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COMMERCIAL LOW-BTU COAL-GASIFICATION PLANT

General Refractories Company
Florence, Kentucky

Feasibility Study

MASTER

DOE/RA/50334--1175 Vol. 1

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Volume I: Project Summary

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November 1981
General Refractories Company

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ACKNOWLEDGEMENTS

Overall supervision of this project was performed by the General Refractories Company.

System design, equipment specifications, cost estimates and report preparation were provided by Dravo Corporation, with support from Gibbs and Hill, Inc. for the environmental evaluation and permit requirements and the socio-economics sections.

Engineering drawings for this project are identified as CAPE-2760
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RALPH V. LAWRENCE
EXECUTIVE VICE PRESIDENT

April 5, 1982

U. S. Department of Energy
Washington, DC 20585

Re: Feasibility Study:
Commercial Low BTU Coal Gasification Plant
Florence, Kentucky
Grant No. DE-FG01-80RA50334

Gentlemen:

Delivered herewith are ten (10) copies of the final report of this Company pursuant to the requirements of the above referenced Grant.

Your attention is directed in particular to Section 1, Executive Summary and 15 Conclusions and Recommendations, for a summary of the results of this project.

The cooperation and assistance of the several officials and staff members of the Department during the progress of the study has been most appreciated.

Yours very truly,

Ralph V. Lawrence

Ralph V. Lawrence

cc: R. L. Hamilton
H. L. Campbell

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1.0 EXECUTIVE SUMMARY

In response to a 1980 Department of Energy solicitation, the General Refractories Company submitted a Proposal for a feasibility study of a low Btu gasification facility for its Florence, KY plant. The proposed facility would substitute low Btu gas from a fixed bed gasifier for natural gas now used in the manufacture of insulation board.

The Proposal from General Refractories was prompted by a concern over the rising costs of natural gas, and the anitcipation of a severe increase in fuel costs resulting from deregulation.

The proposed feasibility study consisted of the following tasks:

- Perform preliminary engineering of a gasification facility, including cooling, tar removal, and desulfurization. The facility would replace the existing natural gas requirement of the Florence plant with low Btu gas from coal.
- Provide a definitive cost estimate base upon the preliminary engineering design.
- Investigate potential sources of supply to determine the preferred source of coal.
- Investigate potential sources of supply to determine the preferred source of coal.
- Determine the potential for the disposition of, and income from, by-products resulting from the gasification process.
- Develop a health and safety program for the proposed facility.
- Perform an analysis of the risks involved in constructing and operating such a facility, and,
- Prepare a Financial Analysis of the impact of the proposed facility based upon a compilation of capital costs, operating costs, maintenance costs, and the cost of capital.

The intent of this Proposal is to provide General Refractories with the basis upon which to determine the feasibility of incorporating such a facility in Florence.

To perform the work of this study, a Grant for which was awarded by the DOE, General Refractories selected Dravo Engineers and Constructors. This selection was based upon the qualifications of Dravo in the field of coal conversion, and the fact that Dravo has acquired the rights to the Wellman-Galusha® technology.

To ensure maximum responsiveness to the requirements of General Refactories, Dravo retained as consultants the manufacturers of the principal pieces of equipment used in the insulation board fabrication process. These manufacturers were retained to select and qualify the retrofit equipment to be used to convert their equipment to low Btu gas. In addition, Dravo retained Gibbs and Hill to perform the required environmental and socioeconomic analyses for the study.

The primary function of the feasibility study is to provide General Refractories with sufficient engineering and financial information to permit its Management to make an informed decision as to the potential of a gasification facility to enhance the profitability and future growth of the Florence plant.

The proposed gasification facility would be located on GREFCO property behind insulation board plant and near the east end. The plant will be designed to be aesthetically pleasing, consistent with high standards of the Northern Kentucky Industrial Park. The facility will produce a cool, cleaned and desulfurized fuel gas, and be designed and operated so as to meet all local, state and federal requirements, including those of EPA and OSHA. The LBG will be used to fuel the perlite expander furnaces and the dryers in the insulation board plant.

This study is based on a gasification facility capable of producing 6 billion Btu's per day from producer gas. The facility would provide all of GREFCO's current energy needs and would provide for future expansion. To produce 6 billion Btu's per day requires five Wellman-Galusha gasifiers. However, because the insulation board plant now uses just half that amount, it was proposed to stage the design of the complete plant. General Refractories requested a design for a two stage installation which would first utilize two gasifiers and then the remaining three. This plan was suggested to accommodate potential future expansion plans at GREFCO. An initial installation of only one or two gasifiers would minimize initial capital expenditure. At the same time, the initial but partial installation could be used to iron out process problems and improve operational experience. Since Dravo or its agent is willing to build, own and operate LBG facilities and sell the gas "over the fence" it was decided that the study would consider both a GREFCO-own and operate and Dravo-own and operate case. The study therefore addresses four alternatives, i.e., five-gasifier installation vs. a two-gasifier installation for each ownership option.

One of the disadvantages in replacing natural gas as a fuel is that the most obvious substitutes, oil or coal, have significantly higher sulfur contents. In the initial design requirements for this feasibility study, it was decided that an optimum gasification facility would be one in which commercially available coal, having a sulfur content of 2% or more, would be gasified in a manner so as to reduce the sulfur content in the product gas to levels approaching that of natural gas, that is 5 ppm of sulfur or less.

The initial process design was based on this requirement, and a process system having the capability of reducing high sulfur coal to very low sulfur gas was developed. When the cost estimates of the capital and operating expense for this process were analyzed, it became obvious that the resultant gas costs were prohibitive.

Before the technical feasibility of an alternative process could be determined attempts were undertaken to establish the cause of the corrosive attack in the dryer. Tests on gas samples and metal specimens, which were obtained from the dryer, indicated that agents other than sulfur could be responsible for the problem. However, further tests will have to be made to substantiate this inference. These tests should also be designed to pinpoint the corrosive elements in the dryer and the portion of each attributable to fuel, process chemistry, product content and operating procedure. Any such program, unfortunately, is beyond the scope of this study.

From the results of the gas chromatograhic analysis it was inferred that the single largest contributor to the sulfur content in the atmosphere was the composition of the product itself, and that the sulfur content of the fuel used had minor effect upon the total sulfur level. Considerably more testing is required to support this conclusion.

As a result of this new knowledge, the sulfur treatment process was redesigned with a more cost effective goal of reducing the sulfur level of the LBG to 150 ppm. This level is still far below the environmental requirement for the process.

To provide an environmental analysis federal and state requirements were reviewed. Of the two major requirements it appears that the Prevention of Significant Deterioration (PSD) air permit would apply to this project but the Environmental Assessment Report (EAR) would not. Final decisions will be made on both after more specific project information is supplied to the permitting agency.

The net increase in SO_2 emissions for the proposed modification is classified under Prevention of Significant Deterioration (PSD) Regulations as significant, i.e., greater than 40 tons/yr, therefore a PSD Permit would be needed. The permit would require demonstration of Best Available Control Technology (BACT) for all pollutants emitted in significant amounts on an annual basis; this would include SO_2 because it is emitted at a rate greater than 40 tons/yr and H_2SO_4 because it is emitted at a rate greater than 7 tons/yr. PM emissions are less than the 25 tons/yr significant PM emissions cutoff and therefore require no BACT review. Air quality impacts during construction will be minimal. Impacts on meterology, though insignificant, will be from dust generated during project construction and from cooling tower drift during operation.

Only minor construction or operational impacts are expected on rare, threatened, or endangered species, physiography, soil, geology, surface water, and ground water.

In Chapter 8 the potential effects of project construction and operation are presented. Unemployment in the county will be reduced as a result of construction and operation. The construction payroll will add $4.3 million to the local economy. Operational impacts will include the addition of 35 new jobs, producing an additional $1 million annually for labor. Traffic in the project area will increase but impacts are expected to be minimal as roadways are not currently used to capacity.

The safety and health hazards associated with the Wellman-Galusha gas plant are anticipated to be not greater than operations typical of the chemical processing industries.

A safety and health program is included to provide guidance for operators of the Wellman-Galusha Gas Producer System in dealing with the associated occupational safety and health hazards. The program is site-specific because it is based on a feedstock (Ohio sub-bituminous coal) and operating parameters particular to the GREFCO project design.

The program presents a conceptual Occupational Safety and Health (OSH) adminstation guide, OSHA compliance requirements and training and accident prevention plans. Also included is applicable support information on industrial hygiene, system safety, traditional industrial safety, and loss prevention. The intent is to assist safety and health professionals as well as line management in dealing with the subject.

The total installed value for a five-gasifier installation owned and operated by Dravo, including distribution pipeline and all retrofit expense is estimated to be $33,007,000. If the facility is owned by GREFCO the office/change house planned for Dravo personnel would be eliminated with a capital cost reduction of approximately $400,000 and resulting in a total installed cost of $32,607,000. A two-gasifier installation owned and operated by Dravo is estimated to cost $24,316,000. This includes the total battery limits plant, the distribution main and the retrofit costs. The total installed cost of a two-gasifier installation owned and operated by GREFCO would be $23,916,000.

Using a 20 percent return on investment or discount rate in the financial analysis, a Dravo owned and operated five-gasifier installation would yield a 1984 current dollar gas price of $7.94 per million Btu's. Current dollar analysis is the method preferred by General Refractories; 1984 prices were used as a base since this is the scheduled year for gasification plant start-up. The equivalent 1981 constant dollar price for the gas is $6.08 per million Btu's. A 20 percent discount factor was used in light of today's prevailing inflation and interest rates. For the same gasification plant and 20 percent discount rate, a GREFCO owned and operated gas price would be $7.58 per million Btu's in 1984 current dollars and $5.88 in 1981 constant dollars. Again with the same discount rate, an initial two-gasifier installation owned and operated by Dravo would require a gas price of $12.38 per million Btu's. This price is economically unattractive and is due to a lessened economy of scale and, to a lesser extent, to the influence of the design requirements for the future addition of the three gasifiers.

Sensitivity analyses were performed on the capital costs and operating costs. A variation of 15 percent in the capital costs caused the gas prices to vary by only about 3.5 percent to 5.5 percent. The operating costs were varied by the same 15 percent, and result on gas prices was considerably more -- in the range of 9 to 12 percent. Finally, a sensitivity analysis was performed for the five-gasifier case with a utilization rate of 345 days per year instead of the base 279 days per year. This high utilization rate reduced the gas price by 13 to 14 percent. Higher utilization of the facility is recommended

The gas prices produced in the financial analyses for a two-gasifier case were not at all attractive. The two gasifier LBG prices would not become competitive with natural gas until after 1990 if at all. The LBG prices for the five-gasifier case are much more encouraging. Given the various natural gas forecasts available, there seems to be a reasonable possibility that the five-gasifier LBG prices will break even with natural gas prices somewhere between 1984 and 1989. General Refractories recognizes that there are many uncertainties in developing these natural gas forecasts, and if the present natural gas decontrol plan is not fully implemented some financial risks occur in undertaking the proposed gasification facility. Because of this, General

Refractories has decided to wait for more substantiating evidence that natural gas prices will rise as is now being predicted.

2.0 INTRODUCTION

The General Refractories Company is interested in the feasibility of substituting low Btu industrial fuel (IFG) gas, made via coal gasification, for the natural gas now in use at its Florence, Kentucky, insulation board plant.

Dravo Engineers and Constructors was retained to perform a site-specific detailed engineering evaluation and to provide an estimate for a battery-limits low-Btu commercial-scale coal gasification facility, including the required retrofit and peripheral work, to be constructed at the plant. The design of the proposed low-Btu plant would incorporate several Wellman-Galusha fixed-bed, atmospheric gas producers and a complete downstream cleanup train, providing the required energy output for GREFCO's roofing insulation plant.

The plant would use a highly volatile, bituminous coal containing about 4.1 percent sulfur, which would necessitate particulate and tar removal and purification of sulfur-bearing compounds from the product gas stream. Therefore, the gasification plant would be designed to meet all existing environmental safety requirements. Related factors such as coal supply, waste, and by-product disposal, and their impact on the industrial fuel gas price, were also addressed. The Kentucky Center for Energy Research assisted in coordinating and expediting the State agencies' reviews and licenses.

It is GREFCO's opinion that the best approach for implementing the installation of a coal gasification system at Florence would be to initially install a single gas producer unit providing only a portion of the plant's total required energy. As soon as operational confidence and long-term reliability data for a low-Btu gas supply have been established, and evaluation of product quality confirmed, then GREFCO could elect to complete the full-size installation. Thus, the plant would be designed to permit the initial installation of one or two gasifiers and later installation of the remaining gasifiers.

The feasibility study was performed with the intention of developing capital cost information for the total number of gasifiers and cleanup equipment required for providing the total alternate energy requirement for all anticipated equipment that would be converted.

The definitive cost estimate developed from the engineering performed during the course of this study will enable GREFCO to make a decision regarding the economic viability of constructing an alternate energy supply plant. GREFCO must be assured that a decision to build a plant entails minimal financial risk with a reasonable guarantee of continuing productive operations utilizing this alternate energy mode, and that the IFG cost be competitive with the cost of the existing fuels that it expects to replace. If the process is not economically viable, IFG will not be considered as an acceptable alternate energy replacement.

3.0 BACKGROUND

Projections for availability and cost of natural gas and petroleum based fuels indicate that domestic coal, in comparison, will most likely be the least expensive fossil fuel available for industry. GREFCO intends to assure itself of a non-curtailable source of energy to continue its perlite manufacturing operations by utilizing coal in a Gasification Facility. Preliminary economic evaluations indicate that a low Btu fuel gas made from coal could be the lowest cost fuel due to the rapidly escalating cost of natural gas and the future prospect of even higher cost gas under the provisions of the incremental pricing structure for industrial natural gas users. This pricing situation results from the Natural Gas Policy Act (NGPA) now in effect which will have much of the natural gas wellhead prices completely decontrolled by 1985. Gas prices have been and will continue to rise. Some believe that under the present decontrol system, natural gas will reach parity with fuel oil after 1985 and a huge, almost unbearable, increase in the price for natural gas will occur then. This has spawned a push for immediate or more rapid decontrol of natural gas by the administration. In any event, most forecasts predict natural gas prices after 1985 at extremely high levels. (See Natural Gas Forecasts in the Appendix Section of Financial Analysis 12.0.)

Considering the above and the fact that GREFCO's major cost in manufacturing insulation board at its Florence, Kentucky plant is for natural gas, General Refractories decided to undertake the preliminary design/engineering and feasibility study outlined in this report. The majority of this work was accomplished by Dravo Corporation and its subsidiary, Gibbs and Hill, Inc. - both noted experts in the field of alternate fuels. Dravo was instructed to begin their work by establishing a base energy requirement of 6.0 billion Btu's/day - 5 days per week for the first six months of the calendar year and 6 days per week during the remainder of the year. This would accommodate not only GREFCO's present needs but also any future energy demands due to expansions.

3.1 Technology

The energy requirements and proximity of Ohio and Kentucky coals as the fuel for the proposed gasification plant indicate that the Wellman-Galusha fixed bed, stirred, atmospheric gas producer is the most logical technical and economic choice for this project.

The high free swelling index of these coals (typically 7-8 FSI) categorize them as "caking type" and generally rule out other types of gasifiers because of inherent operational problems with these coals. Also, there have been more commercially operating Wellman-Galusha installations, with highly caking coals than any other gas producers. The Wellman-Galusha producer with its high turndown capability, is ideally suited for low-demand operation expected to be typically of the GREFCO plant.

Since an integrated system will be designed to include removal of particulate, tar, and sulfur removal, the clean gas produced will be environmentally acceptable. The plant will be designed to meet all EPA regulations. An environmental impact assessment will be made and a comprehensive report will be prepared. The environmental impacts associated with constuction, operation and maintenance of the proposed facility will be described in this report. The process to be used for this facility is described in Section 4.0.

The proposed gasification system for the Florence plant will utilize a single stage Wellman-Galusha fixed bed, atmospheric gasifier to produce 150 Btu/SCF industrial fuel gas. This gasifier has performed in commercial situations with proven reliability for over forty years in many industrial applications such as normalizing, annealing, smelting, firing of kilns, iron ore processing, etc. This gasifier is considered to be a viable process for the production of low Btu gas because of its demonstrated ease of operation and demonstrated reliability. 330 days per year or more of operation are typical. The process will require minimum development effort for commercial application. It is anticipated that all process elements in the proposed installation are commercially available.

The low Btu gas produced in the gasification facility will be used to fuel expander ovens and tunnel dryers used in the production of a perlite based roofing insulation board. The fuel gas is burned and the combustion gases flow into the expander ovens at a temperature of 3020°F. The flow of hot gases produces an expansion of the siliceous raw material. Gas also provides heat for drying the formed perlite board. The substitution of low Btu gas for higher heating value natural gas is not expected to affect the structural characateristics of the manufactured product in any manner nor harm production. It is expected that the increased flow of combustion products will improve dryer efficiency.

3.2 Study Objectives

The objectives of this proposal study are:

A. General Refractories Company has engaged Dravo Engineers and Constructors to perform all preliminary design and engineering required in the evaluation of its roofing board plant to determine whether onsite production of industrial fuel gas will be economically viable for GREFCO to implement to guarantee future energy requirements for continued production of perlite-cellulose roof insulation.

B. To determine whether LBG can be produced in sufficient quantity and with proper characteristics to maintain GREFCO's present level of productive capacity without detriment to product quality.

C. To provide assurance by means of substantive data that a coal gasification plant can be located and operated by GREFCO in an environmentally and sociologically acceptable mode at Florence, Kentucky.

D. To do the preliminary design and perform engineering sufficient to allow detail design and construction of a completely integrated gasification facility suitable for GREFCO's Florence Plant.

   This work will necessitate the provision of a definitive capital cost estimate for a battery-limits plant and an estimated annual operating and maintenance cost for same of sufficient accuracy to permit GREFCO to arrive at a decision point for construction of a plant to produce its own energy supply.

E. To determine the extent and magnitude of retrofit required to accomplish the conversion of existing equipment to utilize the LBG fuel and provide associated costs necessary to accomplish this conversion.

F. Determine through investigation that a contract for the purchase of a base coal fuel supply can be secured at reasonable cost to assure its continued use.

G. Determine what market exists for the sale of the resultant sulfur by-product and tars or alternately determine the most environmentally acceptable disposal method.

3.3 Statement of Work

Dravo Engineers and Constructors, the study contractor, will provide all preliminary design and engineering work requisite for the detailed design and construction of a battery-limits coal gasification facility on land owned by General Refractories Company at Florence, Kentucky.

3.3.1 Retrofit

Investigation of the conversion of burners on this equipment to accommodate this natural gas replacement, including a detailed study of the required distribution system, will be performed.

There are two services included in this study: 1) Perlite expanders and 2) perlite board dryers. This retrofit study will investigate the technical and economic feasibility of the use of a low Btu IFG for these services. The use of IFG for space heating is not included.

The technical feasibility will consist of an in-depth check with the furnace and burner manufacturers to determine if the system is indeed retrofittable and, if so, what changes are required to the system, as follows:

3.3.1.1 General

a. Determination of loads and operating requirements of the existing installation to determine design basis.

b. Process review of users including determination of heat and material balances.

c. Review of existing process controls, flame safety, blowers, gas trains, ducting, etc.

d. Design of the gas distribution piping in sufficient detail for a $\pm$ 15 percent estimate.

e. The retrofitted services are viewed as requiring backup-feed for reliability of supply. Retention of the existing natural gas supply lines and installed propane system will be considered as the backup.

3.3.1.2 Perlite Expanders

a. Determination of required burner modifications for small scale test in furnace manufacturer's facilities.

b. Procurement of three-element gas mixture, hydrogen-carbon monoxide-nitrogen, for test of expander in the manufacturer's shop.

c. Development and execution of a test to determine final design and configuration for input to the capital cost estimate.

3.3.1.3 Board Dryer

a. Determination of scope of design work or test program required to define modification to burners and combustor of the existing dryer.

b. Execution of test or design work to determine final design basis.

c. Development of design in sufficient detail for input to the capital cost estimate.

3.3.1.4 Documentation

The above will be initiated, checked and coordinated by Dravo. The following documentation will be provided:

a. Ladder diagram - Industrial fuel gas users with design gas flow rate.

b. Engineering flow diagram - A schematic indicating piping, gas train and burner components with sizes and a tabular bill-of-materials for major components.

c. Service description - A brief description of the existing service and status of design with respect to retrofit. For example, service name, burner and furnace manufacturer, available vendor information and summary of changes required to the system.

d. Routing of distribution header - Preliminary routing of the distribution header and individual service drops in sufficient detail for estimating.

e. Piping and instrument specifications - Preliminary specifications to indicating the piping system design features and describing major components in the gas trains.

f. Preliminary equipment specifications - At Dravo's option, preliminary specifications may be included if major equipment items require replacement. (For example, combustion air fans, total burner system replacement, building exhaust system modifications.)

g. General specifications - Dravo will prepare general specifications as required for the preparation of the estimate.

The capital cost estimate for the retrofit will be based on the above listed documents, with an expected accuracy of $\pm$ 15 percent. Vendor quotations on furnace modification, burner rebuilds or replacements, and gas train components will be obtained. Pricing of piping and piping components will also be obtained. A preliminary take-off for piping items will be made and their cost estimated. (NOTE: It is assumed that used components of present gas trains have no scrap value.)

3.3.1.5 GREFCO's Work Scope

GREFCO's responsibility in the retrofit area will be as follows:

a. Load requirements - GREFCO will provide load requirements, including variation with respect to time for each service.

b. Service information and description - Information on each service, including location, area, access, firing system, auxiliaries and any unusual features of the services to be studied will be provided by GREFCO.

3.3.1.6 Items Not Included

Dravo has not included engineering and preparation of such documents as:

a. Instrument item lists

b. Equipment requisitions

c. Electrical one-lines

d. Completed, detailed engineering drawings and specifications beyond that indicated above.

e. Piping supports and stress analysis

f. Any special testing, such as testing for sensitivity of processes to sulfur or other trace elements.

g. Individual metering of gas flows, either by building or service.

h. Establishment of insurance requirements.

3.3.2 Battery Limits Gasification Plant

Dravo will define the major elements of the battery-limits gasifier plant including the gas distribution line from the gasification plant to the intended users and the necessary piping to bring water to the plant and take waste water away.

