Dia., in Act/Max	Mat'l Case, Impeller	Seal-Type Mat'l	HP, RPM	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
P	CENTRIFUGAL PUMPS, POSITIVE DISPLACEMENT PUMPS																	
CENTRIFUGAL PUMPS:																		
P-401A/B	V-401A/B SUCTION DRUM PUMP	10	23		CI CS		0.5 1,800	2	EA	11,400		25	50		22,800			
P-501A/B -1,2	QUENCH TOWER CIRC PUMP & SPARE Viking Type,Thrml Jkt	680	29		CI CS		25 1,800	4	EA	16400		25	100		65,600			
P-503 -1,2	OIL TRANSFER PUMP & SPARE Viking Type,Thrml Jkt	40	30		CI CS		1.5 1,800	2	EA	11,600		35	70		23,200			
P-505A/B	V-501A/B SUCTION DRUM PUMP	10	22		CI CS		0.5 1,800	2	EA	11,400		25	50		22,800			
P-901	MAIN BOILER FEED WATER PUMP Multistage,Stm Turb Dr	560	1,500		CI 316 SS		N/A	1	EA	140,000		410	410		140,000			
P-902	STARTUP BOILER FEED WATER PUMP Multistage	220	1,500		CI 316 SS		400 3,600	1	EA	67,000		250	250		67,000			
P-903 -1,2	CONDENSATE RECYCLE PUMP & SPARE Canned,100% Spare	560	50		CI 316 SS		50 3,600	2	EA	10,000		50	100		20,000			
P-904	FLASH TANK WATER PUMP	10	30		CI CS		5 1,800	1	EA	11,600		25	25		11,600			
P-905 -1,2,3	COOLING WATER PUMPS & SPARE Vertical,3-50%	35,000	30		CI CS		1,000 600	3	EA	190,000		450	1,350		570,000			
P-906 -1,2,3	BRINE PUMPS & SPARE 3-50%	3,500	35		CI CS		150 1,800	3	EA	22,600		130	390		67,800			
P-907 -1,2	RAW WATER PUMP & SPARE Vertical Well	3,500	35		CI CS		150 1,800	2	EA	24,500		130	260		49,000			
P-908 -1,2	WATER TREATMENT FEED PUMP, SPARE	50	80		CI CS		5 3,600	2	EA	10,500		25	50		21,000			
P-909-1	FIRE WATER PUMP	1,000	50		CI CS		40 3,600	1	EA	14,800		50	50		14,800			
P-909-2	BACKUP FIRE WATER PUMP DIESEL ENGINE DR	1,000	50		CI CS		N/A	1	EA	15,000		50	50		15,000			
P-910	FIRE WATER JOCKY PUMP	100	50		CI CS		5 3,600	1	EA	7,200		25	25		7,200			
P-911 -1,2	BOILER MAKEUP PUMP & SPARE	50	60		CI 316 SS		5 3,600	2	EA	10,500		25	50		21,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							30	EA				3,280		1,138,800			

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COST CODE	ITEM AND DESCRIPTION	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
P	CENTRIFUGAL PUMPS, POSITIVE DISPLACEMENT PUMPS (contd)											
POSITIVE DISPLACEMENT PUMPS:	Cap'y gpm / TDH-ft, Delta P psi / Impeller Dia., In Act/Max / Mat'l Case, Internal / Seal-Type, Mat'l / HP, RPM											
P-601A/B	BINDER FEED PUMP Metring,Pos Disp — Mat'l Case, Internal: CI CS — HP: 1	2	EA	6,500		25	50		13,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992	2	EA				50		13,000			

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COST CODE	ITEM AND DESCRIPTION	Cap'y Wkg Vol cf	Size Dia- ft Ht- ft	DP Postve, Vacuum	Mat'l Vessel, Lining	CA- WT-	in lb	Fabricted Shop, Field	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
T	STORAGE TANKS (ATMOSPHERIC, API), BINS, SILOS																		
T-101	COAL SILO, 48h cap'y	80,000	40 OAH 100		CS				1	EA	140,000		2,800	2,800		140,000			
T-102	CRUSHER FEED BIN	4,675	SQ 20 OAH 25		CS				1	EA	50,000		1,000	1,000		50,000			
T-103A/B	REJECT COAL HOPPER, 24h cap'y	2,700	11 29		CS				2	EA	33,800		60	120		67,600			
T-104A/B	COAL SURGE HOPPER, 2h cap'y	780	9 13		CS				2	EA	15,200		25	50		30,400			
T-301A/B	CARBONIZER FEED HOPPER, 2h cap'y	780	9 13		CS				2	EA	15,200		25	50		30,400			
T-302A/B	CARBNZR SCRNR FD HOPPER, 2h cap'y	750	9 12		CS				2	EA	14,800		25	50		29,600			
T-303A/B	CARBNZR REJCT CHAR HOPPER, 24h cap'y	1,100	10 15		CS				2	EA	17,300		30	60		34,600			
T-304A/B	CARBNZR CHAR SURGE HOPPER, 2h cap'y	660	9 11		CS				2	EA	14,100		25	50		28,200			
T-401A/B	CALCINER FEED HOPPER, 2h cap'y	660	9 11		CS				2	EA	14,100		25	50		28,200			
T-402A/B	CALCNTE PROD STRGE HOPPER, 48h cap'y	11,000	24 25	(	CS				2	EA		92,600						185,200	
T-403A/B	CALCINATE REJECT HOPPER, 24h cap'y	260	6 10		CS				2	EA	10,600		25	50		21,200			
T-404A/B	CALCNTE FINES PROD HOPPER, 48h cap'y	2,400	12 22		CS				2	EA	33,200		60	120		66,400			
T-501	OIL STORAGE TANK, API 120, 48h cap	1000 bbl	21.5 16	8 oz/si 0.5 oz/si	CS	0.125			1	EA		28,400						28,400	
T-601A/B	BRIQUETTING FEED HOPPER, 2h cap'y	410	7.5 11		CS				2	EA	12,700		25	50		25,400			
T-602A/B	BRIQUETING FINES FD HOPPER, 2h cap'y	90	4.5 6.5		CS				2	EA	8,400		25	50		16,800			
T-603A/B	BINDER FEED TANK, 2h cap'y	20 bbl	4.5 7		CS				2	EA	8,500		25	50		17,000			
T-604A/B	FORMCOKE PRODUCT SILO				CS				2	EA		207,700						415,400	
T-903	BRINE TANK, API 120, 6min cap	1000 bbl	21.5 16	8 oz/si 0.5oz/si	CS	0.125			1	EA		28,400						28,400	
T-904	RAW WATER TANK, API 120	5000 bbl	55 24	3 oz/si 0.5oz/si	CS	0.125			1	EA		136,700						136,700	
T-905	DEMIN WATER TANK, API 120	3000 bbl	29.75 24	4 oz/si 0.5oz/si	CS Epoxy				1	EA		74,100						74,100	
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992								34	EA				4,550		585,800		868,200	

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COST CODE	ITEM AND DESCRIPTION	Cap'y Wkg Vol cf	Size Dia- ft T/T- ft	DP psig	DT F	Mat'l Vessel	CA- in WT- lb	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
V	PRESSURE VESSELS																	
V-401A/B	CALCINER RECYCLE GAS COMP S DRUM Vert., demist pad	125	4 11	25	500	CS		2	EA	12,400		25	50		24,800			
V-501A/B	CARBONIZER GAS COMP S DRUM Vert.	310	6 12	15	1,400	CS		2	EA	43,000		25	50		86,000			
V-901	DEAERATOR Vert.	110	4.5 7.5	75		CS 516-70	0.375 8,000	1	EA	80,000		80	80		80,000			
V-902	BOILER BLOWDOWN DRUM, Vert.	280	6 8	75		CS	0.25 3,000	1	EA	18,700		25	25		18,700			
V-903	CONDENSATE FLASH TANK, Vert.	100	4 6	15		CS	0.25 1,500	1	EA	10,700		25	25		10,700			
V-904	DEAERATOR STORAGE TANK, Horiz.	1,700	8 17	75		CS 516-70	0.5 17,000	1	EA	W/V-901		W/V-901			W/V-901			
V-905	FUEL GAS DRUM, Vert.					CS		1	EA	18,400		25	25		18,400			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							9	EA				260		238,600			

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COST CODE	ITEM AND DESCRIPTION	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
Z	PACKAGED EQUIPMENT & SYSTEMS											
Z-901	ATMOSPHERIC FLUIDIZED BED COMBUSTOR (AFBC): INCLUDES ERECTION Vendor: Tampella Power Co. Complete boiler system (B1) to generate 280,000 lb/h steam @ 1200psia & 950°F, with superheaters (H6,H8), economizer (H5), air heaters (H1,H2,H3, & H4), steam drum (T4), attemperator (H7), waterwalls, mud drums, boiler trims, and soot blowers. The package includes: 1. Duel fuel silos for reject coal (T1) & reject char (T2) 2. Fuel weighing and feed equipment (F1 & F2, 10 HP/ea) 3. Limestone silo (T3), limestone feed equipment (F3,10 HP), and limestone blower (K4,20 HP) 4. Baghouse (G5) with eight ash dischage outlets 5. Primary blower with 300 HP motor (K8) 6. Induced draft fan with 1000 HP motor (K5) 7. Secondary air blower with 1000 HP motor (K7) 8. All ducts and breechings 9. Boiler support steel 10. Soot blower control system, 20 HP connected total 11. Burner management system 12. Boiler trim consists of: a. Boiler non-return valve (motor operated) b. Steam drum and superheater safety relief valves c. Electromatic relief valve with 2 HP motor d. Continuous blowdown valves (2 in tandem) e. Mud drum and lower header blowdown valves f. All vent and drain valves g. Steam drum level gauges and remote level indicators h. Steam drum and superheater temperature indicators i. Superheater temperature control spray assembly 13. Cyclone separator (C1) and ash reinjection system 14. Natural gas startup burner 15. Fuel hopper baghouses (G1 & G2) & vent blowers (K1 & K2), each with 3 HP motor 16. Limestone hopper baghouse (G3) and vent blower (K3) with 3 HP motor 17. Steam coil airheaters for primary and secondary airheaters (H2 & H3) 18. Fly ash blower (K6,10 HP) and steam coil airheater (H4) 19. Seal pot blower with 150 HP motor (K9)	1	EA		16000000						16,000,000	
	LIME STONE RECEIVING AND TRANSFER SYSTEM CONSISTS OF:	1	EA	645,000		2,600	2,600		645,000			
T-202	SILO: CAP 755 TN (36 HR), 28'D,46'S/S,75.5'OAL											
SP-202	SILO DISCH GATE:											
F-202	BELT FEEDER:											
F-204	TRANSFER CONVEYOR:25 T/HR,24"W,480'L,120' LIFT,20 HP											
SP-204	BELT SCALE: 25 T/HR											
G-201	SILO VENT BAGHUSE:600 CFM, 113 SF,											
K-201	VENT BLOWER: 600 CFM											
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992	2	EA				2,600		645,000		16,000,000	

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COST CODE	ITEM AND DESCRIPTION	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	TOTAL COST SUB-CONT.	TOTAL COST TOTAL
Z	PACKAGED EQUIPMENT & SYSTEMS (contd)											
Z-902	TURBOGENERATOR SYSTEM: Vendor: ABB Double automatic extraction/condensing steam turbine complete with 3600 rpm, 19,620 kva totally-enclosed synchronous generator and brushless excitation system, including: 1. Complete combined hydraulic and lube oil system with reservoir, two full capacity AC motor-driven pumps, one DC emergency oil pump, two lube oil coolers, filters, etc. 2. Steam seal system 3. Woodward 50 SE governor and selected instruments and controls 4. Four fin-tube surface air coolers for generator heat sink (water to air coolers) 5. Lube oil, control oil, steam seal and leak-off piping 6. AC motor-driven turning gear, 5 HP 7. Gland steam condenser (H1)	1	EA	6,200,000		4,400	4,400		6,200,000			
	VENDOR REPRESENTATIVE: 100 DAYS @ SITE ALLOW	1	LOT		100,000						100,000	
Z-903	WATER TREATMENT SYSTEM: Vendor: Glegg Water Cond. Co. 50 gpm treatment system to provide demin water to the AFBC. System includes: 1. Two full capacity carbon filters (X1 & X2) 2. Two full capacity zeolite softeners (X3 & X4) 3. Two full capacity cartridge filters (X5 & X6) 4. Two full capacity reverse osmosis (RO) units (X7 & X8) 5. Two full capacity mixed bed demineralizers (X9 & X10) 6. Three 50% capacity RO feed pumps (P1, P2 & P3,25 HP/ea) 7. Three 50% capacity demineralizer feed pumps (P4,P5&P6,5 HP/ea 8. Chemical injection systems for acid and anti-scaling (T2 & P7, 0.5 HP; T3 & P8, 0.5 HP) 9. RO product storage tank (T1) 10. Interconnecting piping and valves, PLC-based controller	1	EA	650,000		850	850		650,000			
Z-904	COOLING TOWER: Vendor: MARLEY Five-cell (including spare) field erected, wooden, counter-flow, cooling tower with the following features and accessories: 1. 65,000 gpm cooling water capacity from 105°F to 88°F with 77°F wet bulb 2. 240'L x 48'W framework with 246'x54' concrete basin 3. Five (5) fans, each with 200 HP 460 V motor and gear reducer 4. Deluge type fire protection system	1	EA		1200000						1,200,000	
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992	4	EA				5,250		6,850,000		1,300,000	

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COST CODE	ITEM AND DESCRIPTION	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	TOTAL COST SUB-CONT.	TOTAL COST TOTAL
Z	PACKAGED EQUIPMENT & SYSTEMS (contd)											
Z-905	ASH HANDLING SYSTEM: Vendor: JOY Bottom ash and fly ash removal system to handle ashes generated at the fluidized bed combustor. System includes: 1. Bottom ash hopper (T1) & fly ash hopper (T2) 2. Water cooled drag chain for bottom ash (F1, 5 HP) 3. Bottom ash fluid bed air blower (K3, 5 HP) & air heater (H1) 4. Fly ash fluid bed air blower (K4, 5 HP) & air heater (H2) 5. Bottom ash baghouse (G1) and vent blower (K1, 3 HP) 6. Fly ash baghouse (G2) and vent blower (K2, 3 HP)	1	EA	650,000		9,000	9,000		650,000			
NOTE: JOY	OFFERS SCREW CONVEYOR FOR 2.QUOTE ADJUSTD TO INCLD DRAG CONVEYOR											
Z-906	CHEMICAL INJECTION SYSTEM: SKID MOUNTED ALLOW Vendor: Chemical injection tank and six pumps each with 2 HP motor	1	EA	35,000		100	100		35,000			
Z-907	PLANT & INSTRUMENT AIR SYSTEM: Vendor: 1000 SCFM air system to supply plant and instrument air to the en the entire plant. System includes: 1. Compressor and spare equipped with inlet filter, intercooler and aftercooler to produce 150 psig. 2. Complete automatic dryer unit to provide -40°F dew point 3. Instrument air receiver 4. Plant air receiver	1	EA	300,000		700	700		300,000			
Z-908	CONDENSATE POLISHER SYS: 30% FLOW REQUIRED = 170 GPM 100%	1	EA	300,000		400	400		300,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992	4	EA				10,200		1,285,000			

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COST CODE	ITEM AND DESCRIPTION			QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	TOTAL COST SUB-CONT.	TOTAL COST TOTAL
	MAJOR ELECTRICAL, AND CONTROL SYSTEM COMPONENTS													
	METERS-	13.8 KV	@ IQ DATA PLUS 2 OR EQUAL	2	EA	2,000		20	40		4,000			
	SWITCHGEAR-	13.8 KV, 24 MVA	3 BRKRs, 1200 A	1	EA	120,000		170	170		120,000			
	SWITCHGEAR-	4160 V, 6 MVA	2 BRKRs, 800 A	2	EA	35,000		60	120		70,000			
	TRANSFER SWITCH-	4160 V, 6 MVA, AUTOMATIC	ALLOW	2	EA	40,000		60	120		80,000			
	DISCONNECT SWITCH-	4160 V MANUAL		8	EA	2,500		8	64		20,000			
	TRANSFORMER-	13.8 KV - 4160 V, 6 MVA		2	EA	120,000		200	400		240,000			
	TRANSFORMER-	4160 V - 480 V, 1 MVA		4	EA	24,000		100	400		96,000			
	TRANSFORMER-	480 V - 120 V, 30 KVA		20	EA	1,500		25	500		30,000			
	UPS SYSTEM-	50 KVA Static converter type INCLDS BATTERIES,RACKS,CHARGERS,INVERTERS		1	EA	200,000		250	250		200,000			
	BALANCE EQUIPMENT-			1	LOT	310,000		2,100	2,100		310,000			
	DCS SYSTEM & ASSOCIATED COMPONENTS-			1	LOT	1,500,000		6,600	6,600		1,500,000			
	STACK MONITORING SYSTEM-			1	LOT	200,000		350	350		200,000			
	WATER/STEAM SAMPLING SYSTEM-			1	LOT	150,000		250	250		150,000			
	VENDOR REPRESENTATIVE-	300 DAYS @ SITE		1	LOT		300,000						300,000	
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992			47	EA				11,360		3,020,000		300,000	

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COST CODE	ITEM AND DESCRIPTION	Size Dia- in Ht- ft	DP psig	DT F	Mat'l	WT- lb	HP, RPM	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
C,H,J,M, N,Q,R	MISCELLANEOUS EQUIPMENT																	
C-101A/B -1,2	COAL CYCLONE 2 cyclones in parallel,each trn Vndr: Sprout	113 30	+/-17"WG	300	CS	3,400		4	EA	30,000		25	100		120,000			
C-103A/B	FINE COAL GRAVITY TABLE Vndr:Trple/SDyn.	6.25 t/h -24 mesh 25 SF				6,000	Deck-2 Blowr-15	2	EA	22,000		40	80		44,000			
C-104A/B	INTERMEDATE COAL GRAVITY TABLE Vndr:Trple/SDyn.	7.5 t/h 10x24 mesh 25 SF				6,000	Deck-2 Blowr-20	2	EA	30,000		40	80		60,000			
C-105A/B	LARGE COAL GRAVITY TABLE Vndr:Trple/SDyn.	10 t/h 0.25x10 mesh 25 SF				6,000	Deck-2 Blowr-30	2	EA	41,000		40	80		82,000			
C-301A/B -1,2	PRIMRY CARBONZR CYCLONE 2 cyclones in parallel,each trn Vndr: Sprout	113 30	20	1,400	CS, REFRACT LINED	3,400 +linng		4	EA	43,000		50	200		172,000			
C-302A/B -1,2	SECONDY CARBONZR CYCLONE 2 cyclones in parallel,each trn Vndr: Sprout	113 30	20	1,400	CS, REFRACT LINED	3,400 +linng		4	EA	43,000		50	200		172,000			
C-304A/B	FINES MAGNETIC SEPARATOR Vndr: Eriez	36 1'W drum 15 t/h -40 mesh				2,700	3 300 fpm, drum spd	2	EA	30,000		40	80		60,000			
C-305A/B	INTERMD MAGNETIC SEPARATOR Vndr: Eriez	36 1'W drum 15 t/h 40x20 mesh				2,700	3 300 fpm, drum spd	2	EA	30,000		40	80		60,000			
C-306A/B	LARGE PART. MAG SEPARATOR Vndr: Eriez	36 1'W drum 15 t/h +20 mesh				2,700	3 300 fpm, drum spd	2	EA	30,000		40	80		60,000			
C-401A/B -1,2	PRIMRY CALCINER CYCLONE 2 cyclones in parallel,each trn Vndr: Sprout	113 30	30	1,900	CS, REFRACT LINED	3,400 +linng		4	EA	43,000		50	200		172,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							28	EA				1,180		1,002,000			

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COST CODE	ITEM AND DESCRIPTION	Size Dia- in Ht- ft	DP psig	DT F	Mat'l	WT- lb	HP, RPM	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
C,H,J,M, N,Q,R	MISCELLANEOUS EQUIPMENT (contd)																	
C-402A/B -1,2	SECONDY CALCINER CYCLONE 2 cyclones in parallel,each trn Vndr: Sprout	113 30	30	1,900	CS, REFRACT LINED	3,400 +linng		4	EA	43,000		50	200		172,000			
C-405A/B	CALCINER GRAVITY TABLE Vndr:Trple/SDyn.	2 t/h -40 mesh 25 SF				6,000	Deck-2 Blowr-25	2	EA	21,000		40	80		42,000			
C-601A/B	BRIQUET FINES CYCLONE							2	EA	43,000		50	100		86,000			
C-602A/B	FORMCOKE FINES CYCLONE							2	EA	43,000		50	100		86,000			
H-101A/B	COAL DRYER- moisture redctn 13% to 8% W/DUCTWORK,CONT	45 t/h Fluid bed type PNL					25	2	EA	470,000		2,300	4,600		940,000			
H-301A/B	CARBONIZER CHAR COOLER Vndr:HoloFlite	8.8 MMbtu/h Screw type	Screw 150 Jkt 30		CS	44,860	30	2	EA	305,000		120	240		610,000			
H-401A/B	BED CALCINATE COOLER Vndr:HoloFlite	10.7 MMbtu/h Screw type	Screw 150 Jkt 30		CS	44,860	30	2	EA	305,000		120	240		610,000			
H-402A/B	CALCINATE FINES COOLER Vndr:HoloFlite	2.7 MMbtu/h Screw type	Screw 150 Jkt 30		CS	19,690	3	2	EA	145,000		80	160		290,000			
H-502	OIL STORAGE TK HEATER	0.65 MMbtu/h Electric bayonet type					191 KW	1	EA	10,000		24	24		10,000			
H-601A/B	BRIQUET CURING OVEN							2	EA	200,000		1,000	2,000		400,000			
J-101A/B	COAL CRUSHER size reduction 2"x0 to 1/4"x0 Vndr: Penna.	50 t/h 6'L,4'W, 5'H,Dble roll type				11,000	2 @ 15 2 @ 30	2	EA	125,000		130	260		250,000			
J-601A/B	BRIQUET PRESS						750	2	EA	1,190,000		5,300	10,600		2,380,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							25	EA				18,600		5,876,000			

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COST CODE	ITEM AND DESCRIPTION	Size Dia- ft Ht- ft	DP psig	DT F	Mat'l	CA-in, WT- lb	HP, RPM	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
C,H,J,M, N,Q,R	MISCELLANEOUS EQUIPMENT (contd)																	
M-101A/B	CARBONIZER FEED MIXER Vndr: Koflo	20 t/h Vert,Static type 8"D,50"L						2	EA	2,100		8	16		4,200			
M-301A/B	CARBONIZER FEED MIXER Vndr: Koflo	10 t/h Vert,Static type 6"D,33"L						2	EA	1,400		8	16		2,800			
M-501	OIL STORAGE TANK MIXER	Paddle type,roof mounted			Shaft-CS Blades- 316 SS		7.5 Gear Red	1	EA	11,000		60	60		11,000			
M-601A/B	BRIQUETTING FEED MIXER	Paddle					15	2	EA	14,200		80	160		28,400			
N-901	BOILER STACK	T-8,B-12 300 Steel						1	EA	160,000		4,000	4,000		160,000			
Q-501A/B	QUENCH TOWER Vert, Trays:410 SS, 9 discs,8 donuts, @ 20"	9 37	20/FV	1,400	CS	0.125		2	EA	380,000		120	240		760,000			
R-301A/B	CARBONIZER Spoutd bed type, multiple coal injectn,ceramic distrbtn medium, 3hr resdnce time	14.25 28.5 L/D=2 4 fps gas vel	20	1,400	CS Refract lined			2	EA	400,000		600	1,200		800,000			
R-401A/B	CALCINER Bubing bed type, ceramic distrbn medium, 3hrs residence time	17.25 26 L/D=1.5 2 fps gas vel	30	1,900	CS Refract lined			2	EA	480,000		700	1,400		960,000			
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							14	EA				7,090		2,726,400			

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COST CODE	ITEM AND DESCRIPTION	Size Dia- ft Ht- ft	DP psig	DT F	Mat'l	CA-in, WT- lb	HP, RPM	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	MATERIAL	TOTAL COST LABOR	SUB-CONT.	TOTAL
C,H,J,M, N,Q,R	MISCELLANEOUS EQUIPMENT (contd)																	
MISC.	AIRLOCK Vndr: Sprout or Nikropul				CS		1	62	EA	2,500		16	992		155,000			
	SCREW FEEDER Vndr: Nikropul				CS		2	2	EA	7,500		40	80		15,000			
	SLIDE GATE Vndr: Pebco						2	4	EA	25,000		40	160		100,000			
	METAL DETECTOR Vndr: Eriez	50 t/h						2	EA	8,500		30	60		17,000			
	OVERHEAD ELCTRO-MAGNETIC SEPARA-TOR Vndr: Eriez	50 t/h					1	2	EA	15,000		30	60		30,000			
	BELT SCALE Vndr: Ramsey	250 t/h +/-0.25% accuracy				800		1	EA	11,000		30	30		11,000			
	BELT SCALE Vndr: Ramsey	50 t/h +/- 0.5% accuracy				400		1	EA	10,000		25	25		10,000			
	STATIONARY MAINT. EQUIPMENT:			HOIST (EA)- MONORAIL (EA)- STRAINERS (EA)- MISCELLANEOUS		10 10 40	ALLOW	1	LOT	100,000		1,000	1,000		100,000			
	OTHERS:																	
	ADJUST																	
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992							75	EA				2,410		438,000			

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COST CODE	ITEM AND DESCRIPTION	QTY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MANHOURS UNIT	MANHOURS TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	TOTAL COST SUB-CONT.	TOTAL COST TOTAL
	BULKS											
	ELECTRICAL	1	LOT	1,086,000	324,000	41,900	41,900		1,086,000		324,000	
	CIVIL/STRUCTURAL	1	LOT	3,160,000	3805000	124800	124,800		3,160,000		3,805,000	
	PIPING	1	LOT	3,744,000	588,000	135500	135,500		3,744,000		588,000	
	INSTRUMENTATION											
	PRIMARY ELEMENT: FE(12), TFS(10), ULS(3), TC W/WELL(28)	53	EA	350		4	212		18,600			
	GAUGES: LG(1), PG(22), DPG(19), TG W/WELL(31)	73	EA	270		4	292		19,700			
	SWITCHES: FS/TFS(12), LS/ULS(45), PS(5), DPS(15), RPMS(19), Vibs(5)	101	EA	690		8	808		69,700			
	TRANSMITTER: FT(4), PT(20), TT(28), DPT(36)	88	EA	1,010		12	1,056		88,900			
	ANALYZER:	2	EA	20,000		24	48		40,000			
	MAG FLOW METER:	1	EA	4,000		24	24		4,000			
	CONTROLLER: PLC	6	EA	26,000		30	180		156,000			
	WEIGH BELT FEEDER CONTROLLER:	14	EA	4,000		24	336		56,000			
	WEIGH SCALE:	16	EA	14,380		16	256		230,100			
	METAL DETECTOR:	1	EA	1,000		16	16		1,000			
	CONTROL VALVES: INCLDS AIR ACTUATED ON/OFF VLVS	55	EA	4,000		12	660		220,000			
	SOLENOID VALVES:	70	EA	250		6	420		17,500			
	ALLOWANCE FOR MISSING ITEMS	1	LOT	184,300		860	860		184,300			
	TUBING, LOCAL MOUNTING & MISC. MAT/OPS	1	LOT	26,600		1,130	1,130		26,600			
	TEST & CALIBRATE	1	LOT			1,150	1,150					
	TOTAL ESTIMATED PRESENT DAY- 2ND QUARTER 1992						309,650		9,122,400		4,717,000	

11.0 PROJECT FINANCIAL ANALYSIS

11.1 General

A preliminary financial analysis was carried out using the capital cost estimate prepared by XBi and an operating cost estimate prepared by AMAX. J. E. Sinor supplied the product revenue data.