Dravo will prepare a preliminary capital cost estimate for the design and construction of the facility within defined battery limits by quotations for major equipment items and from bulk takeoffs of major materials. The expected accuracy is within ±10 to 15 percent. Sufficient information for a plant specification suitable for construction bids will be developed.

Plant operating labor and maintenance cost estimates, raw material and chemical costs, purchased supplies and utilities will also be furnished. Pricing of piping and piping components for the distribution of the fuel gas will also be obtained and a typical cost analysis and delivered cost of coal to the battery-limits plant will be furnished.

3.3.2.1 Design Basis

The Battery Limits of the Industrial Fuel Gas Facility includes the following components:

Coal Unloading System - from trucks

On Site Coal Storage and Feed System

Gasification System

Coal Tar Removal and Storage System

Sulfur Removal System

Process Wastewater Treatment

Product Gas Compression

Sanitary Waste Sewers

Flare

Cooling Water System

Air Supply System

Steam Generation

Electrical Substation

Electrical and Motor Control Center

Office and Change House

3.3.2.2 Design Standards

The facility will be designed in accordance with Dravo's normal commercial practice using current codes and standards.

The preliminary design includes the following items:

a. Process flow diagrams and material balances. These are pictorial presentations of the process with the equipment shown and identified, as well as a tabular listing of the major components of each process stream shown on the drawing. Items such as pressure, temperature and flow rate are listed.

b. The overall thermal efficiency will be indicated.

c. Description of the sulfur removal system is included.

d. Preliminary engineering (P&I) flow diagrams.

e. Process equipment specifications for major equipment quotations. Included are the type, size, capacity and major features of equipment in the battery-limits plant.

f. A conceptual battery-limit plot plan for the gasification plant developed by studying the process areas and having layed out the plant to scale in block form to determine the overall area requirements. Offsite buildings and facilities will also be shown on the plot plant.

g. A plot plan of existing facilities showing proposed location of retrofitted equipment, routing of distribution header outside of the buildings and the primary supply to services inside the building. (Piping supports and individual burner piping, etc. will not be detailed.)

h. Preliminary specifications indicating the piping system design features and describing major components in the gas trains.

i. General specifications for civil, architectural, electrical and HVAC work. Also included is a motor list.

j. The utility requirements as shown in block diagrams of the major equipment components of the utility systems.

k. A bar chart schedule for the engineering, procurement, construction and start-up of the plant.

3.3.2.3 Items Not Included

This study will not include the following systems and components in the Design Basis:

Electrical Power Generation

Access Roads

Raw Water Treatment Facilities

Laboratory or pilot testing, such as testing for sensitivity of processes to sulfur or other trace elements.

3.3.2.4 Site Evaluation, Selection

The selected site for the gasification facility is directly adjacent to GREFCO's existing manufacturing operation. A rail spur behind the plant services the production area and will divide the property set aside for the proposed gasification facility. Several acres of cleared level land are available, and if necessary, an existing outside product storage area can be relocated slightly to provide additional space. A large settling pond in this area will also be filled in to enlarge the area for coal storage. The proximity of this location to the intended LBG users is ideal with regard to final gas distribution and should provide an efficient workable system.

3.3.3 Other Work

3.3.3.1 Environmental and Socioeconomic Analysis

The environmental assessment will have three major goals. These are (1) to determine whether the proposed facility can meet federal, state and local statutory requirements (2) to identify the principal regional and local concerns which might arise if the facility were to be constructed, and (3) to ensure that environmental, health, safety and socioeconomic considerations are an integral component of all subsequent planning and decisions.

3.3.3.2 Health Program

Health protection, both public and occupational, will be a major concern in the preparation of the feasibility study. The first step is to review applicable regulations and standards on a federal, state and local basis. From this review a set of exposure levels will be established. Engineering activities will be coordinated to include control measures to meet these health considerations. The feasibility study will include a plan to ensure required health and safety objectives are met.

The carcinogenic aspects of coal products have been well studied and documented from early work in coke ovens where coal-derived liquids are present. The most hazardous environment, from the standpoint of carcinogenicity, is liquified coal conversion products. In the process, the raw liquids are limited to the vapor quench and oil condensing area. The systems handling these products are essentially hermetic. Other systems involving chemicals and catalysts will be studied for carcinogenic properties. Where found, substitutions will be made. Where this is not possible, engineering precautions will be included. Where personnel contact is unavoidable, protective clothing and administrative surveillance of exposure times will be utilized.

3.3.3.3 System Safety

Safety will be an on-going consideration in all engineering and operational activities of the coal conversion plant. The aspects of system safety originate in the engineering phase and are carried out in the plant operation.

A Hazards Committee will publish a Hazard Specification defining hazardous conditions on an area basis. This analysis is made from flow diagrams and layouts so that control techniques can be introduced early in the engineering stages of the project.

In addition to these considerations, the General Design Specifications will specify mandatory and voluntary codes, which incorporate safe design of equipment and piping. As a normal step in the engineering, the process operating conditions are analyzed and design conditions of temperature and pressure are specified.

3.3.3.4 Risk Analysis

The risks involved in any commercial plant are technical, operating, environmental and financial. Technical risks are posed when inadequate design information is available for reliable design and operation.

Operating risks, which could affect the economic viability of the proposed project, are, typically; control of the integrated plant, yield of product, overall thermal efficiency and quality of product. All of the above risks will be considered during in the development of this project.

3.3.3.5 Financial Analysis

Input from the Market Analysis, Coal Supply, Engineering and Estimating will be used for financial analyses of the proposed commercial project. Analyses will be made of the following two project alternatives as predicted from the Market Analysis:

a. Gasification facility owned and operated by GREFCO.

b. Gasification facility owned and operated by Dravo and GREFCO purchasing output "over-the-fence" on a long term take or pay type contract.

3.3.3.6 Commercial Project Management Plan

The commercialization program will include a Management Plan for the execution of the project. The plan will encompass Project Mobilization, Project Execution and Procedural Outlines.

3.4 Optional Schemes Analyzed

During this preliminary study, it was necessary to identify and analyze a number of design basis options. In a project of this size and complexity, there is no single design path which can be followed to the exclusion of all other considerations. Rather, various engineering and economic options will arise, and will require analysis and selection.

The extent to which design basis options were analyzed varied considerably. Some fairly obvious options, such as ash handling and storage, required only moderate review. The several options available were listed, and the preferred configuration was selected based upon Dravo engineering judgement and experience.

In other cases, notably determination of the extent of sulfur removal, considerable engineering effort was required to provide the basis for selection. It was necessary to identify and design several processes, and prepare a cost estimate of each before a final selection could be made.

Finally, the selection of the construction phasing option which best meets the future energy needs of General Refractories required maximum design effort. To make sufficient economic information available to General Refractories to allow a corporate decision as to the construction option which best meets their needs, it was necessary to do a complete design and cost estimate of the two options.

In this section the several design basis options are identified and explained.

3.4.1 Phasing Options

The design basis fuel requirement of the GREFCO gasification facility was established at 6.0 billion Btu/day. The energy output of the gasification facility would supply an insulating board dryer, and several perlite expander furnaces.

The design basis of 6.0 billion Btu/day was predicated upon the assumption that the Florence, KY plant would expand, and approximately 40% of the 6.0 billion Btu/day would be utilized in the newly expanded plant.

The nominal energy output of a 10.0' diameter Wellman-Galusha gasifier operating on bituminous coal is 1.5 billion Btu/day. The energy output is significantly affected by the quality and size of the feedstock and the extent to which subsequent cleanup reduces overall thermal efficiency.

Considering the extent of cleanup, the anticipated coal characteristics, and provision for reliability by providing extra coal gasification capability, it was decided that the total plant requirement of 6.0 billion Btu/day would best be supplied by five 10' diameter Wellman-Galusha gasifiers. These gasifiers would produce hot raw gas which would then be processed to remove tar, moisture, and sulfur.

While five gasifiers will satisfy the ultimate energy requirements of the proposed expanded GREFCO plant in Florence, two gasifiers would be adequate to satisfy the present energy usage.

The first major decision confronting GREFCO management, therefore, is to determine whether to construct a full scale 6 billion Btu/day gasification facility now, in anticipation of future needs, or to construct an expandable gasifier facility which would include two gasifiers in the initial phase, and eventually expand to five gasifiers. This expansion would occur if and when the Florence plant expanded.

The choice of building a five gasifier plant at the outset, or building a two gasifier plant with provision for expansion, is a difficult one. To begin with, while the Wellman-Galusha gasifier module is a basic building block, and can be replicated at will, the cleanup systems can not. The cost and complexity of a sulfur cleanup system for two gasifiers is almost the same as that required for five gasifiers.

In terms of installed gasification capacity, therefore, the capital cost and gas cost per million Btu will be lowest if the total five gasifier plant were built initially.

This approach, however, necessitates a high initial capital outlay to build a gasification facility for 6 billion Btu/day which may not be fully utilized for some time pending the expansion of the Florence plant.

An additional argument for constructing a smaller two gasifier facility initially is that it would permit a more gradual familiarization with low Btu gasifier operating techniques.

The final construction option must be decided by GREFCO. The design basis selected for the purpose of this study is a gasification facility initially comprising two gasifiers, and having an energy output adequate to replace the current usage of natural gas.

The initial installation would include sufficient capacity in ancillary systems to accomadate future expansion to a five gasifier facility. These ancillary full capacity systems include:

- o coal handling
- o tar separation and storage
- o sulfur processing and storage
- o wastewater treatment
- o gas distribution piping

The remainder of the phase one equipment, including scrubbers, precipitators, gas compressors, and heat exchangers, would be sized for two gasifiers to reduce initial capital expenditure.

In this study, a cost estimate is presented for the five gasifier case as well as the two gasifier case. Apparent in the cost figures is a considerable reduction in initial capital for the two gasifier expandable option. Also apparent is the considerable increase in gas cost imposed on the initial installation by including the full capacity ancillary systems.

Sufficient engineering data and cost analysis have been presented in this report to allow the management of General Refractories to select a final engineering design basis from one of three options:

- o Construct a facility for 6 billion Btu/day initially.
- o Construct a 2.4 billion Btu/day gasification facility with built in expansion features as listed above.
- o Construct a 2.4 billion Btu/day gasification facility with no provision for expansion.

A reasonable preliminary cost of the third option can be obtained by selectively factoring the five gasifier case.

Finally, it is possible to reduce the total cost of the five gasifier facility slightly by designing for five gasifier capacity only, and not considering phasing options.

Dravo is prepared to discuss these phasing options with GREFCO and assist in determining the design basis for final design.

3.4.2 Sulfur Removal Considerations

Early in the project it was decided that the sulfur concentration in the LBG should not exceed 5 parts per million (ppm). This decision was based on process considerations imposed by GREFCO. As the design work on the sulfur removal system proceeded, it became obvious that exorbitant capital costs would be incurred resulting in a prohibitive gas cost. Consequently, an economical alternative had to be developed or the financial penalty for the low sulfur

level could result in termination of the project. Before the technical feasibility of an alternative process could be determined, attempts were undertaken to establish the cause of the corrosive attack in the dryer. Samples of the gas were obtained from the dryer internal atmosphere which were representative of steady state conditions during normal operation. Simultaneously, specimens of corroded metal were removed from the dryer for analysis.

Results of the gas chromatographic analysis showed that the total sulfur level in the dryer atmosphere was higher than in the fuel. From this it was inferred that a portion of the sulfur in the dryer's atmosphere was produced from the drying operation itself (most probably from the raw materials used to make the product) rather than from the combustion. The analysis of the corroded metal specimens did not substantiate the belief that the dryer corrosion was caused by sulfur compounds. As a result of this it was thought that the problem could be caused or aggravated by two other possible mechanisms:

(1) Metal deterioration due to extended periods of high operating temperatures in the dryer, and (2) weekend shutdowns which allowed metal surfaces to cool, causing vapor to condense and absorb carbon dioxide, thereby producing corrosive attack.

As a result of these considerations, the sulfur treatment process was redesigned with a more cost effective goal of reducing the sulfur level of the LBG to 150 ppm. This level is still far below the environmental requirement for the process.

The level of sulfur in a given fuel is a misleading index on which to base a determination of environmental or process impact, the more significant consideration is the concentration of sulfur in the combustion products, and in the stack gases. To obtain the stoichiometric combustion of low Btu gas requires the addition of approximately one volume of air for every volume of gas burned. Thus the level of sulfur present in the gas is diluted by the added air during combustion. This same process occurs for every fuel in different ratios of air/fuel mixture.

To evaluate properly the impact of sulfur, or any other contaminant in a fuel requires an analysis of the contaminant level in the stack gases.

Such an analysis was made for various fuels which might be burned in an appliance such as a board dryer. The results of this analysis are shown on Table 3-1. For each fuel considered, an evaluation was made on both a stoichiometric ratio of air and fuel, and an air/fuel ratio with 10 to 20% excess air.

Note the low Btu gas which has been desulfurized to 150 ppm has an impact on SO_2 release less than No. 2 Fuel Oil.

The initial process design was based on this requirement, and a process system having the capability of reducing high sulfur coal to low sulfur gas was developed. When the cost estimates of the capital and operating expense for this process were analyzed, it became obvious that the resultant gas costs were prohibitive.

As a result, the sulfur treatment process was redesigned with a more cost effective goal of reducing the sulfur level of the LBG to 150 ppm. This level is still far below the environmental requirement for the process.

The level of sulfur in a given fuel is misleading indice on which to base a determination of environmental or process impact, the more significant consideration is the concentration of sulfur in the combustion products, and in the stack gases. To obtain the stochiometric combustion of low Btu gas requires the addition of approximately one volume of air for every volume of gas burned. Thus the level of sulfur present in the gas is diluted by the added air during combustion. This same process occurs for every fuel in different ratios of air/fuel mixture.

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TABLE 3-1

SO_2 IN FLUE GAS FOR
COMBUSTION OF VARIOUS FUELS
TO PRODUCE 1 MILLION BTU'S

Fuel Name	SO_2 Released (ppm)	SO_2 (lbs)	Excess Air %
Natural Gas (6 ppm)	.6	.00099	0
"	.5	"	20
Propane[1] (7 ppm)	.7	.00117	0
"	.6	"	20
LBG (5 ppm)	1.2	.00259	0
"	1.0	"	20
LBG (50 ppm)	38.3	.09088	0
"	36.3	"	20
No. 2 Fuel Oil (.1% S)	58.7	.10304	0
	49.7	"	20
LBG (150 ppm)	94.4	.22400	0
"	89.5	"	10
No. 2 Fuel Oil (.3% S)	176	.30720	0
	149	"	20
LBG (7,300)	4,100	8.92160	0
"	3,635	"	10

[1] Propane diluted with air from 2,590 Btu/scf to 1,000 Btu/scf to be fired.

3.4.3 Material Handling and Processing Options

The quantity and quality of fuel supplied to the proposed gasification facility, the means by which fuel is delivered, monitored, and stored, and the form and disposition of waste and byproduct discharges from the facility are all essential components of the overall facility design. Each of these material handling and processing options has a significant impact upon the economic viability of the GREFCO coal gasification plant, and each was analyzed in this study.

In this section, the material handling and processing options are identified and the basis for selection of the chosen option is presented.

3.4.3.1 Coal Delivery

The GREFCO plant in Florence is accessible by rail, truck, and a combination of barge and truck. A preliminary analysis eliminated rail transportation for two reasons:

- There is insufficient space at the site to accommodate a rail unloading system.
- The transporation cost for rail delivery was significantly higher than truck delivery, partly because of rail interchange rates.

Based upon the lower cost and greater convenience of truck transport, this means of coal delivery was selected as the design basis for incoming fuel (refer also section 3.5).

In addition to selecting the means of transporting incoming coal, the degree to which the purchased coal was processed was also addressed.

For this facility, coal which has been washed and sized (by double screening) is the preferred fuel, but is also the most expensive coal. Delivery of unwashed unscreened coal to this facility will result in lower delivered price, but will require additional capital investment in coal handling equipment and coal storage space (refer section 3.5).

3.4.3.2 Coal Handling

The cost and control effectiveness of an onsite weigh station were considered. It was decided that the purchase price of an onsite weigh scale was more than justified by the improved control of inventory and verification of coal delivery amounts that the scale would provide.

3.4.3.3 Coal Storage

Three on-site storage systems with various feed systems were analyzed: 1) an open coal pile with either a tunnel conveyor, a silo with two bucket elevators, or a front end loader with a bucket elevator, 2) three different types of enclosed buildings utilizing either a distribution conveyor, an underpile recovery system, or a front end loader with a bucket elevator, and 3) coal silos using either a front end loader and bucket elevator, an incline loading conveyor or a feeder and conveyors (recovery). The exposed coal pile is the most economical choice.

The coal would be sprayed with a coal pile-de-icer solution prior to leaving the mine. Once stored the coal would be treated with antidust suppressant. The tunnel conveyor system was considered the most convenient and economical transporter of coal from the pile to the gasifiers.

The problem of ash should be collection was analyzed. The alternative studied were to collect ash directly into trucks, or into dumpsters. the most economical method would be to collect the ash in dumpsters which could then be hauled away by trucks. Dumpsters would also offer versatility. If collected in dumpsters, the dumpsters could be taken to a central storage pile for dewatering prior to removal.

The option of storing the sulfur in liquid or solid form was examined. Although it is more expensive to store sulfur in the liquid state, the marketability of liquid sulfur indicates that the sulfur be stored in this manner. (See by-product credits, Section 11.3.)

The necessity of providing a separate office and change house was evaluated. It was determined that for a Dravo-owned and -operated gasification plant this building would be required. However, if GREFCO were to own and operate the facility, the existing plant could accommodate the new requirements.

The question of whether to provide a separate ground flare or to use the standard gasifier flares was addressed. The cost of the ground flares made them uneconomical.

The by-products of coal tar, sulfur and ash will have to be disposed of in some manner. Either they would have to be hauled away for disposal, or sold. Sale of these by-products is economically attractive (See Section 11.3).

The sludge from the wastewater treatment plant poses a similar problem. It could be hauled away for use as land fill, incinerated, or pyrolyzed in the gasifiers. The last alternative would be the most economical.

The use of debt financing was studied as well as the sensitivity of the gas price to capital costs, operating costs and discount factor (rate of return used). An analysis of these options is presented in Section 12.0.

3.5 Fuel (Coal) Supply

3.5.1 Coal Requirements

The Wellman-Galusha gasifier can easily accommodate almost any kind of coal found in the United States. Coal ranging from lignite to anthracite can be gasified, provided certain design and operating features are implemented for proper gasification and clean up. However all available coal within a reasonable distance from Florence will perform equally well with the same gasifier design. Any one coal within this area may require minor modifications of operating procedures, and although the gas characteristics may vary slightly when using different coals, the gasifier's performance and capacity rating will remain essentially constant. Because of this versatility the Wellman-Galusha will meet the objective of operating on a coal with the lowest available price. This is important when considering that the cost of coal is one of, if not the most important component, of the gas price.

Coal can be selected on the basis of dollars per million Btu's. As a general rule the higher quality coals retain a premium when priced on an equivalent million Btu basis. These coals, low in sulfur, ash, moisture and volatiles usually have a concomitant high heating value and are used primarily by electric utilities and coking industry. Conversely, in the gasification of coal using the Wellman-Galusha process, it is usually to the benefit of the user to employ low cost coals. Given comparable heating values, coals with high sulfur, volatiles and ash levels will usually be priced lower than coals with lower levels of these characteristics. There are some trade-offs, however; higher levels of sulfur and ash will produce slightly higher operating costs. Also, since all the volatiles are not gasified but a certain percentage are entrained in the gas in the form of tars, gas produced per pound of coal is slightly less with higher volatile coals. On the whole the lower cost for lower cost coals coupled with a market for sulfur, tars and ash as by-products, creates a trade-off in favor of lower cost coals.

3.5.2 Coal Source

The cost of shipping the coal from the mine to the customer is a large portion of the total coal cost and care should be taken to limit consideration to those mines that are close to the final user. Because of this and the fact that Florence is surrounded by coal mines to the west, east, and south, coal found outside of the states of Ohio, Kentucky, and Indiana were excluded from the coal search. Knowing that there are coals in other states which are cheaper, it was decided that the additional transportation charges to move the coal to Florence, Kentucky would more than offset any price advantage. Additionally, it is realized that the further a coal source is from the user the less control one has over its availability. It should be noted that although distance is important, another main determinant of the transportation cost is the number of shipping agencies handling the coal. In other words, if one mine is further from the plant site than another, yet a railroad servicing that mine also services the gasification plant user, and the second mine requires two or more railroads to ship coal to the gasification plant, it may be that the total transportation cost will be lower for the first mine. Also, when selecting a coal source, all modes of coal transportation to the final user should be considered. More will be said about the transportation aspect in the following section.

In selecting which coal companies to contact for a coal source, the following guidelines should be used:

1. The coal companies should be of sufficient size to be able to mine the volume of coal required. Also companies with a proven record of experience in mining these volumes are preferred.

2. The coal company should possess sufficient reserves to be able to supply coal of consistent quality over a long period of time thereby negating the possibility of having to constantly switch suppliers.

3. The company should be large enough to supply creditable information on its coal -- both prices and coal characteristics.

4. Some offsetting influences on the selection of larger coal companies are that the smaller mines, as a general rule, offer lower prices due to lower overhead. Also, the larger a coal supplier the higher the probability that all of its coal from a certain mine is committed.

With the above guidelines in mind a list of was complied of all the coal suppliers in the states of Indiana, Kentucky, and Ohio. The list was culled using the above guidelines, and the remaining coal companies were contacted. Of those companies contacted, 19 mines were able and willing to provide the coal and pricing information for the proposed GREFCO requirement of approximately 120,000 tons per year. These companies and the prices for their coals in dollars per million Btu's are listed in Table 2 at the end of this section.

Table 3 lists many of each coal's characteristics for use in the selection process. Except for a few random deviations, most coals fall in a very narrow band when considering each characteristic. This is good in that it indicates how suitable these groups of coals are for the gasification process and that no one coal offers a great advantage, aside from price, over the other. Therefore even though one coal is selected for design and engineering of the proposed project if a switch to another coal source becomes necessary it can be made with little modification of the gasification facility or operations.

Of the coals listed all but four are considered high sulfur coals, which is typical of this region of the country. The other four are labeled as medium to low sulfur coals and can only be found in the southeastern part of Kentucky.

The grindability index is a measure of coal friability or fracturing capability. This affects the ease with which fines are created during the coal's transportation, storage, and handling. A low index produces less fines than a high index and its coal is therefore considered better for use in coal gasification.