11.2 Formed Coke Value

A wide range of opinions exists as to the potential market value of formed coke. Because it is not a currently purchased commodity in the steel industry, there is no precise measure of its value. It is generally expected that formed coke would be somewhat less valuable than conventional metallurgical coke, because the formed coke properties will be less desirable or may require changes in blast furnace operating procedures. A fully optimized formed coke process could theoretically produce a more uniform product and might eventually command a higher market price. Prices of as much as $200 per ton have been suggested for such a premium, low-sulfur product. At the moment, that possibility is purely speculative.

Because only a small fraction of the total amount of coke produced is actually sold in a market transaction, reported prices fluctuate a great deal in response to changing demand. Prices in the past have generally ranged from about $80 to $150 per ton. Current values appear to lie in the range $100 to $120. Prices required for investment replacement are expected to be $150 to $160 per ton. A value analysis, in which the value of coke was computed as the product of the additional output of steel generated by a marginal increase in coke times the price of steel), led to a price of $157 per ton.

The biggest hurdle for a formed coke produced from Indiana coal is to make a product that will be marketable from the standpoint of sulfur content. Standard practice is to set an absolute limit of 1.0% sulfur in coke. In actuality, there is nothing magic about this value. Higher sulfur levels simply mean more expense in removing sulfur during the steelmaking process. In the United Kingdom, because of the scarcity of low-sulfur coking coals, a sulfur level of up to 1.5% in metallurgical coke is tolerated. However, there seems to be a general consensus that sulfur should be no higher than 1.0% for the U.S. market.

In spite of the key importance of sulfur in coke, there is no widely accepted scale for coke value as a function of sulfur content. Depending on the individual coke producer, sulfur penalties or premiums may be assessed on coking coal, ranging from $1.00 to $2.50 per ton per 0.1% sulfur above or below a desired level such as 0.7%. If it is assumed that these values flow through to the coke and that they can be extended to higher sulfur levels, a 3% sulfur coke might have to carry a discount of $30 to $70 per ton. The lower figure might be acceptable, but there is no indication that a 3% sulfur coke could be sold even at a much higher discount.

For the purposes of this analysis, it was assumed that a formed coke with no more than 1.0% sulfur could be produced and that the market value would be between $100 and $200 per ton.

11.3 Electricity Value

The project case analyzed has only two products--formed coke and electricity. If the project could be structured as a cogeneration facility, it could obtain "qualifying facility" status from the Federal Energy Regulatory Commission. This results in certain financial benefits for the plant owner. The electrical utility in whose service area the plant is built would be required to purchase the electricity produced by such a facility.

Without designation as a cogeneration facility, the formed coke plant would be classified as an independent power producer (IPP). As an IPP, electricity sales would have to be negotiated with a utility. It would not necessarily have to be the utility in whose service area the plant is located. Electricity could be "wheeled" over the transmission lines of the local utility to the final purchaser.

Current electricity purchase prices offered by Indiana utilities are on the order of \$0.03 per kWh (combined energy rate and demand rate). However, the current price being paid for electricity by the Chinook mine is on the order of \$0.04 to \$0.05 per kWh. Therefore, power could be supplied to the mine by the mild gasification plant to realize an internal income of up to \$0.05 per kWh. In the future, when the utilities again begin building new generation facilities, it is expected that their avoided cost could go as high as \$0.07 per kWh. Therefore, the electricity prices used for a sensitivity analysis were \$0.03, \$0.05 and \$0.07 per kWh.

11.4 Product Rates

11.4.1 Formed Coke

To obtain a product flow rate for use in the financial analysis, the following streams from the XBi report were used:

- Stream 13: calcinate, 25,100 lb/hr.
- Stream 15: calcinate fines, 5,614 lb/hr.
- Stream 20: tar oil, 5,278 lb/hr.

Streams 13a and 15 are at 7% volatiles content, while the final formed coke product is assumed to be at 4.5% volatiles. Furthermore, it was assumed that 40% of the tar oil used as binder is volatilized during briquette curing. Therefore, total product yield was computed by:

- Stream 13a: 25,100 x 0.955 = 23,970 lb/hr.
- Stream 15: 5,614 x 0.955 = 5,361 lb/hr.
- Stream 20: 5,278 x 0.60 = 3,167 lb/hr.
- Total = 32,498 lb/hr.

On the basis of 330 days per year, total formed coke product for revenue is then 128,700 tpy.

11.4.2 Electricity

The gross plant electrical capacity in the XBi design is 24 MW, with a net output for sale of 19.2 MW. On the same basis of 330 days per year, the total production for revenue is 152 million kWh per year. It appears that this figure may be low because it is not clear that the fuel value of that fraction of the binder volatilized during curing has been added to the fuel stream. If that is the case, electrical output should be increased by over 10%.

11.5 Capital Costs

The total capital cost determined by XBi is $116.4 million in 1992 dollars. A 3-year construction schedule was assumed, with expenditure profile as follows:

- 40% in 1995.
- 30% in 1996.
- 30% in 1997.

The first year of production is 1998, and production starts at full capacity. Operating life is 20 years, and a salvage value of 20% of capital cost was assumed.

11.6 Operating Costs

11.6.1 Coal

The major operating cost is the cost of coal. Plant input is 1,000 tons per day, dry basis, at 8.2% moisture. This translates to 1,089 tpd wet basis, or 359,477 tpy. It takes 2.79 tons of coal to produce a ton of formed coke.

The nominal price of coal is $20 per ton, and sensitivity cases were run at $15 and $25 per ton.

11.6.2 Limestone

To calculate limestone required for sulfur removal, the following data were used:

- 90% sulfur removal efficiency.
- 2,047 lb/hr sulfur removed (streams 2, 8, 16, 20, and 26).
- 1 mole of CaO per mole of sulfur = 1.75 lb CaO per lb of S.
- Limestone = 56% CaO.
- 1.8 stoichiometric ratio limestone/sulfur.
- 45,600 tpy limestone.
- Cost of crushed limestone, $7/ton.
- Total cost: $319,000.

11.6.3 Disposal Costs

Fly ash and spent limestone/gypsum are disposed of in the coal mine. Disposal costs were calculated as follows:

- 5,375 lb/hr fly ash (streams 2, 8, and 16).
- 5,117 lb/hr excess limestone.
- 11,000 lb/hr gypsum ($CaSO_4 \bullet 2H_2O$).
- Disposal cost, $2/ton.
- Total cost: $170,200/yr.

11.6.4 Water

Water requirements were calculated as follows:

- Cooling tower heat load 350 million Btu/hr.
- Assume 75% latent heat transfer.
- 270,600 lb/hr evaporated = 32,000 gal/hr.
- Adding blowdown and drift, need at 40,000 gal/hr.
- 317 million gal/yr.
- Cost $0.50 per 1,000 gal.
- Total cost: $158,400/yr.

11.6.5 Chemicals

Water treatment chemicals include:

- Biocide for cooling tower, $32,000/yr.
- Boiler feed water treatment, $24,000/yr.
- Makeup brine and glycol, $8,000/yr.
- Total cost: $64,000/yr.

11.6.6 Supplies and Maintenance

Calculated as 2.5% of capital cost, or $2,910,000/yr, including labor for maintenance.

11.6.7 Other Costs

There is no cost for electricity, since the 5 MW required to operate the plant is deducted from the gross output of the power plant and is not sold as product. Compressed air is included in the electric power consumption. Some natural gas is used in the plant for starting up the briquette curing oven, but the amount is small and is less than $5,000 per year so it was not included in the operating costs. Wastewater disposal costs were also so small that they were not included.

11.6.8 Manpower

Operating labor costs were estimated as follows:

- Operations, 40 persons, $2,617,000/yr.
- Support, 10 persons, $482,000/yr.
- Engineering, 7 persons, $534,000/yr.
- Supervision, 7 persons, $591,000/yr.
- Total cost: $4,224,000/yr.

11.6.9 Operating Cost Summary

Total operating costs amount to $15,041,000 per year, as summarized in Table 1.

11.7 Financial Evaluation

11.7.1 Evaluation Parameters

Financial analyses were carried out using the following parameters:

- 4% general inflation rate.
- All costs and revenues inflated at 4% per year.
- 100% equity basis.
- Taxes calculated on stand-alone project basis.
- Project subject to Indiana income taxes.

TABLE 1

Operating Cost Summary (dollars per year)

		Totals
Feedstocks		
Coal ($20/ton)	$7,190,000	
Limestone	$319,000	
		$7,509,000
Chemicals		$64,000
Disposal		$170,000
Supplies and Maintenance		$2,910,000
Utilities		
Gas	$5,000	
Water	$158,000	
Wastewater	$1,000	
		$164,000
Labor		
Operations	$2,617,000	
Support	$482,000	
Engineering	$534,000	
Supervision	$591,000	
		$4,224,000
Grand Total		$15,041,000

11.7.2 Base-Case Results

Base-case results are combined with a capital cost sensitivity analysis in Figure 5 and Table 2. For the best-guess capital cost estimate of $116.4 million, the discounted cash flow rate of return (DCFRR) is 8.1% at a formed coke price of $150 per ton. Increasing the capital cost by 20% drops the rate of return to 6.9%, and decreasing the capital cost by 20% increases the rate of return to 9.6%.

Indicated in the figure for reference are the estimated formed coke value for current coke prices and also the value required to justify replacing conventional coke ovens. If formed coke values reach the latter level, the base-case DCFRR becomes 8.9%.

The calculated rate of return is not sufficiently attractive to draw outside investors into such a project. The major reason for the poor economics as compared to conventional coke ovens is the small plant size and consequent high cost per unit of capacity. In terms of unit cost, the mild gasification formed coke plant costs $900 per yearly ton of capacity, about 3 times the estimated cost for conventional coke ovens. This overwhelms the fact that cheaper coals can be used as feedstock. The small size does not appear to be an attractive commercial venture. Thus a plant of this size should more properly be considered a demonstration project and not expected to earn full commercial rates of return on investment.

11.7.3 Sensitivity to Electricity Prices

The effect of three different levels for the price of electricity is shown in Figure 6 and Table 3. The nominal level of $0.05/kWh corresponds to electricity replacement cost at the Chinook mine. As before, the indicated rate of return is 8.1% at a coke price of $150/ton. Decreasing the price of electricity to $0.03/kWh, the current avoided cost offered by Indiana utilities, drops the rate of return to 5.8%. Increasing the price of electricity to $0.07/kWh, the expected future value, increases the rate of return to 10.1%. Electricity prices thus have a major effect on the project's financial performance.

11.7.4 Sensitivity to Coal Cost

The effect of three different levels for coal cost is shown in Figure 7 and Table 4. The nominal level of $20/ton corresponds to the expected cost of coal from the Chinook mine. As before, the indicated rate of return is 8.1% at a coke price of $150/ton. Increasing the cost of coal to $25/ton decreases the rate of return to 6.8%. Decreasing the cost of coal to $15/ton raises the rate of return to 9.4%. Although the effect is significant, coal cost swings of this magnitude cannot push the project into an attractive financial regime.

11.7.5 Probability Distribution on Cost Sensitivity

A final economic run investigated the result of a probability distribution on capital costs. The results shown earlier in Figure 5 simply give the values (DCFRR) which would result from specific changes in capital cost. In reality, capital cost may be

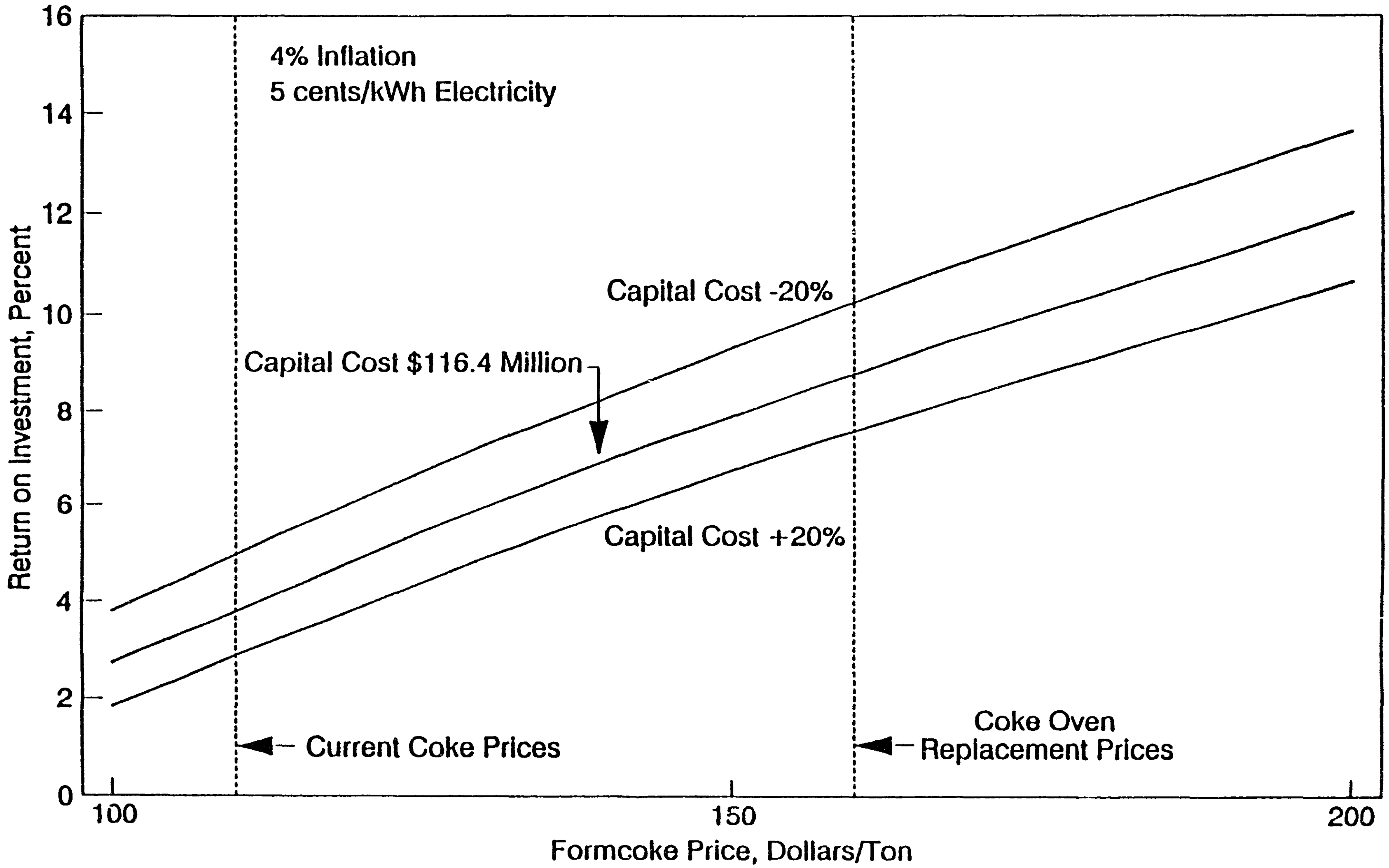

Figure 5. DCFRR as a function of capital cost and formed coke prices.

TABLE 2

Capital Cost Sensitivity
(discounted cash flow rate of return)

	DCFRR, percent
Nominal Capital Cost	
Coke Price $100/ton	2.7
Coke Price $150/ton	8.1
Coke Price $200/ton	12.0
Capital Cost Reduced 20%	
Coke Price $100/ton	3.8
Coke Price $150/ton	9.6
Coke Price $200/ton	13.7
Capital Cost Increased 20%	
Coke Price $100/ton	1.8
Coke Price $150/ton	6.9
Coke Price $200/ton	10.7

thought of as a random variable whose most likely value is the estimate of a $116.4 million. If the plant is actually built, it could end up costing less than the estimate, but it is far more likely to end up costing more than the estimate. This effect can be analyzed using the technique of Monte Carlo analysis.

A triangular probability distribution for capital costs was assumed, with $116.4 million as the most likely value, $92.8 million as the lower limit, and $151.3 million as the upper limit. Using a random number generator to choose capital values from the triangular probability distribution, several hundred computer runs were then made to generate probability distributions for the DCFRR as a function of formed coke prices. Results are presented in Figure 8 and Table 5.

Shown are the DCFRR values for 10%, 25%, 50%, 75% and 90% probabilities. These may be interpreted as follows. For any given coke price, there is a 90% probability that the DCFRR will exceed the values on the lower line in Figure 8, a 75% probability that the DCFRR will exceed the values on the second lowest line, a 50% probability that the DCFRR will exceed the values on the middle (heaviest) line, etc. Thus the thickness of the lines in Figure 8 indicates, in a qualitative way, the likelihood of the actual project rate of return falling in the vicinity of the line. It is most likely to fall near the middle line and increasingly less likely to fall on the lines farther away from the middle.

Because cost overruns are more likely than cost underruns, the probable DCFRR is shifted toward the lower lines. Thus as seen in Table 5, the base-case rate of return (50% probability) at $150 coke price is 7.9%, compared to 8.1% for the nominal case in Table 2.

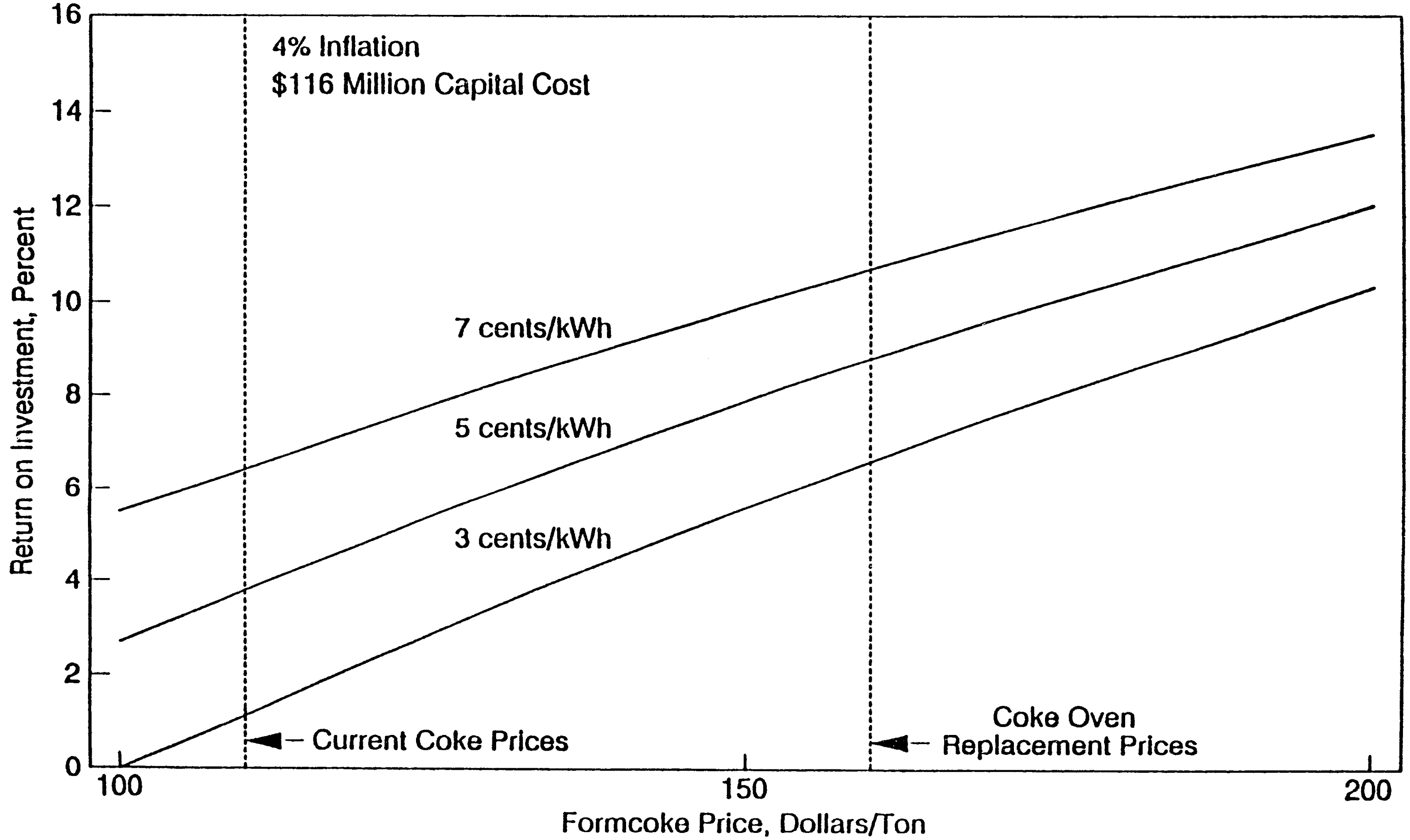

Figure 6. DCFRR as a function of formed coke and electricity prices.

TABLE 3

Electricity Price Sensitivity
(discounted cash flow rate of return)

	DCFRR, percent
Nominal Electricity Price ($0.05/kWh)	
Coke Price $100/ton	2.7
Coke Price $150/ton	8.1
Coke Price $200/ton	12.0
Increased Electricity Price ($0.07/kWh)	
Coke Price $100/ton	5.5
Coke Price $150/ton	10.1
Coke Price $200/ton	13.6
Decreased Electricity Price ($0.03/kWh)	
Coke Price $100/ton	-1.0
Coke Price $150/ton	5.8
Coke Price $200/ton	10.3

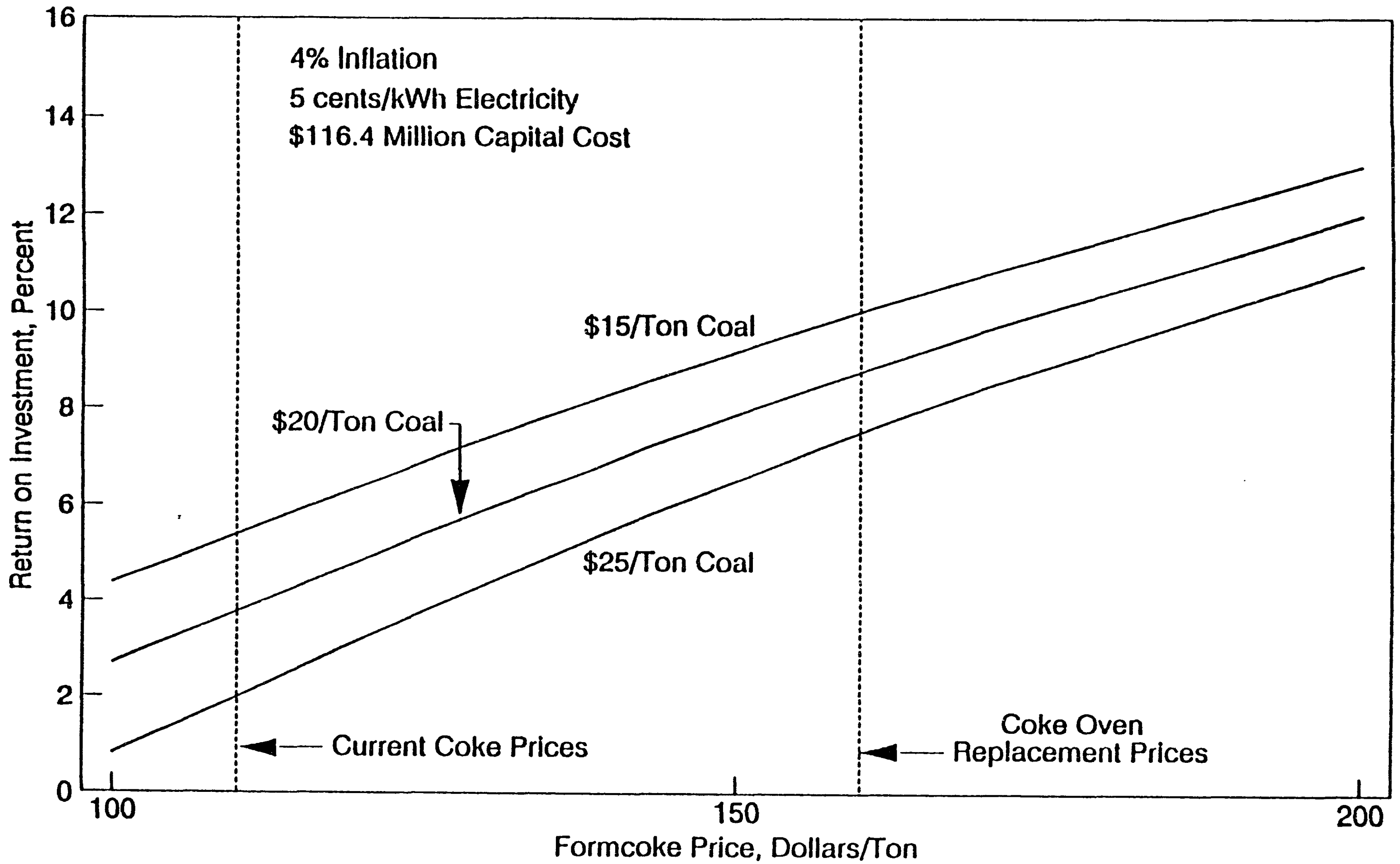

Figure 7. DCFRR as a function of coal costs and formed coke prices.

TABLE 4

Coal Cost Sensitivity
(discounted cash flow rate of return)

	DCFRR, percent
Nominal Coal Cost ($20/ton)	
Coke Price $100/ton	2.7
Coke Price $150/ton	8.1
Coke Price $200/ton	12.0
Decreased Coal Cost ($15/ton)	
Coke Price $100/ton	4.4
Coke Price $150/ton	9.4
Coke Price $200/ton	13.0
Increased Coal Cost ($25/ton)	
Coke Price $100/ton	0.8
Coke Price $150/ton	6.8
Coke Price $200/ton	11.0

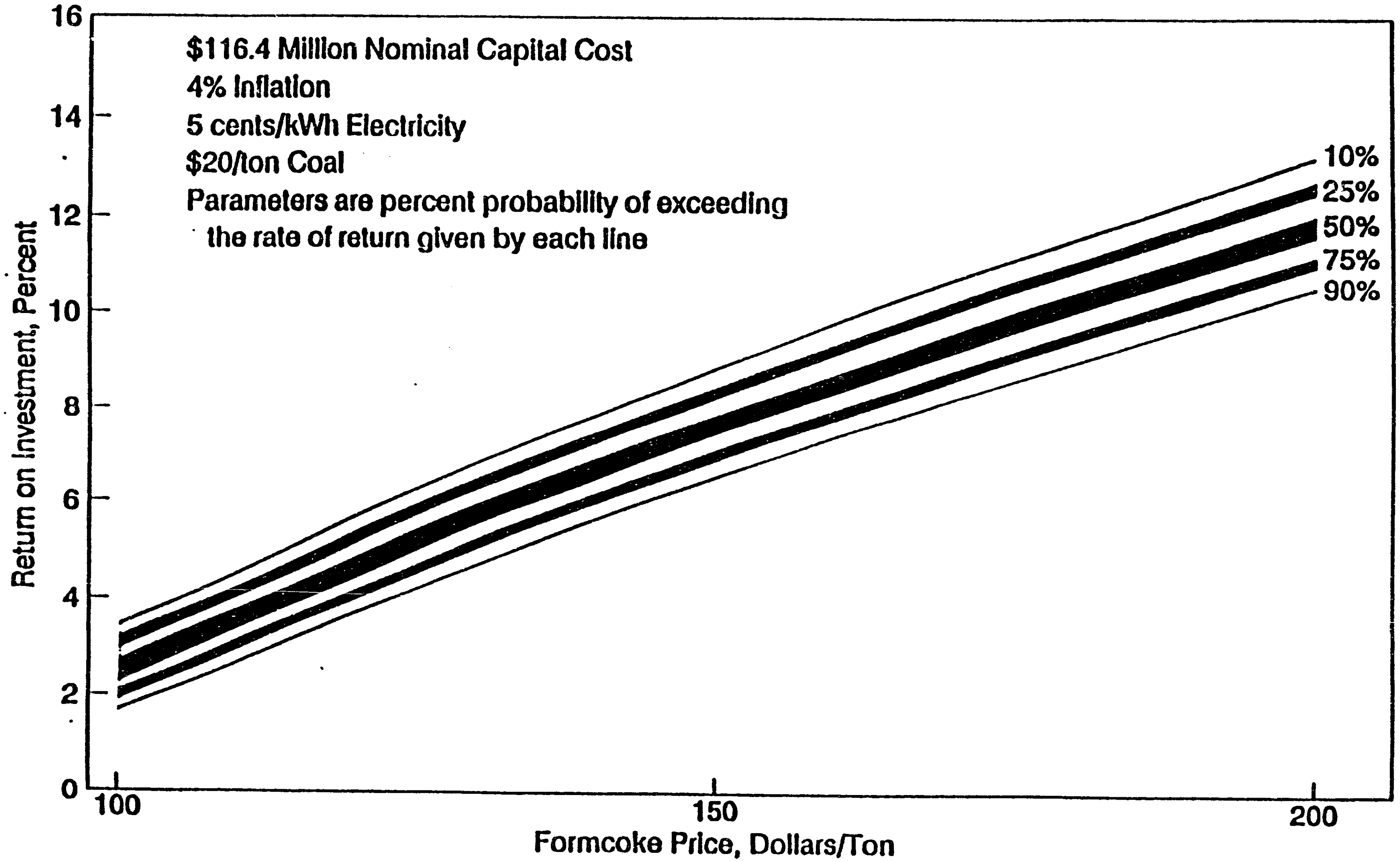

Figure 8. DCFRR as a function of capital cost and formed coke prices.