Only nine mines were able and/or willing to offer coal of the right size consist, which is accomplished by double screening. Five of these mines quoted prices on both ROM 2" x 0" and sized 2" x 1/2", and the premium attached to sized coal ranged between $4 and $8 per ton. This low turnout of sized coal suppliers should not be construed as final. Based on discussions with the coal companies, some simply do not currently have the capability to provide sized coal, but may once the project becomes more firm and visible. These same discussions have confirmed the going premium for sized coal will most probably stay close to the $4-to-$8-per-ton range.

As previously stated the F.O.B. mine costs are given in Table 2 (in some cases the mine gave the price for coal loaded in a barge on the Ohio River and is so indicated). Next to the F.O.B. mine cost is the delivered cost in dollars per million Btu's to the gasification facility in Florence. In those cases where prices for two coal size consists were obtained, delivered prices are also reported. Delivered cost is the most important of the two since a large transportation cost could easily offset a low F.O.B. mine coal price. It was this delivered coal price that was used in the selection of a coal supply source. In developing the delivered cost, the cheapest available mode of transportation was used (rail, truck or barge and truck) even though, as will be seen, the transportation of coal by railroad was effectively ruled out.

Nine quotations on coal for another project Dravo was working on at about the same time this project was undertaken were obtained for the same general area -- Ohio, Kentucky, West Virginia, Indiana, and Illinois. These coals were very similar to the coals that are given in Tables 2 and 3 and as such could have been included in this study. However almost all of the mines were owned by large coal companies and the quotations were as high or higher than the highest prices given in Table 2. Because of this and the fact that the quotations applied to a specific project which required considerably more annual tonnage, it was decided that these prices should not be included in this report.

3.5.3 Coal Pricing Results and Selection

Table 2 shows that only four coal prices fall below $1.45 per million Btu's. However, they are all of the "unsized variety" and should not be considered for selection. The United Coal Company gave a delivered price of $30 per ton, which included stated delivery charge by truck of $6 per ton. This delivery charge is quite low and therefore questionable, and this is the reason why the F.O.B. mine cost was marked estimated in Table 2. All other delivered costs given in Table 2 include total delivery charges with the mine cost, even if it required adding a truck delivery charge and loading fee into a barge.

The basic coal cost is lower in Ohio than it is in Kentucky. This can readily be seen by comparing all the F.O.B. mine costs for the two states. Comparing the run-of-mine 2" x 0" coals, six Ohio coals ranged between $.80 and $1.01 per million Btu's with one Ohio mine offering it at $1.09. In Kentucky the same unsized coals ranged between $1.01 to $1.17 for seven mines. Although this demonstrates a trend, it is not the unsized coal or the F.O.B. mine price that is important. The selection must be made from coals meeting the sized requirements on a delivered basis. Two coals, one in eastern Kentucky and one in Ohio, offered the lowest price of $1.47 per million Btu's. Of the two it was decided to select the coal offered by Sands Hill Coal Company in Hamden, Ohio for the following reasons:

1. The Paul Coffee Construction Company said that it can meet the sizing specification without screening because of the coal's low grindability index.

2. It further stated that even if their coal did not meet this specification, it would install screening facilities and supply the properly sized coal at the same price.

3. This same coal supplier did not follow up its quotation in writing.

4. Sands Hill Coal Company already has screening facilities.

5. It stated that their ability to sell their coal delivered at such a low price was due to their inability to market it elsewhere because of its high sulfur content.

6. If necessary, there are numerous other coal suppliers in this same geographical area of Ohio which could offer coal with the same characteristics at relatively low prices.

The coal being offered by the Sands Hill Coal Company was used to begin design and engineering of the proposed gasification facility. A more complete analysis of Sands Hill coal characteristics than was given in Table 3 is found below:

Proximate Analysis	Ulimate Analysis	
11,350 Btu/lb	C - 64.0%	
4.1% Sulfur	H - 5.3	
2180°F Ash Softening Temp.	N - 1.2	
1.5 FSI	O - 7.4	
	S - 4.1	
10.2% Ash	Ash	- 10.2
7.8% Moisture	Moist	- 7.8
39.0 Vols	100%	
43.0 F.C.		
100%		

Sizing - Top 2" or 3"	Suflur (Organic)	0.93%
Sizing - Bottom 1/2"	(Pyritic)	2.82%
Sizing - w/ 10% 1/2"	(Sulfate)	0.35%
	TOTAL	4.1%

3.5.4 Coal Transportation

Approximately 120,000 tons of coal per year are to be delivered to the proposed gasification plant, which is located in an industrial park with excellent highway access. The plant is located on the Southern Railway, but does not have an available siding nor a hopper car unloading facility. It is located approximately 10 miles due south of Cincinnati or about 8 miles below the Ohio River where a few barge unloading terminals can be used for unloading and storage of coal. Dravo's Transportation Department was asked to conduct a transportation study on delivering the required coal to the plant. Three modes of transportation were analyzed -- truck, rail, and barge/truck combination.

Delivery by truck would not require a major truck unloading facility but would significantly limit the area from which coal could be economically hauled. As a general rule, truck rates beyond a 150-mile-radius are considered noncompetitive with other modes of shipping. When transporting by truck, all coal stockpiling would be at the plant.

Delivery by railroad would require significant expenditures for a siding and unloading facility. Also, it is doubtful whether there would be space available for these facilities as there is barely enough ground available to accommodate the rest of the gasification plant. Again all coal stockpiling would be at the plant using the railroad for shipping coal. Coal sources would be limited since there are relatively few mines on the Southern, and more than one line would be involved for most of the coal mines that have rail capability.

Shipment of coal by barge and then truck would involve minimum expenditures for installation and operation of coal unloading and stockpiling facilities. There are a few barge terminals with storage capability in the Cincinnati area. Two of these unloading terminals have been contacted for pricing. Using this method, principal stockpiles would be maintained at the off-loading river terminals with surge or emergency stocks only at the plant. Because of relatively lower barge rates, mile for mile, coal could be obtained from a wider range of sources with small cost differentials for the added mileage from distant mines.

Dravo's analysis of the estimated delivery cost by the above methods is given in Table 4. The following comments are pertinent:

1. All costs reflect use of public facilities only and do not include cost data for delivery by the vendor.

2. As noted, certain costs were estimated because published data did not reflect the appropriate basis. For example: A rail rate of $10 per net ton is shown from Oak Hill which could be negotiated versus the current actual rate of $22.34, which is a published combination of rates using a circuitous route from Oak Hill to Florence.

3. For bulk materials, rates are negotiable and could vary considerably, depending on economic and physical conditions.

Table 4 reveals the following relationships. From the Ohio area the barge/truck rates are about the same as those for trucking only. The transportation charge from the mine to the dock and loaded into the barge must be added to the rate shown in the table. This charge is on the order of $3 to $4 per ton and was already included in the coal price by those mines in Table 2 which listed their prices "in the barge". The barge/truck rates are actually cheaper than the truck rates when shipment is made from the farther mines in western and northeastern Kentucky and Indiana.

Even though the rail rates are slightly cheaper than barge/truck and more so when compared with truck rates, it is felt that rail is the less preferred mode of transportation because of the following:

1. Rail capability will require considerably more ground space which is not available at the proposed plant site.

2. Large additional capital expenditures for siding and unloading facilities which are not necessary when shipment is made by truck or barge/truck.

3. The railroad rates are estimated and subject to error. A more exact figure cannot be reported until negotiations are made with the individual carriers during later stages of the project .

4. There are limited coal mines having rail capability. Of the 19 listed in Table 2 and 3, only seven are served by rail. If the plant were designed for sole use of rail transportation, it would restrict competition from many other mines not served with a railroad and consequently eliminate many more economical coal sources.

From Table 4, truck rates appear to be the least competitive mode of transportation. Paradoxically, Sands Hill Coal Company has offered its own truck delivery service at a cost which is lower than any rate of any kind given in Table 4. All truck rates given in Table 4 are public; because the truck rate given by Sands Hill is so much lower than the rest, it is felt that the mines closer to Florence in southern Ohio and northeast Kentucky may offer better rates if they can provide their own transportation. Again this possibility cannot be determined until serious negotiations are entered with individual coal companies. These lower truck rates from the individual mines would not be possible for coal coming from southern or western Kentucky and Indiana where barge/truck or railroad are the preferred modes of transportation.

If barge/truck delivery is used, there is a capability of reducing the rates given in Table 4 further by GREFCO operating its own fleet of trucks between the gasification plant and the barge terminal. This would also give them a certain and reliable surge capability for coal storage through use of the barge terminal storage area.

3.5.5 Other Coal Supply Options

It should be noted that 2" crushed run-of-mine (ROM) coal has a fraction of 1/2" and below which ranges between 40 percent to 65 percent of the total. Also, analyses of the 2" ROM versus the sized coal reveals that the sized coals have a higher heating value than that of the 2" run-of-mine. It follows, and it has been proven, that the fraction 1/2" x 0" has an even lower heating value than the crushed 2" x 0" run-of-mine. The reason for this is the fines, a great majority of which are much smaller than 1/2", are composed of particles which are of a much lower grade coal. These particles have a much higher concentration of ash and water as well as sulfur. An inspection of Table 3 shows the difference between the heating values, which are listed for the five mines offering sized and unsized coals. The difference between these two coals ranges between 300 to 900 Btu's per pound. The difference between the 1/2" x 0" versus the sized 2" x 1/2" can be as great as 1,000 to 2,000 Btu's per pound.

Most coal goes to the utility market, and it is sold as "nut and slack" or 2" crushed ROM. Most utilities are very particular about the quality and specifications of the coal they are receiving. Once the specifications are set, any deviations may cause the buyer or power company to refuse delivery. It can easily be understood that when a miner screens his coal the screened portions will deviate somewhat from his typical coal being sold. Depending on the market and the particular requirements of the customer, the screenings from screened coal can create a problem. Either he has to dispose of it as unsaleable coal (which is rarely the case), sell the fines as is, or more likely blend these fines in with his normal coal production which, although minmizing the problem, still yield a blended product different from typical 2" ROM.

It is readily apparent, then, why some coal miners refuse to sell sized coal. (More than 50 percent of the miners contacted for this study refused to supply a sized coal.) These miners either did not have a screening capability or they did not want to encounter the problem of marketing the screenings. A few of the miners stated that the only way that they would supply a sized coal was to charge approximately double their regular 2" ROM price (based on the theory that they may be forced to "swallow" the portion below 1/2", and that this fraction approximates half of the 2" ROM).

Of those coal operators who stated that they could supply sized coal, the premium attached to the sized coal, as stated before, ranged between $4 and $8 per ton. This is roughly equivalent to 1/4 to 1/3 the price of their 2" ROM. Apparently they feel that they would be able to market these screenings but through a discount -- the discount approximating the premium that GREFCO would be paying for sized coal.

The question addressed was whether GREFCO should buy 2" ROM at a price cheaper than if can buy sized coal, screen it themselves, and market the fraction 1/2" and below. This is not a very practical option since: 1) GREFCO is not in the business nor does it have experience in the marketing of coal let alone the sale of fines, 2) GREFCO has no other coal sales with which it could blend the fines, and 3) the purchaser of fines from a mine (either as is or blended with another coal product) incurs only one transportation cost, e.g. the freight charge from the coal mine to the coal consumption point; if GREFCO were to market its fines it would have to sell it to a customer who would incur not only the transportation cost from the mine to GREFCO's plant but also the cost in transferring the fines to this ultimate consumer.

An example can be used to illustrate the infeasibility of buying 2" ROM and marketing its fines after screening. GREFCO can purchase a ton of sized coal from Sands Hill Coal Company at a delivered price of $33.20. If it were to purchase 2" ROM, it would have to buy roughly two tons of unscreened coal to yield one ton of 2" x 1/2". At a delivered price of $25.20 per ton of 2" ROM and a very nominal screening cost of $1 per ton, the total cost for one ton of screened coal is $54.40. This ignores any costs involved in the sale of these fines and any concomitant overhead and general administrative costs. Taking the delivered cost credit of $33.20 for the sized coal, GREFCO would have to sell the coal fines at $19.20 to break even. It is not realistic to expect GREFCO to be able to easily sell these fines which incidently have a much lower heating value than the original 2" ROM Sands Hill is offering. Here GREFCO would be competing with Sands Hill and other coal companies with an inferior product at higher price. Also, it should be pointed out that the 2" x 0" coal is easier to transport and handle than the fines.

A brief investigation was made into the possiblity of purchasing strictly run-of-mine coal which has not been crushed. Coal of this nature has a top size ranging from 6" to 12". There are a few larger pieces, but they are insignificant. The cost savings in purchasing this uncrushed coal, where possible, is only of the order of $1 to $2 per ton. However, it should be remembered that Grefco would have to pick up this same cost if they were to purchase the coal like this and then crush and double screen it. The resulting fraction of coal 1/2" and below may be slightly less than if a 2" ROM were purchased, but certainly not enough to make a difference.

Another coal purchasing option would be to buy washed coal versus raw or unwashed coal. The washed coal is of a higher quality, but a premium of $2 to $7 per ton is attached to this washing operation. The washing of coal not only improves its heating value but also reduces other undesirables such as sulfur, ash and moisture. The reduction of these parameters is not as critical to GREFCO's intended use of the coal as it is to most washed coal purchasers (utilities and coke oven operators). On the whole the premium does not match the increase in heating value on a dollar-per-million-Btu basis. During the course of this search for a coal source, three coal operators gave prices for

their coal on both a washed and unwashed basis; they were the R & F Coal Company, The Blue Diamond Coal Company, and the B & M Coal Company. When their prices were converted to an equivalent Btu basis, in all three cases the washed version was considerably more expensive. There were a few coal suppliers contacted which were unwilling to supply their coal unwashed. Since the premium for washed coal is not offset by the improvement in quality, it is considered not worthwhile to purchase washed coal where there is a choice or even to seek out washed coal suppliers.

The choice of purchasing a coal with a low sulfur content versus one with a high sulfur loading follows the same philosophy. The increase in premium here is even more out of line with the improvement in the quality of coal than is the case with the washed versus unwashed. This premium can range from $5 per ton to $15 per ton depending on how low a sulfur level is provided. Obviously the lower the sulfur level, the higher the premium. In some cases lower sulfur coals with their higher premiums had lower heating values than some of their higher sulfur counterparts.

4.0 BATTERY LIMITS COAL GASIFICATION PLANT

4.1 Overall System Description

A coal gasification installation consisting of five Wellman-Galusha fixed-bed atmospheric gasifiers with agitation has been designed to provide 6,000 MM Btu's/day of low Btu gas (LBG) for GREFCO's, industrial insulation board plant. It includes all auxiliary process equipment needed to deliver coal to the gasifiers, remove particulates from the raw product gas, quench the gas and remove its tars, and then scrub the gas to extract the hdydrogen sulfide (H_2S) and ammonia (NH_3). Equipment for the removal and storage of coal tar is provided. In addition, facilities have been designed to convert the hydrogen sulfide to liquid elemental sulfur. Clean, cool, and pressurized LBG of 130 Btu/SCF higher heating value is delivered to the main gas distribution header for GREFCO's internal consumption.

The five-gasifier plant was designed for initial installation of two gasifiers, with provision for the later addition of three gasifiers. Certain pieces of process equipment, common to both facilities, have been designed to accommodate five gasifiers.

Process flow diagrams CPD-2994-100-001 through 003 were developed to depict the processing sequence from coal delivery to clean LBG, tar and sulfur removal and storage. Process flow diagrams CPD-2994-100-004 through 009 show the auxiliary support systems necessary for the five-gasifier system.

Equipment which is duplicated for a two- and three-gasifier operation is so indicated and is given separate item numbers in the equipment list.

4.2 System Components

4.2.1 Coal Receipt, Storage and Preparation

Sized coal at 1/2" x 2" will be delivered to the gasification installation by truck and weighed on Weigh Scale (48001). The coal will be inventoried on an open 10-foot-high coal pile of approximately 5400 tons, which is sufficient for 13.5 days of continuous operation at full capacity. A Front End Loader (49001) moves the coal from the main storage pile to a smaller pile of 70 tons of live storage located over a Vibrating Discharger (43003).

Coal is passed from this smaller pile by the vibrating discharger via Knife Gate (43004) and Vibrating Feeder (43005) onto a horizontal troughed Coal Reclaim Conveyor (43006). The coal feed is weighed by Weigh Belt (48002) and cleaned of tramp iron by a Magnetic Separator (45001) located in the head pully of the reclaim conveyor. The reclaim conveyor brings the coal to the Coal Distribution Bucket Elevator (43007) for delivery to the enmasse-type Coal Distribution Conveyor (43003).

Controls provide for the proper sequencing of equipment such that all downstream equipment must be operating or in proper position to permit the operation of each preceding piece of upsteam equipment. Coal is delivered to the upper compartment of the coal storage bin of any gasifier by placing that gasifier's slide gate in the open position, permitting the coal to drop down through the feed pipe. As a precaution, an interlock on the coal distribution conveyor is provided to permit its operation only if one gasifier feed gate is open and that gasifier's feed bin is less than full.

4.2.2 Coal Gasification

Coal is supplied from a two-compartment fuel bin which forms the top of the Gasifier (33001-1,5A). The upper compartment serves as a storage bin and has a capacity of approximately 15 tons. The lower compartment is separated from the upper by disc valves through which the coal is fed as required. Similar valves cover the entrance to each of the heavy steel feed pipes connecting the lower compartment with the gasifier. Coal from the lower compartment flows continuously through these feed pipes to fill the gasifier.

The fuel feed pipe valves are arranged and interlocked in such a manner as to permit continuous fuel feed to the gasifier and still maintain a gas seal even during the charging of fuel to the upper compartment.

This system, besides being simple in design and operation, contributes greatly to the efficiency of the gas producing facility by constantly feeding fuel to the fire chamber where it is continuously pre-heated.

An agitator keeps the coal in the gasifier bed uniformly distributed and helps prevent caking. As the coal moves down through the bed it is dried, partially volatilized and eventually gasified as it contacts the rising stream of hot gas.

The consumed coal ash rests on a revolving grate. The grate is made of circular flat plates without perforations. The plates are eccentric with the center of the support and are rotated very slowly, which gradually dumps the ash to an integral cone-shaped ash hopper at the bottom of the gasifier. Once a day these ashes are dumped and sluiced out with water to a dumpster located on the ground floor. The dumpster is then either hauled away to a suitable land fill and/or sold as a by-product.

The gas producing chamber of the gasifier is completely water-jacketed. Waste heat in the water jacket evaporates a portion of the water supplied to it.

The air necessary for gasification is supplied by the penthouse Conveyor Dust Collector Exhaust Blower (50001), and this clean air is delivered to each gasifier by its own Air Blower (33001-1,5C). The air passes over the water jacket picking up sufficient moisture to saturate it before entering the gasifier. Saturation is automatically controlled by regulating the rate of supply of jacket water to obtain and sustain the desired saturation temperature. A live steam connection is provided in the saturation air pipe should additional steam be required. The saturated air introduced into the gasifier under the motorized ash grate and through the ash layer helps moderate the combustion temperature thereby avoiding the formation of ash clinkers.

The exiting gases at 755°F contain entrained coal and ash particles of which approximately 60 percent is removed in a Cyclone (33001-1,5B), which is close coupled to each gasifier. The gases also contain tar which may be present as either a vapor or a mist. The removal of this tar and its eventual recovery will be discussed in subsequent sections.

A flare is provided between the gasifier and cyclone for use during start ups to burn off specification gas or excess gas generated during process upsets.

4.2.3 Fuel Gas Processing

4.2.3.1 Gas Quench

The hot LBG stream, after exiting the Cyclone, enters Quench Tank (35002-1,5). In the Quench Tank, the filtered raw gas is cooled to 138°F by direct contact with a recirculating stream of 120°F quench water sprayed from two rows of non-clogging nozzles.

Most of the tar in the product gas is scrubbed out in the Quench Tank. The quench water underflow from the tank enters the Gasifier Tar Separator (45004). After the tar is removed, the quench water is delivered by Recycle Pumps (41004 and 41005-1,2) through shell and tube Recycle Coolers (31001 and 31002) back to the Quench Tanks. The exchangers cool the recycle water back to 120°F from approximately 156°F.

Since there is a net gain of water in this operation, a bleed stream or blowdown is provided to the waste water treatment system. This waste treatment facility will be discussed in Section 4.2.4.

Should there be for any reason a requirement for additional water, a connection is provided for the injection of city water.

From this point onward the product gas enters two similar but separate and parallel conditioning trains. One system is designed to handle the combined production of two gasifiers while the other will process that of three.

4.2.3.2 Tar Removal and Recovery

As mentioned in Section 4.3.2.1, the tars are removed in bulk from the product gas in the quench tanks. The quench water underflow is drained by gravity to the steam-heated concrete tar separator. Here the two liquid phases are allowed to dissociate, with the slightly heavier tar settling to the bottom. Tar fluidity, and hence, transferability, is maintained by a steam coil in the separator. Tar Transfer Pumps (41006-1,2 and 41007) deliver the separated tar to a 50,000 gallon Tar Storage Tank (34001). This tank is also heated by a steam coil. The tar is continuously recirculated around the storage tank by Tar Loading Pumps (41003-1,2) to aid in keeping the tar sufficiently warm. The loading pump is also used to fill tank trucks. All lines in the tar removal, recovery and storage area are steam-traced.

Connections are supplied on the separator for the additional flows of water and tar from the Electrostatic Precipitators (45002 and 45003) and Gas Coolers (31003 and 31004). The entire system is designed to handle the production of all five gasifiers.

4.2.3.3 Gas Compression

As mentioned in Section 4.2.3.1 there are two distinct parallel conditioning systems from this point onward. For the ease of explanation, the two systems will be described as if they were one.

Quenched gas at approximately 157°F is compressed from essentially atmospheric pressure to 3 psig by the ESP Compressors (42004 and 42005). The gas now flows through the electrostatic precipitators where approximately 99 percent of the entrained solids and residual tar left from the quench operation is removed.

After leaving the electrostatic precipitators, the warm, moist gas then enters the ESP Aftercoolers (31003 and 31004). These one pass shell and tube heat exchangers cool the gas from the heat of compression temperature (180°F) down to 100°F. This cooling step lowers the inlet volume to the System Compressors (42006 and 42007) thereby lowering the required horsepower. The condensate from this operation is returned to the tar separator for the removal of any possible tar carry over.