TABLE 5

Probability Distribution on DCFRR as a Function of Capital Cost and Coke Prices (probability of reaching or exceeding the specified discounted cash flow rate of return)

	Probability, percent	DCFRR, percent
Formed coke Price $100/ton	90	1.69
	75	2.09
	50	2.50
	25	2.96
	10	3.41
Formed coke Price $150/ton	90	6.76
	75	7.33
	50	7.89
	25	8.51
	10	9.12
Formed coke Price $200/ton	90	10.55
	75	11.19
	50	11.83
	25	12.53
	10	13.22

APPENDIX A

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REFERENCES

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1. Report for the Period July - September 1989, issued November 1989.

2. Report for the Period October - December 1989, issued February 1990.

3. Report for the Period January - March 1990, issued April 1990.

4. Report for the Period April - June 1990, issued August 1990.

5. Report for the Period July - September 1990, issued October 1990.

6. Report for the Period October - December 1990, issued February 1991.

7. Report for the Period January - March 1991, issued May 1991.

8. Report for the Period April - June 1991, issued July 1991.

9. Report for the Period July - September 1991, issued October 1991.

10. Report for the Period October - December 1991, issued January 1992.

MINUTES OF MONTHLY PROGRESS REVIEW MEETINGS attended by:

- University of North Dakota, Energy and Environmental Research Center (UND/EERC), Grand Forks, North Dakota
- AMAX Coal Company, Research & Development Center, Golden, Colorado
- Xytel-Bechtel, Inc. (XBi), Houston, Texas
- et al., as applicable

11. Conference Notes No. CN-001, 07 March 1991 Kickoff Meeting (Grand Forks, ND) with METC, 11 March 1991.

12. Conference Notes No. CN-002, 09/10 April 1991 Meeting (Houston, TX), 10 April 1991.

13. Conference Notes No. CN-003, 09/10 July 1991 Meeting (Grand Forks, ND), 15 July 1991.

14. Conference Notes No. CN-004, 06 November 1991 Meeting (Golden, CO) with Sinor, 11 November 1991.

15. Conference Notes No. CN-005, 12 December 1991 Meeting (Houston, TX), 17 December 1991.

16. Conference Notes No. CN-006, 21 January 1992 Meeting (Golden, CO) with Sinor, 24 January 1992.

17. Conference Notes No. CN-007, 20 February 1992 Meeting (Houston, TX), 25 February 1992.

18. Conference Notes No. CN-008, 25 March 1992 Meeting (Houston, TX), 30 March 1992.

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21. Fax: R. Ness to R. Gravois, Subject: Scope of work for 1 t/h unit, 26 March 1991.

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25. Fax: R. Ness to S. McFeely, Subject: Stream splits from Calciner Cyclones and Fines Magnetic Separator, 26 April 1991.

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27. Fax: R. Ness to S. McFeely, Subject: Scope change, 06 May 1991.

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33. Fax: L. Sharp to S. McFeely, Subject: Revised balance around carbonizer, 05 August 1991.

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41. L. Sharp and S. McFeely, Subject: Material Balance, 05 August 1991.

42. L. Sharp and J. Fong, Subject: Oil for Formcoke Binder, 19 September 1991.

43. B. Runge and J. Fong, Subject: Carbonizer Sizing Criteria, 15 October 1991.

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CALCULATION SHEET

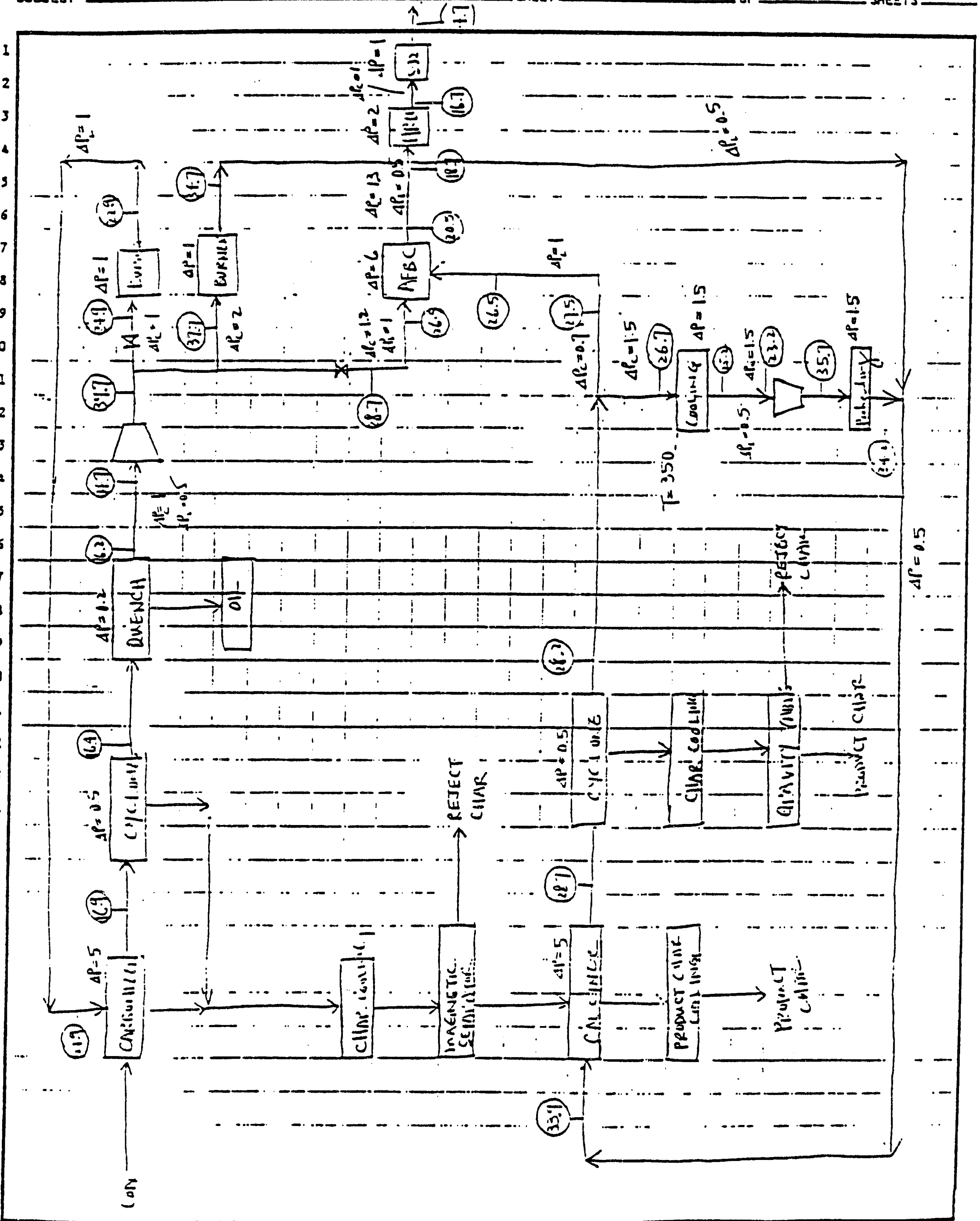
P.O BOX 2166
HOUSTON, TEXAS 77252-2166

CALC. NO.

SIGNATURE ______ DATE 11/11/91 CHECKED ______ DATE ______

PROJECT UND/EERC Mild Coal Gasification ______ JOB NO. ______

SUBJECT Pressure Profile ______ SHEET ______ OF ______ SHEETS ______



CALCULATION SHEET

P.O BOX 2166
HOUSTON, TEXAS 77252-2166

CALC. NO.

SIGNATURE ______ DATE 4/1/92 CHECKED ______ DATE ______

PROJECT UND / EERC Mild Coal gasification JOB NO. ______

SUBJECT Dew Point SHEET ______ OF ______ SHEETS ______

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Stream ⟨7⟩ P = 16.4 psia water dew point = 151°F
oil dew point = 277°F

Stream ⟨9A⟩ P = 14.7 psia Water dew point = 147°F
oil dew point = 188°F

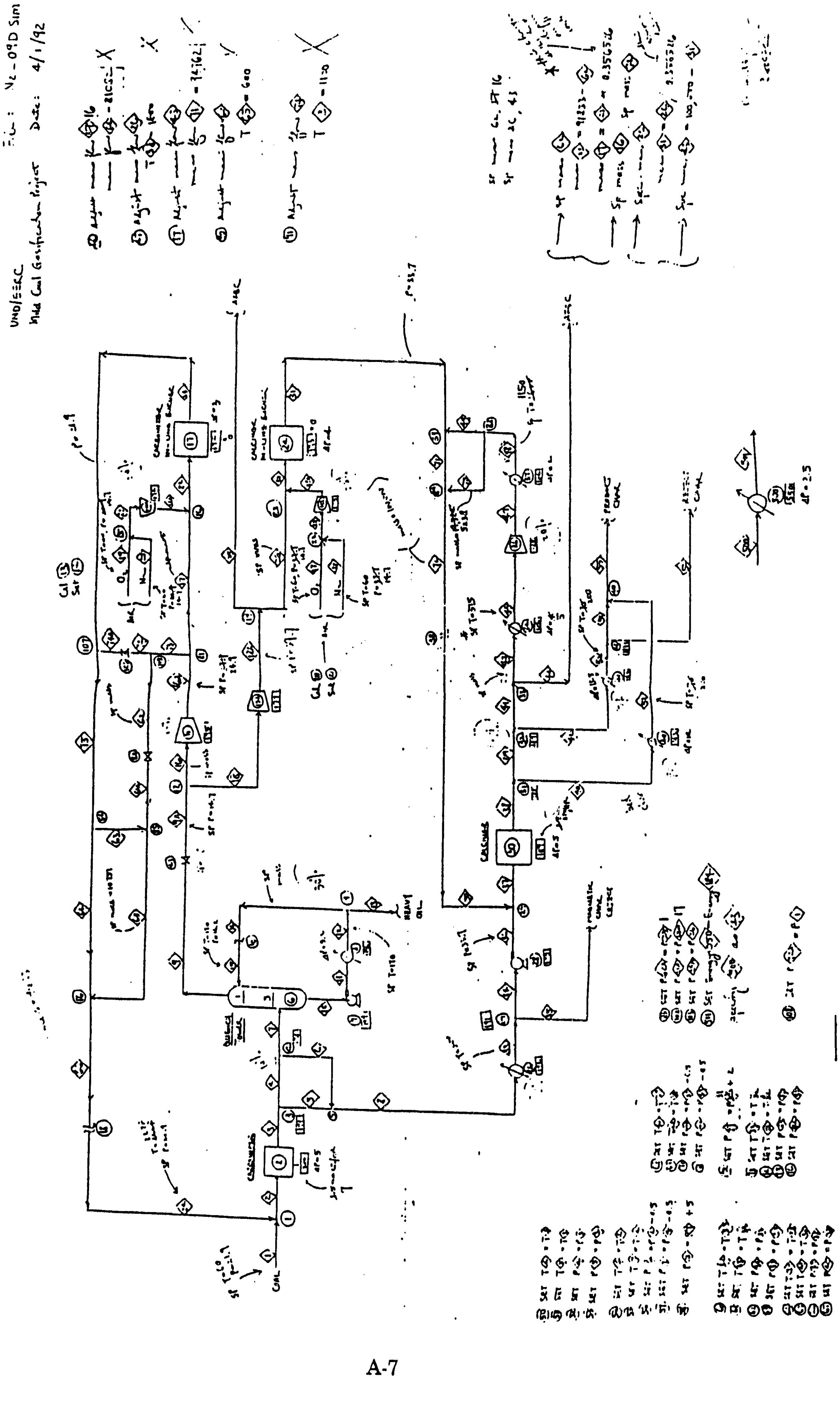
Stream ⟨6A⟩ P = 24.9 psia water dew point = 168°F
oil dew point = 204°F

Stream ⟨8A⟩ P = 37.7 psia water dew point = 187°F
oil dew point = 217°F

Stream ⟨45⟩ P = 23.2 psia Water dew point = 155°F
oil dew point = 353°F

Stream ⟨47⟩ P = 33.7 psia Water dew point = 175°F
oil dew point = 363°F

HO-90101 (9/85)


UND/EERC
Mild Coal Gasification Project
File: V2-09D Sim
Date: 4/1/92
COAL
HEAVY OIL
CASCADE
PRODUCT CHAR

```
Unit Operations
Mix            1:-2            24           1

Stoc           2: 2            -3           -200
                  DP:        5.0000 Psi
                  Reaction  1 BaseComp: IND_COAL     Conversion:  100.00%
                  Reactants:    -1.000 IND_COAL
                  Products:      0.372 CO          +    0.769 Methane      +
                                 0.088 Ethane      +    0.023 Ethylene     +
                                 0.678 Propane     +    0.017 Propene      ...

Frac           3: 3            199          -4            -5

Frac           4: 4            198          -7            -6

Mix            5:-8            6            5

Colu           6: 7            15           -9            -10

Pump           7: 10           -11          197
                  Efficiency:     75.00%

Cool           8: 11           -12          -196
                  DP:        5.2000 Psi

Tee            9: 12           -14          -13

Recy          10: 14           -15
                  Max Numb Iter:      25              Type:        Nested
                  Wegstein  Cnt:      3
                     VapFr Sens:      10.0000    Temp Sens:      10.0000
                     Press Sens:      10.0000    Enth Sens:      10.0000
                  Rel Flow Sens:       0.3000 Rel Comp Sens:      0.0500

Comp          11: 16           -16A         195
                  Type: Adiabatic
                  Adiabatic Eff:   75.00%     Polytropic Eff:   76.46%

Tee           12: 9A           -18          -16

Calc          13: 17           -19
                  OXYGEN

Set           14: Flow         of stream 20 =
                  stream 19 *     3.7742 +    0.0000 Lbmole/h

Mix           15:-21           20           19

Mix           16:-22           21A          17

Stoc          17: 22           -23          194
                  DP:        3.0000 Psi
                  Reaction  1 BaseComp: Methane       Conversion:  100.00%
                  Reactants:    -2.000 Oxygen       +   -1.000 Methane
                  Products:      1.000 CO2          +    2.000 H2O
                  Reaction  2 BaseComp: Ethane        Conversion:  100.00%
                  Reactants:    -3.500 Oxygen       +   -1.000 Ethane
                  Products:      2.000 CO2          +    3.000 H2O
                  Reaction  3 BaseComp: Ethylene      Conversion:  100.00%
                  Reactants:    -3.000 Oxygen       +   -1.000 Ethylene
                  Products:      2.000 CO2          +    2.000 H2O
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          Reaction  4 BaseComp: Propane      Conversion:  100.00%
          Reactants:   -5.000 Oxygen      +   -1.000 Propane
          Products:     3.000 CO2         +    4.000 H2O
          Reaction  5 BaseComp: Propene      Conversion:  100.00%
          Reactants:   -4.500 Oxygen      +   -1.000 Propene
          Products:     3.000 CO2         +    3.000 H2O
          Reaction  6 BaseComp: H2S          Conversion:  100.00%
          Reactants:   -1.500 Oxygen      +   -1.000 H2S
          Products:     1.000 H2O         +    1.000 SO2
          Reaction  7 BaseComp: Hydrogen     Conversion:  100.00%
          Reactants:   -0.500 Oxygen      +   -1.000 Hydrogen
          Products:     1.000 H2O
          Reaction  8 BaseComp: CO           Conversion:  100.00%
          Reactants:   -1.000 Oxygen      +   -2.000 CO
          Products:     2.000 CO2
          Reaction  9 BaseComp: NBP[1]_334   Conversion:  100.00%
          Reactants:  -13.228 Oxygen      +   -1.000 NBP[1]_334
          Products:    10.192 CO2         +    6.073 H2O
          Reaction 10 BaseComp: NBP[1]_369   Conversion:  100.00%
          Reactants:  -14.326 Oxygen      +   -1.000 NBP[1]_369
          Products:    11.037 CO2         +    6.576 H2O
          Reaction 11 BaseComp: NBP[1]_403   Conversion:  100.00%
          Reactants:  -15.429 Oxygen      +   -1.000 NBP[1]_403
          Products:    11.387 CO2         +    7.083 H2O
          Reaction 12 BaseComp: NBP[1]_437   Conversion:  100.00%
          Reactants:  -16.593 Oxygen      +   -1.000 NBP[1]_437
          Products:    12.784 CO2         +    7.617 H2O
          Reaction 13 BaseComp: NBP[1]_471   Conversion:  100.00%
          Reactants:  -17.806 Oxygen      +   -1.000 NBP[1]_471
          Products:    13.719 CO2         +    8.174 H2O
          Reaction 14 BaseComp: NBP[1]_506   Conversion:  100.00%
          Reactants:  -19.161 Oxygen      +   -1.000 NBP[1]_506
          Products:    14.763 CO2         +    8.796 H2O
          Reaction 15 BaseComp: NBP[1]_542   Conversion:  100.00%
          Reactants:  -20.592 Oxygen      +   -1.000 NBP[1]_542
          Products:    15.366 CO2         +    9.453 H2O
          Reaction 16 BaseComp: NBP[1]_574   Conversion:  100.00%
          Reactants:  -21.925 Oxygen      +   -1.000 NBP[1]_574
          Products:    16.393 CO2         +   10.065 H2O
          Reaction 17 BaseComp: NBP[1]_605   Conversion:  100.00%
          Reactants:  -23.300 Oxygen      +   -1.000 NBP[1]_605
          Products:    17.952 CO2         +   10.696 H2O
          Reaction 18 BaseComp: NBP[1]_648   Conversion:  100.00%
          Reactants:  -25.279 Oxygen      +   -1.000 NBP[1]_648
          Products:    19.477 CO2         +   11.604 H2O

Recy      18: 66         -24
          Max Numb Iter:       15              Type:        Nested
          Wegstein  Cnt:        3
             VapFr Sens:       10.0000    Temp Sens:       10.0000
             Press Sens:       10.0000    Enth Sens:       10.0000
          Rel Flow Sens:        0.5000 Rel Comp Sens:       0.0500

Tee       19: 18A        -26          -25

Calc      20: 26         -27
          OXYGEN

Set       21: Flow       of stream 28 =
          stream 27 *    3.7742 +     0.0000 Lbmole/h

Mix       22:-29          28          27

Mix       23:-30          29A         26

Stoc      24: 30         -31          193
```

```
          DP:          4.0000 Psi
          Reaction  1 BaseComp: Methane       Conversion:  100.00%
          Reactants:   -2.000 Oxygen       +   -1.000 Methane
          Products:     1.000 CO2          +    2.000 H2O
          Reaction  2 BaseComp: Ethane        Conversion:  100.00%
          Reactants:   -3.500 Oxygen       +   -1.000 Ethane
          Products:     2.000 CO2          +    3.000 H2O
          Reaction  3 BaseComp: Ethylene      Conversion:  100.00%
          Reactants:   -3.000 Oxygen       +   -1.000 Ethylene
          Products:     2.000 CO2          +    2.000 H2O
          Reaction  4 BaseComp: Propane       Conversion:  100.00%
          Reactants:   -5.000 Oxygen       +   -1.000 Propane
          Products:     3.000 CO2          +    4.000 H2O
          Reaction  5 BaseComp: Propene       Conversion:  100.00%
          Reactants:   -4.500 Oxygen       +   -1.000 Propene
          Products:     3.000 CO2          +    3.000 H2O
          Reaction  6 BaseComp: H2S           Conversion:  100.00%
          Reactants:   -1.500 Oxygen       +   -1.000 H2S
          Products:     1.000 H2O          +    1.000 SO2
          Reaction  7 BaseComp: Hydrogen      Conversion:  100.00%
          Reactants:   -0.500 Oxygen       +   -1.000 Hydrogen
          Products:     1.000 H2O
          Reaction  8 BaseComp: CO            Conversion:  100.00%
          Reactants:   -1.000 Oxygen       +   -2.000 CO
          Products:     2.000 CO2
          Reaction  9 BaseComp: NBP[1]_334    Conversion:  100.00%
          Reactants:  -13.228 Oxygen       +   -1.000 NBP[1]_334
          Products:    10.192 CO2          +    6.073 H2O
          Reaction 10 BaseComp: NBP[1]_369    Conversion:  100.00%
          Reactants:  -14.326 Oxygen       +   -1.000 NBP[1]_369
          Products:    11.037 CO2          +    6.576 H2O
          Reaction 11 BaseComp: NBP[1]_403    Conversion:  100.00%
          Reactants:  -15.429 Oxygen       +   -1.000 NBP[1]_403
          Products:    11.387 CO2          +    7.083 H2O
          Reaction 12 BaseComp: NBP[1]_437    Conversion:  100.00%
          Reactants:  -16.593 Oxygen       +   -1.000 NBP[1]_437
          Products:    12.784 CO2          +    7.617 H2O
          Reaction 13 BaseComp: NBP[1]_471    Conversion:  100.00%
          Reactants:  -17.806 Oxygen       +   -1.000 NBP[1]_471
          Products:    13.719 CO2          +    8.174 H2O
          Reaction 14 BaseComp: NBP[1]_506    Conversion:  100.00%
          Reactants:  -19.161 Oxygen       +   -1.000 NBP[1]_506
          Products:    14.763 CO2          +    8.796 H2O
          Reaction 15 BaseComp: NBP[1]_542    Conversion:  100.00%
          Reactants:  -20.592 Oxygen       +   -1.000 NBP[1]_542
          Products:    15.866 CO2          +    9.453 H2O
          Reaction 16 BaseComp: NBP[1]_574    Conversion:  100.00%
          Reactants:  -21.925 Oxygen       +   -1.000 NBP[1]_574
          Products:    16.893 CO2          +   10.065 H2O
          Reaction 17 BaseComp: NBP[1]_605    Conversion:  100.00%
          Reactants:  -23.300 Oxygen       +   -1.000 NBP[1]_605
          Products:    17.952 CO2          +   10.696 H2O
          Reaction 18 BaseComp: NBP[1]_648    Conversion:  100.00%
          Reactants:  -25.279 Oxygen       +   -1.000 NBP[1]_648
          Products:    19.477 CO2          +   11.604 H2O

Cool         26: 8             -33          -192
          DP:          0.0000 Psi

Frac         27: 33            191          -34          -35

Pump         28: 34            -36          190
          Efficiency:    75.00%

Mix          29:-37            50           36
```

```
Stoc      30: 37           -38          -189
              DP:        5.0000 Psi
              Reaction  1 BaseComp: CARB_CHAR    Conversion:  100.00%
              Reactants:    -1.000 CARB_CHAR
              Products:      0.132 CO           +    0.409 CO2         +
                             0.231 Methane      +    0.004 Ethane      +
                             0.001 Ethylene     +    0.030 Propane    ...

Frac      31: 38           188          -39          -40

Frac      32: 39           187          -41          -42

Tee       33: 41           -44          -43

Cool      34: 43           -45          -186
              DP:        5.0000 Psi

Comp      36: 45           -47          185
              Type: Adiabatic
              Adiabatic Eff:    75.00%     Polytropic Eff:    76.29%

Cool      37: 47           -48          184
              DP:        2.0000 Psi

Recy      38: 72           -50
              Max Numb Iter:       10                Type:        Nested
              Wegstein  Cnt:       3
                 VapFr Sens:       10.0000     Temp Sens:        10.0000
                 Press Sens:       10.0000     Enth Sens:        10.0000
              Rel Flow Sens:       0.5000 Rel Comp Sens:          0.0500

Mix       39:-71           49           31

Cool      40: 40           -51          -183
              DP:       14.0000 Psi

Cool      41: 42           -52          -182
              DP:       13.5000 Psi

Frac      42: 52           181          -53          -54

Valv      43: 9            -9A

Adju      46: (ignored)     Adj Var: Mass_Flow    of stream 16
              Dep Var: Mass_Flow    of stream 64
              Target:     81082.00 Lb/hr
              Tol:          1.0000 Lb/hr     Step:      500.0000 Lb/hr
              Type: Simultaneous

Adju      47: (ignored)     Adj Var: Mass_Flow    of stream 26
              Dep Var: Temperature  of stream 38
              Target:      1800.00 F
              Tol:          1.0000 F         Step:      100.0000 Lb/hr
              Type: Simultaneous

Mix       49:-55           53           51

Set       50: Temperature   of stream 4 =
              stream 3 *      1.0000 +     0.0000 F

Set       51: Temperature   of stream 5 =
              stream 3 *      1.0000 +     0.0000 F

Set       52: Pressure      of stream 4 =
              stream 3 *      1.0000 +     0.0000 Psi
```

```
Set     53: Pressure     of stream 5 =
            stream 3 *    1.0000 +    0.0000 Psi

Set     54: (ignored)    Temperature  of stream 6 =
            stream 4 *    1.0000 +    0.0000 F

Set     55: Temperature  of stream 7 =
            stream 4 *    1.0000 +    0.0000 F

Set     56: Pressure     of stream 6 =
            stream 4 *    1.0000 -    0.5000 Psi

Set     57: Pressure     of stream 7 =
            stream 4 *    1.0000 -    0.5000 Psi

Set     58: Pressure     of stream 11 =
            stream 7 *    1.0000 +    5.0000 Psi

Set     60: Temperature  of stream 34 =
            stream 33 *   1.0000 +    0.0000 F

Set     61: Temperature  of stream 35 =
            stream 33 *   1.0000 +    0.0000 F

Set     62: Pressure     of stream 34 =
            stream 33 *   1.0000 +    0.0000 Psi

Set     63: Pressure     of stream 35 =
            stream 33 *   1.0000 +    0.0000 Psi

Set     64: Temperature  of stream 39 =
            stream 38 *   1.0000 +    0.0000 F

Set     65: Temperature  of stream 40 =
            stream 38 *   1.0000 +    0.0000 F

Set     66: Pressure     of stream 39 =
            stream 38 *   1.0000 +    0.0000 Psi

Set     67: Pressure     of stream 40 =
            stream 38 *   1.0000 +    0.0000 Psi

Set     68: Temperature  of stream 41 =
            stream 39 *   1.0000 +    0.0000 F

Set     69: Temperature  of stream 42 =
            stream 39 *   1.0000 +    0.0000 F

Set     70: Pressure     of stream 41 =
            stream 39 *   1.0000 -    0.5000 Psi

Set     71: Pressure     of stream 42 =
            stream 39 *   1.0000 -    0.5000 Psi

Set     72: Pressure     of stream 47 =
            stream 31 *   1.0000 +    2.0000 Psi

Set     73: Temperature  of stream 53 =
            stream 52 *   1.0000 +    0.0000 F

Set     74: Temperature  of stream 54 =
            stream 52 *   1.0000 +    0.0000 F

Set     75: Pressure     of stream 53 =
            stream 52 *   1.0000 +    0.0000 Psi
```

```
Set         76: Pressure      of stream 54 =
                stream 52 *      1.0000 +    0.0000 Psi

Adju        77: (ignored)     Adj Var: Mass_Flow    of stream 43
                Dep Var: Mass_Flow    of stream 71
                Target:    94762.00 Lb/hr
                Tol:          1.2248 Lb/hr    Step:      100.0000 Lb/hr
                Type: Simultaneous

Tee         81: 16A            -73             -17

Valv        82: 62             -62A

Set         83: Pressure      of stream 62A =
                stream 1 *       1.0000 +    0.0000 Psi

Tee         84: 75             -63             -64

Mix         85:-65              62A             63

Mix         86:-66              65              64

Tee         88: 48             -49             -70

Mix         89:-72              71              70

Adju        90: (ignored)     Adj Var: Mass_Flow    of stream 62
                Dep Var: Temperature  of stream 65
                Target:       600.00 F
                Tol:          1.0000 F        Step:      500.0000 Lb/hr
                Type: Simultaneous

Adju        91: (ignored)     Adj Var: Mass_Flow    of stream 74
                Dep Var: Temperature  of stream 3
                Target:      1100.00 F
                Tol:          1.0000 F        Step:      100.0000 Lb/hr
                Type: Simultaneous

Comp       100: 21             -21A             179
                Type: Adiabatic
                Adiabatic Eff:    75.00%     Polytropic Eff:    76.77%

Comp       101: 29             -29A             178
                Type: Adiabatic
                Adiabatic Eff:    75.00%     Polytropic Eff:    78.02%

Set        102: Pressure      of stream 21A =
                stream 17 *      1.0000 +    0.0000 Psi

Set        103: Pressure      of stream 29A =
                stream 26 *      1.0000 +    0.0000 Psi

Comp       104: 18             -18A             177
                Type: Adiabatic
                Adiabatic Eff:    75.00%     Polytropic Eff:    77.46%

Tee        105: 73             -62             -74

Valv       106: 74             -74A

Mix        107:-75              74A             23

Set        108: Pressure      of stream 74A =
                stream 1 *       1.0000 +    0.0000 Psi

Cool       500: 500            -501            -550
```

```
        DP:          2.5000 Psi

Set            501: Energy_Flow  of stream 550 =
                    stream 184 *     1.0000 +     0.0000 Btu/hr
```