The gas, having been cooled and the bulk of its moisture removed, is now ready for final compression to about 8 psig in the system compressors. These two staged intercooled compressors supply sufficient pressure to drive the product gas through the System Aftercoolers (31005 and 31006) and the Absorber Reactor Columns (32005 and 32006) and on through the distribution main to the retrofitted burners in the board plant. The system aftercoolers drop the temperature from the heat of compression at 139°F down to 100°F, which is in the middle of the operating range for the sulfur removal system selected.

4.2.3.4 Sulfur Removal and Recovery

Sulfur Removal Requirements

To meet the air quality standards of the Environmental Protection Agency, and to satisfy the requirements of GREFCO, Inc. (that is, minimization of the corrosive atmosphere in the dryer), it is necessary to reduce the level of sulfur in the LBG stream. The sulfur in the gas is derived from pyritic and organic sulfur in the fuel feed stock, and occurs in the gas primarily as hydrogen sulfide, H_2S, with small amounts of sulfur dioxide and carbonyl sulfide.

The extent to which sulfur must be removed, and the equipment and capital costs required for various levels of sulfur removal, are described in Section 3.4.2. It was decided that a total sulfur level of 150 ppm in the LBG would be well within environment constraints.

Process Overview

The sulfur removal process selected for this facility is a proprietary system known as the Stretford Process. Basically, this process uses a counter current flow of a dilute solution of aqueous alkaline reagent to scrub the gas stream in an absorber where the H_2S is oxidized to produce elemental sulfur. The oxidation of the H_2S causes a concomitant reduction of the solvent. The reduced solvent or reagent is subsequently re-oxidized and, after this regeneration, made available for continued use.

Gas Pre-Treatment

Prior to the removal of the sulfur, the coal gas must first be stripped of tar, compressed and cooled. These operations are described in Sections 4.2.3.2 and 4.2.3.3 respectively.

Gas Clean-Up Description

As mentioned earlier, the gas clean-up facilities consist of two separate parallel trains, one for handling the production of two gasifiers the other for three.

The first step in sulfur removal occurs when the feed gas to be cleaned enters the bottom of the Absorber Reactor Columns (32005 and 32006) while the regenerated alkaline Stretford solution is being recirculated to the top by Liquor Pumps (41013-1,2 and 41019-1,2). As the gas contacts the solution the H_2S, NH_3, HCN, and SO_2 are removed. Upon absorption, the H_2S is oxidized to elemental sulfur by the vanadic salt in the solution which causes a concomitant reduction of the salt to the vanadous form, from the pentavalent to quadrivalent state.

The solution then enters the reactor section at the base of the absorber where the ionized H_2S is provided additional liquid hold-up to insure the total conversion H_2S to elemental sulfur. As the clean, H_2S-free LBG rises to the top of the absorber, its entrained liquid is removed by a wire mesh demister before exiting for eventual combustion in GREFCO's commercial insulation board drier and perlite expander.

The ammonia will dissolve in the solution, but does not chemically degrade it. The HCN and SO_2 react irreversibly with the Stretford reagent chemicals forming sodium thiocyanate, sodium thiosulfate and sodium thiosulfite. The method of handling this degradation is discussed under Side Reactions and Treatment.

Solvent Regeneration

The spent solution from the reactor section of the absorbers flows to the Oxidizer Tanks (35012 and 35013) for the introduction of air supplied by the Air Blowers (42008-1,2 and 42009-1,2).

In reoxidizing the quadrivalent vanadium complexes to sodium ammonium isopolyvanadate, the anthraquinone disulfonic acid (ADA), originally present in the Stretford solution is reduced to hydroquinone disulfonate. The air delivered by the air blowers supplies the oxygen necessary to reoxidize the hydroquinone disulfonate back to ADA, thereby reactivating the solution. The reactivated solution overflows from the oxidizers to the Liquor Tanks (34003 and 34004) for recirculation by the liquor pumps.

Excess air beyond that required for the regeneration of ADA is provided to facilitate the formation of a sulfur froth. This froth also overflows from the oxidizers, but is piped to the Slurry Tanks (36001-1,2 and 36002-1,2).

Solvent Recirculation

The liquor tanks supply a reservoir of solution from which the liquor pumps draw. The pH of the solution is an important parameter to monitor since at low pH the thiosulfate formation is minimized while at high pH the rate of absorption is favored. Yet at pH values above 9.5 the rate of conversion of absorbed hydrogen sulfide is adversely affected. Thus the process is best operated within a pH range of 8.5 to 9.5 for pH control and solution makeup. A Reagent Mixing Tank (36003) and Reagent Pump (41022-1,2), each common to both Stretford trains, are provided for the addition of fresh solution makeup.

The fresh solution and that which is recirculated is maintained at about 100°F by steam coils located in the mixing and liquor tanks.

A continuous blowdown, or purge stream is required to control the total dissolved solids. Not doing so results in precipitation of the thiosulfate causing blockage in the lines and equipment. This purge stream is taken off after the discharge of the liquor pumps and is piped to the common Effluent Purge Tank (35016).

Sulfur Recovery

The sulfur froth from the oxidizers which has overflowed to the slurry tank is kept agitated at a temperature of 120°F. The slurry is transferred by the Slurry Pumps (41024-1,2 and 41025-1,2) to the Sulfur Filters (45013 and 45019). Here the sulfur is washed of the residual Stretford solution with water. The resultant cake is dropped into the refractory-lined concrete Sulfur Melters (44001-1,2 and 44002-1,2).

The sulfur cake is held in one of the two melting compartments for about a day before the actual melting by steam coils. As the cake is heated, steam is driven off and vented through the Exhaust Heads (43010-1,6). The cake is then heated to a temperature of 260°F. Next the liquid sulfur is allowed to flow into the transfer compartment of the melter where its temperatue is raised by another set of steam coils to 280°F. The vertical type Liquid Sulfur Transfer Pumps (41036-1,2 and 41037-1,2) deliver the sulfur to the Liquid Sulfur Storage Tank (35033) which is also equipped with a steam coil for maintaining the 280°F temperature. The Liquid Sulfur Loading Pumps (41034-1,2) recirculate the liquid sulfur around the storage tank as well as deliver it to tank trucks.

Side Reactions and Treatment

As mentioned in earlier sections there are irreversible reactions between the Stretford solution and the gas which lead to the formation of by-product sodium salts of thiocyanate, thiosulfate and thiosulfite during the absorption and regeneration operations. The concentrations of these undesirable salts can build up to unacceptable levels. It is necessary therefore to purge a portion of the solution as effluent. There are several ways to treat this effluent and a number of proprietary methods have been developed. Reductive incineration is one of these methods and has been selected for this design. Effluent is pumped from the purge tank by the Effluent Purge Pumps (41020-1,2) to Reductive Incinerator Package (47003) on a batch basis. Here is it decomposed under a reducing atmosphere in a vertical furnace (47003-B). The resultant gas is cooled in Quench Tank (47003-C) and then scrubbed in a Venturi Scrubber (47003-D). Scrubbing water is delivered from a sump under the venturi's stack (47003-F) by a Recirculation Pump (47003-G). Circulation Pump (47003-E) transports the recovered dissolved salts back to the top of the furnace downcomer tube so that a falling film of liquid is always present on the inner surface of the tube. This prevents clogging due to salt deposits. The circulation pump can also deliver the recovered salts back to the reactor section of the absorber reactor column.

Since the products of this process can be recycled, the process results in no effluent discharge.

4.2.4 Water Treatment

4.2.4.1 Raw Water Treatment

"Raw water" is city water. Water as received from the city distribution system is stored in the Deionizer Makeup Tank (35038). This water is treated for cooling water use and for low pressure (65 psig) boiler water use.

Cooling Water Treatment

To prevent scaling, upper limits on cooling water hardness and alkalinity exist. The city water hardness and alkalinity exceed these limits.

To reduce hardness to the acceptable level requires pumping two thirds of the cooling water makeup requirement through a cation exchanger. In this vessel hardness-producing calcium and magnesium ions are captured on an ion exchange resin. Sodium, an ion which does not cause water hardness, is displaced from the resin by the calcium and magnesium.

The second step in preventing scale is the reduction of alkalinity. This is accomplished by adding sulfuric acid to the circulating cooling water. Equipment used in the above processes is the following:

ITEM	NUMBER	PURPOSE
Carbon Adsorber Feed Pump	41043-1,2	Pump water through Carbon Adsorber, Cation Exchanger

Raw Water Carbon Adsorber	45020-1,2	Dechlorination, Suspended solids removal
Cation Exchanger	47009-1,2	Remove hardness
Cooling Water Makeup Tank	35036	Store cooling makeup water for use
Cooling Water Acid Pump	41047-1,2	Pump acid for alkalinity reduction
Cooling Water Makeup Pump	41046-1,2	Pump makeup water to the cooling water circulation system

Boiler Water Treatment

Water used in 65 psig boilers requires the removal of virtually all hardness. Also required is the reduction of alkalinity to an acceptable level.

To accomplish the first requirement of near-zero hardness, water is diverted (directly from the cation exchanger) to the Condensate Receiver. This water is at near-zero hardness.

To meet the second requirement of alkalinity reduction, sulfuric acid is added to the boiler makeup water. Sulfuric acid is pumped by the Boiler Water Acid Pump (41048-1,2).

Blowdown and Regenerant Disposal

The cooling water and boiler water blowdowns are accumulated in a sump along with periodic regenerations of the cation exchanger. The combined flows are pumped at an equalized rate to the sanitary sewer collection system by the Spent Water Disposal Pump (41044-1,2). Constituent concentrations in the equalized flow do not violate effluent limitations.

4.2.4.2 Wastewater Treatment

Since water temperature is critical to the biotreatment process, the feed stream is cooled from 157°F to 100°F in Quench Tank Blowdown Cooler (31007) prior to entering the treatment facility.

Emergency Storage

Influent flow may be diverted to the Emergency Storage Tank (34010) for the following reasons:

1. Reacclimation of the Wastewater Treatment System during periods of inadequate wastewater treatment.

2. Extreme pH fluctuations.

3. Toxic spill.

4. Major phenolic loading surge.

5. Extreme hydraulic fluctuation.

The tank has sufficient volume to hold seven days of flow. This time is chosen for reacclimation of the biosystem.

After whatever corrective action is taken with the diverted flow, it is returned to the treatment system at the Tube Settler.

Primary Clarification, Equalization, Centrifugation

The Tube Settler (45021) removes the bulk of the suspended solids from the influent flow. A Primary Coagulant (47013) is added to the flow to enhance suspended solids removal through charge destabilization and particle bridging.

The flow enters the Equalization Tank (36010) from the Tube Settler by gravity. The water level in this tank is allowed to fluctuate in accordance with the influent flow. The tank also stores two days of flow. This is the quantity required to keep the bioplant operating when the main plant is shut down for two days a week. The Equalization Tank Agitator (39010) mixes the wastewater, preventing the settling of suspended solids which remain in the wastewater.

Sludge from the Tube Settler is pumped to the Primary Sludge Centrifuge (45022) by the Centrifuge Feed Pump (41050-1,2). The inert discrete solids present are amenable to dewatering by centrifuge. The concentrated solids are disposed of by others; the centrate is sent to the equalization tank for subsequent biological treatment.

Biotreatment and Clarification

Flow is pumped from the Equalization Tank to the Aeration Tank (43011) by the Aeration Tank Feed Pump (41060-1,2). Here phenolics are biologically converted to carbon dioxide and water. Oxygen for this reaction is provided through a diffused air system by the Aeration Blower (42016-1,2).

Influent phenolics are diluted to a biologically amenable treatment level of about 500 Mg/l. This is done by recycling flow from the Biosludge Clarifier (45023) with the Dilution Recycle Pump (41051-1,2).

Since the aeration tank contains a completely mixed solution, an amount of biologically activated sludge must be recycled to maintain equilibrium. Also, a net increase in biosludge in the aeration tank must be wasted. This net increase is the result of the phenolic conversion. Both sludge wasting and sludge recycle are accomplished by the Biosludge Pump (41052-1,2). Sludge is pumped from the Biosludge Clarifier (45023).

Any odor from the bio-treatment system is controlled by the Aeration Tank Carbon Adsorber (45028-1,2) as received from the Exhauster (42017-1,2).

Pressure Filtration, Carbon Adsorption

Flow is pumped from the sump after the Biosludge Clarifier to the Pressure Filter (45024-1,2) by the Pressure Filter Feed Pump (41053-1,2). Pressure filters are used because of the nominal flow quantity. The filter removes residual suspended solids prior to carbon adsorption. The filters are periodically backwashed. The backwash is sent to the head end of the bioplant.

The final treatment step of carbon adsorption (by 45025-1,2) removes the residual phenolics from the flow. Carbon is replaced when it becomes exhausted. After carbon adsorption, the flow has received the pretreatment required and is discharged to the municipal sewer system.

Biosludge Treatment

Biosludge is pumped from the Biosludge Clarifier to the Biosludge Thickener (47011) by the Biosludge Pump (41052-1, 2). Sludge is thickened by dissolved air flotation. Sludge is pumped by the Digester Feed Pump (41055-1, 2) from the thickener to the Aerobic Digester Tank (34009). Here it is biologically stabilized. Air is provided to the tank by the Aerobic Digester Aerator (45026) for use in sludge stabilization. Stabilized sludge flows by gravity from digester to the Biosludge Press Feed Tank (36009). The sludge is conditioned in this tank and mixed by the Biosludge Tank Mixer (39009). Sludge is pumped from the tank to the Biosludge Press (45027) by the Biosludge Press Feed Pump (41061-1, 2). Here the sludge is dewatered. The dewatered sludge solids are disposed of by others. Underflow from the thickener and water from the belt press are sent to the aeration tank.

Chemical Feed Systems

Sulfuric acid is pumped to three locations from the Sulfuric Acid Storage Tank (35037). Pumping of acid to the cooling water system and boiler makeup water is explained in the treatment descriptions for these waters. The third location is to the head end of Aeration Tank (34011). Pumping to this location is controlled by the pH of the water in this tank. The acid is pumped by the Wastewater Acid Pump (41062-1, 2).

Caustic is pumped to the head end of the Aeration Tank by the Aeration Tank Caustic Metering Pump (41049-1, 2). Pumping of caustic is controlled by the pH of water in the Aeration Tank. Caustic is also pumped by the Coal Pile Runoff Caustic Metering Pump (41059-1, 2) to neutralize the coal pile runoff. The caustic is dispersed by the inline Coal Pile Runoff Static Mixer (48012).

Phosphoric acid is pumped by the Phosphoric Acid Metering Pump (41056-1, 2) to the head end of the Aeration Tank. Phosphorus is a nutrient required in the bio-oxidation process.

Mixing of chemicals added upstream of the Aeration Tank is done by the Aeration Tank Static Mixer (48013).

The Primary Sludge Conditioning System (47010) makes possible a greater percentage solids in the centrifuge cake.

The Tube Settler Feed Conditioning System (47012) enhances suspended solids removal.

The Coagulant Aid System (47013) agglomerates sludge particles to achieve higher percentage solids in the thickened sludge from the Biosludge Thickener. The Filter Aid System (47014) helps in the removal of particles through the Pressure Filter.

The Biosludge Conditioning System (47015) makes possible a greater percentage solids in the Biosludge Press cake.

4.2.5 Utilities and Facilities

4.2.5.1 Cooling Water

Cooling water required for the plant exchangers and coolers will be supplied at 85°F from the Cooling Tower (44003). Warm cooling water from the gasifier jackets and the plant exchangers and coolers will be returned to the cooling tower at 108°F. The recirculating cooling water, pumped by Cooling Water Pumps (41038-1,2 and 41039), will be treated with chlorine and slug-fed biocides to control algae growth, and with scale formation and corrosion inhibitors to control heat exchanger fouling. The pH of the water will be adjusted by manual addition of sulfuric acid through a drip pot delivery system to hold the required pH for good scale formation inhibition and corrosion protection, without tower delignification. Acid is supplied to the drip pot from the Sulfuric Acid Storage Tank (35037) by the Cooling Water Acid Pump (41047-1,2). The continuous blowdown required to limit the build up of dissolved solids in the system is discharged to the plant sewer and then to the municipal waste water treatment system.

4.2.5.2 Steam System

Required plant steam will be provided by a package fire tube Utility Boiler (47004) capable of supplying 25,000 pph of 65 psig saturated steam. The boiler will be fired on product LBG, or propane at start-up, and be forced-draft. Boiler feed water will be mostly condensate return from the plant uses listed below, with the remainder softened city water. This feed water will be deaerated and treated with sodium sulfite and a chelating agent prior to entering the boiler.

Steam is used in heat jacketed vessels and in steam heating coils in the desulfurization and tar removal areas, in line heat tracing, to pressurize the gasifier rodding nozzles, to purge tar lines, and to provide space heating for the various buildings.

4.2.5.3 Plant Air Supply

One positive displacement oil-free package Plant Air Compressor (42014) will be used to supply an instantaneous peak demand of 700 SCFM of plant air for the flame front generators with the gasifier and system flares and for utility stations. The package will be complete with all the necessary controls and instrumentation, aftercooler, separator, receiver and all interconnecting pipe required for normal operation. An interconnection will also be supplied for the use of plant air as a backup to the instrument air supply.

4.2.5.4 Instrument Air Supply

One positive displacement oil-free package Instrument Air Compressor (42015) will be used to supply 450 SCFM of dry instrument air for process control instruments and control valve operators. The package will be complete with all necessary controls and instrumentation, aftercooler, separator, receiver, two driers with electric heaters, oil filter and all interconnecting pipe required for normal operation. An interconnection will be supplied for the use of plant air as a backup to this system.

4.3.0 PROCESS EQUIPMENT ITEM LIST

4.3.1 Vessels

ITEM NO.	NO. REQ'D	DESCRIPTION	EFD
31001	1	2-Gasifier Recycle Cooler	100-111
31002	1	3-Gasifier Recycle Cooler	100-111
31003	1	2-Gasifier ESP Gas Cooler	100-104
31004	1	3-Gasifier ESP Gas Cooler	100-105
31005	1	2-Gasifier System Aftercooler	100-106
31006	1	3-Gasifier System Aftercooler	100-107
31007	1	Quench Tank Blowdown Cooler	100-111
32005	1	2-Gasifier Absorber Column	100-106
32006	1	3-Gasifier Absorber Column	100-107
33001-A	5	Gasifier	100-103
33001-B	5	Cyclone	100-103
33001-C	5	Air Blower	100-103
33001-C1	5	Filter for Air Blower 33001C	100-102
34001	1	Tar Storage Tank	100-111
34003	1	2-Gasifier Liquor Tank	100-106
34004	1	3-Gasifier Liquor Tank	100-107
34006	1	2-Gasifier Oxidizer Tank	100-106
34007	1	3-Gasifier Oxidizer Tank	100-107
34009	1	Aerobic Digester Tank	100-122
34011	1	Aeration Tank	100-120

4.3.1 Vessels (Cont'd)

35002	2	Quench Tank	100-104
35002	3	Quench Tank	100-105
35016	1	Effluent Purge Tank	100-108
35018	1	2-Gasifier Filtrate Tank	100-109
35019	1	3-Gasifier Filtrate Tank	100-110
35020	1	2-Gasifier Wash Tank	100-109
35021	1	3-Gasifier Wash Tank	100-110
35024	1	2-Gasifier K.O. Drum	100-109
35025	1	3-Gasifier K.O. Drum	100-110
35032	1	Condensate Receiver	100-112
35033	1	Liquid Sulfur Storage Tank	100-109
35034	1	Sulfuric Acid Feed Tank	100-114
35035	1	Cooling Tower Chemical Feed Tank	100-114
35036	1	Cooling Water Make-Up Tank	100-126
35037	1	Sulfuric Acid Storage Tank	100-125
35038	1	Deionizer Make-Up Tank	100-126
36001	2	2 Gasifier Slurry Tank	100-108
36002	2	3 Gasifier Slurry Tank	100-108
36003	1	Reagent Tank	100-108
36009	1	Biosludge Press Feed Tank	100-123
36010	1	Equilization Tank	100-120
36011	1	Emergency Storage Tank	100-118
39001	2	2 Gasifier Slurry Mixer	100-108
39002	2	3 Gasifier Slurry Mixer	100-108
39003	1	Reagent Mixer	100-108
39009	1	Biosludge Press Feed Tank Mixer	100-123
39010	1	Equilization Tank Agitator	100-120
39011	1	Emergency Storage Tank Agitator	100-118

4.3.2 Mechanical Equipment

ITEM NO.	NO. REQ'D.	DESCRIPTION	EFD
41001	2	Coal Receiving Sump Pump	100-101
41002	2	Coal Reclaiming Sump Pump	100-101
41003	2	Tar Loading Pump	100-111
41004	1	2 Gasifier Recycle Pump	100-111
41005	2	3 Gasifier Recycle Pump	100-111
41006	2	2 Gasifier Tar Pump	100-111
41007	1	3 Gasifier Tar Pump	100-111
41008	2	Gasifier Building Sump Pump	100-103
41018	2	2 Gasifier Liquor Pump	100-106
41019	2	3 Gasifier Liquor Pump	100-107

4.3.2 Mechanical Equipment (Cont'd)

41020	2	Effluent Purge Pump	100-108
41022	2	Reagent Pump	100-108
41024	2	2 Gasifier Slurry Pump	100-108
41025	2	3 Gasifier Slurry Pump	100-108
41030	2	2 Gasifier Filtrate Pump	100-109
41031	2	3 Gasifier Filtrate Pump	100-110
41032	2	2 Gasifier Wash Pump	100-109
41033	2	3 Gasifier Wash Pump	100-110
41034	2	Liquid Sulfur Loading Pump	100-109
41035	2	Tar Separator Sump Pump	100-111
41036	2	2 Gasifier Liquid Sulfur Transfer Pump	100-109
41037	2	3 Gasifier Liquid Sulfur Transfer Pump	100-110
41038	2	2 Gasifier Equipment Cooling Water Pump	100-114
41039	1	3 Gasifier Equipment Cooling Water Pump	100-114
41040	2	Condensate Pump	100-112
41041	2	Utility Boiler Feed Water Pump	100-112
41042	1	Chlorinator Water Booster Pump	100-114
41043	2	Carbon Adsorber Feed Pump	100-126
41044	2	Spent Water Disposal Pump	100-124
41046	2	Cooling Water Make-Up Pump	100-126
41047	2	Cooling Water Acid Pump	100-125
41048	2	Boiler Water Acid Pump	100-125
41049	2	Aeration Tank Caustic Metering Pump	100-119
41050	2	Centrifuge Feed Pump	100-118
41051	2	Dilution Recycle Pump	100-121
41052	2	Biosludge Pump	100-121
41053	2	Pressure Filter Feed Pump	100-121
41055	2	Digester Feed Pump	100-122
41056	2	Phosphoric Acid Feed Pump	100-120
41058	2	Emergency Storage Pump	100-118
41059	2	Coal Pile Caustic Metering Pump	100-119
41060	2	Aeration Feed Tank Pump	100-120
41061	2	Biosludge Press Feed Pump	100-123
41062	1	Waste Water Acid Pump	100-125
41063	2	Filter Back Wash Water Pump	100-126
42004	1	2 Gasifier E.S.P. Compressor	100-104
42005	1	3 Gasifier E.S.P. Compressor	100-105
42006	1	2 Gasifier System Compressor	100-106
42007	1	3 Gasifier System Compressor	100-107
42008	2	2 Gasifier Air Blower with Filter	100-106