Hyprotech's Process Simulator HYSIM - Licensed to Bechtel Inc
Date 92/04/01 Version 386|C1.51 Case Name 42_090.SIM
Time 14:33:37 Prop Pkg PR

Stream		1	2	3	4	5	6	7	8
Description									
Vapour frac.		0.0000	0.9481	0.9383	0.9935	0.0000	0.0000	1.0000	0.0000
Temperature F		60.0000*	1024.8637	1100.6667	1100.6667	1100.6667	1100.6052	1100.6667	1100.5606
Pressure	Psia	21.8960*	21.8960	16.8960	16.8960	16.8960	16.3960	16.3960	16.3960
Molar Flow	Lbmole/hr	491.1700	3803.2617	4377.8601	4134.6541	243.2057	27.0260	4107.6281	270.2317
Mass Flow	Lb/hr	64506.0018*	156339.1746	156341.1725	118460.3057	37880.8538	4209.2004	114251.1043	42090.0553
LiqVol Flow	Barrel/day	3398.0364	11105.3295	13482.4132	10597.5348	2884.8769	320.5529	10276.9819	3205.4298
Enthalpy	Btu/hr	6.44791E+06	8.33271E+07	8.20009E+07	6.13626E+07	2.06383E+07	2.29318E+06	5.90694E+07	2.29314E+07
Density	Lbmole/ft3	0.6189	0.0014	0.0011	0.0010	0.3604	0.3604	0.0010	0.3604
Mole Wt.		131.3313	41.1066	35.7118	28.6506	155.7564	155.7466	27.8144	155.7554
Spec. Heat	Btu/lbmole-F	61.0919	18.3895	15.2639	11.7999	74.1549	74.1500	11.3895	74.1544
Therm Cond	Btu/hr-ft-F	0.0426	---	---	---	---	---	0.0422	---
Viscosity	Cp	3.8684	---	---	---	---	---	0.0345	---
Z Factor		0.0063	---	---	---	0.0028	0.0027	1.0002	0.0027
Sur Tension	Dyne/cm	73.7276	---	---	---	---	---	---	---
Std Density	Lb/ft3	81.2872	---	---	---	56.1294	56.1303	---	56.1295
IND_COAL	Lb/hr	52778.0011*	52777.9998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nitrogen	Lb/hr	0.0000*	60912.5829	60912.5813	60912.5819	0.0000	0.0000	60912.5805	0.0000
Oxygen	Lb/hr	0.0000*	0.0131	0.0131	0.0131	0.0000	0.0000	0.0131	0.0000
CO	Lb/hr	0.0000*	254.8619	1355.8966	1355.8966	0.0000	0.0000	1355.8966	0.0000
CO2	Lb/hr	0.0000*	14954.4282	14954.4277	14954.4279	0.0000	0.0000	14954.4276	0.0000
Methane	Lb/hr	0.0000*	301.6070	1604.5988	1604.5989	0.0000	0.0000	1604.5989	0.0000
Ethane	Lb/hr	0.0000*	64.3474	342.3473	342.3473	0.0000	0.0000	342.3473	0.0000
Ethylene	Lb/hr	0.0000*	15.5082	82.5076	82.5076	0.0000	0.0000	82.5076	0.0000
Propane	Lb/hr	0.0000*	730.9320	3888.9337	3888.9336	0.0000	0.0000	3888.9336	0.0000
Propene	Lb/hr	0.0000*	17.8219	94.8211	94.8211	0.0000	0.0000	94.8211	0.0000
H2S	Lb/hr	0.0000*	284.9298	1515.9297	1515.9298	0.0000	0.0000	1515.9298	0.0000
H2O	Lb/hr	5290.0006*	17362.7498	17362.7498	17362.7495	0.0000	0.0000	17362.7494	0.0000
CARB_CHAR	Lb/hr	0.0000*	0.0000	35652.0570	3565.2057	32086.8515	3565.2056	0.0000	35652.0559
ASH	Lb/hr	6438.0009*	6438.0010	6438.0006	644.0001	5794.0006	644.0001	0.0000	6438.0009
Hydrogen	Lb/hr	0.0000*	95.5995	508.5995	508.5995	0.0000	0.0000	508.5995	0.0000
CALC_CHAR	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[1]_334	Lb/hr	0.0000*	229.8591	1278.4829	1278.4829	0.0000	0.0000	1278.4829	0.0000
NBP[1]_369	Lb/hr	0.0000*	240.7124	1485.7649	1485.7649	0.0000	0.0000	1485.7649	0.0000
NBP[1]_403	Lb/hr	0.0000*	228.2993	1698.8390	1698.8390	0.0000	0.0000	1698.8390	0.0000
NBP[1]_437	Lb/hr	0.0000*	158.5984	1607.6374	1607.6375	0.0000	0.0000	1607.6375	0.0000
NBP[1]_471	Lb/hr	0.0000*	72.8689	1185.5434	1185.5434	0.0000	0.0000	1185.5434	0.0000
NBP[1]_506	Lb/hr	0.0000*	28.8947	933.2022	933.2022	0.0000	0.0000	933.2022	0.0000
NBP[1]_542	Lb/hr	0.0000*	13.4795	1005.2705	1005.2706	0.0000	0.0000	1005.2705	0.0000
NBP[1]_574	Lb/hr	0.0000*	4.4089	753.4999	753.4999	0.0000	0.0000	753.4999	0.0000
NBP[1]_605	Lb/hr	0.0000*	0.8778	359.0956	359.0956	0.0000	0.0000	359.0956	0.0000
NBP[1]_648	Lb/hr	0.0000*	0.1163	170.6941	170.6941	0.0000	0.0000	170.6941	0.0000
NBP[2]_225	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_301	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_363	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_427	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_494	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_559	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_630	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_697	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_767	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_901	Lb/hr	0.0000*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO2	Lb/hr	0.0000*	1149.6723	1149.6723	1149.6722	0.0000	0.0000	1149.6722	0.0000
Total:	Lb/hr	64506.0018*	156339.1746	156341.1725	118460.3057	37880.8538	4209.2004	114251.1043	42090.0553

Hyprotech's Process Simulator HYSIM - Licensed to Bechtel Inc
Date 92/04/01 Version 386|C1.51 Case Name N2_090.SIM
Time 14:33:37 Prop Pkg PR

Stream		9	9A	10	11	12	13	14	15
Description									
Vapour frac.		1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Temperature	F	191.1279	191.0173	357.0599	357.0839	170.0000*	170.0000	170.0000	170.0000*
Pressure	Psia	16.1960	14.6960*	16.3960	21.3960	16.1960	16.1960	16.1960	16.1960*
Molar Flow	Lbmole/hr	4079.8513	4079.8513	1933.2271	1933.2271	1933.2271	27.7924	1905.4348	1905.4500
Mass Flow	Lb/hr	108975.3587	108975.3587	367135.7583	367135.7583	367135.7583	5278.0002*	361857.7736	361860.0127*
LiqVol Flow	Barrel/day	9839.3728	9839.3728	30453.5347	30453.5347	30453.5347	437.8047	30015.7310	30015.9245
Enthalpy	Btu/hr	2.02514E+07	2.02514E+07	3.27739E+07	3.27842E+07	-6.13630E+06	-88216.4043	-6.04808E+06	-6.04812E+06
Density	Lbmole/ft3	0.0023	0.0021	0.2315	0.2315	0.2574	0.2574	0.2574	0.2574
Mole Wt.		26.7106	26.7106	189.9082	189.9082	189.9082	189.9082	189.9082	189.9079
Spec. Heat	Btu/lbmole-F	8.3823	8.3796	117.7925	117.7885	97.3303	97.3303	97.3303	97.3302
Therm Cond	Btu/hr-ft-F	0.0185	0.0184	0.0552	0.0552	0.0663	0.0663	0.0663	0.0663
Viscosity	Cp	0.0169	0.0169	0.3499	0.3499	1.1037	1.1037	1.1037	1.1037
Z Factor		0.9977	0.9979	0.0081	0.0105	0.0093	0.0093	0.0093	0.0093
Sur Tension	Dyne/cm	---	---	15.5282	15.5272	23.7130	23.7130	23.7130	23.7130
Std Density	Lb/ft3	---	---	51.5770	51.5770	51.5770	51.5770	51.5770	51.5770
IND_COAL	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
Nitrogen	Lb/hr	60911.9644	60911.9644	42.9056	42.9056	42.9056	0.6168	42.2888	42.2894*
Oxygen	Lb/hr	0.0131	0.0131	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
CO	Lb/hr	1355.8823	1355.8823	0.9978	0.9978	0.9978	0.0143	0.9834	0.9835*
CO2	Lb/hr	14953.9989	14953.9989	29.9143	29.9143	29.9143	0.4301	29.4843	29.4849*
Methane	Lb/hr	1604.5693	1604.5693	2.0655	2.0655	2.0655	0.0297	2.0358	2.0359*
Ethane	Lb/hr	342.3324	342.3324	1.0415	1.0415	1.0415	0.0150	1.0266	1.0266*
Ethylene	Lb/hr	82.5047	82.5047	0.2033	0.2033	0.2033	0.0029	0.2004	0.2004*
Propane	Lb/hr	3888.6065	3888.6065	22.8099	22.8099	22.8099	0.3279	22.4819	22.4826*
Propene	Lb/hr	94.3139	94.3139	0.5058	0.5058	0.5058	0.0073	0.4985	0.4985*
H2S	Lb/hr	1515.8456	1515.8456	5.8671	5.8671	5.8671	0.0843	5.7827	5.7828*
H2O	Lb/hr	17362.1727	17362.1727	40.2043	40.2043	40.2043	0.5780	39.6264	39.6272*
CARB_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
ASH	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
Hydrogen	Lb/hr	508.5958	508.5958	0.2591	0.2591	0.2591	0.0037	0.2554	0.2554*
CALC_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[1]_334	Lb/hr	1223.9620	1223.9620	3842.2173	3842.2173	3842.2173	55.2363	3786.9811	3787.6965*
NBP[1]_369	Lb/hr	1281.4601	1281.4601	14292.7216	14292.7216	14292.7216	205.4744	14087.2477	14088.4170*
NBP[1]_403	Lb/hr	1214.1678	1214.1678	33688.8168	33688.8168	33688.8168	484.3156	33204.5024	33204.1453*
NBP[1]_437	Lb/hr	843.3906	843.3906	53183.9796	53183.9796	53183.9796	764.5811	52419.4004	52419.7323*
NBP[1]_471	Lb/hr	387.4800	387.4800	55532.3204	55532.3204	55532.3204	798.3412	54733.9811	54734.2583*
NBP[1]_506	Lb/hr	153.6486	153.6486	54232.3920	54232.3920	54232.3920	779.6532	53452.7407	53452.8405*
NBP[1]_542	Lb/hr	71.6767	71.6767	64942.8009	64942.8009	64942.8009	933.6277	64009.1754	64009.2041*
NBP[1]_574	Lb/hr	23.4439	23.4439	50781.9395	50781.9395	50781.9395	730.0490	50051.8922	50051.8829*
NBP[1]_605	Lb/hr	4.6677	4.6677	24653.1623	24653.1623	24653.1623	354.4177	24298.7455	24298.7341*
NBP[1]_648	Lb/hr	0.6184	0.6184	11829.8706	11829.8706	11829.8706	170.0680	11659.8029	11659.7946*
NBP[2]_225	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_301	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_363	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_427	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_494	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_559	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_630	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_697	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_767	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_901	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
SO2	Lb/hr	1149.5465	1149.5465	8.7610	8.7610	8.7610	0.1259	8.6350	8.6353*
Total:	Lb/hr	108975.3587	108975.3587	367135.7583	367135.7583	367135.7583	5278.0002*	361857.7736	361860.0127*

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Stream		16	16A	17	18	18A	19	20	21
Description									
Vapour frac.		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature	F	191.0173	304.9376	304.9376	191.0173	402.0992	60.0000*	60.0000*	60.0025
Pressure	Psia	14.6960	24.8960*	24.8960	14.6960	37.6960*	14.6960*	14.6960*	14.6960
Molar Flow	Lbmole/hr	1719.2598	1719.2598	952.3365	2360.5916	2360.5916	333.3513	1258.1276	1591.4789
Mass Flow	Lb/hr	45922.4983*	45922.4983	25437.4994	63052.8690	63052.8690	10667.2402	35243.9283	45911.1696
LiqVol Flow	Barrel/day	4146.3370	4146.3370	2296.7488	5693.0358	5693.0358	642.0224	2992.7198	3634.7424
Enthalpy	Btu/hr	8.53401E+06	1.01937E+07	5.64655E+06	1.17174E+07	1.59973E+07	1.20000E+06	4.53474E+06	5.73474E+06
Density	Lbmole/ft3	0.0021	0.0030	0.0030	0.0021	0.0041	0.0026	0.0026	0.0026
Mole Wt.		26.7106	26.7106	26.7106	26.7106	26.7106	32.0000	28.0130	28.3481
Spec. Heat	Btu/lbmole-F	8.3796	8.6525	8.6525	8.3796	8.3876	6.9984	6.9509	6.9609
Therm Cond	Btu/hr-ft-F	0.0184	0.0215	0.0215	0.0184	0.0241	0.0148	0.0145	0.0146
Viscosity	Cp	0.0169	0.0198	0.0198	0.0169	0.0220	0.0204	0.0179	0.0184
Z Factor		0.9979	0.9982	0.9982	0.9979	0.9985	0.9989	0.9994	0.9993
Sur Tension	Dyne/cm	---	---	---	---	---	---	---	---
Std Density	Lb/ft3	---	---	---	---	---	---	---	---
INO_COAL	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
Nitrogen	Lb/hr	25668.4583	25668.4583	14218.3333	35243.5080	35243.5080	0.0000*	35243.9283*	35243.9223
Oxygen	Lb/hr	0.0055	0.0055	0.0031	0.0076	0.0076	10667.2402*	0.0000*	10667.2405
CO	Lb/hr	571.3723	571.3723	316.4959	784.5101	784.5101	0.0000*	0.0000*	0.0000
CO2	Lb/hr	6301.6536	6301.6536	3490.6269	8652.3458	8652.3458	0.0000*	0.0000*	0.0000
Methane	Lb/hr	676.1696	676.1696	374.5455	928.3997	928.3997	0.0000*	0.0000*	0.0000
Ethane	Lb/hr	144.2597	144.2597	79.9087	198.0726	198.0726	0.0000*	0.0000*	0.0000
Ethylene	Lb/hr	34.7677	34.7677	19.2586	47.7370	47.7370	0.0000*	0.0000*	0.0000
Propane	Lb/hr	1638.6688	1638.6688	907.6953	2249.9378	2249.9378	0.0000*	0.0000*	0.0000
Propene	Lb/hr	39.9548	39.9548	22.1319	54.8591	54.8591	0.0000*	0.0000*	0.0000
H2S	Lb/hr	638.7812	638.7812	353.8352	877.0644	877.0644	0.0000*	0.0000*	0.0000
H2O	Lb/hr	7316.4642	7316.4642	4052.7532	10045.7091	10045.7091	0.0000*	0.0000*	0.0000
CARB_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
ASH	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
Hydrogen	Lb/hr	214.3236	214.3236	118.7186	294.2722	294.2722	0.0000*	0.0000*	0.0000
CALC_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[1]_334	Lb/hr	515.7807	515.7807	285.7025	708.1813	708.1813	0.0000*	0.0000*	0.0000
NBP[1]_369	Lb/hr	540.0106	540.0106	299.1239	741.4495	741.4495	0.0000*	0.0000*	0.0000
NBP[1]_403	Lb/hr	511.6534	511.6534	283.4163	702.5144	702.5144	0.0000*	0.0000*	0.0000
NBP[1]_437	Lb/hr	355.4070	355.4070	196.8679	487.9837	487.9837	0.0000*	0.0000*	0.0000
NBP[1]_471	Lb/hr	163.2850	163.2850	90.4472	224.1949	224.1949	0.0000*	0.0000*	0.0000
NBP[1]_506	Lb/hr	64.7479	64.7479	35.8653	88.9007	88.9007	0.0000*	0.0000*	0.0000
NBP[1]_542	Lb/hr	30.2047	30.2047	16.7311	41.4719	41.4719	0.0000*	0.0000*	0.0000
NBP[1]_574	Lb/hr	9.8793	9.8793	5.4724	13.5646	13.5646	0.0000*	0.0000*	0.0000
NBP[1]_605	Lb/hr	1.9670	1.9670	1.0896	2.7007	2.7007	0.0000*	0.0000*	0.0000
NBP[1]_648	Lb/hr	0.2606	0.2606	0.1444	0.3578	0.3578	0.0000*	0.0000*	0.0000
NBP[2]_225	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[2]_301	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[2]_363	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[2]_427	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[2]_494	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[2]_559	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[2]_630	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[2]_697	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[2]_767	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
NBP[2]_901	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*	0.0000
SO2	Lb/hr	484.4218	484.4218	268.3321	665.1247	665.1247	0.0000*	0.0000*	0.0000
Total:	Lb/hr	45922.4983*	45922.4983	25437.4994	63052.8690	63052.8690	10667.2402	35243.9283	45911.1696

Stream		21A	22	23	24	25	26	27	28
Description									
Vapour frac.		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature	F	172.4083	228.3541	2886.6732	2236.9123*	402.0992	402.0992	60.0000*	60.0000*
Pressure	Psia	24.8960	24.8960	21.8960	21.8960*	37.6960	37.6960	14.6960*	14.6960*
Molar Flow	Lbmole/hr	1591.4789	2543.8153	2545.1628	3312.0918*	1487.9050	872.6866	305.4710	1152.9025
Mass Flow	Lb/hr	45911.1696	71348.6668	71348.2147	91833.1728	39742.8667	23310.0001*	9775.0715	32296.2576
LiqVol Flow	Barrel/day	3634.7424	5931.4912	5857.7256	7707.2936	3588.3788	2104.6572	588.3261	2742.4198
Enthalpy	Btu/hr	6.97992E+06	1.26264E+07	7.23344E+07	7.68792E+07	1.00833E+07	5.91406E+06	1.09963E+06	4.15547E+06
Density	Lbmole/ft3	0.0037	0.0034	0.0006	0.0008	0.0041	0.0041	0.0026	0.0026
Mole Wt.		28.8481	28.0479	28.0329	27.7266	26.7106	26.7106	32.0000	28.0130
Spec. Heat	Btu/lbmole-F	7.0008	7.5685	9.3802	9.9730	8.8876	8.8876	6.9984	6.9509
Therm Cond	Btu/hr-ft-F	0.0170	0.0186	0.0481	0.0541	0.0241	0.0241	0.0148	0.0145
Viscosity	Cp	0.0213	0.0209	0.0686	0.0558	0.0220	0.0220	0.0204	0.0179
Z Factor		0.9998	0.9990	1.0002	1.0003	0.9985	0.9985	0.9989	0.9994
Sur Tension	Dyne/cm	---	---	---	---	---	---	---	---
Std Density	Lb/ft3	---	---	---	---	---	---	---	---
IND_COAL	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
Nitrogen	Lb/hr	35243.9283	49462.2628	49462.2639	60912.5811*	22214.3439	13029.1642	0.0000*	32296.2572*
Oxygen	Lb/hr	10667.2405	10667.2435	0.0107	0.0131*	0.0048	0.0028	9775.0715*	0.0000*
CO	Lb/hr	0.0000	316.4959	0.0016	254.8619*	494.4847	290.0253	0.0000*	0.0000*
CO2	Lb/hr	0.0000	3490.6270	12143.5030	14954.4286*	5453.6621	3198.6837	0.0000*	0.0000*
Methane	Lb/hr	0.0000	374.5455	0.0019	301.6070*	585.1798	343.2199	0.0000*	0.0000*
Ethane	Lb/hr	0.0000	79.9087	0.0004	64.3474*	124.8472	73.2254	0.0000*	0.0000*
Ethylene	Lb/hr	0.0000	19.2586	0.0001	15.5082*	30.0891	17.6479	0.0000*	0.0000*
Propane	Lb/hr	0.0000	907.6952	0.0046	730.9320*	1418.1588	831.7790	0.0000*	0.0000*
Propene	Lb/hr	0.0000	22.1319	0.0001	17.8219*	34.5782	20.2808	0.0000*	0.0000*
H2S	Lb/hr	0.0000	353.8352	0.0018	284.9298*	552.8227	324.2417	0.0000*	0.0000*
H2O	Lb/hr	0.0000	4052.7532	8808.3813	12072.7497*	6331.9133	3713.7958	0.0000*	0.0000*
CARB_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
ASH	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
Hydrogen	Lb/hr	0.0000	118.7186	0.0006	95.5995*	185.4828	108.7894	0.0000*	0.0000*
CALC_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[1]_334	Lb/hr	0.0000	285.7025	0.0015	229.8591*	446.3739	261.8074	0.0000*	0.0000*
NBP[1]_369	Lb/hr	0.0000	299.1239	0.0015	240.7124*	467.3432	274.1063	0.0000*	0.0000*
NBP[1]_403	Lb/hr	0.0000	283.4163	0.0014	228.2993*	442.8020	259.7124	0.0000*	0.0000*
NBP[1]_437	Lb/hr	0.0000	196.8679	0.0010	158.5984*	307.5811	180.4026	0.0000*	0.0000*
NBP[1]_471	Lb/hr	0.0000	90.4472	0.0005	72.8689*	141.3124	82.8826	0.0000*	0.0000*
NBP[1]_506	Lb/hr	0.0000	35.8653	0.0002	28.8947*	56.0350	32.8657	0.0000*	0.0000*
NBP[1]_542	Lb/hr	0.0000	16.7311	0.0001	13.4795*	26.1402	15.3318	0.0000*	0.0000*
NBP[1]_574	Lb/hr	0.0000	5.4724	0.0000	4.4089*	8.5499	5.0147	0.0000*	0.0000*
NBP[1]_605	Lb/hr	0.0000	1.0896	0.0000	0.8778*	1.7023	0.9984	0.0000*	0.0000*
NBP[1]_648	Lb/hr	0.0000	0.1444	0.0000	0.1163*	0.2255	0.1323	0.0000*	0.0000*
NBP[2]_225	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[2]_301	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[2]_363	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[2]_427	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[2]_494	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[2]_559	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[2]_630	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[2]_697	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[2]_767	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
NBP[2]_901	Lb/hr	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000*	0.0000*
SO2	Lb/hr	0.0000	268.3321	933.5402	1149.6724*	419.2349	245.8898	0.0000*	0.0000*
Total:	Lb/hr	45911.1696	71348.6668	71348.2147	91833.1728	39742.8667	23310.0001*	9775.0715	32296.2576

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Stream		29	29A	30	31	33	34	35	36
Description									
Vapour frac.		1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000
Temperature	F	60.0025	272.9010	328.0337	2967.5684	200.0000*	200.0000	200.0000	200.2339
Pressure	Psia	14.6960	37.6960	37.6960	33.6960	16.3960	16.3960	16.3960	33.6960*
Molar Flow	Lbmole/hr	1458.3734	1458.3734	2331.0599	2332.2946	270.2317	229.4845	40.7472	229.4845
Mass Flow	Lb/hr	42071.3291	42071.3291	65381.3227	65380.9094	42090.0553	36663.1912	5426.8630	36663.1912
LiqVol Flow	Barrel/day	3330.7459	3330.7459	5435.4024	5367.8065	3205.4298	2810.8346	394.5955	2810.8346
Enthalpy	Btu/hr	5.25511E+06	7.42322E+06	1.33372E+07	6.30514E+07	7.66057E+06	6.62781E+06	1.03275E+06	6.63062E+06
Density	Lbmole/ft3	0.0026	0.0048	0.0045	0.0009	0.3604	0.3490	0.4414	0.3490
Mole Wt.		28.8481	28.8481	28.0479	28.0329	155.7554	159.7632	133.1838	159.7632
Spec. Heat	Btu/lbmole-F	6.9609	7.0527	7.6948	9.3410	51.3311	52.2785	45.9953	52.2845
Therm Cond	Btu/hr-ft-F	0.0146	0.0191	0.0209	0.0467	---	---	---	---
Viscosity	Cp	0.0184	0.0236	0.0231	0.0700	---	---	---	---
Z Factor		0.9993	1.0002	0.9995	1.0003	0.0064	0.0066	0.0052	0.0136
Sur Tension	Dyne/cm	---	---	---	---	---	---	---	---
Std Density	Lb/ft3	---	---	---	---	56.1295	55.7561	58.7888	55.7561
IND_COAL	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nitrogen	Lb/hr	32296.2562	32296.2562	45325.4189	45325.4186	0.0000	0.0000	0.0000	0.0000
Oxygen	Lb/hr	9775.0712	9775.0712	9775.0740	0.0098	0.0000	0.0000	0.0000	0.0000
CO	Lb/hr	0.0000	0.0000	290.0253	0.0015	0.0000	0.0000	0.0000	0.0000
CO2	Lb/hr	0.0000	0.0000	3198.6836	11127.8643	0.0000	0.0000	0.0000	0.0000
Methane	Lb/hr	0.0000	0.0000	343.2199	0.0018	0.0000	0.0000	0.0000	0.0000
Ethane	Lb/hr	0.0000	0.0000	73.2254	0.0004	0.0000	0.0000	0.0000	0.0000
Ethylene	Lb/hr	0.0000	0.0000	17.6479	0.0001	0.0000	0.0000	0.0000	0.0000
Propane	Lb/hr	0.0000	0.0000	831.7790	0.0043	0.0000	0.0000	0.0000	0.0000
Propene	Lb/hr	0.0000	0.0000	20.2808	0.0001	0.0000	0.0000	0.0000	0.0000
H2S	Lb/hr	0.0000	0.0000	324.2417	0.0017	0.0000	0.0000	0.0000	0.0000
H2O	Lb/hr	0.0000	0.0000	3713.7959	3072.1383	0.0000	0.0000	0.0000	0.0000
CARB_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	35652.0559	31691.1926	3960.8633	31691.1926
ASH	Lb/hr	0.0000	0.0000	0.0000	0.0000	6438.0009	4972.0006	1466.0003	4972.0006
Hydrogen	Lb/hr	0.0000	0.0000	108.7894	0.0006	0.0000	0.0000	0.0000	0.0000
CALC_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[1]_334	Lb/hr	0.0000	0.0000	261.8074	0.0014	0.0000	0.0000	0.0000	0.0000
NBP[1]_369	Lb/hr	0.0000	0.0000	274.1063	0.0014	0.0000	0.0000	0.0000	0.0000
NBP[1]_403	Lb/hr	0.0000	0.0000	259.7124	0.0013	0.0000	0.0000	0.0000	0.0000
NBP[1]_437	Lb/hr	0.0000	0.0000	180.4026	0.0009	0.0000	0.0000	0.0000	0.0000
NBP[1]_471	Lb/hr	0.0000	0.0000	82.8826	0.0004	0.0000	0.0000	0.0000	0.0000
NBP[1]_506	Lb/hr	0.0000	0.0000	32.8657	0.0002	0.0000	0.0000	0.0000	0.0000
NBP[1]_542	Lb/hr	0.0000	0.0000	15.3318	0.0001	0.0000	0.0000	0.0000	0.0000
NBP[1]_574	Lb/hr	0.0000	0.0000	5.0147	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[1]_605	Lb/hr	0.0000	0.0000	0.9984	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[1]_648	Lb/hr	0.0000	0.0000	0.1323	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_225	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_301	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_363	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_427	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_494	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_559	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_630	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_697	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_767	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_901	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO2	Lb/hr	0.0000	0.0000	245.3898	855.4622	0.0000	0.0000	0.0000	0.0000
Total:	Lb/hr	42071.3291	42071.3291	65381.3227	65380.9094	42090.0553	36663.1912	5426.8630	36663.1912

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Stream		37	38	39	40	41	42	43	44
Description									
Vapour frac.		0.9401	0.8405	0.9634	0.0000	1.0000	0.0000	1.0000	1.0000
Temperature	F	1639.0474	1799.9466	1799.9466	1799.9466	1799.9466	1799.9466	1799.9466	1799.9466
Pressure	Psia	33.6960	28.6960	28.6960	28.6960	28.1960	28.1960	28.1960	28.1960
Molar Flow	Lbmole/hr	3828.0384	4582.1190	3997.2358	584.8837	3851.0901	146.1457	1266.2568	2584.8332
Mass Flow	Lb/hr	136663.1971	136659.7351	111559.5374	25100.2106	105287.7088	6271.8243	34619.1008*	70668.6080
LiqVol Flow	Barrel/day	11146.4946	11410.2389	9502.7751	1907.4647	9026.1540	476.6209	2967.8426	6058.3114
Enthalpy	Btu/hr	9.06378E+07	1.00307E+08	7.72809E+07	2.30265E+07	7.15272E+07	5.75363E+06	2.35185E+07	4.80087E+07
Density	Lbmole/ft3	0.0016	0.0014	0.0012	1.3107	0.0012	1.3107	0.0012	0.0012
Mole Wt.		35.7006	29.8246	27.9092	42.9149	27.3397	42.9148	27.3397	27.3397
Spec. Heat	Btu/lbmole-F	13.9864	12.0728	10.0967	25.5783	9.5091	25.5782	9.5091	9.5091
Therm Cond	Btu/hr-ft-F	---	---	---	---	0.0520	---	0.0520	0.0520
Viscosity	Cp	---	---	---	---	0.0478	---	0.0478	0.0478
Z Factor		---	---	---	0.0009	1.0004	0.0009	1.0004	1.0004
Sur Tension	Dyne/cm	---	---	---	---	---	0.0000	---	---
Std Density	Lb/ft3	---	---	---	56.2495	---	56.2495	---	---
IND_COAL	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nitrogen	Lb/hr	67529.1748	67529.1796	67529.1799	0.0000	67529.1772	0.0000	22203.9150	45325.2599
Oxygen	Lb/hr	0.0146	0.0146	0.0146	0.0000	0.0146	0.0000	0.0048	0.0098
CO	Lb/hr	288.0033	875.8287	875.8287	0.0000	875.8287	0.0000	287.9767	587.8520
CO2	Lb/hr	17976.0586	20827.2856	20827.2854	0.0000	20827.2854	0.0000	6848.1106	13979.1741
Methane	Lb/hr	288.0776	876.0536	876.0537	0.0000	876.0536	0.0000	288.0506	588.0030
Ethane	Lb/hr	8.9392	27.1835	27.1835	0.0000	27.1835	0.0000	8.9381	18.2454
Ethylene	Lb/hr	2.1781	6.6234	6.6234	0.0000	6.6234	0.0000	2.1778	4.4456
Propane	Lb/hr	101.4294	308.4391	308.4391	0.0000	308.4391	0.0000	101.4163	207.0229
Propene	Lb/hr	2.4608	7.4831	7.4831	0.0000	7.4831	0.0000	2.4605	5.0226
H2S	Lb/hr	128.6782	391.3122	391.3122	0.0000	391.3122	0.0000	128.6653	262.6468
H2O	Lb/hr	12285.6132	12814.5374	12814.5379	0.0000	12814.5381	0.0000	4213.4811	8601.0565
CARB_CHAR	Lb/hr	31691.1930	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ASH	Lb/hr	4972.0004	4972.0008	993.9899	3978.0111	0.0000	993.9899	0.0000	0.0000
Hydrogen	Lb/hr	86.0756	261.7589	261.7589	0.0000	261.7589	0.0000	86.0676	175.6913
CALC_CHAR	Lb/hr	0.0000	26400.0343	5277.8284	21122.2054	0.0000	5277.8284	0.0000	0.0000
NBP[1]_334	Lb/hr	0.0020	0.0020	0.0020	0.0000	0.0020	0.0000	0.0007	0.0014
NBP[1]_369	Lb/hr	0.0021	0.0021	0.0021	0.0000	0.0021	0.0000	0.0007	0.0014
NBP[1]_403	Lb/hr	0.0020	0.0020	0.0020	0.0000	0.0020	0.0000	0.0007	0.0013
NBP[1]_437	Lb/hr	0.0014	0.0014	0.0014	0.0000	0.0014	0.0000	0.0005	0.0009
NBP[1]_471	Lb/hr	0.0006	0.0006	0.0006	0.0000	0.0006	0.0000	0.0002	0.0004
NBP[1]_506	Lb/hr	0.0003	0.0003	0.0003	0.0000	0.0003	0.0000	0.0001	0.0002
NBP[1]_542	Lb/hr	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0001
NBP[1]_574	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[1]_605	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[1]_648	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_225	Lb/hr	2.6129	7.9461	7.9461	0.0000	7.9461	0.0000	2.6127	5.3334
NBP[2]_301	Lb/hr	1.9387	5.8956	5.8956	0.0000	5.8956	0.0000	1.9385	3.9571
NBP[2]_363	Lb/hr	4.5453	13.8226	13.8226	0.0000	13.8226	0.0000	4.5449	9.2777
NBP[2]_427	Lb/hr	4.7452	14.4304	14.4304	0.0000	14.4304	0.0000	4.7448	9.6856
NBP[2]_494	Lb/hr	3.6052	10.9635	10.9635	0.0000	10.9635	0.0000	3.6048	7.3586
NBP[2]_559	Lb/hr	2.4250	7.3745	7.3745	0.0000	7.3745	0.0000	2.4248	4.9497
NBP[2]_630	Lb/hr	1.5722	4.7812	4.7812	0.0000	4.7812	0.0000	1.5721	3.2091
NBP[2]_697	Lb/hr	1.3719	4.1721	4.1721	0.0000	4.1721	0.0000	1.3718	2.8003
NBP[2]_767	Lb/hr	1.2326	3.7484	3.7484	0.0000	3.7484	0.0000	1.2325	2.5159
NBP[2]_901	Lb/hr	4.7106	14.3252	14.3252	0.0000	14.3252	0.0000	4.7102	9.6150
SO2	Lb/hr	1274.5311	1274.5312	1274.5312	0.0000	1274.5312	0.0000	419.0719	855.4593
Total:	Lb/hr	136663.1971	136659.7351	111559.5374	25100.2106	105287.7088	6271.8243	34619.1008*	70668.6080

Stream		45	47	48	49	50	51	52	53
Description									
Vapour frac.		1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
Temperature	F	375.0000*	502.6848	1150.0000*	1150.0000	2329.1307*	200.0000*	200.0000*	200.0000
Pressure	Psia	23.1960	35.6960	33.6960	33.6960	33.6960*	14.6960	14.6960	14.6960
Molar Flow	Lbmole/hr	1266.2568	1266.2568	1266.2568	1074.6673	3598.5539*	584.8837	146.1457	132.3718
Mass Flow	Lb/hr	34619.1008	34619.1008	34619.1008	29381.1003	100000.0015	25100.2106	6271.8243	5614.3681
LiqVol Flow	Barrel/day	2967.8426	2967.8426	2967.8426	2518.7968	8335.6594	1907.4647	476.6209	430.9004
Enthalpy	Btu/hr	7.79391E+06	9.06803E+06	1.59556E+07	1.35415E+07	8.40072E+07	4.49427E+06	1.12299E+06	994477.1582
Density	Lbmole/ft3	0.0026	0.0035	0.0019	0.0019	0.0011	1.3107	1.3107	1.3132
Mole Wt.		27.3397	27.3397	27.3397	27.3397	27.7889	42.9149	42.9148	42.4136
Spec. Heat	Btu/lbmole-F	7.8201	7.9819	8.8231	8.8231	9.5787	14.0291	14.0291	13.7139
Therm Cond	Btu/hr-ft-F	0.0218	0.0248	0.0396	0.0396	0.0538	---	---	---
Viscosity	Cp	0.0224	0.0249	0.0361	0.0361	0.0582	---	---	---
Z Factor		0.9993	0.9997	1.0005	1.0005	1.0004	0.0016	0.0016	0.0016
Sur Tension	Dyne/cm	---	---	---	---	---	---	0.0000	---
Std Density	Lb/ft3	---	---	---	---	---	56.2495	56.2495	55.6957
IND_COAL	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000
Nitrogen	Lb/hr	22203.9150	22203.9150	22203.9150	18844.3790	67529.1735*	0.0000	0.0000	0.0000
Oxygen	Lb/hr	0.0048	0.0048	0.0048	0.0041	0.0146*	0.0000	0.0000	0.0000
CO	Lb/hr	287.9767	287.9767	287.9767	244.4047	288.0033*	0.0000	0.0000	0.0000
CO2	Lb/hr	6848.1106	6848.1106	6848.1106	5811.9657	17976.0581*	0.0000	0.0000	0.0000
Methane	Lb/hr	288.0506	288.0506	288.0506	244.4675	288.0776*	0.0000	0.0000	0.0000
Ethane	Lb/hr	8.9381	8.9381	8.9381	7.5857	8.9392*	0.0000	0.0000	0.0000
Ethylene	Lb/hr	2.1778	2.1778	2.1778	1.8483	2.1781*	0.0000	0.0000	0.0000
Propane	Lb/hr	101.4163	101.4163	101.4163	86.0716	101.4294*	0.0000	0.0000	0.0000
Propene	Lb/hr	2.4605	2.4605	2.4605	2.0882	2.4608*	0.0000	0.0000	0.0000
H2S	Lb/hr	128.6653	128.6653	128.6653	109.1978	128.6782*	0.0000	0.0000	0.0000
H2O	Lb/hr	4213.4811	4213.4811	4213.4811	3575.9656	12285.6132*	0.0000	0.0000	0.0000
CARB_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000
ASH	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000*	3978.0111	993.9899	745.4924
Hydrogen	Lb/hr	86.0676	86.0676	86.0676	73.0452	86.0756*	0.0000	0.0000	0.0000
CALC_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000*	21122.2054	5277.8284	4868.8758
NBP[1]_334	Lb/hr	0.0007	0.0007	0.0007	0.0006	0.0020*	0.0000	0.0000	0.0000
NBP[1]_369	Lb/hr	0.0007	0.0007	0.0007	0.0006	0.0021*	0.0000	0.0000	0.0000
NBP[1]_403	Lb/hr	0.0007	0.0007	0.0007	0.0006	0.0020*	0.0000	0.0000	0.0000
NBP[1]_437	Lb/hr	0.0005	0.0005	0.0005	0.0004	0.0014*	0.0000	0.0000	0.0000
NBP[1]_471	Lb/hr	0.0002	0.0002	0.0002	0.0002	0.0006*	0.0000	0.0000	0.0000
NBP[1]_506	Lb/hr	0.0001	0.0001	0.0001	0.0001	0.0003*	0.0000	0.0000	0.0000
NBP[1]_542	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0001*	0.0000	0.0000	0.0000
NBP[1]_574	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000
NBP[1]_605	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000
NBP[1]_648	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000	0.0000
NBP[2]_225	Lb/hr	2.6127	2.6127	2.6127	2.2174	2.6129*	0.0000	0.0000	0.0000
NBP[2]_301	Lb/hr	1.9385	1.9385	1.9385	1.6452	1.9387*	0.0000	0.0000	0.0000
NBP[2]_363	Lb/hr	4.5449	4.5449	4.5449	3.8573	4.5453*	0.0000	0.0000	0.0000
NBP[2]_427	Lb/hr	4.7448	4.7448	4.7448	4.0269	4.7452*	0.0000	0.0000	0.0000
NBP[2]_494	Lb/hr	3.6048	3.6048	3.6048	3.0594	3.6052*	0.0000	0.0000	0.0000
NBP[2]_559	Lb/hr	2.4248	2.4248	2.4248	2.0579	2.4250*	0.0000	0.0000	0.0000
NBP[2]_630	Lb/hr	1.5721	1.5721	1.5721	1.3342	1.5722*	0.0000	0.0000	0.0000
NBP[2]_697	Lb/hr	1.3718	1.3718	1.3718	1.1642	1.3719*	0.0000	0.0000	0.0000
NBP[2]_767	Lb/hr	1.2325	1.2325	1.2325	1.0460	1.2326*	0.0000	0.0000	0.0000
NBP[2]_901	Lb/hr	4.7102	4.7102	4.7102	3.9975	4.7106*	0.0000	0.0000	0.0000
SO2	Lb/hr	419.0719	419.0719	419.0719	355.6648	1274.5311*	0.0000	0.0000	0.0000
Total:	Lb/hr	34619.1008	34619.1008	34619.1008	29381.1003	100000.0015	25100.2106	6271.8243	5614.3681

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Stream		54	55	62	62A	63	64	65	66
Description									
Vapour frac.		0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature	F	200.0000	200.0000	304.9376	304.7820	2480.2514	2480.2514	600.3212	2236.9754
Pressure	Psia	14.6960	14.6960	24.8960	21.8960	21.8960	21.8960	21.8960	21.8960
Molar Flow	Lbmole/hr	13.7738	717.2555	346.7909	346.7909	53.4376	2911.8573	400.2285	3312.0859
Mass Flow	Lb/hr	657.4501	30714.5798	9263.0004*	9263.0004	1487.9995	81082.2083	10750.9999*	91833.2072
LiqVol Flow	Barrel/day	45.7200	2338.3651	836.3552	836.3551	123.8217	6747.1361	960.1768	7707.3132
Enthalpy	Btu/hr	128513.2220	5.48875E+06	2.05617E+06	2.05617E+06	1.34843E+06	7.34770E+07	3.40460E+06	7.68816E+07
Density	Lbmole/ft3	1.2878	1.3112	0.0030	0.0027	0.0007	0.0007	0.0019	0.0008
Mole Wt.		47.7320	42.8224	26.7106	26.7106	27.8455	27.8455	26.8622	27.7267
Spec. Heat	Btu/lbmole-F	17.0579	13.9709	8.6525	8.6489	9.8089	9.8089	9.1758	9.9731
Therm Cond	Btu/hr-ft-F	---	---	0.0215	0.0215	0.0535	0.0535	0.0288	0.0541
Viscosity	Cp	---	---	0.0198	0.0198	0.0607	0.0607	0.0259	0.0553
Z Factor		0.0016	0.0016	0.9982	0.9984	1.0002	1.0002	0.9999	1.0003
Sur Tension	Dyne/cm	---	---	---	---	---	---	---	---
Std Density	Lb/ft3	61.4688	56.1474	---	---	---	---	---	---
IND_COAL	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nitrogen	Lb/hr	0.0000	0.0000	5177.5696	5177.5696	1004.3983	54730.4157	6181.9676	60912.3837
Oxygen	Lb/hr	0.0000	0.0000	0.0011	0.0011	0.0002	0.0118	0.0013	0.0131
CO	Lb/hr	0.0000	0.0000	115.2512	115.2512	2.5162	137.1106	117.7674	254.8780
CO2	Lb/hr	0.0000	0.0000	1271.1028	1271.1028	246.5893	13436.8367	1517.6921	14954.5289
Methane	Lb/hr	0.0000	0.0000	136.3898	136.3898	2.9777	162.2585	139.3675	301.6260
Ethane	Lb/hr	0.0000	0.0000	29.0985	29.0985	0.6353	34.6176	29.7338	64.3514
Ethylene	Lb/hr	0.0000	0.0000	7.0130	7.0130	0.1531	8.3431	7.1661	15.5092
Propane	Lb/hr	0.0000	0.0000	330.5349	330.5349	7.2164	393.2268	337.7513	730.9781
Propene	Lb/hr	0.0000	0.0000	8.0593	8.0593	0.1760	9.5878	8.2352	17.8231
H2S	Lb/hr	0.0000	0.0000	128.8482	128.8482	2.8131	153.2866	131.6613	284.9473
H2O	Lb/hr	0.0000	0.0000	1475.7997	1475.7997	190.9650	10405.3269	1666.7647	12072.5912
CARB_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ASH	Lb/hr	248.4975	4723.5034	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hydrogen	Lb/hr	0.0000	0.0000	43.2311	43.2311	0.9438	51.4306	44.1749	95.6056
CALC_CHAR	Lb/hr	408.9527	25991.0816	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[1]_334	Lb/hr	0.0000	0.0000	104.0378	104.0378	2.2714	123.7705	106.3092	230.0797
NBP[1]_369	Lb/hr	0.0000	0.0000	108.9252	108.9252	2.3781	129.5848	111.3033	240.8882
NBP[1]_403	Lb/hr	0.0000	0.0000	103.2053	103.2053	2.2532	122.7801	105.4585	228.2386
NBP[1]_437	Lb/hr	0.0000	0.0000	71.6889	71.6889	1.5651	85.2860	73.2541	158.5401
NBP[1]_471	Lb/hr	0.0000	0.0000	32.9361	32.9361	0.7191	39.1831	33.6552	72.8383
NBP[1]_506	Lb/hr	0.0000	0.0000	13.0603	13.0603	0.2851	15.5374	13.3454	28.8823
NBP[1]_542	Lb/hr	0.0000	0.0000	6.0926	6.0926	0.1330	7.2481	6.2256	13.4737
NBP[1]_574	Lb/hr	0.0000	0.0000	1.9927	1.9927	0.0435	2.3707	2.0363	4.4070
NBP[1]_605	Lb/hr	0.0000	0.0000	0.3968	0.3968	0.0087	0.4720	0.4054	0.8774
NBP[1]_648	Lb/hr	0.0000	0.0000	0.0526	0.0526	0.0011	0.0625	0.0537	0.1163
NBP[2]_225	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_301	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_363	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_427	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_494	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_559	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_630	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_697	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_767	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NBP[2]_901	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO2	Lb/hr	0.0000	0.0000	97.7124	97.7124	18.9566	1032.9609	116.6691	1149.6299
Total:	Lb/hr	657.4501	30714.5798	9263.0004*	9263.0004	1487.9995	81082.2083	10750.9999*	91833.2072

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Date 92/04/01 Version 386|C1.51 Case Name N2_090.SIM
Time 14:33:37 Prop Pkg PR

Stream		70	71	72	73	74	74A	75	177
Description									
Vapour frac.		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	2.0000*
Temperature	F	1150.0000	2394.3244	2329.1324	304.9376	304.9376	304.7820	2480.2514	0.0000*
Pressure	Psia	33.6960	33.6960	33.6960	24.8960	24.8960	21.8960	21.8960	0.0000*
Molar Flow	Lbmole/hr	191.5894	3406.9620	3598.5515	766.9233	420.1325	420.1325	2965.2952	0.0000*
Mass Flow	Lb/hr	5237.9999*	94762.0097	100000.0101	20484.9990*	11221.9985	11221.9985	82570.2100	0.0000*
LiqVol Flow	Barrel/day	449.0457	7886.6030	8335.6490	1849.5882	1013.2330	1013.2330	6870.9579	0.0000*
Enthalpy	Btu/hr	2.41415E+06	8.15930E+07	8.40071E+07	4.54720E+06	2.49103E+06	2.49103E-06	7.48254E+07	4.27992E-06
Density	Lbmole/ft3	0.0019	0.0011	0.0011	0.0030	0.0030	0.0027	0.0007	0.0000
Mole Wt.		27.3397	27.8142	27.7890	26.7106	26.7106	26.7106	27.8455	0.0000
Spec. Heat	Btu/lbmole-F	8.8231	9.5781	9.5787	8.6525	8.6525	8.6439	9.8089	0.0000
Therm Cond	Btu/hr-ft-F	0.0396	0.0537	0.0538	0.0215	0.0215	0.0215	0.0535	---
Viscosity	Cp	0.0361	0.0594	0.0582	0.0198	0.0198	0.0198	0.0607	---
Z Factor		1.0005	1.0004	1.0004	0.9982	0.9982	0.9984	1.0002	---
Sur Tension	Dyne/cm	---	---	---	---	---	---	---	---
Std Density	Lb/ft3	---	---	---	---	---	---	---	---
IND_COAL	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
Nitrogen	Lb/hr	3359.5356	64169.7981	67529.3323	11450.1250	6272.5554	6272.5554	55734.8182	0.0000*
Oxygen	Lb/hr	0.0007	0.0138	0.0146	0.0025	0.0014	0.0014	0.0120	0.0000*
CO	Lb/hr	43.5719	244.4062	287.9781	254.8764	139.6252	139.6252	139.6268	0.0000*
CO2	Lb/hr	1036.1448	16939.8303	17975.9752	2811.0267	1539.9238	1539.9238	13683.4270	0.0000*
Methane	Lb/hr	43.5831	244.4692	288.0524	301.6241	165.2344	165.2344	165.2363	0.0000*
Ethane	Lb/hr	1.3524	7.5861	8.9384	64.3510	35.2525	35.2525	35.2529	0.0000*
Ethylene	Lb/hr	0.3295	1.8484	2.1779	15.5091	8.4961	8.4961	8.4962	0.0000*
Propane	Lb/hr	15.3447	86.0759	101.4205	730.9735	400.4386	400.4386	400.4432	0.0000*
Propene	Lb/hr	0.3723	2.0883	2.4606	17.8229	9.7637	9.7637	9.7638	0.0000*
H2S	Lb/hr	19.4675	109.1994	128.6670	284.9460	156.0978	156.0973	156.0996	0.0000*
H2O	Lb/hr	637.5155	11648.1037	12285.6194	3263.7110	1787.9113	1787.9113	10596.7927	0.0000*
CARB_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
ASH	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
Hydrogen	Lb/hr	13.0223	73.0458	86.0681	95.6050	52.3739	52.3739	52.3745	0.0000*
CALC_CHAR	Lb/hr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[1]_334	Lb/hr	0.0001	0.0019	0.0020	230.0782	126.0404	126.0404	126.0419	0.0000*
NBP[1]_369	Lb/hr	0.0001	0.0020	0.0021	240.8866	131.9614	131.9614	131.9629	0.0000*
NBP[1]_403	Lb/hr	0.0001	0.0019	0.0020	228.2372	125.0318	125.0318	125.0333	0.0000*
NBP[1]_437	Lb/hr	0.0001	0.0013	0.0014	158.5391	86.8502	86.8502	86.8512	0.0000*
NBP[1]_471	Lb/hr	0.0000	0.0006	0.0006	72.8378	39.9017	39.9017	39.9021	0.0000*
NBP[1]_506	Lb/hr	0.0000	0.0002	0.0003	28.8826	15.8223	15.8223	15.8225	0.0000*
NBP[1]_542	Lb/hr	0.0000	0.0001	0.0001	13.4737	7.3811	7.3811	7.3812	0.0000*
NBP[1]_574	Lb/hr	0.0000	0.0000	0.0000	4.4069	2.4142	2.4142	2.4142	0.0000*
NBP[1]_605	Lb/hr	0.0000	0.0000	0.0000	0.8774	0.4807	0.4807	0.4807	0.0000*
NBP[1]_648	Lb/hr	0.0000	0.0000	0.0000	0.1163	0.0637	0.0637	0.0637	0.0000*
NBP[2]_225	Lb/hr	0.3953	2.2174	2.6127	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_301	Lb/hr	0.2933	1.6452	1.9385	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_363	Lb/hr	0.6877	3.8573	4.5449	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_427	Lb/hr	0.7179	4.0269	4.7448	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_494	Lb/hr	0.5454	3.0594	3.6048	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_559	Lb/hr	0.3669	2.0579	2.4248	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_630	Lb/hr	0.2379	1.3342	1.5721	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_697	Lb/hr	0.2076	1.1642	1.3718	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_767	Lb/hr	0.1865	1.0460	1.2325	0.0000	0.0000	0.0000	0.0000	0.0000*
NBP[2]_901	Lb/hr	0.7127	3.9975	4.7102	0.0000	0.0000	0.0000	0.0000	0.0000*
SO2	Lb/hr	63.4072	1211.1270	1274.5341	216.0897	118.3773	118.3773	1051.9176	0.0000*
Total:	Lb/hr	5237.9999*	94762.0097	100000.0101	20484.9990*	11221.9985	11221.9985	82570.2100	0.0000*

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Date 92/04/01 Version 386|C1.51 Case Name 42_090.SIM
Time 14:33:37 Prop Pkg PR

Stream		178	179	181	182	183	184	185	186
Description									
Vapour frac.		2.0000*	2.0000*	2.0000*	2.0000*	2.0000*	2.0000*	2.0000*	2.0000*
Temperature	F	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Pressure	Psia	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Molar Flow	Lbmole/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Mass Flow	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
LiqVol Flow	Barrel/day	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Enthalpy	Btu/hr	2.16810E+06	1.24518E+06	0.0000*	4.63064E+06	1.35322E+07	6.38764E+06	1.27412E+06	1.57245E+07
Density	Lbmole/ft3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mole Wt.		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Spec. Heat	Btu/lbmole-F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Therm Cond	Btu/hr-ft-F	---	---	---	---	---	---	---	---
Viscosity	Cp	---	---	---	---	---	---	---	---
Z Factor		---	---	---	---	---	---	---	---
Sur Tension	Dyne/cm	---	---	---	---	---	---	---	---
Std Density	Lb/ft3	---	---	---	---	---	---	---	---
IND_COAL	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Nitrogen	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Oxygen	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
CO	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
CO2	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Methane	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Ethane	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Ethylene	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Propane	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Propene	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
H2S	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
H2O	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
CARB_CHAR	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
ASH	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Hydrogen	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
CALC_CHAR	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_334	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_369	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_403	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_437	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_471	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_506	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_542	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_574	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_605	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_648	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_225	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_301	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_363	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_427	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_494	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_559	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_630	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_697	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_767	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_901	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
SO2	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Total:	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*