4.3.2 Mechanical Equipment (Cont'd)

42009	2	3 Gasifier Air Blower with Filter	100-107
42012	2	2 Gasifier Vacuum Pump	100-109
42013	2	3 Gasifier Vacuum Pump	100-110
42014	1	Plant Air Compressor	100-115
42015	1	Instrument Air Compressor	100-116
42016	2	Aeration Blower	100-120
42017	2	Aeration Tank Exhauster	100-120
43003	1	Vibrating Discharger	100-101
43004	1	Knife Gate	100-101
43005	1	Vibrating Feeder	100-101
43006	1	Coal Reclaim Conveyor	100-101
43007	1	Coal Distribution Bucket Elevator	100-102
43008	1	Coal Distribution Conveyor	100-102 100-103
44001	1	2 Gasifier Sulfur Melter	100-109
44002	1	3 Gasifier Sulfur Melter	100-110
44003	1	Equipment Water Cooling Tower	100-114
45001	1	Magnetic Separator	100-102
45002	1	2 Gasifier Electrostatic Precipitator	100-104
45003	1	3 Gasifier Electrostatic Precipitator	100-105
45004	1	Gasifier Tar Separator	100-111
45018	1	2 Gasifier Sulfur Filter	100-109
45019	1	3 Gasifier Sulfur Filter	100-110
45020	2	Raw Water Carbon Adsorber	100-126
45021	1	Tube Settler	100-118
45022	1	Primary Sludge Centrifuge	100-118
45023	1	Biosludge Clarifier	100-121
45024	2	Pressure Filter	100-124
45025	2	Waste Water Carbon Adsorber	100-124
45026	1	Digestor Aerator	100-122
45027	1	Biosludge Press	100-124
45028	2	Aeration Tank Carbon Adsorber	100-120
47003	1	Reductive Incinerator System	100-117
47004	1	Utility Boiler System	100-113
47005	1	Boiler Feed Water Treatment System	100-113
47008	1	Utility Boiler Deaerator	100-112
47009	3	Cation Exchanger	100-127

ıge Conditioning System	100-119
ıickener	100-122
- Feed Conditioning System	100-119
id System	100-123
System	100-121
onditioning System	100-123
	100-101
	100-102
Generator	100-103
er Chlorinator	100-114
on Trough	100-114
er Exhaust Head	100-109
er Exhaust Head	100-110
Generator	100-106
un Off Static Mixer	100-101
nk Static Mixer	100-120
oader	100-101

	EFD
ıst Collector Exhaust	100-102
	100-102
bution Conveyor Dust	100-102
	100-102
Exhaust Fan	100-102
Dust Collector	100-102
ıilding Make-Up Air Unit	100-102
l Air Supply Blower	100-102

ll not be outlined in the next Section
scription and pertinent information
y discussed in Section 6.4 General

N	EFD
overy Building Make-Up	
quipment Room H & V Unit	

4.3.4 HVAC Equipment Item List (Cont'd)

51104	1	Control Lab & Office A/C Unit
51105	1	H & V Equipment Room Unit Heater
51106	6	Sulfur Recovery Building Unit Heater
51111	2	Waste Water Treatment Building Roof Ventilator
51112	1	Waste Water Treatment Building Make-Up Air Unit
51113	1	Waste Water Treatment Building Make-Up Air Unit
51204	1	Gasifier Building Cabinet Unit Heater
51205	1	Gasifier Building Cabinet Unit Heater
51301	1	Gasifier Building Filter Unit
51401	1	Gasifier Building Wall Louver
51402	1	Gasifier Building Wall Louver
51405	1	Gasifier Building Wall Louver
51406	1	Gasifier Building Wall Louver
51407	1	Electric Equipment Room Wall Shutter
51408	4	Waste Water Treatment Building Wall Louvers
51409	1	Gasifier Building Electric Equipment Room Intake Louvers
51410	1	Gasifier Building Electric Equipment Room Intake Louvers
51411	4	Sulfur Recovery Building Wall Louvers
51412	1	Waste Water Treatment Building Wall Louvers
51413	1	Waste Water Treatment Building Relief Damper
51500	1	Gasifier Building Sidewall Exhaust Fan
51501	1	Gasifier Building Supply Air Fan
51502	1	Sulfur Recovery Building Wall Fan
51503	1	Sulfur Recovery Building Wall Fan
51504	1	Sulfur Recovery Building Exhaust Fan
51505	1	Sulfur Recovery Building Exhaust Fan
51601	1	Gasifier Building Roof Ventilator
51602	1	Gasifier Building Roof Ventilator
51605	2	Gasifier Building Gravity Roof Vent

Item No. 31002 - Three Gasifier Recycle Cooler

Type	- Vertical shell and tube exchanger, with fixed tube sheets for the cooling of recycled quenching water
Material	
Shell Side	- Carbon steel with 1/8" corrosion allowance
Tube Side	- Stainless steel Type 304
Duty	- 14,105,900 Btu/hour

Item No. 31003 - Two Gasifier ESP Gas Cooler

Type	Vertical shell and tube exchanger, fixed tube sheets and integral separator head for the cooling of coal gasification products after electrostatic precipitation
Material	
Shell Side	- Carbon steel with 1/8" corrosion allowance
Tube Side	- Stainless steel Type 304
Duty	- 8,547,136 Btu/hour

Item No. 31004 - Three Gasifier ESP Gas Cooler

Type	- Vertical shell and tube exchanger, fixed tube sheets and integral separator head for the cooling of coal gasification products after electrostatic precipitation
Material	
Shell Side	- Carbon steel with 1/8" corrosion allowance
Tube Side	- Stainless steel Type 304
Duty	- 12,820,704 Btu/hour

Item No. 31005 - Two Gasifier System Aftercooler

Type	- Vertical shell and tube exchanger, fixed tube sheets and integral separator head for the cooling of compressed coal gas
Material	
Shell Side	- Carbon steel with 1/8" corrosion allowance
Tube Side	- Stainless steel Type 304
Duty	- 1,368,092 Btu/hour

Item No. 31006 - Three Gasifier System Aftercooler

Type	- Vertical shell and tube exchanger, fixed tube sheets and integral separator head for the cooling of compressed coal gas
Material	
Shell Side	- Carbon steel with 1/8" corrosion allowance
Tube Side	- Stainless steel Type 304
Duty	- 2,052,137 Btu/hour

Item No. 31007 - Quench Tank Blowdown Cooler

Type	- Horizontal shell and tube exchanger, with fixed tube sheets for cooling of blowdown from recycle quench water.
Material	- Shell side- Carbon steel with 1/3" corrosion allowance - Tube side - Stainless steel Type 304
Duty	- 493,410

Item No. 32005 - Two Gasifier Absorber Column

Item No. 32006 - Three Gasifier Absorber Column

Item No. 33001-1A, thru 5A - Gasifiers

No. Required	- Five (5)
Type	- Wellman-Galusha low Btu gasifier (10 ft. I.D.) with water jacketed combustion chamber, motor driven water cooled fuel agitator assembly, powered rotating grate assembly, ash cone and pit assembly with manually operated slide gate, motor operated fuel feed valves, fuel feed pipes, upper and lower fuel bins, agitator counterweight assembly, saturation piping and gate assembly, gas discharge elbow, vent and relief ducting, instrumentation and various valves and interconnecting piping
Capacity	- 3.25 TPH max. (est. 65% efficiency) using Southern Ohio high sulfer bituminous coal at 12,174 Btu/# (dry basis) gas
Materials of Construction	- Mfr.'s standard
HP - 6.5 HP total per gasifier	

Item No. 33001-1B thru 5B - Cyclones

No. Required	- Five (5)
Type	- 8'-0" internal diameter by 15'-6" tall steel cylindrical refractory lined assembly consisting of a low conical roof, conical bottom dust collector with discharge valve, gas inlet and outlet, water flushing ring for bottom cone, various valves and fittings
Design Pressure	- 20 psi
Working Pressure	- 6 to 10" WG
Design Temperature	- 1200°F
Materials of Construction	- Mfr.'s standard

Item No. 33001-1C thru 5C - Air Blowers

No. Required	- Five (5)
Type	- Single stage scroll turbo-compressor complete with common base for machine and motor, flange adapter, motor silencer and outlet sleeve with clamps
Capacity	- 5600 ACFM
Discharge Pressure	- 24 oz.
Materials of Construction	- Mfr.'s standard
HP - 50 HP/3500 RPM	

Item No. 33001-1C1 thru 1C5 - Filter for Air Blower

No. Required	- Five (5)
Type	- Integral filter-silencer for air blowers inlet, tubular type with leg support
Materials of Construction	- Mfr.'s standard
Volume Capacity	- 6500 CFM

Item No. 34001 - Tar Storage Tank

Type	- Vertical, insulated, cylindrical tank with flat bottom and self supported cone roof and internal coil for the storing of tars produced from the gasification of Bituminous Coal
Size	- 20'-0" O.D. x 22'-0" straight side (50,000 gal. capacity)
Material	
Tank	- Carbon Steel with 1/8" corrosion allowance
Heating Coil	- Stainless steel, Type 304

Item No. 34003- two - Gasifier Pumping Liquor Tank

Item No. 34004- three - Gasifier Pumping Liquor Tank

Item No. 34006 - Two Gasifier Oxidizer

Item No. 34007 - Three Gasifier Oxidizer

Item No. 34009 - Aerobic Digestor Tank

Type	- Vertical, cylindrical tank with flat bottom and open top
Size	- 20'-0" O.D. x 14'-0" straight side (32,000 gal. capacity)
Material	- Carbon steel with 1/8" corrosion allowance

CONCRETE VESSELS

Item No. 34011 - Aeration Tank

No. Required	- One (1)
Type	- Rectangular concrete tank with wood framed FRP cover and steel air headers and laterals
Capacity	- 120 GPM

VESSELS

Item No. 35002-1 to 5 - Quench Tanks

Type	- Vertical, insulated, cylindrical direct contact spray cooler for quenching low Btu gas produced from Bituminous Coal Gasifiers
Size	- 10'-0" O.D. x 43'-0" straight shell and dished heads
Material	
Tank	- A516 Gr.70 carbon steel with 1 4" C.A.
Internal Sprays	- Carbon steel

Item No. 35016 - Effluent Purge Tank

Type	- Vertical, insulated, cylindrical tank with internal coil for the collecting of the effluent purge from the Stretford Process.
Size	- 5'-6" O.D. x 6'-0" straight shell and dished heads (1,000 gal. capacity)
Material	
Tank	- A516 Gr. 70 carbon steel with 1/8" corrosion allowance
Heating Coil	- Stainless steel Type 304

Item No. 35018 - Two Gasifier Filtrate Tank

Part of Stretford package

Item No. 35019 - Three Gasifier Filtrate Tank

Part of Stretford package

Item No. 35020 - Two Gasifier Wash Tank

Part of Stretford package

Item No. 35021 - Three Gasifier Wash Tank

Part of Stretford package

Item No. 35024 - Two Gasifier KO Drum

Part of Stretford package

Item No. 35025 - Three Gasifier KO Drum

Part of Stretford package

Item No. 35032 - Condensate Receiver

Type	- Vertical, insulated, cylindrical tank
Size	- 5'-0" O.D. x 9'-4" straight shell and dished heads (1,500 gal. capacity)
Material	- Carbon steel with 1/8" corrosion allowance

Item No. 35033 - Liquid Sulfur Storage Tank

Type	- Vertical, insulated, cylindrical tank with flat bottom and dished roof with internal heating coil for the storing of liquid sulfur
Size	- 11'-6" O.D. x 13'-0" straight side (10,000 gal. capacity)
Material	
Tank	- Carbon steel with 1/8" corrosion allowance
Coil	- Stainless steel Type 304

Item No. 35034 - Sulfuric Acid Feed Tank

Type	- Vertical, insulated, cylindrical tank to store sulfuric acid
Size	- 1'-0" O.D. x 4'-0" straight shell with dished heads
Material	- Carbon steel with 1/8" corrosion allowance

Item No. 35035 - Cooling Tower Chemical Feed Tank

Type	- Vertical, insulated, cylindrical tank
Size	- 1'-0" O.D. x 4'-0" straight shell with dished heads (30 gal. capacity)
Material	- Carbon steel with 1/8" corrosion allowance

Item No. 35036 - Cooling Water Make Up Tank

Type	- Horizontal, cylindrical tank
Size	- 10'-0" O.D. x 30'-6" straight shell with dished heads (15,000 gal. capacity)
Material	- Carbon steel with 1/16" corrosion allowance

Item No. 35037 - Sulfuric Acid Storage Tank

Type	- Horizontal, cylindrical tank for storing sulfuric acid
Size	- 4'-6" O.D. x 8'-0" straight shell, supported on saddles (1,000 gal. capacity)
Material	- Carbon steel with 1/8" corrosion allowance

Item No. 35038 - Deionizer Make Up Tank

Type	- Vertical, cylindrical tank
Size	- 11'-6" O.D. x 13'-0" straight side with flat bottom and dished head (10,000 gal. capacity)
Material	- Carbon steel with 1/16" corrosion allowance

Item No. 36001-1, 2 - Two Gasifier Slurry Tank

Item No. 36002-1,2 - Three Gasifier Slurry Tank

Item No. 36003 - Reagent Mixing Tank

Item No. 36009 - Biosludge Press Feed Tank

Type	- Vertical, cylindrical tank
Size	- 3'-0" O.D. x 4'-0" straight side with flat bottom and dished head which supports an agitator (200 gal. capacity)
Material	- Carbon steel with 1/16" corrosion allowance

Item No. 36010 - Equilization Tank

Type	- Vertical, cylindrical tank
Size	- 21'-0" O.D. x 25'-0" straight side with flat bottom and self-supporting dome roof which supports an agitator (60,000 gal. capacity)
Material	- Carbon steel with 1/16" corrosion allowance

Item No. 36011 - Emergency Storage Tank

Type	- Vertcial, cylindrical tank
Size	- 33'-0" O.D. x 35'-0" straight side with flat bottom, open top and support for a top entering agitator (202,000 gal. capacity)
Material	- Carbon steel with 1/16" corrosion allowance

Item No. 39001-1, 2 - Two Gasifier Slurry Mixers

Type	- Vertical mount mixer with 7-1/2 HP electric motor
Purpose	- Maintain sulfur froth in suspension
Material	- 304 stainless steel impeller. Stainless clad shaft

Item No. 39002-1, 2 - Three Gasifier Slurry Mixers

Type	- Vertical mount mixer with 10 HP electric motor
Purpose	- Maintain sulfur froth in suspension
Material	- 304 stainless steel impeller. Stainless clad shaft

Item No. 39003 - Reagant Mixing Tank Agitator

Type	- Vertical mount direct drive mixer with 1 HP electric motor
Purpose	- Mix reagent into solution
Material	- 304 stainless steel impeller and lined shaft

Item No. 39009-Biosludge Press Feed Tank Agitator

Type	- Top entering agitator with propeller
Purpose	- Maintain a homogeneous solution
Material	- Wetted parts to be carbon steel with 1/16" corrosion allowance

Item No. 39010-Equalization Tank Agitator

Type	- Top entering agitator with axial turbine impellers
Purpose	- Prevent settling of solids
Material	- Wetted parts to be carbon steel with 1/16" corrosion allowance

Item No. 39011 - Emergency Storage Tank Agitator

Type	- Top entering agitator with axial turbine impellers
Purpose	- Prevent settling of solids
Material	- Wetted parts to be carbon steel with 1/16" corrosion allowance

4.4.2 Mechanical Equipment

Item No. 41001-1, 2 - Coal Receiving Sump Pump

Type	- Volute type vertical centrifugal pump complete with motor, coupling, coupling guard, support plate, above support plate flanged discharge, water lubricated steady bearings, suction strainer and float switch - 316 SS pump
Flow	70 GPM of coal pile run-off with coal fines at ambient temperature
Head	- 50 ft.
Pit Depth	- 14 ft.
Motor HP	- 2

Item No. 41002-1, 2 - Coal Reclaiming Sump Pump

Type	- Volute type vertical centrifugal pump complete with motor, coupling, coupling guard, support plate, above support plate flanged discharge, water lubricated steady bearings, suction strainer and float switch - 316 SS pump
Flow	- 10 GPM of coal pile run-off with coal fines at ambient temperature
Head	- 20 ft.
Pit Depth	- 4 ft.
Motor HP	- 1/2

Item No. 41003-1, 2 - Tar Loading Pump

Type	- Horizontal, rotary, positive displacement gear pump complete with built in relief valve, metal shaft packing, external lubricator, coupling, coupling guard, gear speed reducer, motor and baseplate - Colmonoy and hardened steel pump
Flow	- 225 GPM of coal tar with coal ash at 200 F
Discharge Pressure	- 30 psig
Motor HP	- 20

Item No. 41004 - Two Gasifier Recycle Pump

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - 316 SS pump
Flow	- 580 GPM of quench water with coal ash and tar at 200 F
Head	- 140 ft.
Motor HP	- 40

Item No. 41005-1, 2 - Three Gasifier Recycle Pump

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - 316 SS pump
Flow	- 840 GPM of quench water with coal ash and tar at 200 F
Head	- 150 ft.
Motor HP	- 40

Item No. 41006-1, 2 - Two Gasifier Tar Pump

Type	- Horizontal, rotary, positive displacement gear pump complete with built in relief valve, metal shaft packing, external lubricator, coupling, coupling guard, gear speed reducer, motor and baseplate. Colmonoy and hardened steel pump
Flow	- 5 GPM of coal tar with coal ash at 200 F
Discharge Pressure	- 15 psig
Motor HP	- 1

Item No. 41007 - Three Gasifier Tar Pump

Type	- Horizontal, rotary, positive displacement gear pump complete with built in relief valve, metal shaft packing, external lubricator, coupling, coupling guard, gear speed reducer, motor and baseplate - Colmonoy and hardened steel pump
Flow	- 5 GPM of coal tar with coal ash at 200 F
Discharge Pressure	- 15 psig
Motor HP	- 1

Item No. 41008-1, 2 - Gasifier Building Sump Pump

Type	- Volute type vertical centrifugal pump complete with motor, coupling, coupling guard, support plate, above support plate flanged discharge, water lubricated steady bearings, suction strainer and float switch - Carpenter-20 pump
Flow	- 50 GPM of coal ash sluice water at 80 F
Head	- 75 ft.
Pit Depth	- 6 ft.
Motor HP	- 5

Item No. 41018-1, 2 - Two Gasifier Liquor Pump

Type	- Horizontal centrifugal pump complete with motor, coupling, base and guard
Flow	- 2100 GPM
Head	- 160 ft.
Motor HP	- 125 HP at 1800 RPM

Item No. 41019-1, 2 - Three Gasifier Liquor Pump

Type	- Horizontal centrifugal pump complete with motor, coupling, base and guard
Flow	- 3160 GPM
Head	- 160 ft.
Motor HP	- 200 HP at 1800 RPM

Item No. 41020-1, 2 - Effluent Purge Pump

Type	- Controlled volume plunger pump complete with packing, inlet and discharge check valves, manual capacity adjustment, coupling, coupling guard, motor and baseplate - 304 SS pump
Flow	- 1 GPM of Stretford purge liquor at 100 F
Discharge Pressure	- 40 psig
Motor HP	- 1/2

Item No. 41022-1, 2 - Reagent Pump

Type	- End suction stainless steel horizontal centrifugal pump
Flow	- 250 GPM
Head	- 30 ft.
Motor HP	- 5 HP at 1200 RPM

Item No. 41024-1, 2 - Two Gasifier Slurry Pump

Type	- Progressive cavity single screen positive displacement pump, stainless steel lined. Complete with electric motor, coupling and base
Flow	- 300 GPH
Discharge Pressure	- 4 psig
Motor HP	- 3 HP

Item No. 41025-1, 2 - Three Gasifier Slurry Pump

Type	- Progressive cavity single screw positive displacement pump, stainless steel lined. Complete with electric motor, coupling and base
Flow	- 450 GPH
Discharge Pressure	- 4 psig
Motor HP	- 5 HP

Item No. 41030-1, 2 - Two Gasifier Filtrate Pump

Part of Stretford package

Item No. 41031-1, 2 - Three Gasifier Filtrate Pump

Part of Stretford package

Item No. 41032-1, 2 - Two Gasifier Wash Pump

Part of Stretford package

Item No. 41033-1, 2 - Three Gasifier Wash Pump

Part of Stretford package

Item No. 41034-1, 2 - Liquid Sulfur Loading Pump

Type	- End suction, radially split, steam jacketed horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - 316 SS pump
Flow	- 100 GPM of molten sulfur at 300 F
Head	- 35 ft.
Motor HP	- 2

Item No. 41035-1, 2 - Tar Separator Sump Pump

Type	- Volute type vertical centrifugal pump complete with motor, coupling, coupling guard, support plate, above support plate flanged discharge, water lubricated steady bearings, suction strainer and float switch - Cast iron pump
Flow	- 10 GPM of rainwater at ambient temperature
Head	- 20 ft.
Pit depth	- 4 ft.
Motor HP	- 1

Item No. 41036-1, 2 - Two Gasifier Liquid Sulfur Transfer Pump

Type	- Volute type steam jacketed vertical centrifugal pump complete with motor, coupling, coupling guard, support plate, above support plate flanged discharge, product lubricated steady bearings and suction strainer - 316 SS pump
Flow	- 85 GPM of molten sulfur at 280 F.
Head	- 25 ft.
Pit Depth	- 10 ft.
Motor HP	- 3