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Date 92/04/01 Version 386|C1.51 Case Name H2_090.SIM
Time 14:33:37 Prop Pkg PR

Stream		187	188	189	190	191	192	193	194
Description									
Vapour frac.		2.0000*	2.0000*	2.0000*	2.0000*	2.0000*	2.0000*	2.0000*	2.0000*
Temperature	F	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Pressure	Psia	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Molar Flow	Lbmole/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Mass Flow	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
LiqVol Flow	Barrel/day	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Enthalpy	Btu/hr	0.0000*	0.0000*	6.99999E-06*	2806.4597	0.0000*	1.52709E-07	0.0000*	0.0000*
Density	Lbmole/ft3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mole Wt.		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Spec. Heat	Btu/lbmole-F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Therm Cond	Btu/hr-ft-F	---	---	---	---	---	---	---	---
Viscosity	Cp	---	---	---	---	---	---	---	---
Z Factor		---	---	---	---	---	---	---	---
Sur Tension	Dyne/cm	---	---	---	---	---	---	---	---
Std Density	Lb/ft3	---	---	---	---	---	---	---	---
IND_COAL	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Nitrogen	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Oxygen	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
CO	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
CO2	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Methane	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Ethane	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Ethylene	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Propane	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Propene	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
H2S	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
H2O	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
CARB_CHAR	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
ASH	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Hydrogen	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
CALC_CHAR	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_334	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_369	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_403	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_437	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_471	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_506	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_542	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_574	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_605	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[1]_648	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_225	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_301	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_363	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_427	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_494	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_559	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_630	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_697	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_767	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
NBP[2]_901	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
SO2	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Total:	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*

Hyprotech's Process Simulator HYSIM - Licensed to Bechtel Inc
Date 92/04/01 Version 386|C1.51 Case Name 42_390.SIM
Time 14:33:37 Prop Pkg PR

Stream		195	196	197	198	199	200	500	501
Description									
Vapour frac.		2.0000*	2.0000*	2.0000*	2.0000*	2.0000*	2.0000*	1.0000	1.0000
Temperature	F	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	1799.9466*	1210.1668
Pressure	Psia	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	28.1960*	25.6960
Molar Flow	Lbmole/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	1266.2568*	1266.2568
Mass Flow	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	34619.1008	34619.1008
LiqVol Flow	Barrel/day	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	2967.3426	2967.3426
Enthalpy	Btu/hr	1.65974E+06	3.39205E+07	10301.6701	0.0000*	0.0000*	6.99999E+06*	2.35185E+07	1.66308E+07
Density	Lbmole/ft3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0014
Mole Wt.		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	27.3397	27.3397
Spec. Heat	Btu/lbmole-F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	9.5091	8.3967
Therm Cond	Btu/hr-ft-F	---	---	---	---	---	---	0.0520	0.0409
Viscosity	Cp	---	---	---	---	---	---	0.0478	0.0371
Z Factor		---	---	---	---	---	---	1.0004	1.0004
Sur Tension	Dyne/cm	---	---	---	---	---	---	---	---
Std Density	Lb/ft3	---	---	---	---	---	---	---	---
IND_COAL	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
Nitrogen	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	22203.9171*	22203.9171
Oxygen	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0048*	0.0048
CO	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	287.9767*	287.9767
CO2	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	6848.1110*	6848.1110
Methane	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	288.0506*	288.0506
Ethane	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	8.9381*	8.9381
Ethylene	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	2.1778*	2.1778
Propane	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	101.4163*	101.4163
Propene	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	2.4605*	2.4605
H2S	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	128.6653*	128.6653
H2O	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	4213.4815*	4213.4815
CARB_CHAR	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
ASH	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
Hydrogen	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	36.0676*	86.0676
CALC_CHAR	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
NBP[1]_334	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0007*	0.0007
NBP[1]_369	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0007*	0.0007
NBP[1]_403	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0007*	0.0007
NBP[1]_437	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0005*	0.0005
NBP[1]_471	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0002*	0.0002
NBP[1]_506	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0001*	0.0001
NBP[1]_542	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
NBP[1]_574	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
NBP[1]_605	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
NBP[1]_648	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
NBP[2]_225	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	2.6127*	2.6127
NBP[2]_301	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	1.9385*	1.9385
NBP[2]_363	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	4.5449*	4.5449
NBP[2]_427	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	4.7448*	4.7448
NBP[2]_494	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	3.6048*	3.6048
NBP[2]_559	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	2.4248*	2.4248
NBP[2]_630	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	1.5721*	1.5721
NBP[2]_697	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	1.3718*	1.3718
NBP[2]_767	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	1.2325*	1.2325
NBP[2]_901	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	4.7102*	4.7102
SO2	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	419.0720*	419.0720
Total:	Lb/hr	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	34619.1008	34619.1008

Stream		550	CALC_OIL	CARB_OIL
Description				
Vapour frac.		2.0000*	0.0000	0.0000
Temperature F		0.0000*	60.0000*	60.0000*
Pressure	Psia	0.0000*	14.6960*	14.6960*
Molar Flow	Lbmole/hr	0.0000*	0.3243	55.3037
Mass Flow	Lb/hr	0.0000*	59.0000*	9500.0003*
LiqVol Flow	Barrel/day	0.0000*	4.9072	800.3325
Enthalpy	Btu/hr	6.38764E-06	-3969.7752	-666103.4285
Density	Lbmole/ft3	0.0000	0.2825	0.2954
Mole Wt.		0.0000	181.9169	171.7786
Spec. Heat	Btu/lbmole-F	0.0000	81.7146	76.5464
Therm Cond	Btu/hr-ft-F	---	0.0734	0.0733
Viscosity	Cp	---	4.3557	2.2559
Z Factor		---	0.0093	0.0089
Sur Tension	Dyne/cm	---	27.3939	28.0277
Std Density	Lb/ft3	---	51.3941	50.7400
INO_COAL	Lb/hr	0.0000*	0.0000*	0.0000*
Nitrogen	Lb/hr	0.0000*	0.0000*	0.0000*
Oxygen	Lb/hr	0.0000*	0.0000*	0.0000*
CO	Lb/hr	0.0000*	0.0000*	0.0000*
CO2	Lb/hr	0.0000*	0.0000*	0.0000*
Methane	Lb/hr	0.0000*	0.0000*	0.0000*
Ethane	Lb/hr	0.0000*	0.0000*	0.0000*
Ethylene	Lb/hr	0.0000*	0.0000*	0.0000*
Propane	Lb/hr	0.0000*	0.0000*	0.0000*
Propene	Lb/hr	0.0000*	0.0000*	0.0000*
H2S	Lb/hr	0.0000*	0.0000*	0.0000*
H2O	Lb/hr	0.0000*	0.0000*	0.0000*
CARB_CHAR	Lb/hr	0.0000*	0.0000*	0.0000*
ASH	Lb/hr	0.0000*	0.0000*	0.0000*
Hydrogen	Lb/hr	0.0000*	0.0000*	0.0000*
CALC_CHAR	Lb/hr	0.0000*	0.0000*	0.0000*
NBP[1]_334	Lb/hr	0.0000*	0.0000*	1048.6413*
NBP[1]_369	Lb/hr	0.0000*	0.0000*	1245.0707*
NBP[1]_403	Lb/hr	0.0000*	0.0000*	1470.5357*
NBP[1]_437	Lb/hr	0.0000*	0.0000*	1449.0710*
NBP[1]_471	Lb/hr	0.0000*	0.0000*	1112.6965*
NBP[1]_506	Lb/hr	0.0000*	0.0000*	904.3082*
NBP[1]_542	Lb/hr	0.0000*	0.0000*	991.7859*
NBP[1]_574	Lb/hr	0.0000*	0.0000*	749.0958*
NBP[1]_605	Lb/hr	0.0000*	0.0000*	358.2151*
NBP[1]_648	Lb/hr	0.0000*	0.0000*	170.5801*
NBP[2]_225	Lb/hr	0.0000*	5.3581*	0.0000*
NBP[2]_301	Lb/hr	0.0000*	4.0363*	0.0000*
NBP[2]_363	Lb/hr	0.0000*	9.2669*	0.0000*
NBP[2]_427	Lb/hr	0.0000*	9.7097*	0.0000*
NBP[2]_494	Lb/hr	0.0000*	7.3558*	0.0000*
NBP[2]_559	Lb/hr	0.0000*	4.9572*	0.0000*
NBP[2]_630	Lb/hr	0.0000*	3.2970*	0.0000*
NBP[2]_697	Lb/hr	0.0000*	2.8175*	0.0000*
NBP[2]_767	Lb/hr	0.0000*	2.5369*	0.0000*
NBP[2]_901	Lb/hr	0.0000*	9.6646*	0.0000*
SO2	Lb/hr	0.0000*	0.0000*	0.0000*
Total:	Lb/hr	0.0000*	59.0000*	9500.0003*

XBi XYTEL-BECHTEL, INC.

INSTRUMENT COST

Date: 01-Apr-92
Sheet No. 1 of 5

Client: UND/EERC Unit: 1,000 T/D MILD COAL GASIFICATION
Location: CLAY COUNTY, IN

Dwg. No. PFD-001 Equipment No.
P&ID No. Unit No.

TYPE		INSTRUMENTS	QUAN-TITY	UNIT COST	HARDWARE COST	LABOR COST	TOTAL COST
FLOW	1	Transmitter					
	2	ΔP Transmitter					
	3	Orifice Plate & Flange					
	4	Variable Area Meter (Rotameter)					
	5	Indicating Meter					
	6	Sight Flow Indicator					
	7	Switch	5	$500			$2,500
	8	Thermal Flow Switch					
	9	Thermal Flow Sensor	5	$400			$2,000
	10						
LEVEL	11	ΔP Transmitter					
	12	Displacer & Float					
	13	Gauge Glass					
	14	Magnetic Level Indicator					
	15	Switch	9	$800			$7,200
	16	Ultrasonic Level Sensor					
	17	Ultrasonic Level Switch					
	18						
	19						
PRESSURE	20	Transmitter	5	$1,200			$6,000
	21	Gauge	7	$150			$1,050
	22	Regulator					
	23	Switch					
	24						
	25						
DIFFER-ENTIAL PRESSURE	26	Transmitter	7	$1,200			$8,400
	27	Gauge	7	$300			$2,100
	28	Switch	7	$500			$3,500
	29						
	30						
TEMPER-ATURE	31	Thermocouple	5	$100			$500
	32	RTD					
	33	Temperature Transmitter	5	$500			$2,500
	34	Bimetal Thermometer	8	$150			$1,200
	35	Regulator					
	36	Thermowell	13	$150			$1,950
	37	Safety Switch					
	38	Thermostat					
	39						
	40						
OTHER	41	Density Transmitter					
	42	Viscosity Transmitter					
	43	I/P or E/P					
	44	Weight Scale	6	$10,000			$60,000
	45	Analyzer					
	46	Diaphragm Seal					
	47	Control Valve	3	$4,000			$12,000
	48	Air-Actuated On/Off Valve	4	$4,000			$16,000
	49	Solenoid Valve	30	$250			$7,500
	50	Safety Relief Valve					
	51	Rupture Disc					
	52	Controller PLC	1	$26,000			$26,000
	53	Weigh Belt Feeder Control	7	$4,000			$28,000
	54	Metal Detector	1	$1,000			$1,000
	55	RPM Sensor Switch	5	$800			$4,000
	56	Vibration Switch	3	$500			$1,500
	57	TOTAL COST					$194,900
NOTES	58						
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XBi XYTEL-BECHTEL INC.

INSTRUMENT COST

Date: 01-Apr-92
Sheet No. 2 of 5

Client: UND/EERC
Unit: 1,000 T/D MILD COAL GASIFICATION
Location: CLAY COUNTY, IN

Dwg. No. PFD-002
P&ID No.
Equipment No.
Unit No.

TYPE		INSTRUMENTS	QUANTITY	UNIT COST	HARDWARE COST	LABOR COST	TOTAL COST
FLOW	1	Transmitter					
	2	ΔP Transmitter	1	$1,200			$1,200
	3	Orifice Plate & Flange	1	$350			$350
	4	Variable Area Meter (Rotameter)					
	5	Indicating Meter					
	6	Sight Flow Indicator					
	7	Switch					
	8	Thermal Flow Switch	3	$500			$1,500
	9	Thermal Flow Sensor	3	$400			$1,200
	10						
LEVEL	11	ΔP Transmitter	2	$1,200			$2,400
	12	Displacer & Float					
	13	Gauge Glass					
	14	Magnetic Level Indicator					
	15	Switch	11	$800			$8,800
	16	Ultrasonic Level Sensor					
	17	Ultrasonic Level Switch					
	18						
	19						
PRESSURE	20	Transmitter	1	$1,200			$1,200
	21	Gauge	3	$150			$450
	22	Regulator					
	23	Switch	2	$500			$1,000
	24						
	25						
DIFFERENTIAL PRESSURE	26	Transmitter	6	$1,200			$7,200
	27	Gauge	6	$300			$1,800
	28	Switch	6	$500			$3,000
	29						
	30						
TEMPERATURE	31	Thermocouple	5	$100			$500
	32	RTD					
	33	Temperature Transmitter	5	$600			$3,000
	34	Bimetal Thermometer	8	$150			$1,200
	35	Regulator					
	36	Thermowell	13	$150			$1,950
	37	Safety Switch					
	38	Thermostat					
	39						
	40						
OTHER	41	Density Transmitter					
	42	Viscosity Transmitter					
	43	I/P or E/P					
	44	Weight Scale	4	$10,000			$40,000
	45	Analyzer					
	46	Diaphragm Seal					
	47	Control Valve	5	$4,000			$20,000
	48	Air-Actuated On/Off Valve	8	$4,000			$32,000
	49	Solenoid Valve	10	$250			$2,500
	50	Safety Relief Valve					
	51	Rupture Disc					
	52	Controller PLC	2	$26,000			$52,000
	53	Weigh Belt Feeder Control	6	$4,000			$24,000
	54	Digital Connections					
	55	RPM Sensor Switch	6	$800			$4,800
	56	Vibration Switch					
	57	TOTAL COST					$212,050
NOTES	58						
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XBi XYTEL-BECHTEL INC.

INSTRUMENT COST

Date: 01-Apr-92
Sheet No. 3 of 5

Client: UND/EERC — Unit: 1,000 T/D MILD COAL GASIFICATION

Location: CLAY COUNTY, IN

Dwg. No. PFD-003 — Equipment No.

P&ID No. — Unit No.

TYPE		INSTRUMENTS	QUAN-TITY	UNIT COST	HARDWARE COST	LABOR COST	TOTAL COST
FLOW	1	Transmitter	1	$1,200			$1,200
	2	ΔP Transmitter	7	$1,200			$8,400
	3	Orifice Plate & Flange	7	$350			$2,450
	4	Variable Area Meter (Rotameter)					
	5	Indicating Meter					
	6	Sight Flow Indicator					
	7	Switch					
	8	Thermal Flow Switch					
	9	Thermal Flow Sensor					
	10	Magnetic Flow Meter	1	$4,000			$4,000
LEVEL	11	ΔP Transmitter	3	$1,200			$3,600
	12	Displacer & Float					
	13	Gauge Glass	1	$1,000			$1,000
	14	Magnetic Level Indicator					
	15	Switch	3	$800			$2,400
	16	Ultrasonic Level Sensor					
	17	Ultrasonic Level Switch					
	18						
	19						
PRESSURE	20	Transmitter	3	$1,200			$3,600
	21	Gauge	1	$150			$150
	22	Regulator					
	23	Switch					
	24						
	25						
DIFFER-ENTIAL PRESSURE	26	Transmitter	1	$1,200			$1,200
	27	Gauge					
	28	Switch					
	29						
	30						
TEMPER-ATURE	31	Thermocouple	9	$100			$900
	32	RTD					
	33	Temperature Transmitter	9	$600			$5,400
	34	Bimetal Thermometer	9	$150			$1,350
	35	Regulator					
	36	Thermowell	18	$150			$2,700
	37	Safety Switch					
	38	Thermostat					
	39						
	40						
OTHER	41	Density Transmitter					
	42	Viscosity Transmitter					
	43	I/P or E/P					
	44	Weight Scale					
	45	Analyzer	2	$20,000			$40,000
	46	Diaphragm Seal					
	47	Control Valve	8	$4,000			$32,000
	48	Air-Actuated On/Off Valve	2	$4,000			$8,000
	49	Solenoid Valve					
	50	Safety Relief Valve					
	51	Rupture Disc					
	52	Controller PLC	1	$25,000			$26,000
	53	Weigh Belt Feeder Control					
	54	Digital Connections					
	55	RPM Sensor Switch					
	56	Vibration Switch	1	$500			$500
	57	TOTAL COST					$144,850
NOTES	58						
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XBi XYTEL-BECHTEL INC.

INSTRUMENT COST

Date: 01-Apr-92
Sheet No. 4 of 5

Client: UND/EERC
Unit: 1,000 T/D MILD COAL GASIFICATION
Location: CLAY COUNTY, IN

Dwg. No. PFD-004
P&ID No.
Equipment No.
Unit No.

TYPE		INSTRUMENTS	QUANTITY	COST PER UNIT INSTRUMENT	HARDWARE	LABOR	TOTAL COST
FLOW	1	Transmitter					
	2	ΔP Transmitter	1	$1,200			$1,200
	3	Orifice Plate & Flange	1	$350			$350
	4	Variable Area Meter (Rotameter)					
	5	Indicating Meter					
	6	Sight Flow Indicator					
	7	Switch					
	8	Thermal Flow Switch	4	$500			$2,000
	9	Thermal Flow Sensor	2	$400			$800
	10						
LEVEL	11	ΔP Transmitter	1	$1,200			$1,200
	12	Displacer & Float					
	13	Gauge Glass					
	14	Magnetic Level Indicator					
	15	Switch	12	$800			$9,600
	16	Ultrasonic Level Sensor	3	$1,000			$3,000
	17	Ultrasonic Level Switch	1	$600			$600
	18						
	19						
PRESSURE	20	Transmitter	9	$1,200			$10,800
	21	Gauge	7	$150			$1,050
	22	Regulator					
	23	Switch	3	$500			$1,500
	24						
	25						
DIFFERENTIAL PRESSURE	25	Transmitter	5	$1,200			$6,000
	27	Gauge	4	$300			$1,200
	28	Switch					
	29						
	30						
TEMPERATURE	31	Thermocouple	7	$100			$700
	32	RTD					
	33	Temperature Transmitter	7	$600			$4,200
	34	Bimetal Thermometer	4	$150			$600
	35	Regulator					
	36	Thermowell	10	$150			$1,500
	37	Safety Switch					
	38	Thermostat					
	39						
	40						
OTHER	41	Density Transmitter					
	42	Viscosity Transmitter					
	43	I/P or E/P					
	44	Weight Scale	3	$10,000			$30,000
	45	Analyzer					
	46	Diaphragm Seal					
	47	Control Valve	6	$4,000			$24,000
	48	Air-Actuated On/Off Valve	10	$4,000			$40,000
	49	Solenoid Valve	10	$250			$2,500
	50	Safety Relief Valve					
	51	Rupture Disc					
	52	Controller PLC	1	$26,000			$26,000
	53	Weigh Belt Feeder Control					
	54	Digital Connections					
	55	RPM Sensor Switch	4	$800			$3,200
	56	Vibration Switch	1	$500			$500
	57	TOTAL COST					$172,500
NOTES	58						
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XBi XYTEL-BECHTEL, INC.

INSTRUMENT COST

Date: 01-Apr-92
Sheet No. 5 of 5

Client: UND/EERC | Unit: 1,000 T/D MILD COAL GASIFICATION

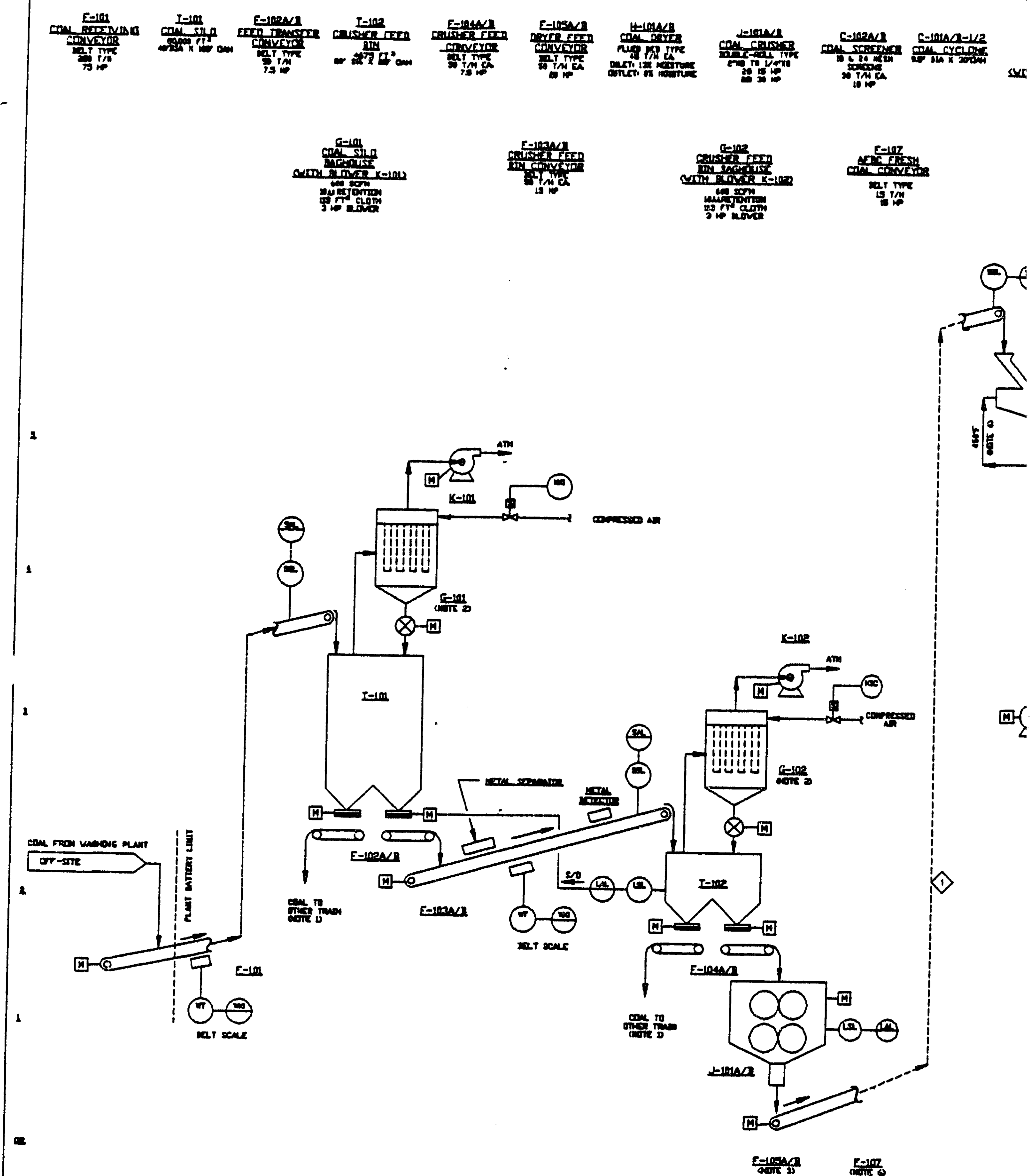
Location: CLAY COUNTY, IN

Dwg. No. PFD-005 | Equipment No.
P&ID No. | Unit No.

TYPE		INSTRUMENTS	QUAN-TITY	COST PER UNIT INSTRUMENT	HARDWARE	LABOR	TOTAL COST
FLOW	1	Transmitter	3	$1,200			$3,600
	2	ΔP Transmitter					
	3	Orifice Plate & Flange	3	$350			$1,050
	4	Variable Area Meter (Rotameter)					
	5	Indicating Meter					
	6	Sight Flow Indicator					
	7	Switch					
	8	Thermal Flow Switch					
	9	Thermal Flow Sensor					
	10						
LEVEL	11	ΔP Transmitter					
	12	Displacer & Float					
	13	Gauge Glass					
	14	Magnetic Level Indicator					
	15	Switch	9	$800			$7,200
	16	Ultrasonic Level Sensor					
	17	Ultrasonic Level Switch					
	18						
	19						
PRESSURE	20	Transmitter	2	$1,200			$2,400
	21	Gauge	4	$150			$600
	22	Regulator					
	23	Switch					
	24						
	25						
DIFFERENTIAL PRESSURE	26	Transmitter	2	$1,200			$2,400
	27	Gauge	2	$300			$600
	28	Switch	2	$500			$1,000
	29						
	30						
TEMPERATURE	31	Thermocouple	2	$100			$200
	32	RTD					
	33	Temperature Transmitter	2	$600			$1,200
	34	Bimetal Thermometer	2	$150			$300
	35	Regulator					
	36	Thermowell	4	$150			$600
	37	Safety Switch					
	38	Thermostat					
	39						
	40						
OTHER	41	Density Transmitter					
	42	Viscosity Transmitter					
	43	I/P or E/P					
	44	Weight Scale – Train	2 / 1	$10M / $80M			$100,000
	45	Analyzer					
	46	Diaphragm Seal					
	47	Control Valve	3	$4,000			$12,000
	48	Air-Actuated On/Off Valve	6	$4,000			$24,000
	49	Solenoid Valve	20	$250			$5,000
	50	Safety Relief Valve					
	51	Rupture Disc					
	52	Controller PLC	1	$26,000			$26,000
	53	Weigh Belt Feeder Control	1	$4,000			$4,000
	54	Digital Connections					
	55	RPM Sensor Switch	4	$800			$3,200
	56	Vibration Switch					
	57	TOTAL COST					$195,350
NOTES	58						
	59						
	60						
	61						

APPENDIX B

COMMERCIAL MILD GASIFICATION PLANT PROCESS-FLOW DIAGRAMS

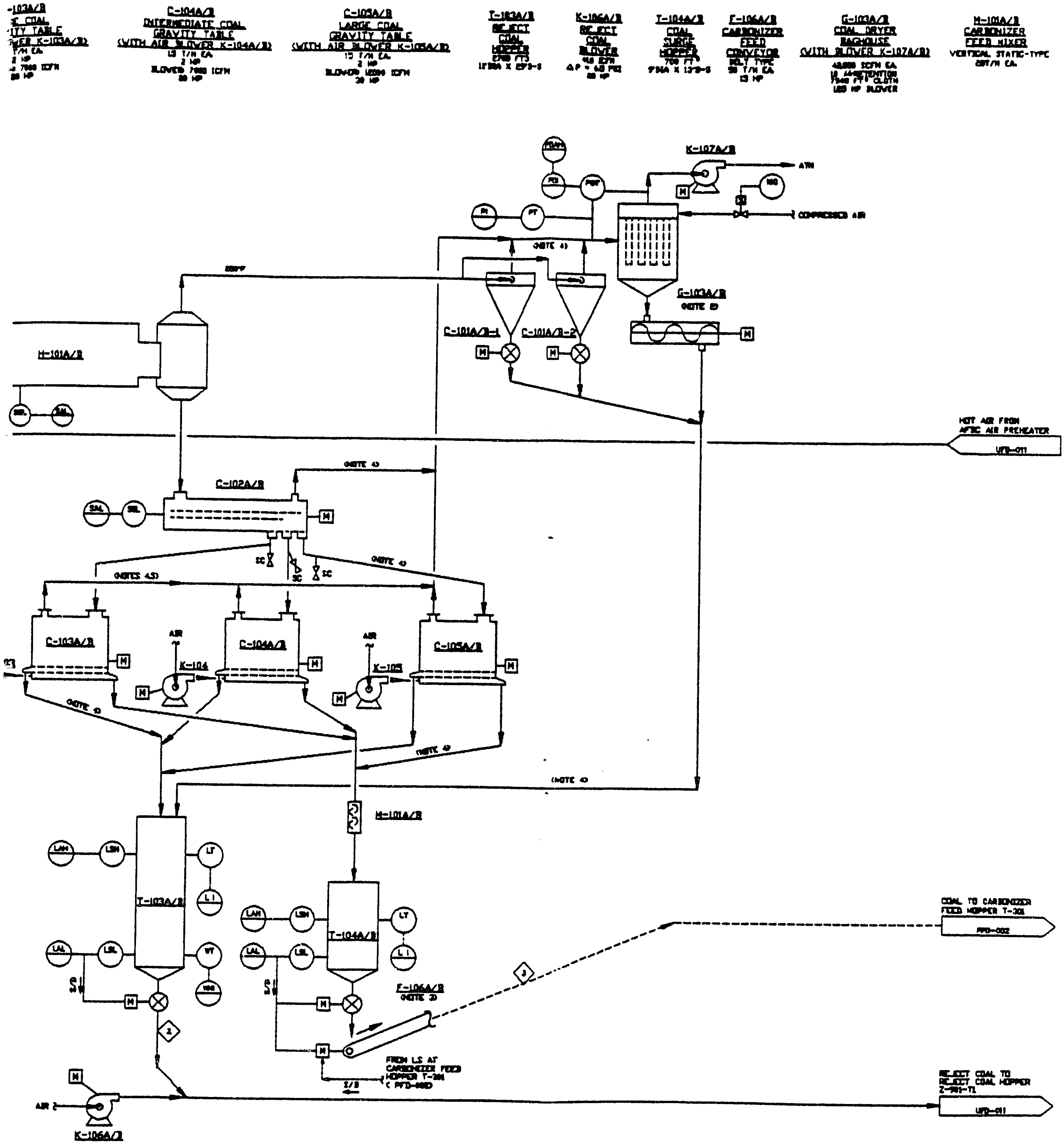


LEGEND

SC - SAMPLE CONNECTION

NOTES

1. THERE ARE TWO PARALLEL TRAINS OF OPERATION ("A" & "B" TRAI
OF T-101. EACH TRAIN IS CAPABLE OF SUPPLYING COAL
TO THE OTHER AS NECESSARY TO REMAIN ONSTREAM.
2. G-101A/B BAGHOUSE TO BE EQUIPPED WITH EXPLOSION SUPPRESS
3. MAX. BELT FEEDER INCLINE TO BE 15°.
4. SOLIDS GRAVITY FLOW LINES AND DUSTY VENT LINES TO BE SLO
5. DAMPERS TO BE PROVIDED IN GRAVITY TABLE VENTS TO BALANCE
6. BELT CONVEYOR F-107 (NOT SHOWN) IS REQUIRED TO TRANSFER FRE
COAL FROM J-101 A OR B TO AFBC FOR STARTUP OR WHEN
SUFFICIENT REJECT COAL/CHAR IS NOT AVAILABLE. F107 IS NORM



NOT USED.

A	4/14/92	FOR CLIENT APPROVAL		
NO.	DATE	REVISIONS	BY	CHK

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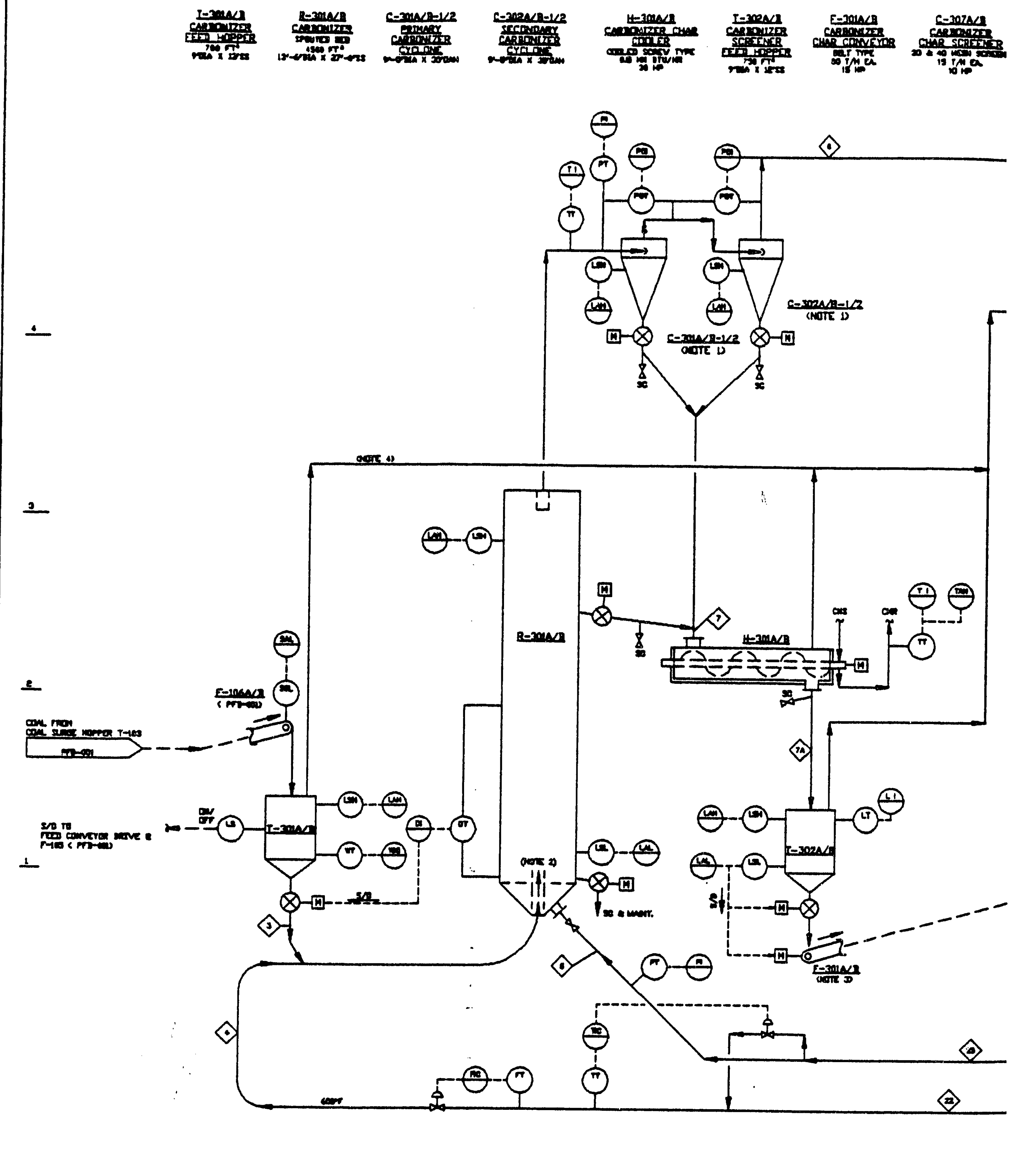
HOUSTON, TEXAS

UNIVERSITY OF NORTH DAKOTA
ENERGY ENVIRONMENTAL RESEARCH CENTER

PROCESS FLOW DIAGRAM
1000 T/D MILD COAL GASIFICATION FACILITY
COAL STORAGE AND PREPARATION

JOB NUMBER	DRAWING NUMBER	REV
28708-308	PFD-001	A

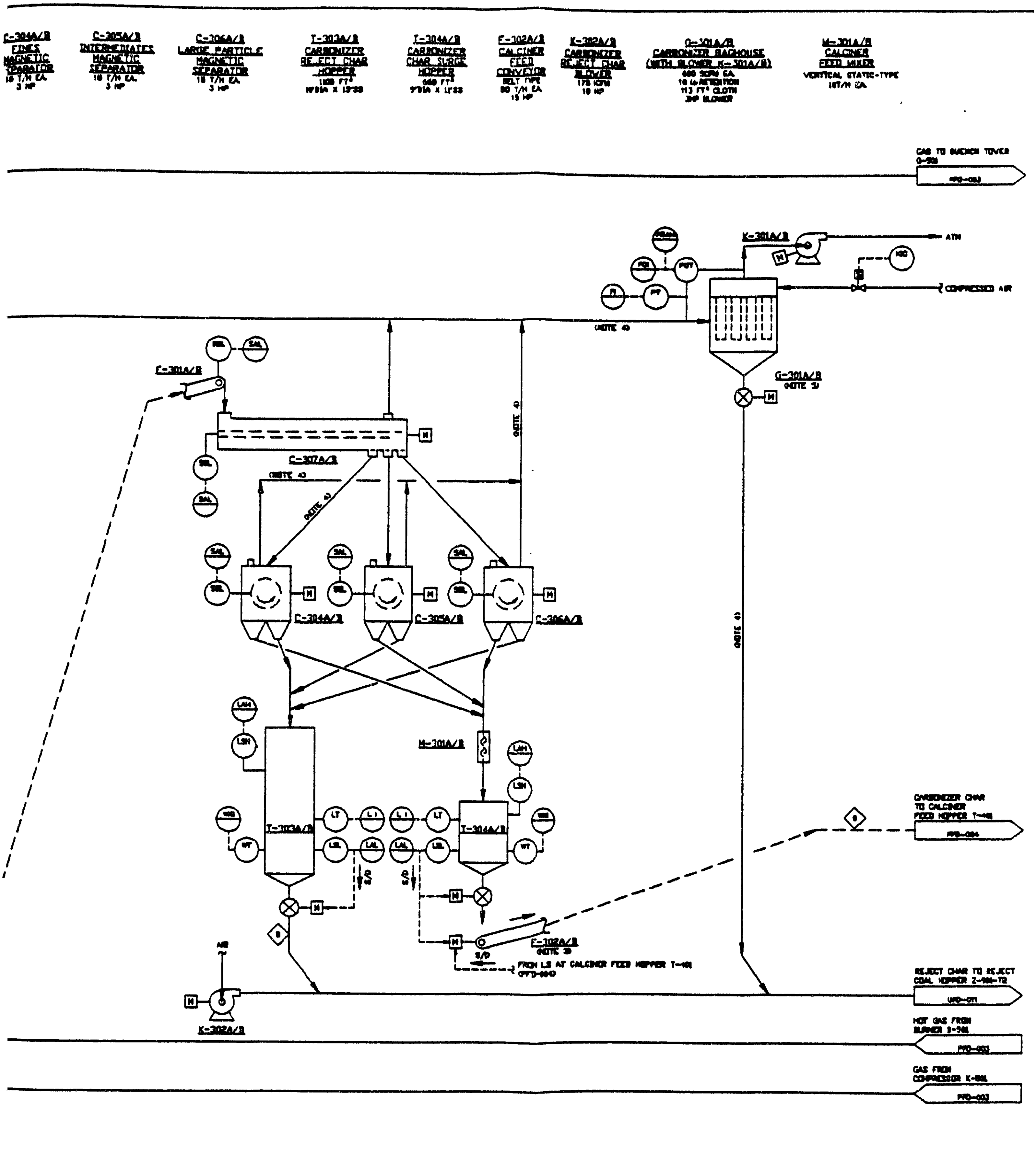


LEGEND

SC - SAMPLE CONNECTION
CMS - COOLING MEDIUM SUPPLY
CMR - COOLING MEDIUM RETURN

NOTES

1. PRIMARY AND SECONDARY CYCLONES REQUIRE TWO OF EACH PER TRAIN.
2. COAL TO CARBONIZER TO BE INJECTED VIA MULTIPLE SPOUTS.
3. MAX. BELT FEEDER INCLINE TO BE 13°.
4. SOLIDS GRAVITY FLOW LINES AND DUSTY VENT LINES TO BE SLOP-
5. G-301A/B BAGHOUSES TO BE EQUIPPED WITH EXPLOSION SUPPRESSI-



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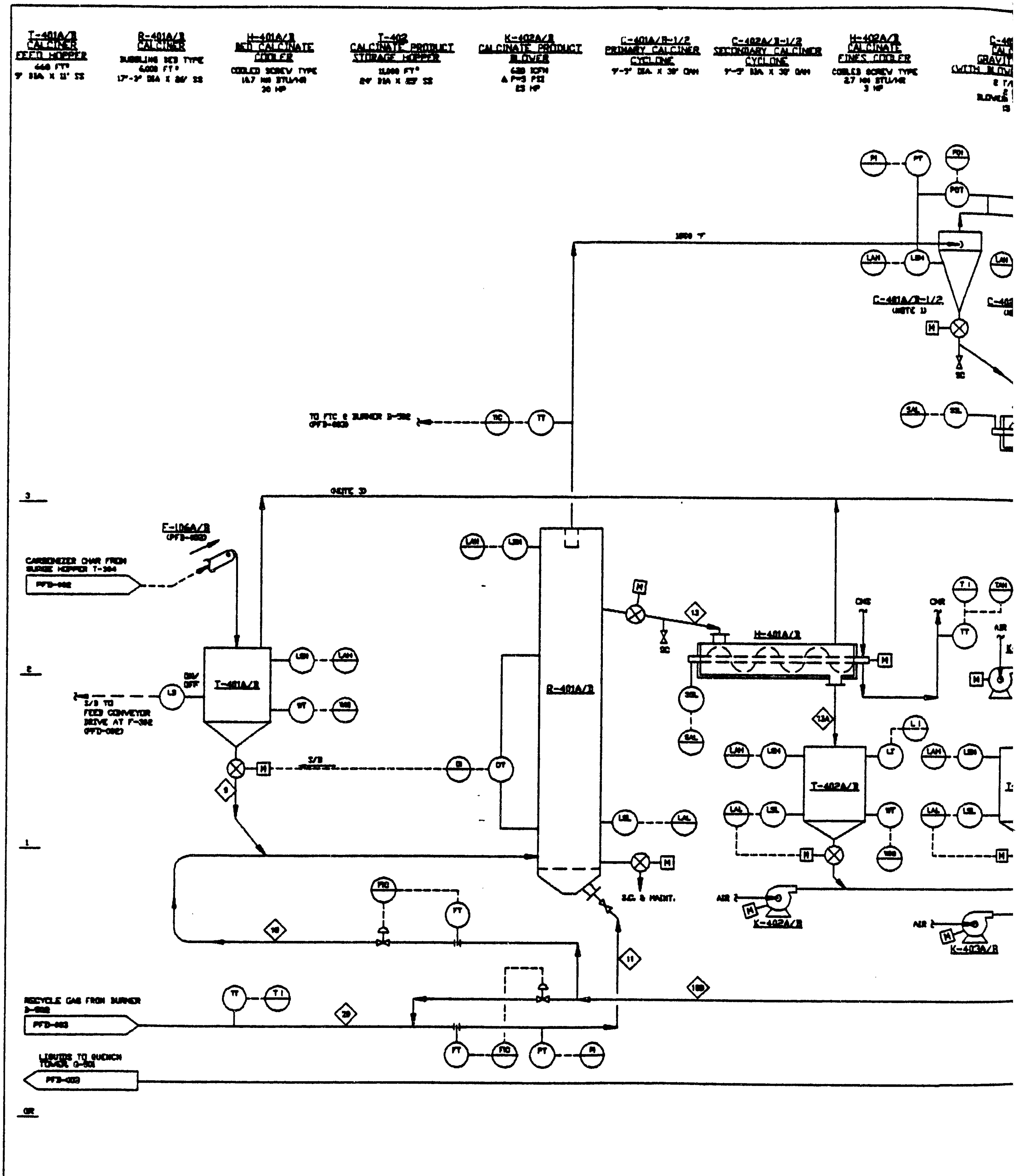
ENERGY ENVIRONMENTAL RESEARCH CENTER

PROCESS FLOW DIAGRAM
1000 T/D MILD COAL GASIFICATION FACILITY
CARBONIZER

NO.	DATE	REVISIONS
A	4/14/92	FOR CLIENT APPROVAL

JOB NUMBER	DRAWING NUMBER	REV.
20708-308	PFD-002	A

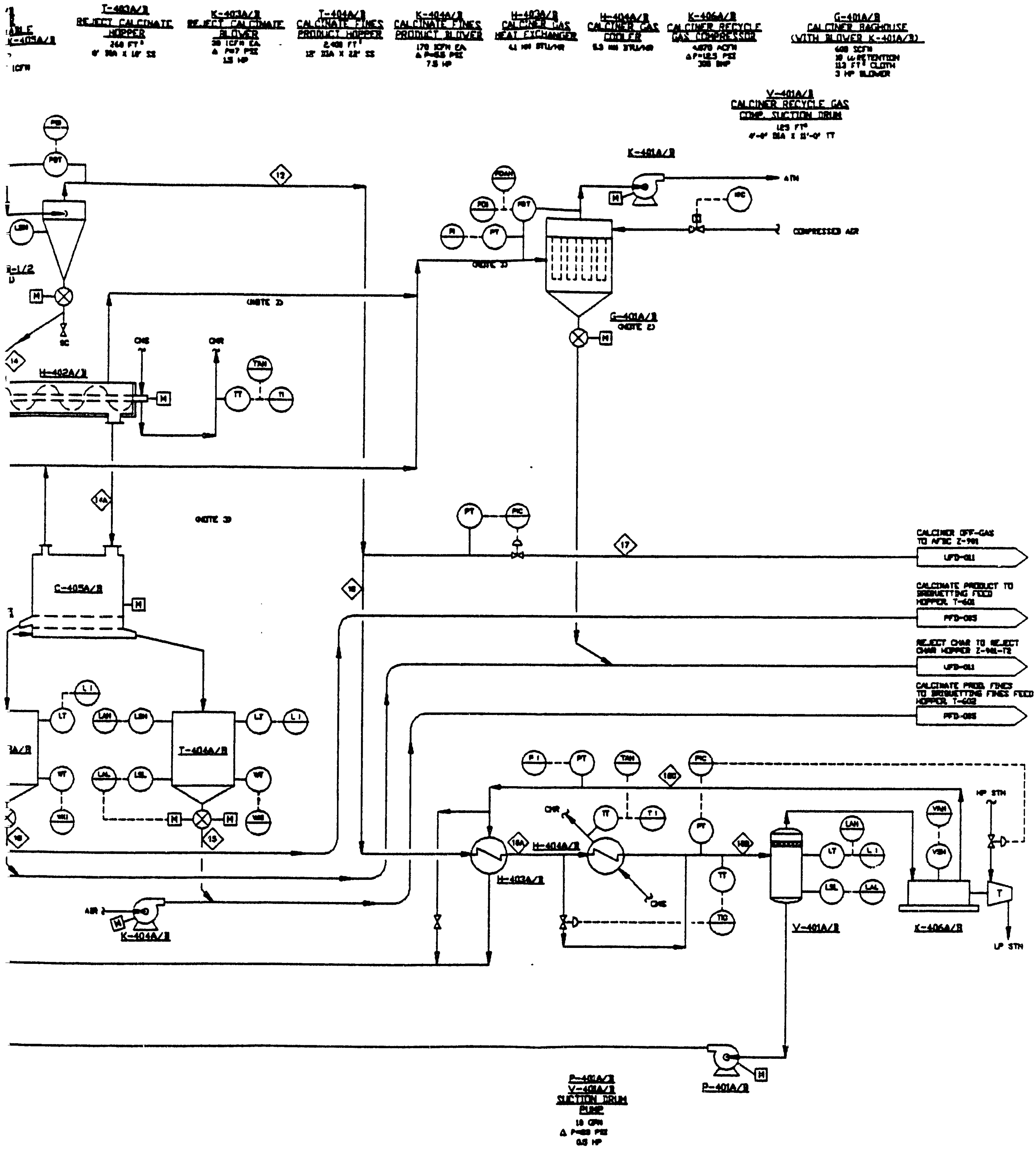


LEGEND

SC - SAMPLE CONNECTION
CMS - COOLING MEDIUM SUPPLY
CMR - COOLING MEDIUM RETURN

NOTES

1. PRIMARY AND SECONDARY CYCLONES REQUIRE TWO OF EACH FOR TR
2. G-401A/B BAGHOUSES TO BE EQUIPPED WITH EXPLOSION SUPPRESSI
3. SOLIDS GRAVITY FLOW LINES AND DUSTY VENTLINES TO BE SLOPED



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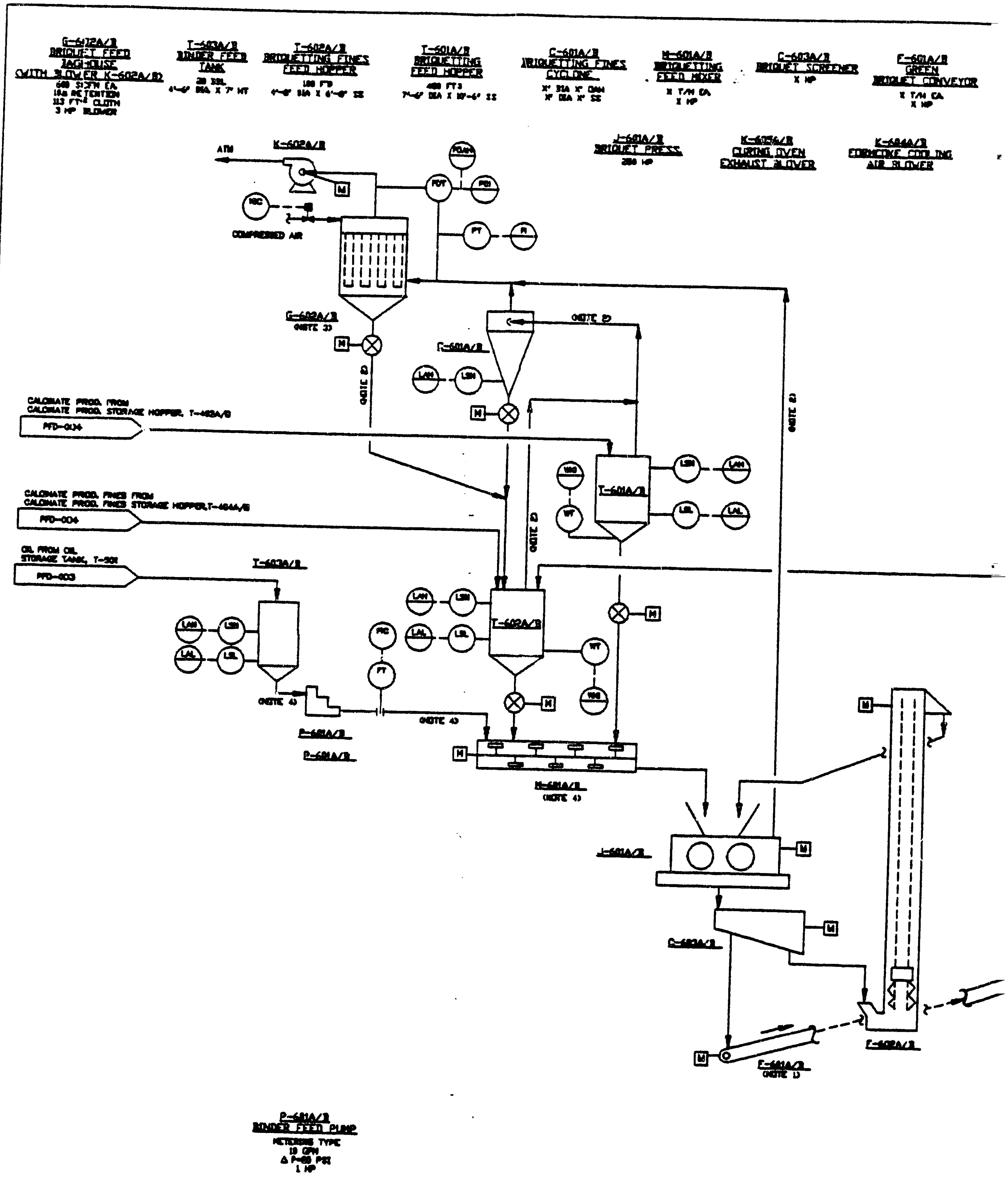
ENERGY ENVIRONMENTAL RESEARCH CENTER

PROCESS FLOW DIAGRAM
1000 T/D MILD COAL GASIFICATION FACILITY
CALCINER

NO.	DATE	REVISIONS	BY	CHK
A	4/14/92	FOR CLIENT APPROVAL		

JOB NUMBER	DRAWING NUMBER	REV.
20708-309	PFD-004	A

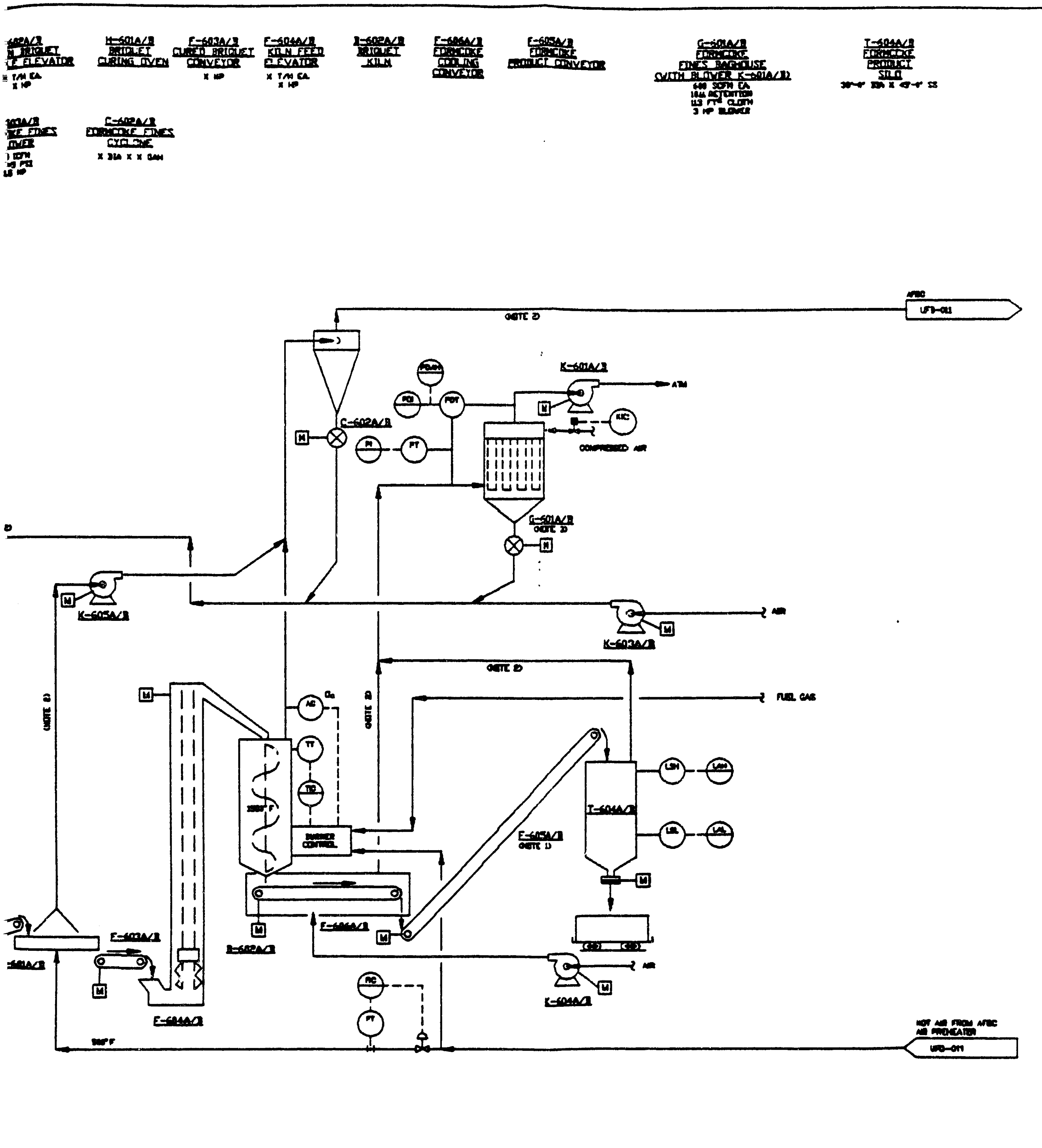


LEGEND

SC - SAMPLE CONNECTION

NOTES

1. MAX. BELT
2. SOLIDS OF
3. BAGHOUSE
4. ALL EQUI... TRACED A...



EEDER INCLINE TO BE 15°.
ITY FLOW LINES AND DUSTY VENT LINES TO BE SLOPED MINIMUM 60°.
O BE EQUIPPED WITH EXPLOSION SUPPRESSION SYSTEM.
ENT AND LINES IN OIL SERVICE TO BE ELECTRIC HEAT.
INSULATED.