Item No. 41037-1, 2 - Three Gasifier Liquid Sulfur Transfer Pump

Type	- Volute type steam jacketed vertical centrifugal pump complete with motor, coupling, coupling guard, support plate, above support plate flanged discharge, product lubricated steady bearings and suction strainer - 316 SS pump
Flow	- 125 GPM of molten sulfur at 280 F
Head	- 25 ft.
Pit Depth	- 10 ft.
Motor HP	- 2

Item No. 41038-1, 2 - Two Gasifier Equipment Cooling Water Pump

Type	- Turbine type vertical centrifugal pump complete with motor, coupling, coupling guard, support plate, above support plate flanged discharge, water lubricated steady bearings and suction strainer - Bronze fitted cast iron pump
Flow	- 3300 GPM of cooling tower water at 85 F
Head	- 250 ft.
Pit Depth	- 12 ft.
Motor HP	- 300

Item No. 41039 - Three Gasifier Equipment Cooling Water Pump

Type	- Turbine type vertical centrifugal pump complete with motor, coupling, coupling guard, support plate, above support plate flanged discharge, water lubricated steady bearings and suction strainer - Bronze fitted cast iron pump
Flow	- 3300 GPM of cooling tower water at 85 F
Head	- 250 ft.
Pit Depth	- 12 ft.
Motor HP	- 300

Item No. 41040-1, 2 - Condensate Pumps

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - Cast iron pump
Flow	- 65 GPM of condensate water at 215 F
Head	- 60 ft.
Motor HP	- 3

Item No. 41041-1, 2 - Utility Boiler Feedwater Pumps

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - Cast Iron pump
Flow	- 65 GPM of boiler feedwater at 260 F
Head	- 145 ft.
Motor HP	- 7-1/2

Item No. 41042-1 - Chlorinator Water Booster Pump

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - Cast iron pump
Flow	- 10 GPM of water at ambient temperature
Head	- 100 ft.
Motor HP	- 15

Item No. 41043-1, 2 - Carbon Adsorber Feed Pump

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - Cast iron pump
Flow	- 20 GPM of waste water at ambient temperature
Head	- 100 ft.
Motor HP	- 5

Item No. 41044-1, 2 - Spentwater Disposal Pump

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - Cast iron pump
Flow	- 50 GPM of waste water at ambient temperature
Head	- 100 ft.
Motor HP	- 5

Item No. 41046-1, 2 - Cooling Water Make-Up Pump

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - Cast iron pump
Flow	- 210 GPM of water at ambient temperature
Head	- 100 ft.
Motor HP	- 10

Item 41047-1, 2 - Cooling Water Acid Pump

Type	- Controlled volume diaphragm pump complete with inlet and discharge check valves, manual capacity adjustment, coupling, coupling guard, motor and baseplate - Carpenter-20 pump
Flow	- 5 GPM of sulfuric acid at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item 41048-1, 2 - Boiler Water Acid Pump

Type	- Controlled volume diaphragm pump complete with inlet and discharge check valves, manual capacity adjustment, coupling, coupling guard, motor and baseplate - Carpenter-20 pump
Flow	- 5 GPM of sulfuric acid at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41049-1, 2 - Aeration Tank Caustic Metering Pump

Type	- Controlled volume diaphragm pump complete with inlet and discharge check valves, manual capacity adjustment, coupling, coupling guard, motor and baseplate - Carpenter-20 pump
Flow	- 5 GPM of sodium hydroxide solution at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41050-1, 2 - Centrifuge Feed Pump

Type	- Rotary, positive displacement progressive cavity pump complete with packing, coupling, coupling guard, variable pitch sheave drive, manual capacity adjustment, motor and baseplate - Cast iron pump
Flow	- 5 GPM of biosludge at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41051-1, 2 - Dilution Recycle Pump

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - Cast iron pump
Flow	- 80 GPM of waste water at ambient temperature
Head	- 100 ft.
Motor HP	- 5

Item No. 41052-1, 2 - Biosludge Pump

Type	- Rotary, positive displacement progressive cavity pump complete with packing, coupling, coupling guard, variable pitch sheave drive, manual capacity adjustment, motor and baseplate - Cast iron pump
Flow	- 5 GPM of biosludge at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41053-1, 2 - Pressure Filter Feed Pump

Type	- Rotary, positive displacement progressive cavity pump complete with packing, coupling, coupling guard, variable pitch sheave drive, manual capacity adjustment, motor and baseplate - Cast iron pump
Flow	- 2 GPM of biosludge at ambient temperature
Discharge Pressure	- 75 psig
Motor HP	- 1

Item No. 41055-1, 2 - Digester Feed Pump

Type	- Rotary, positive displacement progressive cavity pump complete with packing, coupling, coupling guard, variable pitch sheave drive, manual capacity adjustment, motor and baseplate - Cast iron pump
Flow	- 2 GPM of biosludge at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41056-1, 2 - Phosphoric Acid Metering Pump

Type	- Controlled volume diaphragm pump complete with inlet and discharge check valves, manual capacity adjustment, coupling, coupling guard, motor and baseplate - Carpenter-20 pump
Flow	- 5 GPM of phosphoric acid at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41058-1, 2 - Emergency Storage Pump

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - Cast iron pump
Flow	- 20 GPM of waste water at ambient temperature
Head	- 100 ft.
Motor HP	- 5

Item No. 41059-1, 2 - Coal Pile Caustic Metering Pump

Type	- Controlled volume diaphragm pump complete with inlet and discharge check valves, manual capacity adjustment, coupling, coupling guard, motor and baseplate - Carpenter-20 pump
Flow	- 5 GPM of sulfuric acid at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41060-1, 2 - Aeration Tank Feed Pump

Type	- Rotary, positive displacement progressive cavity pump complete with packing, coupling, coupling guard, variable pitch sheave drive, manual capacity adjustment, motor and baseplate - Cast iron pump
Flow	- 5 GPM of waste water at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41061-1, 2 - Biosludge Press Feed Pump

Type	- Rotary, positive displacement progressive cavity pump complete with packing, coupling, coupling guard, variable pitch sheave drive, manual capacity adjustment, motor and baseplate - Cast iron pump
Flow	- 5 GPM of biosludge at ambient temperature.
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41062-1 - Waste Water Acid Pump

Type	- Controlled volume diaphragm pump complete with inlet and discharge check valves, manual capacity adjustment, coupling, coupling guard, motor and baseplate - Carpenter-20 pump
Flow	- 5 GPM of sulfuric acid at ambient temperature
Discharge Pressure	- 25 psig
Motor HP	- 1

Item No. 41063-1, 2 - Filter Backwash Water Pump

Type	- End suction, radially split horizontal centrifugal pump complete with mechanical seal, coupling, coupling guard, motor and baseplate - Cast iron pump
Flow	- 75 GPM of water at ambient temperature
Head	- 100 ft.
Motor HP	- 5

Item No. 42004 - Two Gasifier ESP Compressor

Type	- Single stage centrifugal compressor complete with coupling, guard, speed increaser gear, motor, baseplate, lubrication system and vibration probes - Material-fabricated steel
Material Handled	- Cooled raw product gas from a coal gasifier
Inlet Conditions	- 18,000 acfm at 14.2 psia and 138 F
Discharge Pressure	- 17.2 psia
Motor HP	- 350

Item No. 42005 - Three Gasifier ESP Compressor

Type	- Single stage centrifugal compressor complete with coupling, guard, speed increaser gear, motor, baseplate, lubrication system and vibration probes - Material-fabricated steel
Material Handled	- Cooled raw product gas from a coal gasifier
Inlet Conditions:	- 27,000 acfm at 14.2 psia and 138 F
Discharge Pressure	- 17.2 psia
Motor HP	- 500

Item No. 42006 - Two Gasifier System Compressor

Type	- Multistage centrifugal compressor complete with coupling, guard, gear, electric motor, baseplate, lubrication system, vibration monitoring system and control system - Materials - Cast iron case, stainless steel impellers
Material Handled	- Cooled, detarred gas from a coal gasifier
Inlet Conditions	- 15,000 acfm @ 15.7 psia and 100 F
Discharge Pressure	- 22.0 psia
Speed	- 6284 RPM
Motor HP	- 700

Item No. 42007 - Three Gasifier System Compressor

Type	- Multi-stage centrifugal compressor complete with coupling, guard, gear, electric motor, baseplate, lubrication system, vibration monitoring system and control panel. Materials-cast iron case, stainless steel impellers
Material Handled	- Cooled, detarred gas from a coal gasifier
Inlet Conditions	- 22,000 acfm at 15.7 psia and 100 F
Discharge Pressure	- 22.0 psia
Speed	- 6284 RPM
Motor HP	- 1000

Item No. 42008-1, 2 - Two Gasifier Air Blower

Type	- Rotary positive lobe blower complete with coupling, motor, baseplate, guard, and intake filter
Material Handled	- Atmospheric air
Inlet Conditions	- 1900 ACFM at atmospheric pressure and temperature
Discharge Pressure	- 15 psig
Motor HP	- 150 HP at 1800 RPM

Item No. 42009-1, 2 - Three Gasifier Air Blower

Type	- Rotary positive lobe blower complete with coupling, electric motor, baseplate, guard, and intake filter
Material Handled	- Atmospheric air
Inlet Conditions	- 2800 ACFM at atmospheric pressure and temperature
Discharge Pressure	- 15 psig
Motor HP	- 200 HP at 1800 CFM

Item No. 42012-1,2 - Two Gasifier Vacuum Pump

Part of Stretford package

Item No. 42013-1,2 - Three Gasifier Vacuum Pump

Part of Stretford package

Item No. 42014 - Plant Air Compressor

Type	- Plant compressed air system complete with inlet filter silencer, two stage, water cooled, nonlubricated reciprocating compressor, intercooler, aftercooler, separator, receiver, V-belt drive, drive guard, motor, control panel, interconnecting piping and wiring and baseplate
Capacity	- 500 cfm of free air at 14.2 psia and 93 F
Discharge Pressure	- 125 psig
Motor HP	- 125

Item No. 42015 - Instrument Air Compressor

Type	- Instrument compressed air system complete with inlet filter silencer, two stage, water cooled, nonlubricated reciprocating compressor, intercooler, aftercooler, separator, receiver, V-belt drive, drive guard, motor, control panel, interconnecting piping and wiring and baseplate - Air drying system shall be included complete with prefilter, dual tower electrically heated desiccant type air dryer, afterfilter, moisture monitor, control panel, interconnecting piping and wiring and baseplate
Capacity	- 500 cfm of free air at 14.2 psia and 93 F
Discharge Pressure	- 125 psig
Outlet Dewpoint	- Minus 40 F at 125 psig
Motor HP	- 125

Item No. 42016-1, 2 - Aeration Blower

Type	- Package air blower system complete with rotary positive lobe type blower, V-belt drive, drive guard, electric motor, base, discharge relief valve, flexible connections for inlet and discharge, inlet filter, inlet silencer and discharge silencer
Material Handled	- Atmospheric air
Inlet Conditions	- 1540 cfm at 14.2 psia and 93 F
Discharge Pressure	- 24.2 psia
Motor HP	- 150

Item No. 42017-1,2 - Aeration Tank Exhauster

Type	- Rotary positive displacement lobe type blower complete with V-belt drive, drive guard, electric motor, base, discharge relief valve, flexible connections for inlet and discharge and silencers for inlet and discharge
Material Handled	- Atmospheric air
Inlet Conditions	- 200 scfm at 14.2 psia and 93 F
Discharge Pressure	- 16.2 psia
Motor HP	- 5

Item 43003, 43004 - Vibrating Discharger and Knife Gate

Type	- Circular vibrating storage pile discharger complete with mounting ring, suspension system, baffle, dust seal, bottom cone, gyrator, motor and outlet transition with adjustable gate - Contact materials abrasion resistant steel
Material Handled:	- 1-1/2 in. x 1/2 in. coal
Bulk Density	- 50 lb./ft.^{3}
Capacity	- 70 tons per hr.
Pile Height	- 10 to 15 ft.
Discharge To	- Vibratory feeder
Motor HP	- 3

Item No. 43005 - Vibrating Feeder

Type	- Fixed rate heavy duty electromechanical vibrating feeder complete with trough, AR liner, cover frame, springs, gyrator and motor
Material Handled	- 1-1/2 in. x 1/2 in. coal
Bulk Density	- 50 lb./ft.^{3}
Capacity	- 70 tons per hr.
Feed Method	- Vibratory storage pile discharge
Discharge To	- 24 inch belt conveyor
Motor HP	- 2

Item No. 43006 - Coal Reclaim Conveyor

Type	- Troughed idler rubber belt conveyor complete with screw take-up, feed skirt boards, discharge hood with outlet flange and dust pickup connection, V-belt drive, motor, zero speed switch, drive support, frame and legs suitable for mounting on buyer's concrete floor
Material Handled	- 1-1/2 in. x 1/2 in. coal
Bulk Density	- 50 #/ft.^{3}
Capacity	- 70 tons/hr.
Centers	- 62 ft.
Incline Angle	- 0°
Belt Width/Speed	- 24 in./200 fpm
Trough Angle	- 35°
Motor HP	- 3

Item No. 43007 - Coal Distribution Bucket Elevator

Type	- Self supporting continuous chain type bucket elevator complete with feed hopper, boot section with gravity take up, welded casing with flanged, gasketed connections, head section with split removable hood, discharge spout, inspection doors, drive, motor, drive support, drive platform, ladder and cage
Material Handled	- 1-1/2 in. x 1/2 in. coal
Bulk Density	- 50 lb./ft.^{3}
Capacity	- 70 TPH
Base to Bottom of Discharge Spout	- 83 ft. 0 in.
Method of Feed	- Belt conveyor
Motor HP	- 15

Item No. 43008 - Coal Distribution Conveyer

Type	- Redler Type conveyer for conveying coal from a bucket elevator to gasifier feed bins unit shall be complete with chain, dust tight housing, screw take-up, intermediate discharge openings, drive, drive guard and electric motor - Material of construction shall be carbon steel
Material Handled	- 1-1/2 in. x 1/2 in. coal
Bulk Density	- 50 #/ft.^{3}
Capacity	- 70 tons/hr.
Length	- 44 ft. (two gasifiers) - 106 ft. (five gasifiers)
Size	- 7 in. x 11 in.
Speed	- 87 fpm
Motor HP	- 20 (5 gasifiers)

CONCRETE VESSELS

Item No. 44001- Two - Gasifier Sulfur Melter

No. Required	- One (1)
Type	- Rectangular underground concrete tanks with refractory lining and raised pattern steel plate cover
Capacity	- 22,000 lbs. cake/day

Item No. 44002 - Three Gasifier Sulfur Melter

No. Required	- One (1)
Type	- Rectangular underground concrete tanks with refractory lining and raised pattern steel plate cover
Capacity	- 34,000 lbs. cake/day

Mechanical Equipment

Item No. 44003 - Equipment Water Cooling Tower

Type	- Field erected mechanical induced draft crossflow cooling tower complete with fir framing, distribution boxes and fan deck, FRP casing and louvers, PVC film-type fill and drift eliminators, stainless steel hardware, FRP fan and fan stack, 2 speed motor, gearbox, fir ladder and fir stairs
Capacity	- 5335 GPM
Inlet Temperature	- 108 F
Outlet Temperature	- 85 F
Design Wet Bulb	- 79 F
Area Classification	- Non-hazardous
No. of Cells	- 2
Motor HP	- 75 (leach cell)

Item No. 45001 - Magnetic Separator

Type	- Suspended manual cleaning permanent magnetic separator for removing tramp iron from a belt conveyer handling coal - Unit shall be complete with suspension cable and hardware
Material Handled	- 1-1/2 in. x 1/2 in. coal
Belt Width	- 24 inch
Burden Depth	- 6 inch max.
Belt Speed	- 150 fpm
Rate	- 70 tph

Item No. 45002 - Two Gasifier Electrostatic Precipitator

Type	- Electrostatic precipitator for removal of dust and liquid tar from cooled low BTU coal gas. Equipment shall be complete with carbon steel vessel, flanged inlet and outlet connections, discharge electrodes, carbon steel pipe type collection electrodes, insulators, insulator compartment, insulator heating system, power supply system and control panel - Support steel, ladders, platforms, piping and installation by buyer
Material Handled	- Cooled low Btu coal gas
Inlet Flow	- 16,000 acfm
Pressure	- 3 psig
Temperature	- 180 F
Solids	- 0.139 grains/acf
Tar	- 3.853 grains/acf
Outlet Pressure	- 2.5 psi
Solids	- 0.001 grains/acf
Tar	- 0.031 grains/acf
Removal Efficiency	- 99%
Power Consumption	- 100 kW each

Item No. 45003 - Three Gasifier Electrostatic Precipitator

Type	- Electrostatic precipitator for removal of dust and liquid tar from cooled low BTU coal gas. Equipment shall be complete with carbon steel vessel, flanged inlet and outlet connections, discharge electrodes, carbon steel pipe type collection electrodes, insulators, insulator compartment, insulator heating system, power supply system and control panel - Support steel, ladders, platforms, piping and installation by buyer
Material Handled	- Cooled low Btu coal gas
Inlet Flow	- 24,000 acfm
Pressure	- 3 psig
Temperature	- 180 F
Solids	- 0.139 grains/acf
Tar	- 3.853 grains/acf
Outlet Pressure	- 2.5 psi
Solids	- 0.001 grains/acf
Tar	- 0.031 grains/acf
Removal Efficiency	- 99%
Power Consumption	- 100 kW each

CONCRETE VESSELS

Item No. 45004 - Gasifier Tar Separator

No. Required	- One (1)
Type	- Rectangular underground concrete tank with steel plate cover
Capacity	- 1,200 GPM

Mechanical Equipment

Item No. 45018 - Two Gasifier Sulfur Filter

Item No. 45019 - Three Gasifier Sulfur Filter

Item No. 45020-1,2 - Raw Water Carbon Adsorber

Type	- Dual tank, vertical, cylindrical activated carbon adsorber complete with vessels, inlet distributors, carbon media, underdrain system, face piping, control panel and skid - Unit shall be arranged for manual backwash
Capacity	- 30 GPM
Vessel Size	- 4 ft. dia. by 6 ft. shell
Bed Volume	- 50 cu. ft.

Item No. 45021 - Tube Settler

Type	- Tube settler complete with rectangular housing, tubular settling elements and flanged connections
Capacity	- 30 GPM
Size	- 4 ft. sq. by 6 ft. high

Item No. 45022 - Primary Sludge Centrifuge

Type	- Horizontal, solid bowl, scroll type centrifuge complete with conveyer, bowl, cover, gear box, eddy current speed control, feed tube, V-belt drive, drive guard, motor, slide base, baseplate and forced feed lubrication system - Stainless steel with Tungsten carbide wear surfaces
Capacity	- 20 GPM of 5% by weight biosludge
Cake Moisture	- 15%
Motor HP	- 20 centrifuge - 3 Lube oil pump

Item No. 45023 Biosludge Clarifier

Type	- Side feed, bottom sludge drawoff bridge supported, rotating type clarifier mechanism complete with feedwell, center cage, bottom plow assembly, surface skimmer assembly, scum trough, center drive assembly, drive guard, drive controls, bridge, maintenance platform and walkway - Buyer's basin to be a steel sided, concrete bottom type complete with influent pipe, peripheral baffle and overflow weir, and inlet, sludge drawoff, scum outlet and overflow connections
Capacity	- 20 GPM
Size	- 20 ft. dia. by 13 ft. side water depth
Motor HP	- 1-1/2

Item No. 45024-1, 2 - Pressure Filter

Type	- Dual tank, vertical, cylindrical pressure sand filter complete with vessels, inlet distributors, filter, underdrain system, face piping, control panel and skid - Unit shall be arranged for automatic backwash initiated by high differential pressure
Capacity	- 20 GPM
Vessel Size	- 3 ft. dia. by 5 ft. shell
Bed Volume	- 20 cu. ft.

Item No. 45025-1, 2 - Waste Water Carbon Adsorber

Type	- Dual tank, vertical, cylindrical activated carbon adsorber complete with vessels, inlet distributors, carbon media, underdrain system, face piping, control panel and skid - Unit shall be arranged for manual backwash
Capacity	- 30 GPM
Vessel Size	- 4 ft. dia. by 6 ft. shell
Bed Volume	- 50 cu. ft.

Item No. 45026 - Aerobic Digestor Aerator

Type	Mechanical, low speed surface aerator for flotation mounting in an aerobic digester basin complete with electric motor driver, coupling, gear reducer, floating platform, impeller and deflector ring
Basin Size	14 ft. by 20 ft. by 15 ft. deep
Motor HP	100

Item No. 45027 - Biosludge Press

Type	Fully automatic plate and frame pressure filter press compete with filter media, plates and frames, support frame, plate shifter and guide rail assembly, hydraulic closing device, hydraulic system, infra-red safety curtain and control panel
Feed Rate	5 GPM
Filtering Surface	650 sq. ft.
Cake Capacity	28 cu. ft.
Motor HP	5 hydraulic pump

Item No. 45028-1, 2 - Aeration Tank Carbon Adsorber

Type	Dual tank, vertical, cylindrical activated carbon adsorber complete with vessels, inlet distributors, carbon media, underdrain system, face piping, control panel and skid - Unit shall be arranged for manual backwash
Capacity	30 GPM
Vessel Size	4 ft. dia. by 6 ft. shell
Bed Volume	50 cu. ft.

Item No. - 47003 Reductive Incinerator System

Consisting of the following:

47003-A	Air Blower
47003-B	Furnace
47003-C	Quench Tank
47003-D	Venturi Scrubber
47003-E	Circulation Pumps
47003-F	Stack

Type	- Reductive thermal incineration system for thermal decomposition of purge liquor from a Stretford plant - Equipment shall be complete with burner, burner pipe trains, combustion air blower, thermal oxidizer, quench tank, venturi scrubber, mist eliminator, stack, interconnecting flue gas ducting, scrubber circulating pumps and controls
Material Handled	- Stretford blowdown liquor
Liquor Flow	- 50 GPM
Fuel	- Low Btu coal gas @ 138 Btu/ft.^{3}
Turndown Ratio	- 4:1
Thermal Capacity	- 3 mm Btu/hr.
Motor HP	- 30 - Combustion blower - 5 - Scrubber recirculation pumps

Item No. 47004 - Utility Boiler System

Type	- Packaged firetube boiler system complete with LBG, NG, pilot and air pipe trains, burner, boiler trim, gage glass assembly, blowdown separator, insulation, skid base and control panel
Capacity	- 25,000 lb. per hr.
Pressure	- 65 psig
Motor HP	- 40 HP combustion fan

Item No. 47005 - Boiler Feedwater Treatment System

Type	- Chemical metering system complete with tank, dual controlled volume diaphragm metering pumps and mounting stand - Tank to include dissolving basket, cover, motor driven agitator and level gage - Pumps to be furnished with motor, suction piping, relief valve, discharge piping and manual capacity adjustment - 316 SS construction
Tank Capacity	- 100 gal.
Pump Capacity	- 5 gph
Discharge Pressure	- 25 psig
Motor HP	- 3/4 HP agitator - 1 HP pump

Item No. 47008 - Utility Boiler Dearator

Type	- Spray type deaerating feedwater heater complete with vertical deaerating section, make-up control valve, steam pressure control valve, relief valve, storage section, level controller, overflow control valve, instruments and connections - Stainless steel deaerator with carbon steel vessels
Outlet Capacity	- 25,000 lb./hr.
Storage Capacity	- 600 gal.
Operating Conditions	- 5 psig and 260 F

Item No. 47009-1, 2, 3 - Cation Exchanger

Type	- Packaged, automatic, skid mounted three train cation exchanger unit complete with exchanger vessels, face piping, interconnecting piping, regenerant feed system and control panel
Capacity	- 75 GPM each exchanger
Operation	- 2 exchangers on line, 1 stand by
Operating Pressure	- 75 psig
Exchanger Size	- 3 ft. dia. by 5 ft. shell
Bed Volume	- 32 cu. ft.

Item No. 47010 - Primary Sludge Conditioning System

Type	- Chemical metering system complete with tank, dual controlled volume diaphragm metering pumps and mounting stand - Tank to include dissolving basket, cover, motor driven agitator and level gage - Pumps to be furnished with motor, suction piping, relief valve, discharge piping and manual capacity adjustment - 316 SS construction
Tank Capacity	- 100 gal.
Pump Capacity	- 5 gph
Discharge Pressure	- 25 psig
Motor HP	- 3/4 HP agitator - 1 HP pump

Item No. 47011 - Biosludge Thickener

Type	Rectangular factory assembled electrolytic flotation thickener complete with flotation tank, float scraper with drive, bottom scraper with drive, electric busway, electrodes, effluent discharge sump, sludge hopper, access platforms and rectifier
Capacity	- 20 GPM
Size	- 30 ft. by 5 ft. by 5 ft. high
Motor HP	- 1 HP float scraper - 1 HP bottom - 24 kW electrodes

Item No. 47012 - Tube Settler Feed Conditioning System

Type	- Chemical metering system complete with tank, dual controlled volume diaphragm metering pumps and mounting stand - Tank to include dissolving basket, cover, motor driven agitator and level gage - Pumps to be furnished with motor, suction piping, relief valve, discharge piping and manual capacity adjustment - 316 SS construction
Tank Capacity	- 100 gal.
Pump Capacity	- 5 gph
Discharge Pressure	- 25 psig
Motor HP	- 3/4 HP agitator - 1 HP pump

Item No. 47013 - Coagulant Aid System

Type	- Chemical metering system complete with tank, dual controlled volume diaphragm metering pumps and mounting stand - Tank to include dissolving basket, cover, motor driven agitator and level gage - Pumps to be furnished with motor, suction piping, relief valve, discharge piping and manual capacity adjustment - 316 SS construction
Tank Capacity	- 100 gal.
Pump Capacity	- 5 gph
Discharge Pressure	- 25 psig
Motor HP	- 3/4 HP agitator - 1 HP pump

Item No. 47014 - Filter Aid System

Type	- Chemical metering system complete with tank, dual controlled volume diaphragm metering pumps and mounting stand - Tank to include dissolving basket, cover, motor driven agitator and level gage - Pumps to be furnished with motor, suction piping, relief valve, discharge piping and manual capacity adjustment - 316 SS construction.
Tank Capacity	- 100 gal.
Pump Capacity	- 5 gph
Discharge Pressure	- 25 psig
Motor HP	- 3/4 HP agitator - 1 HP pump

Item No. 47015 - Biosludge Conditioning System

Type	- Chemical metering system complete with tank, dual controlled volume diaphragm metering pumps and mounting stand - Tank to include dissolving basket, cover, motor driven agitator and level gage - Pumps to be furnished with motor, suction piping, relief valve, discharge piping and manual capacity adjustment - 316 SS construction
Tank Capacity	- 100 gal.
Pump Capacity	- 5 gph
Discharge Pressure	- 25 psig
Motor HP	- 3/4 HP agitator - 1 HP pump

Item No. 48001 - Truck Scale

Type	- Heavy duty, 4-section, cast lever, electronic truck scale - Scale shall be complete with solid state digital readout and printer, load cell weigh transmitter assembly and steel package - Carbon steel scale
Nominal Capacity	- 100,000 lbs.
Accuracy	- Plus or minus 0.1% of live load
Platform Size	- 34 ft. x 10 ft.

Item No. 48002 - Weigh Belt

Type	- Belt scale for weighing coal on a belt conveyer complete with lever system, idlers, load cell, speed sensor, rate readout, accumulated total readout, 24-hour chart recorder, test chain and test chain reel - Carbon steel scale
Material Handled	- 1-1/2 in. x 1/2 in. coal
Rate	- 70 tph
Conveyer Size	- 24 inch

Item No. 48005-1, 2, 3, 4, 5 - Flame Front Generator

Type	Flame front generator for igniting a flare stack pilot - Equipment shall include gas shutoff valve, gas pressure gage, air shutoff valve, air pressure gage, ignition chamber, spark plug, transformer, pushbutton and mounting plate - Carbon steel construction
Fuel	- Bottled propane
Compressed Air	- 100 psig
Pipe Size to Pilot	- 1 in.
Distance to Pilot Head	- 10 ft. horizontal, 75 ft. vertical

Item No. 48008 - Cooling Tower Chlorinator

Type	- Duplex chlorinator for feeding chlorine solution into a cooling tower basin - Equipment shall include dual chlorine tank scales, tank mounted vacuum regulators, vent tubing, chlorine gas tubing and fittings, automatic switchover valve, rate control valve, flowmeter, ejector with water shut-off valve, strainer and pressure gage, chlorine solution tubing, chlorine solution diffuser and chlorinator house with heating and ventilation system
Chlorine Rate	- 5 to 30 lb./day
Water Available	- 100 psig from cooling tower pump

Item No. 48009 - Acid Dilution Trough

Type	- Rectangular redwood box with baffles, glass drip tray and outlet weir
Size	- 24 in. long by 6 in. wide by 6 in. high

Item No. 48010-1, 2, 3, 4, 5, 6, - Exhaust Heads

Type	- Steam exhaust head complete with steam inlet connection and water drain connection
Size	- 10 inch

Item No. 48011 - Flame Front Generator

Type	- Flame front generator for igniting a flare stack pilot - Equipment shall include gas shutoff valve, gas pressure gage, air shutoff valve, air pressure gage, ignition chamber, spark plug, transformer, pushbutton and mounting plate
Fuel	- Bottled propane
Compressed Air	- 100 psig
Pipe Size to Pilot	- 1 in.
Distance to Pilot Head	- 10 ft. horizontal, 75 ft. vertical

Item No. 48012 - Coal Pile Run-off Static Mixer

Type	- Inline static mixer for mixing of caustic solution and coal pile run-off water complete with mixing elements, housing and flanged connections 316 SS construction
Capacity	- 50 GPM
Size	- 2 in. dia. by 16 in. length

Item No. 48013 - Aeration Tank Static Mixer

Type	- Inline static mixer for mixing of caustic solution and waste-water complete with mixing elements, housing and flanged connections 316 SS construction
Capacity	- 20 GPM
Size	- 2 in. dia. by 16 in. length

Item No. 49001 - Front End Loader

Type	- Diesel engine driven front end loader complete with material handling type bucket, ROPS cab with heaters, power shift transmission, instrument gages and lights
Bucket Capacity	- 1.5 yds.^{3}

4.4.3 PROCESS - HVAC

Item No. 50001 - Conveyor Dust Collector Exhaust Blower

Type	- Centrifugal, forward curved vertical discharge blower complete with TEFC motor, belt drives, sparkproof type AMCA "B", clockwise rotation, single width, single inlet
Flow	- 5850 SCFM @ 104°F max.
Pressure	- 8.0" W.C.
Motor HP	- 20 at 1750 RPM

Item No. 50002 - Coal Distribution Conveyor Dust Collector

Type	- Bag house dust collector, with polyester bags, inlet and outlet flanges, access manway, inspection doors, relief vent, explosion vent, rotary valve, Class I, Group D, Division 2 electrical classification
Flow	- 5850 SCFM at 104°F max.
Pressure Drop	- 6.0" W.C.
Material of Construction	- Carbon Steel

Item No. 50003 - Coal Tunnel Exhaust Fan

Type	- Centrifugal, forward curved, vertical discharge blower complete with TEFC motor, belt drives, sparkproof type AMCA "B", clockwise rotation, single width, single inlet, integral base, and vibration isolators
Flow	- 2800 SCFM at 104°F max.
Pressure	- 8.0" W.C.
Motor HP	- 15 at 1750 RPM

Item No. 50004 - Coal Tunnel Dust Collector

Type	- Bag house dust collector with polyester bags, inlet and outlet flanges, access manway, inspection door, relief vent, explosion vent, rotary valve, Class I, Group D, Division 2 electrical classification
Flow	- 2800 SCFM at 104°F max.
Pressure Drop	- 6.0" W.C.
Material of Construction	- Carbon Steel

Item No. 51101 - Gasifier Building Make Up Air Unit

Type	- Packaged make up air and heating unit complete with centrifugal fan, belt drive, steam heating coil, face and by pass dampers, throw-away filter section, integral base and vibration isolators.
Flow	- 9000 SCFM at 104°F max.
Pressure	- 1.5" total static pressure
Motor HP	- 7.5 at 1750 RPM

Item No. 51110 - Coal Tunnel Air Supply Blower

Type	- Packaged make up air and heating unit complete with centrifugal fan, belt drive, steam heating coil, face and by pass dampers, throw-away filter section, integral base and vibration isolators
Flow	- 3000 SCFM at 104°F max.
Pressure	- 1.5" total static pressure
Motor HP	- 1.0 at 1750 RPM

4.5 Plot Plans & Layout

A conceptual plot plan & layout drawings were developed for the Wellman-Galusha Gasifier installation along with all accessories required. This installation includes coal storage and handling facilities, gas quench and tar removal facilities, sulfur removal facilities, waste water treatment facilities, utility facilities and optional office and change house. The drawings listed as follows can be found in Volume II-Engineering Drawings:

Drawing No.	Description
2994-200-101	Plot Plan-Coal Gasification Plant
2994-200-102	Gasifier Building First Floor Plan
2994-200-103	Gasifier Building Mezzanine Plan
2994-200-104	Gasifier Building Second Floor Plan
2994-200-105	Gasifier Building Third Floor Plan
2994-200-106	Layout Open Coal Pile Plan and Sections
2994-200-107	Gas Quench & Tar Removal Area Plan
2994-200-108	Gas Quench & Tar Removal Area Plan
2994-200-109	Sulfur Removal and Recovery-First Floor Plan
2994-200-110	Sulfur Removal and Recovery-Second Floor Plan
2994-200-111	Cooling Tower Plan and Section
2994-200-112	Waste Water Treatment Building
2994-200-117	Sulfur Removal and Recovery Plan
2994-200-118	Sulfur Removal and Recovery Plan
2994-200-119	Liquid Sulfur & Tar Storage Tanks Plan
2994-200-120	Waste Water Treatment System Plan
2994-200-201	Gasifier Building Sections
2994-200-202	Gasifier Building Sections
2994-200-203	Gas Quench & Tar Removal Area Section "A-A"
2994-200-204	Gas Quench & Tar Removal Area Sections "B-B", "C-C" & "D-D"
2994-200-205	Sulfur Removal and Recovery Sections "A-A" & "B-B"
2994-200-206	Sulfur Removal and Recovery Section
2994-200-208	Sulfur Removal and Recovery Section
2994-200-209	Liquid Sulfur & Tar Storage Tanks Sections
2994-200-210	Sulfur Removal and Recovery Section

5.0 RETROFIT

The General Refractories plant contains several perlite expander furnaces and an insulation board dryer. These units are the major users of natural gas and must be converted to burn low Btu gas when the coal gasification plant is completed.

In order to ensure maximum flexibility for production of insulation board and minimum dependence upon any single fuel source, it has been decided to convert all burners to triple-fuel devices capable of burning low Btu gas, natural gas or propane.

5.1 Expander Furnaces

5.1.1 Description

There are several perlite expander furnaces in the General Refractories plant which convert finely ground perlite "sand" to expanded insulation beads.

The expander furnaces are vertical cylinders fired from the bottom. The perlite sand is fed into the furnace near the top and flows downward. The countercurrent flow of hot gases serve not only to expand the high density perlite sand grains into lightweight perlite beads, but also to convey the low density beads upwards through the furnace into a plenum chamber. The plenum terminates in an air/perlite separator.

The expander furnaces are equipped with a commercially available burner.

Combustion air is provided by a primary air blower. Gas and air flows are monitored and controlled at a central station which provides temperature control by modulating gas flow. Also incorporated in the control station are temperature recorders and manual control devices for varying primary combustion air and furnace shell cooling air.

The gas and air supply piping, including gas valves, pressure regulators, high and low pressure shut-off devices and gauges are supplied by the furnace manufacturer, and are approved by GREFCO's Insurance Company.

Existing piping consists of a two inch diameter gas line and a six inch diameter air supply manifold.

Fuel Design Conditions:

	Natural Gas	Producer Gas
High Heating Value (HHV), Day - Btu/SCF	1000	138
Heat Release MM Btu/hr	10	10
Fuel Flow, Dry SCFM	167	1207
Combustion Fan HP	20	20
Products of Combustion @ 15% excess air, SCFM	2029	2447

5.1.2 Process

Expander furnaces serve a dual role. First the thermal input is used to convert a high density perlite mineral "sand" into a low density perlite "bubble or bead" having a very low thermal conductivity. Second, the hot combustion gases passing upward through the furnace are used to separate the light density "bubbles" which have been expanded from the perlite "sand". The insulating perlite "bubbles" are carried upward by the hot combustion gases to the plenum chamber above the furnaces.

In the GREFCO plant, perlite sand is fed to a center firing tube at the top of the perlite expander furnace. The "sand" grains drop downward through the hot gases produced by the burner at the bottom of the furnace. As the sand grains are heated, they expand, greatly increasing the ratio of surface area to weight.

The expanded perlite "bubbles" are light enough to be borne aloft in the stream of hot combustion gases. These gases convey the expanded perlite into the upper plenum chamber. Water sprays in the chamber cool the perlite and also cool the hot gases, causing sufficient contraction so that the gases can no longer convey the expanded perlite. The gas/perlite flow passes through a separator; the cooled combustion gases are discharged to the atmosphere through a vent stack, and the expanded perlite beads are stored in the perlite bin for use in insulating boards at a subsequent step in the process.

5.1.3 Expander Furnace Experiment

Since the perlite expander furnace not only provides the thermal input to the perlite mineral conversion process, but also is the source of conveying the expanded beads, it was considered necessary to conduct a test of an expander furnace fired with a synthesis gas approximating low Btu gas from the Wellman-Galusha process.

An expander furnace experiment was conducted by the furnace manufacturer using a standard expander furnace. The standard burner was removed, and replaced with a nozzle mix burner designed for low Btu gas. The burner was fired with a synthesis gas supplied by Union Carbide. The synthesis gas was a mixture of nitrogen, carbon monoxide and hydrogen in a ratio similar to that expected of gas from a Wellman-Galusha gasifier operating on bituminous coal.

After preliminary combustion tests, perlite sand was fed into the furnace. The manufacturer reported that the expander operated very well using the low Btu gas. There was no problem in obtaining the proper product density or obtaining the required production rate. Fuel usage appeared to be the same as when natural gas was used.

During the test it was reported that there was an increase in noise level when low Btu gas was burned and suggested that ear protection or noise partitions might be required. It was suggested by Dravo that changing the burner configuration slightly would reduce noise levels.

5.1.4 Expander Furnace Retrofit Equipment

Based upon the results of the expander furnace experiment conducted the following changes would be required to permit use of producer gas:

- It would be necessary to remove some material from the burner pot at the bottom of the furnace and install an adaptor plate to accommodate the new burner.

- The existing premix burner would need to be replaced with a multifire nozzle mix burner having three nozzles. This burner will burn producer gas, natural gas or propane.

- Existing air and gas manifolds would need to be replaced with a two-inch-diameter natural gas pipe, a six-inch air pipe, and an eight-inch producer gas pipe.

- A new control station would have to be installed. This station would include safety controls, and a temperature recorder/controller which would automatically maintain temperature by modulating gas flow. Also included would be an electronic air ratio controller/recorder for modulating combustion air flow and a "fuel change" system which would allow changing from producer gas to natural gas or vice versa without interrupting production.

All conversion equipment is readily available manufacturers' standard equipment.

5.1.5 Expanded Furnace Retrofit Cost

The cost of labor necessary to remove the existing burners, fire tube adapters, and pipe trains, and the cost of labor and equipment to install new fire tube adapters, burners, pipe trains and instruments has been estimated by Dravo to be $32,600. GREFCO has been furnished with detailed retrofit data.

5.2 Board Dryer

5.2.1 Description

The board dryer at the GREFCO plant is an insulated structure configured to meet the production needs of the plant.

Wet insulating board is conveyed into the dryer via live roller conveyors.

The dryer tunnel is separated into several zones. The first zone is a feed area which has an air-sealed curtain and an exhaust stack. The feed zone is followed by several drying zones, each zone having its own burner system, exhaust and temperature control. Burners above each zone are used to heat air circulated through an upper plenum chamber. A circulating air fan pulls hot air from the plenum, forcing it down and around the insulating board in the dryer. Hot, saturated air is vented to the atmosphere, and make-up air is provided.

After leaving the dryer tunnel, dried insulating board is conveyed through a cooling zone.

5.2.2 Burner Configuration

To prevent direct flame impingement on the insulation board, the burners are installed in the dryer air recirculation plenum and are positioned to provide a downblast of hot gases across the top of the plenum chamber. Each dryer zone has premix burners which use natural gas as fuel. Combustion air is supplied by a primary air fan.

5.2.3 Auxiliary Systems

The dryer temperatures and flows are preset and monitored at a central control station which includes low and high pressure gas cut off devices, other safety controls and a recording temperature controller.

5.2.3.1 Dryer Specifications

The dryer has the following fuel design conditions:

	Natural Gas	Producer Gas
High Heating Value (HHV), Dry - Btu/SCF	1000	138
Heat Release, MM Btu/hr	60	60
Fuel Flow, Dry SCFM	1000	7246
Combustion Air Flow (15% excess air) Dry SCFM	10,994	8252
Combustion Fan HP	60	60
Products of Combustion, 15% excess air - SCFM	12,149	14,643

5.2.4 Board Dryer Retrofit Requirements

It is possible to use the existing burners on producer gas. To do so, however, would require supplying the producer gas at a pressure of 20 psig. Additional burners would have to be added to each of the dryer sections to provide adequate total thermal input.

A preferred alternate is to replace the existing burners with burners designed for use with producer gas; suitable burners for dual-or triple-fuel usage are manufactured by North American, Bloom, Coe, Peabody, Zinc, Zurn and others. The manufacturer of the dryer states that a dual-fuel burner using commercial natural gas or low Btu gas is perfectly feasible and will function as required.

To accommodate the increased volume of combustion products, it would be necessary to enlarge a section of the recirculating air plenum above the dryer. The central section of the dryer air plenum would have to be rebuilt to accommodate the triple-fuel burners. The rebuild would consist of installing a new plenum insulated with ceramic fiber blanket on the top and sides. Block insulation rated for high temperatures would be used to line the bottom of the plenum. A new wide burner support platform would be installed at the top of the plenum. The platform would serve as a mounting surface for the new burners as well as provide access.

It is expected that the new installation would improve dryer efficiency.

5.2.5 Dryer Retrofit Cost

The cost of labor to remove those sections of the dryer which are to be rebuilt and to remove burners, the air blower, pipe trains and existing control panels is estimated by Dravo to be $46,600. GREFCO has been provided with specific retrofit details.

The cost of rebuilding the dryer and purchasing and installing new burners, new blowers, controls, pipe trains and platforms is estimated to be $567,600.

5.3 Distribution Piping

5.3.1 Design Requirements

As part of the design of the General Refractories gasification facility, a new gas distribution system has been developed. This distribution system would supplement the existing natural gas and propane/air system, not replace it.

Due to the large volume of gases which the LBG system must handle and the relatively low pressure of the gas, the distribution piping would be large. The main distribution pipe from the gasification plant to the existing GREFCO building is thirty-inch-diameter carbon steel. The remainder of the distribution system would be designed to accommodate the new triple-fuel burners which would be installed on the dryer and under the expander furnaces.

5.3.2 LBG Main Distribution Piping

Cool, clean, compressed, and de-sulfurized gas from the Wellman-Galusha gasifiers would exit at the top of the absorber columns for distribution to the GREFCO plant. A thirty-inch-diameter gas line from the gasification facility would cross a railroad spur diagonally on an elevated pipe rack and meet the existing building on column 3-J. The gas pipe would be supported outside the building south of column line J for about 50 feet and then would enter the building at J-5.

Newly installed eight-inch-diameter posts would support the gas pipe through the building adjacent column line 5.

The overhead distribution pipe would be routed adjacent the laboratory to column 5-C, next to the asphalt storage tanks. The thirty inch distribution pipe would then run along column line C parallel to the dryer for approximately 250 feet. The thirty-inch line would then be reduced to fourteen inches and would continue for an additional 75 feet before terminating in a blanked end (refer Drawing 200-116).

5.3.3 Distribution Piping at Expander Furnaces

To service the four expander furnaces, a twelve-inch-diameter branch line would be connected to the main thirty-inch header near column 4-J (refer Drawing No. 200-116). This twelve-inch branch would form a header running parallel to the expander furnaces and close to the existing air and natural gas manifolds. Six-inch-diameter gas pipes from the twelve-inch header would supply each of the four new burners. The header would be capped to allow for future expansion (see Detail 1, Drawing No. 200-207).