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A	4/14/92	FOR CLIENT APPROVAL		

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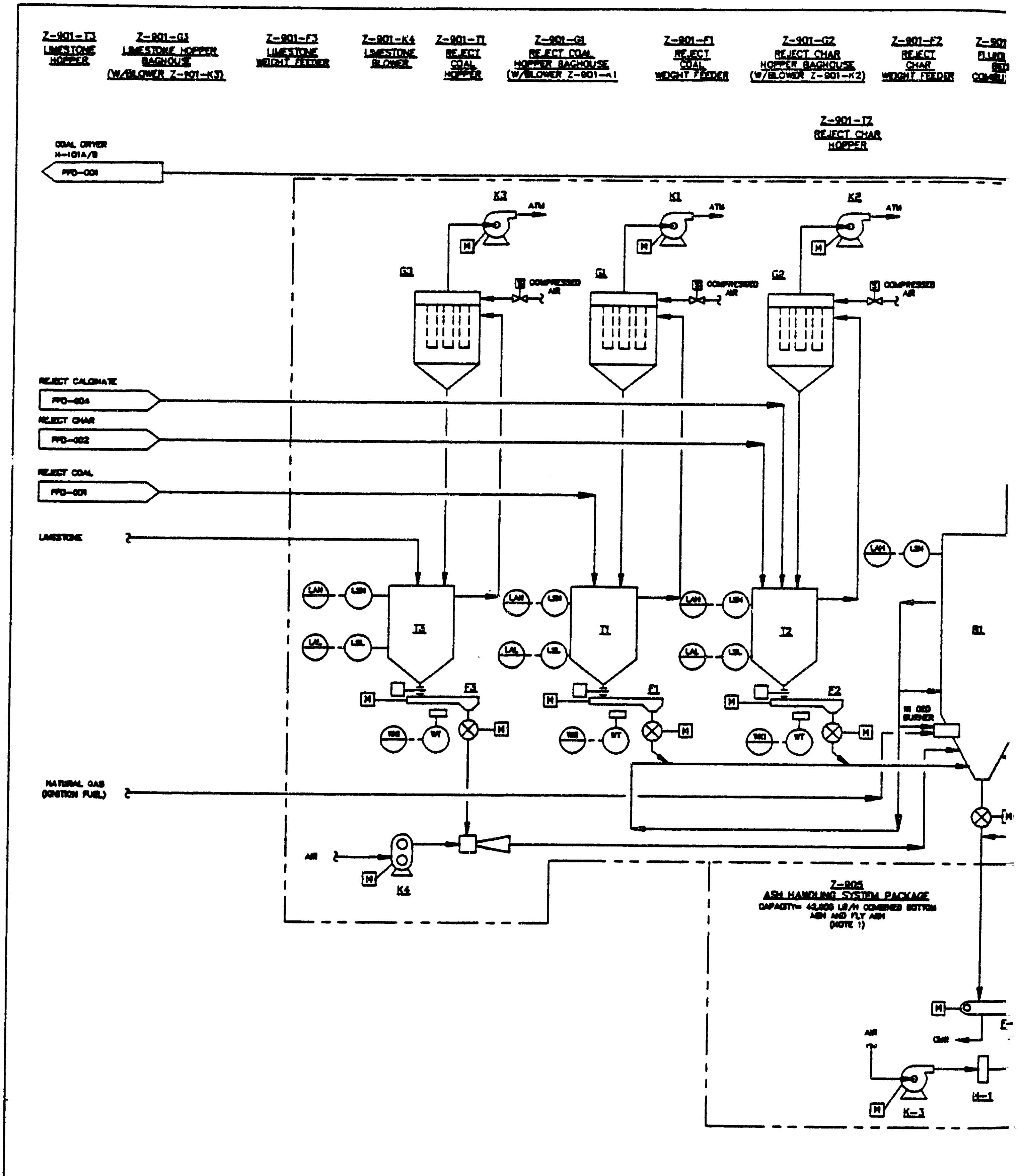
ENERGY ENVIRONMENTAL RESEARCH CENTER

PROCESS FLOW DIAGRAM
1000 T/D MILD COAL GASIFICATION FACILITY
COKE BRIQUETTING & CURING (FORMCOKE)

JOB NUMBER	DRAWING NUMBER	REV.
28708-308	PFD-005	A

XBIA106.DWG 02-27-92 YRG REV. A

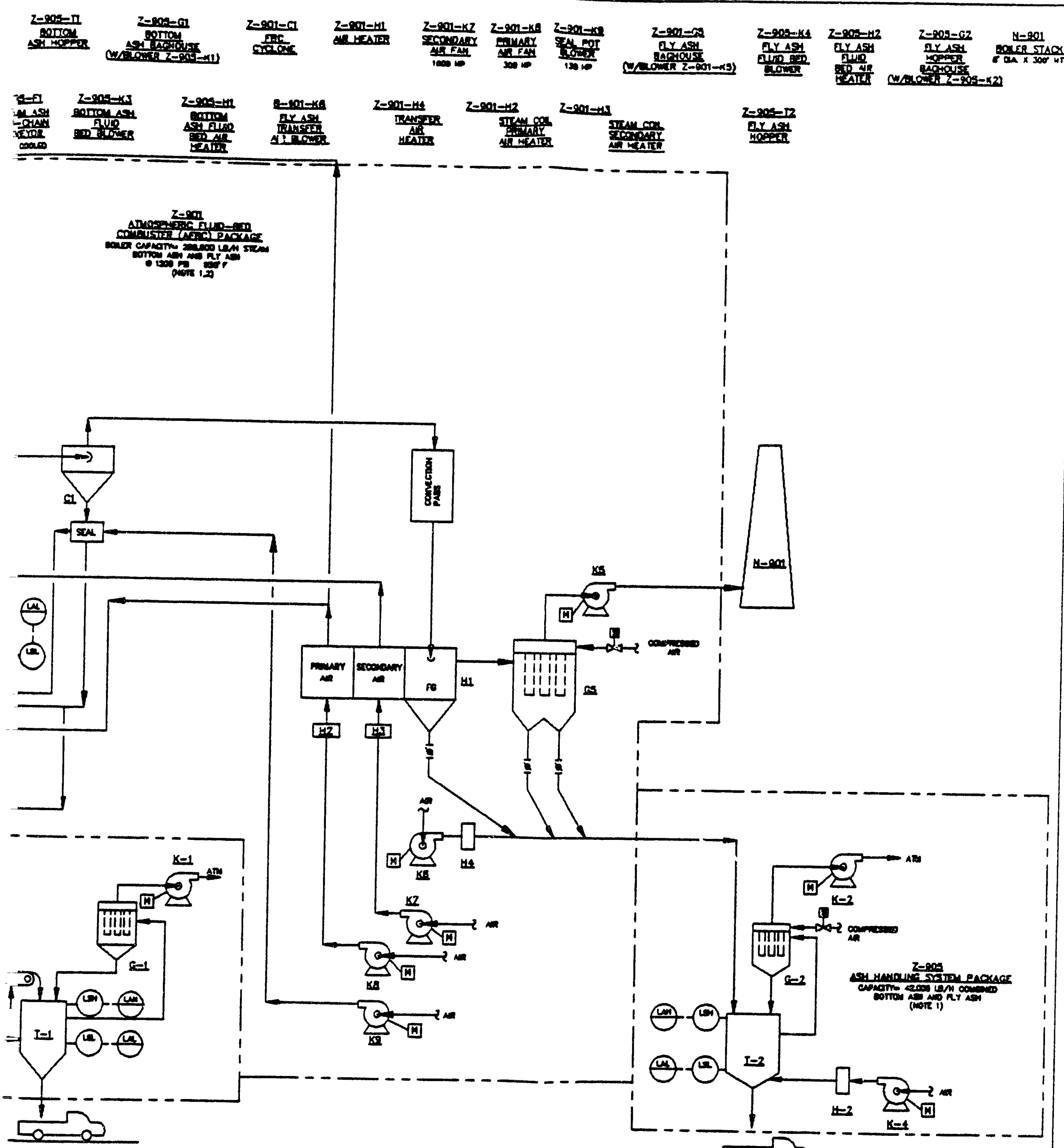


LEGEND

SC - SAMPLE CONNECTION
CMS - COOLING MEDIUM SUPPLY
CMR - COOLING MEDIUM RETURN

NOTES

1. ALL EQUIPMENT INSIDE THE DASHED LINE
FOR AFBC PACKAGE, OR "Z-905-" FOR
2. SEE UFD-012 FOR AFBC STEAM CIRCUIT.



VENDOR ITEMS AND ARE PREFIXED WITH "Z-901-"
HANDLING SYSTEM PACKAGE.

A	4/14/92	FOR CLIENT APPROVAL					
NO.	DATE	REVISIONS	BY	CHK			APPR
SCALE	DESIGNED	DRAWN					

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UNIVERSITY OF NORTH DAKOTA
ENERGY ENVIRONMENTAL RESEARCH CENTER

UTILITY FLOW DIAGRAM
1000 T/D MILD COAL GASIFICATION FACILITY
ATMOSPHERIC FLUID BED COMBUSTER (AFBC)

JOB NUMBER	DRAWING NUMBER	REV.
20708-308	UFD-011	A

XBI107.DWG 02-27-92 TRO REV. A

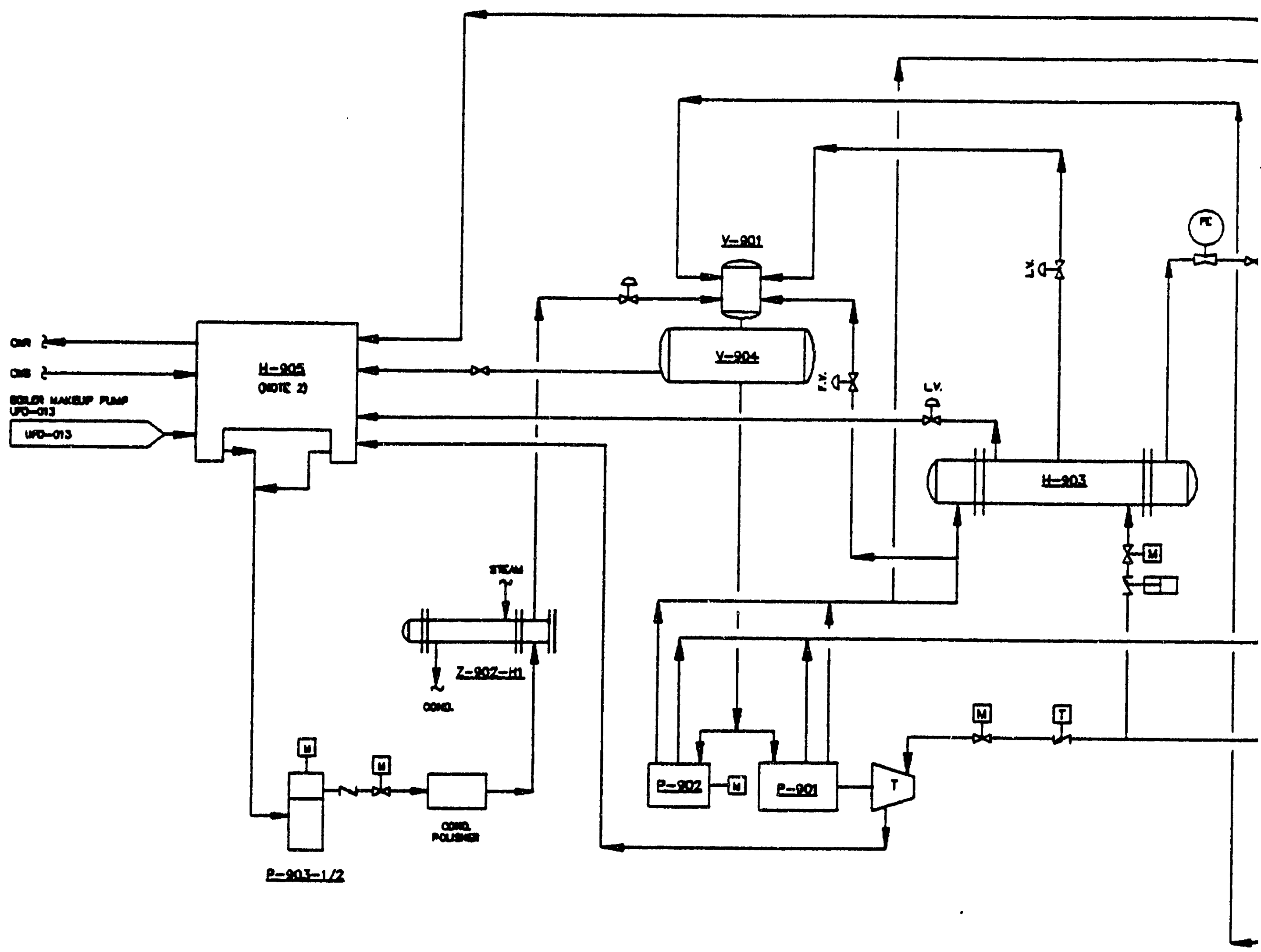
H-905
MAIN SURFACE CONDENSER
250 MM BTU/HR

Z-902-H1
GLAND STEAM CONDENSER
3 MM BTU/HR

V-901
DEAERATOR
190 FT^3
6'-6" DIA X 7'-6" TT

V-904
DEAERATOR STORAGE TANK
1700 FT^3
8' DIA X 17' TT

H-903
HIGH PRESS BOILER FEED WATER HEATER
30 MM BTU/HR



P-903-1/2
CONDENSATE RECYCLE PUMP & SPARE
380 GPM
Δ P=65 PSI
30 HP

P-902
STARTUP BOILER FEED WATER PUMP
220 GPM
Δ P=1500 PSI
900 HP

P-901
MAIN BOILER FEED WATER PUMP
380 GPM
Δ P=1500 PSI

LEGEND

NOTES

1. ALL EQUIPMENT INSIDE DASHED LINE ARE VENDOR ITEMS AND PREFIXED WITH "Z-901-"
2. MAIN SURFACE CONDENSER, H-905, PHYSICAL
   TURBO GENERATOR SYSTEM, Z-902.
3. REFER TO UFD-011 FOR Z-901.

V-902 BOILER BLOWDOWN DRUM 280 FT³ 6' DIA. X 8' TT

Z-901-H5 ECONOMIZER

V-903 CONDENSATE TANK 100 FT³ 4' DIA. X 6' TT

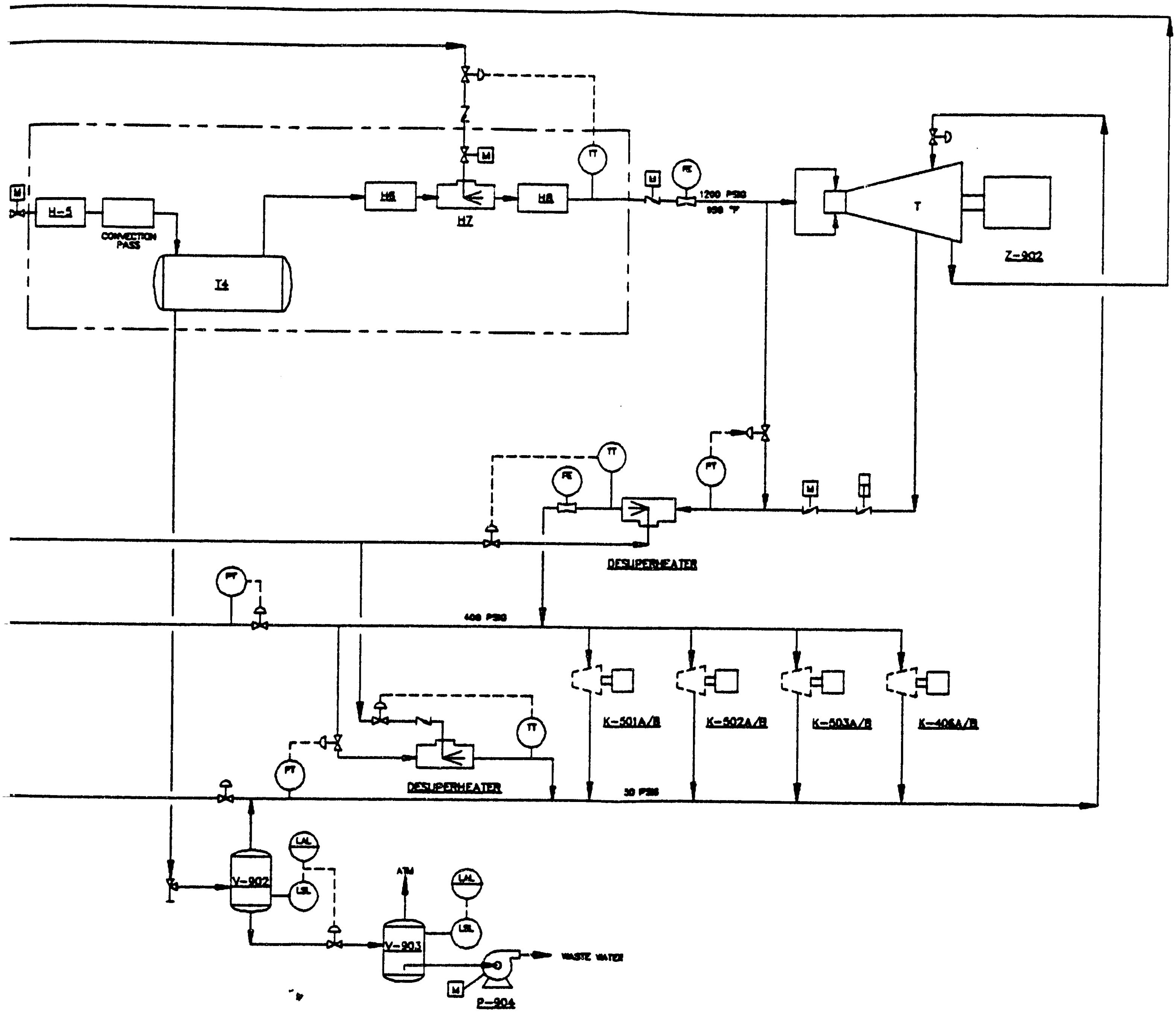
Z-901-T4 H.P. STEAM DRUM

Z-901-H6 PRIMARY SUPERHEATER

Z-901-H7 H.Y.P. ATTEMPERATOR

Z-901-H8 SECONDARY SUPERHEATER

Z-902 TURBOGENERATOR SYSTEM 19620 kW 3600 RPM



P-904 FLASH TANK WATER PUMP 10 GPM Δ P=30 PSI 5 HP

LOCATED UNDER THE

NO.	DATE	REVISIONS	BY	CHK
A	4/14/92	FOR CLIENT APPROVAL		

SCALE | DESIGNED | DRAWN

XBI XYTEL-BECHTEL, INC. HOUSTON, TEXAS

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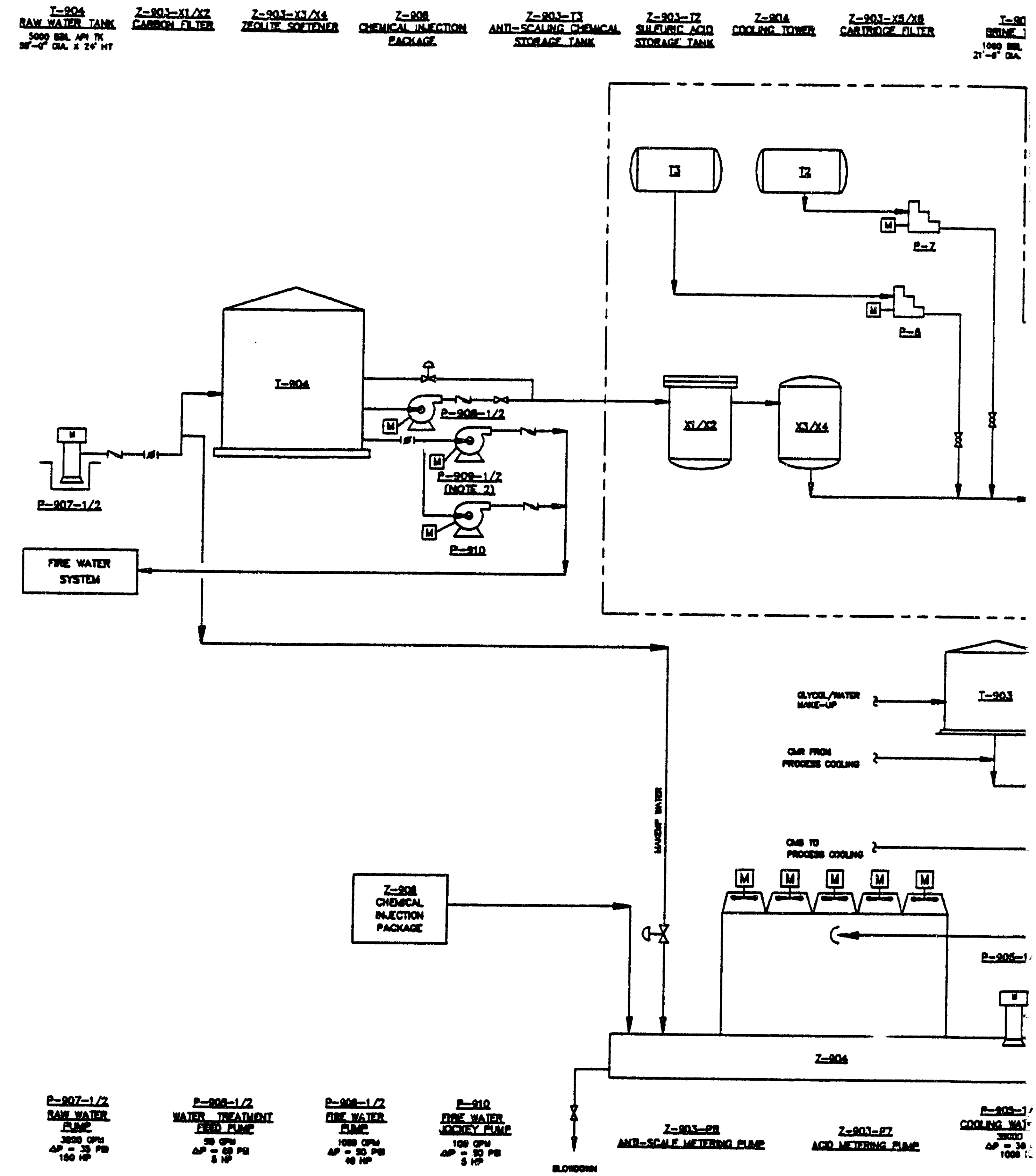
ENERGY ENVIRONMENTAL RESEARCH CENTER

UTILITY FLOW DIAGRAM
1000 T/D MILD COAL GASIFICATION FACILITY
BFW, STEAM & CONDENSATE

JOB NUMBER	DRAWING NUMBER	REV.
20708-308	UFD-012	A

XBIA110.DWG 02-27-92 TRG REV. A



LEGEND

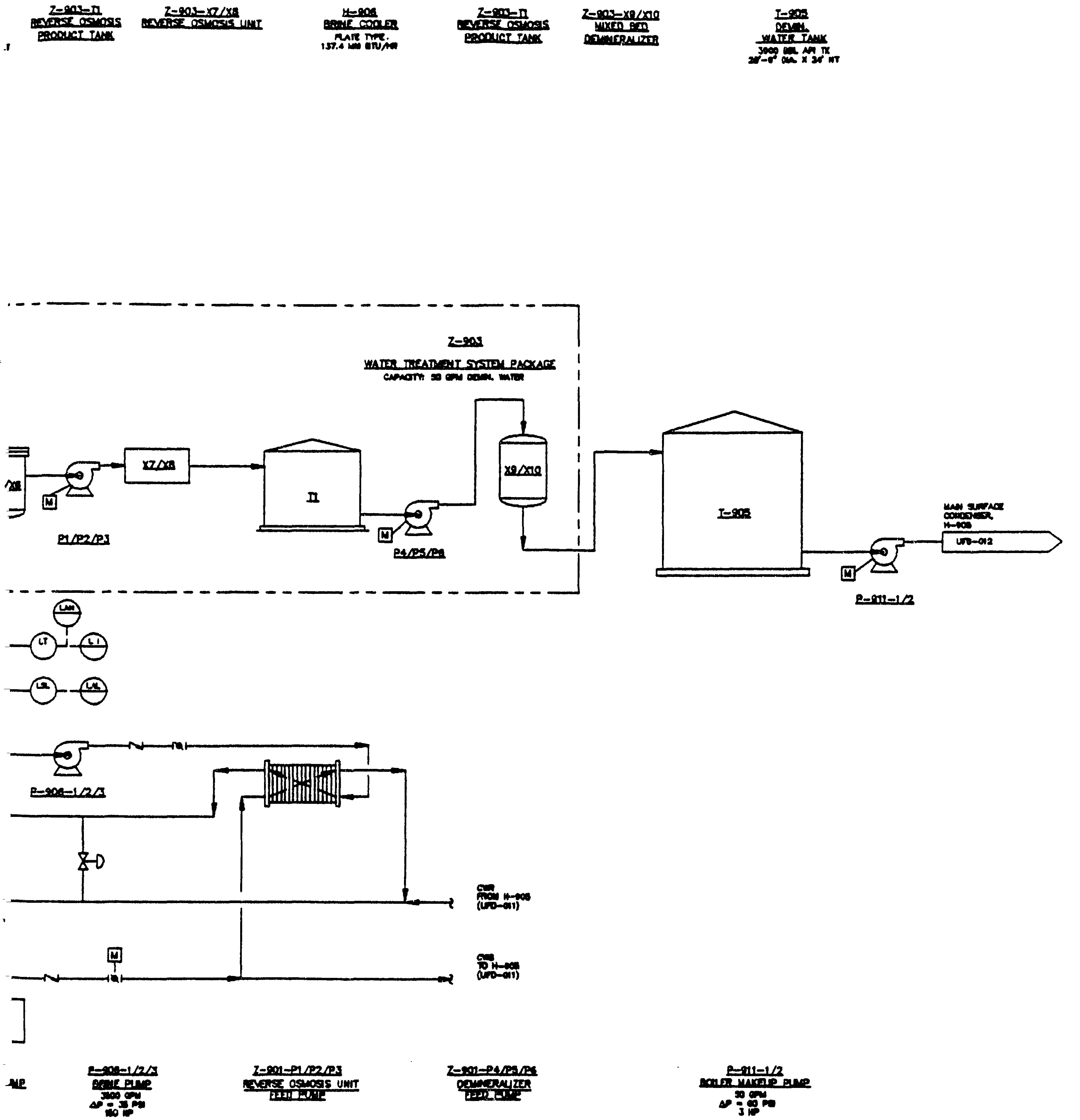
SC – SAMPLE CONNECTION

CMS – COOLING MEDIUM SUPPLY

CMR – COOLING MEDIUM RETURN

NOTES

1. ALL EQUIP... AND ARE...



INSIDE DASHED LINE ARE VENDOR ITEMS
ED WITH "Z-903-".

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UTILITY FLOW DIAGRAM
1000 T/D MILD COAL GASIFICATION FACILITY
WATER TREAT., COOLING WATER & BRINE SYSTEM

NO.	DATE	REVISIONS	BY	CHK				APP
A	4/14/92	FOR CLIENT APPROVAL						

SCALE | DESIGNED | DRAWN

JOB NUMBER	DRAWING NUMBER	REV.
20708-306	UFD-013	A

XB1A09.DWG 02-27-92 TRG REV. A

END

DATE FILMED

7/8/93