5.3.4 Distribution Piping at Dryer

There are two fourteen-inch-diameter manifolds connected to the thirty-inch distribution pipe, one each at Zone 1 and 2. The thirty-inch distribution pipe would be reduced to fourteen inches at column line 15 (just past Zone 2) and a third fourteen-inch-diameter manifold connected to the fourteen-inch distribution pipe at Zone 3 (refer Detail 2, Drawing 200-207). Six 4-inch LBG pipes would branch off the fourteen-inch manifolds at each location supplying gas to the new burners. New control stations described in a preceeding section would complete the dryer/distribution retrofit.

5.3.5 Distribution Piping Drawings

Layout drawings of the Distribution Piping System were developed as follows. They can be found in Volume II-Engineering Drawings.

Drawing No.	Description
2994-200-116	Coal Gasification Plant-Distribution Header-Plan
2994-200-207	Coal Gasification Plant-Distribution Header-Sections & Details

6.0 GENERAL SPECIFICATIONS

6.1 Piping

Plumbing, Fixtures, Material and Workmanship

Piping Materials

Thermal Insulation

6.2 Electrical

Appendix A - Electrical Motor List

6.3 Civil and Architectural

6.4 HVAC Systems

6.5 Instrument Piping Materials and Workmanship

All Areas

6.6 Hazard Specification

6.1 Piping

Plumbing, Fixtures, Material and Workmanship

Piping Materials

Thermal Insulation

1.0 INTENT

1.1 This specification establishes the quality and type characteristics of materials to be used in the furnishing, fabricating and installation of plumbing fixtures.

2.0 DESIGN

2.1 Potable water, soil waste and vent piping for sanitary facilities shall be installed in accordance with local Governing Codes, and with the National Plumbing Code ASA A40.8, latest edition, as the minimum requirement.

2.2 All potable water supply lines to plumbing fixtures shall be disinfected according to AWWA Specification C601.

2.3 All supply lines to plumbing facilities shall have a shut-off valve before each fixture.

LINE DESIGNATION	SERVICE	SPECIFICATION	PAGE
SAN	SANITARY SOIL AND WASTE	P1.600	3
WPC	COLD WATER, POTABLE (TO FIXTURES)	P1.601	4
WPH	HOT WATER, POTABLE (TO FIXTURES)	P1.601	4

Piping Materials

STANDARD SPECIFICATION NO. P1,600

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 50 PSIG @ AMB DEG. F

CONSTRUCTION: ALL SIZES: BELL & SPIGOT (PUSH-ON GASKET)

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		2" TO 12" INCL.	P65	C.I. SOIL PIPE, A74, BELL AND SPIGOT, EXTRA HEAVY.
FITTINGS		2" TO 12" INCL.	FTG65	C.I. SOIL PIPE FITTINGS, A74, BELL AND SPIGOT EXTRA HEAVY.
UNIONS & FLANGES				
VALVES	SHUT-OFF			
	THROTTLE			
	CHECK			
JOINT MAT'L. GASKETS BOLTS		ALL SIZES	G27	PREFORMED NEOPRENE GASKET, C-564, FOR EXTRA HEAVY C.I. BELL & SPIGOT PIPE.

NOTES:

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Piping Materials

STANDARD SPECIFICATION NO. P1.601

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 125 PSIG @ 150 DEG. F

CONSTRUCTION: 3/8" TO 2" - SOLDER JOINT

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		3/8" TO 2" INCL.	P42	COPPER WATER TUBING, B88, HARD, TYPE K.
FITTINGS		3/8" TO 2" INCL.	FTG45	WROUGHT COPPER, B75, SOLDER JOINT B16.18.
UNIONS & FLANGES		3/8" TO 2" INCL.	UN42	BRASS AND IRON DIELECTRIC UNION, SOLDER JOINT TO FEMALE IRON CONNECTION.
VALVES	SHUT-OFF	3/8" TO 2" INCL.	WPL42	BRONZE, BALL OR PLUG, WRENCH OPERATED, SOLDER JOINT ENDS B16.18, 125 LB. SSP.
	THROTTLE	3/8" TO 2" INCL.	VGL43	BRASS OR BRONZE, GLOBE, INSIDE-SCREW RISING STEM, SOLDER JOINT ENDS B16.18, 150# SSP.
	CHECK	3/8" TO 2" INCL.	VCH44	BRONZE OR BRASS, CHECK, SWING TYPE, SOLDER JOINT ENDS B16.18, 125 LB. SSP.
JOINT MAT'L. GASKETS BOLTS			JT7	SOFT SOLDER, 50-50 TIN-LEAD B32 GR. 50A.

NOTES:

PLUMBING FIXTURES
ITEM NO.

MP2 WATER CLOSET TO BE WALL MOUNTED, SIPHON JET ACTION, ELONGATED VITREOUS CHINA BOWL, WASHDOWN TYPE, TO PASS 2-1/4" BALL, 1-1/2" BACK SPUD, OPEN FRONT SEAT LESS COVER, FLUSH VALVE WITH SCREWDRIVER STOP AND VACUUM BREAKER AND OFF THE FLOOR CLOSET CARRIER WITH ADJUSTABLE FEET. FEDERAL SPECIFICATION WW-P-541B PARAGRAPH 10.5 OUTFIT NO. VW 20.

MP3 URINAL: WALL HANGING WASHOUT URINAL OUTFIT, VITREOUS CHINA, EXPOSED FLUSH VALVE COMPLETE WITH SUPPLY AND FLUSH PIPING ADD TO INCLUDE CARRIER, TO BE IN ACCORDANCE WITH FEDERAL SPEC. WW-P-541B, PARA. 10.6 OUTFIT VU13W.

MP4 LAVATORY: CARRIER HUNG, VITRIOUS CHINA PLAIN BACK BOWL, CHROME PLATED COMBINATION POP-UP WASTE FIXTURE WITH STOPS AND SUPPLIES TO WALL, CHROME PLATED TAIL PIECE AND 1-1/4" "P" TRAP. TO BE IN ACCORDANCE WITH FEDERAL SPECIFICATION WW-P-541B, PARA. 10.7, OUTFIT NO. VL20P, EXCEPT TO INCLUDE CHAIR TYPE CARRIER.

MP5 SERVICE SINK: CAST IRON ACID RESISTING ENAMELED, RIM GUARD, COMBINATION FAUCET, "P" TRAP TO WALL. UNIT TO INCLUDE CARRIER AND TO BE IN ACCORDANCE WITH FEDERAL SPECIFICATION WW-P-541B, PARA. 11.10 OUTFIT NO. ES24G.

MP8 FLOOR DRAIN (FINISHED AREA): TRIUMPH FLOOR DRAIN WITH BOTTOM OUTLET INSIDE CAULK, DURA-COATED CAST IRON BODY AND POLISHED BRONZE STRAINER ADJUSTABLE VERTICALLY TO FLOOR LEVEL. ZURN ITEM Z-415 OR EQUAL.

MP12 DRINKING FOUNTAIN: REFRIGERATED DRINKING WATER COOLER, PRESSURE BUBBLER TYPE WITH STATIC AIR OR FAN COOLED CONDENSING UNIT, MINIMUM CAPACITY 4 GALLONS PER HOUR, GENERAL PURPOSE TYPE FOR 120 VOLTS, SINGLE PHASE, 60 HZ. POWER SUPPLY, STAINLESS STEEL TOP WITH DUAL FOOT AND PUSHBUTTON OPERATED BUBBLER. CABINET SHALL BE FLOOR MOUNTED, OF HEAVY GAUGE STEEL WITH TWO COATS OF BAKED ENAMEL FINISH. UNIT SHALL BE WESTINGHOUSE MODEL WFC04LB OR EQUAL.

CAPACITY - SHALL BE BASED ON 90 DEG. F. AMBIENT, 80 DEG. F. INLET WATER AND 50 DEG. F. WATER OUTLET TEMPERATURE, AND ON 60% WASTE THROUGH DRAIN FOR PRECOOLING.

CONDENSING UNIT - HERMETICALLY SEALED. GUARANTEED AGAINST DEFECTS IN WORKMANSHIP FOR A PERIOD OF 5 YEARS FROM DATE OF FINAL ACCEPTANCE.

DESIGN AND CONSTRUCTION - COOLER SHALL MEET ALL APPLICABLE HEALTH AND SANITARY REGULATIONS, AND SHALL BE CERTIFIED UNDER ARI STANDARD 1010. COOLER SHALL ALSO BE LISTED BY THE UNDERWRITER'S LABORATORY, INC.

MP18 WATER HEATER: AUTOMATIC ELECTRIC, STORAGE TYPE, SELF SUPPORTING, COMPLETE WITH DRAIN VALVE, RELIEF VALVE, THERMOSTAT OVER TEMPERATURE SAFETY CONTROL, MAGNESIUM ROD, GLASS LINED STORAGE TANK. RUUDGLAS "POINT-OF-USE", OR EQUAL.

SERVICE CONDITIONS AND PERFORMANCE REQUIREMENTS:

TANK CAPACITY:	30 GALLONS
OUTLET WATER TEMP.:	140 DEG. F.
HEATING ELEMENT:	2000 WATTS
ELECTRIC POWER:	120 VOLTS, SINGLE PHASE, 60 HZ.
RATED PRESSURE:	150 PSI

DESIGN AND CONSTRUCTION:

MANUFACTURER'S STANDARD WITH 5 YEAR WARRANTY ON THE TANK. TANK SHALL BE ADEQUATELY INSULATED AND BEAR AN UNDERWRITER'S LABORATORIES APPROVAL LABEL.

MS7 FREE STAND COMBINATION FROST PROOF EMERGENCY SHOWER AND EYEWASH, FURNISHED COMPLETE INCLUDING PIPING, 3'-6" DEPTH OF BURY UNLESS NOTED OTHERWISE. SPEAKMAN SE-618 OR EQUAL.

1.0 INTENT

1.1 This specification establishes the quality and type characteristics of the materials to be used for all the utility and process piping shown on the flow diagrams.

1.2 Pressure piping material, quality and characteristics shall fulfill the minimum requirements of ANSI B31.3, Chemical Plant and Petroleum Refinery Piping Code, latest edition.

LINE DESIGNATION	SERVICE	SPECIFICATION	PAGE
AA	Aeration Air	P1.2	5
ANA	Anhydrous Ammonia	P1.6	6
BD	Boiler Blowdown	P1.1	4
BI	Bioeffluent	P1.31	19
BR	Biosludge Recycle	P1.31	19
CA	Combustion Air	P1.2	5
CG	Chlorine Gas (Dry)	P1.21	10
CGW	Chlorine Gas (Wet)	P1.28	16
CLS	Clarifier Sludge	P1.31	19
COA	Coagulant Aid "Polymer"	P1.28	16
CS	Chelate Solution	P1.29	17
CST	Caustic	P1.15	7 & 9
CTB	Cooling Tower Blowdown	P1.2	5

CTC	Cooling Tower Chemicals	P1.20	9
DW	Potable Water	P1.16	8
DR	Dilution Recycle	P1.20	9
ECW	Equipment Cooling Water	P1.2	5
ESP	ESP Gas	P1.9	17
FA	Filter Aid "Polymer"	P1.28	16
FLG	Flue Gas	P1.29	17
FG	Filtered Raw Product Gas	P1.22	11
GCP	Clean Product Gas	P1.29	17
GQ	Quenched Gas	P1.9	17
IA	Instrument Air	P1.2	5
LBG	Clean LBG	P1.29	17
LC	Condensate	P1.1	4
LS	Steam (75 psia)	P1.1	4
LSU	Liquid Sulfur	P1.24	13
PA	Plant Air	P1.2	5
PC	Process Condensate	P1.2	5
PFB	Pressure Filter Backwash	P1.31	19
PRA	Process Air	P1.2	5
PHA	Phosphoric Acid	P1.30	18
PP	Propane	P1.26	15
PSU	Process Sewer U/G	P1.32	20
PW	Process Water	P1.2	5

SA	Sulfuric Acid	P1.23	12
SCF	Sulfur Cake Filtrate	P1.25	14
SFW	Service & Flush Waters	P1.20	9
SP	Stretford Purge	P1.20	9
SR	Stretford Reagent	P1.20	9
SS	Sulfur Slurry	P1.25	14
SSS	Sodium Sulfite Solution	P1.20	9
STS	Stretford Solution	P1.20	9
SW	Seal Water	P1.2	5
TR	Tar	P1.20	9
VA	Ventilation Air	P1.2	5
VAC	Vacuum	P1.21	10
WAS	Ash Sluicing Water	P1.2	5
WBF	Boiler Feed Water	P1.1	4
WCG	Chlorine In Water	P1.28	16
WCP	Coal Pile Run-Off	P1.2	5
WCT	Cooling Tower Make-Up	P1.2	5
WGB	Gas Quench Water Blowdown	P1.1	4
WQG	Gas Quench Water	P1.1	4
WR	Rain Water	P1.2	5
WT	Water & Tar Mixture	P1.1	4
WWS	Sulfur Cake Wash Water	P1.2	5

LC BD
LS
WQG WT
WBF WGB

Piping Materials

STANDARD SPECIFICATION NO. P1.1

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 125 PSIG @ 400 DEG. F

CONSTRUCTION: 2" AND UNDER-SCREWED; 2-1/2" AND OVER-FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1-1/2" AND UNDER	P114	C.S., A106 GR. A OR B SEAMLESS - SCH. 80
		2" SIZE	P16	C.S., A53 TYPE S OR E - SCH. 80
		2-1/2" TO 10" INCL.	P15	C.S., A53 TYPE S OR E - SCH. 40
FITTINGS		2" AND UNDER	FTG617	M.I. SCREWED 300 LB. SSP
		2-1/2" TO 10" INCL.	FTG11	C.S. BUTT WELD SCH. 40
UNIONS & FLANGES		2" AND UNDER	UN62	M.I. SCREWED UNION - 300 LB. SSP
		2-1/2" TO 10" INCL.	FS011	C.S., 150 LB. SLIP-ON ANSI B16.5 R.F.
			FS012	C.S., 150 LB. SLIP-ON ANSI B16.5 R.F.
VALVES	SHUT-OFF	2" AND UNDER	VGA41	BRONZE GATE, INSIDE-SCREW RISING STEM, SCREWED, 125 LB. SSP
		2-1/2" TO 10" INCL.	VGA62	C.I. GATE, IBBM, O.S. & Y., FLANGED 125 LB. ANSI B16.1 AND B16.10
	THROTTLE	2" AND UNDER	VGL44	BRONZE GLOBE, INSIDE-SCREW RISING STEM, SCREWED, 125 LB. SSP
		2-1/2" TO 6"	VGL65	C.I., GLOBE, IBBM, O.S. & Y., FLANGED 125 LB. ANSI B16.1 AND B16.10
	CHECK	2" AND UNDER	VCH41	BRONZE CHECK, SWING TYPE, SCREWED 125 LB. SSP
		2-1/2" TO 10" INCL.	VCH63	C.I., CHECK, IBBM, SWING TYPE, FLANGED, 125 LB. ANSI B16.1 AND B16.10
JOINT MAT'L.		FOR SCREWED JOINTS	JT11	CYL.-SEAL OR EQUAL
GASKETS			G1	COMPRESSED WHITE ASBESTOS 1/16" THICK
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS A307 GR. B.

NOTES:
1) USE ITEM FS012 AT CAST IRON VALVES AND EQUIPMENT.
2) USE ITEM N16, C.S. A106 SCH. 80 NIPPLES, AT INSTRUMENT CONNECTIONS.

PA	WCT	WWS	PRA
IA	WR	CTB	SW
CA	WCP	AA	PW
ECW	WAS	VA	PC

Piping Materials

STANDARD SPECIFICATION NO. P1.2

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 145 PSIG @ 180 DEG. F

CONSTRUCTION: 2" AND UNDER SCREWED; 2-1/2" AND OVER - FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1-1/2" AND UNDER 2" SIZE 2-1/2" TO 10" INCL.	P114 P16 P15	C.S., A106 GR. A OR B, SEAMLESS SCH. 80 C.S., A53 TYPE S OR E SCH. 80 C.S., A53 TYPE S OR E SCH. 40
FITTINGS		2" AND UNDER 2-1/2" TO 10" INCL.	FTG617 FTG11	M.I. SCREWED, 300 LB. SSP C.S., BUTT WELD SCH. 40
UNIONS & FLANGES		2" AND UNDER 2-1/2" TO 10" INCL.	UN62 FS011 FS012	M.I. SCREWED UNION 300 LB. SSP. C.S., 150 LB. SLIP-ON ANSI B16.5 R.F. C.S., 150 LB. SLIP-ON ANSI B16.5 F.F.
VALVES	SHUT-OFF	2" AND UNDER 2-1/2" TO 10" INCL.	VBL42 VBY61	BRONZE BALL VALVE, SCREWED, 150 PSI D.I. BUTTERFLY, TAPPED LUG TYPE BODY, BUNA N SEAT, GEAR OPERATED 10" AND OVER, 150 LB.
	THROTTLE	2" AND UNDER 2-1/2" TO 10" INCL.	VGL44 VGL65	BRONZE GLOBE, INSIDE-SCREW RISING STEM, SCREWED, 125 LB. SSP. C.I. GLOBE, IBBM. O.S.& Y., FLANGED 125 LB. ANSI B16.1 AND B16.10.
	CHECK	2" AND UNDER 2-1/2" TO 10" INCL.	VCH41 VCH65	BRONZE CHECK, SWING TYPE, SCREWED 125 LB. SSP. C.I. CHECK, WAFER TYPE, SPRING LOADED, RATED 125 LB. PSIG.
JOINT MAT'L.		FOR SCREWED JOINTS	JT11	CYL. - SEAL OR EQUAL.
GASKETS			G8	RED RUBBER, 1/2" THICK
BOLTS			B1 B15	MACHINE BOLTS WITH HEX NUTS A307 GR. B. CAP SCREWS, HEX HEAD A307 GR. B

NOTES:
1) USE ITEM FS012 AT CAST IRON VALVES AND EQUIPMENT.
2) USE ITEM B15 WITH ITEM VBY61.
3) USE ITEM N16, C.S. A106 SCH. 80 NIPPLES AT INSTRUMENT CONNECTIONS.

Piping Materials

STANDARD SPECIFICATION NO. P1.6

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 150 PSIG @ 350 DEG. F

CONSTRUCTION: 2" AND UNDER - SOCKETWELD; 2-1/2" AND OVER - FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1-1/2" AND UNDER 2" TO 10" INCL.	P114 P15	C.S., A106 GR. A OR B SEAMLESS X-STRONG C.S., A53 TYPE S OR E, SCH. 40
FITTINGS		2" AND UNDER 2-1/2" TO 10" INCL.	FTG17 FTG11	F.S., A105 SOCKETWELD, 3000 LB. WOG C.S., BUTT WELD, SCH. 40
UNIONS & FLANGES		2" AND UNDER 2-1/2" TO 10" INCL.	UN13 FS011	F.S., A105 SOCKETWELD UNION, 3000 LB WOG C.S., 150 LB., SLIP-ON ANSI B16.5 R.F.
VALVES	SHUT-OFF	2" AND UNDER 2-1/2" TO 6" INCL.	VPL124 VPL616	C.S. NON-LUBRICATED PLUG, WRENCH OPERATED, SOCKETWELD 150 LB. RATING D.I. NON-LUBRICATED PLUG, WRENCH OPERATED 3" AND SMALLER, GEAR OPERATED 4" AND LARGER, FLANGED 150 LB, ANSI B16.5 AND B16.10.
	THROTTLE	2" AND UNDER	VGL14	F.S. GLOBE, INSIDE-SCREW RISING STEM, SOCKETWELD, 600 LB.
	CHECK			
JOINT MAT'L.		FOR SCREWED JOINTS	JT11	CYL. - SEAL OR EQUAL
GASKETS			G1	COMPRESSED WHITE ASBESTOS, 1/16" THICK
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS A307 GR. B

NOTES:
1) USE ITEM N16 C.S. A106 SCH. 80 NIPPLES, AT INSTRUMENT CONNECTIONS.
2) USE ITEM VNE11, F.S. NEEDLE VALVE, SCREWED, 600#, AT INSTRUMENT P.1.S.

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Piping Materials

STANDARD SPECIFICATION NO. P1.15

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 100 PSIG @ 120 DEG. F

CONSTRUCTION: 3/4" AND UNDER-SCREWED; 1"-1-1/2"- SOCKETWELD; 2" & OVER-FLANGED & WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		3/4" AND UNDER	P118	C.S., A106 GR. B SEAMLESS, X-STRONG
		1" TO 1-1/2" INCL.	P113	C.S., A106 GR. A OR B SEAMLESS SCH. 40
		2" TO 6" INCL.	P15	C.S., A53 TYPE S OR E, SCH. 40
FITTINGS		3/4" AND UNDER	FTG19	F.S., A105, SCREWED, 3000 LB. WOG
		1" TO 1-1/2" INCL.	FTG17	F.S., A105, SOCKETWELD, 3000 LB. WOG
		2" TO 6" INCL.	FTG11	C.S., BUTT WELD, SCH. 40
UNIONS & FLANGES		3/4" AND UNDER	UN12	F.S., A105 SCREWED UNION, 3000 LB. WOG
		1" TO 6" INCL.	FS011	C.S., SLIP-ON, 150 LB. ANSI B16.5 R.F.
VALVES	SHUT-OFF	3/4" AND UNDER	VPL615	D.I. NON-LUBRICATED PLUG, WRENCH OPERATED SCREWED, 150 LB. RATING
		1" TO 6" INCL.	VPL616	D.I. NON-LUBRICATED PLUG, WRENCH OPERATED 3" AND SMALLER GEAR OPERATED 4" AND LARGER, FLANGED 150 LB. ANSI B16.5 AND B16.10.
	THROTTLE			
	CHECK			
JOINT MAT'L.		FOR SCREWED JOINTS	JT12	TEFLON TAPE
GASKETS			G1	COMPRESSED WHITE ASBESTOS 1/16" THICK
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS A307 GR. B.
NEEDLE VALVE		3/4" AND UNDER @ INST. P1's	VNE11	C.S., A108 600# SCREWED

NOTES: 1) USE ITEM N12 C.S. A106 SCH. 80 NIPPLES, AT INSTRUMENT CONNECTIONS.

Piping Materials

STANDARD SPECIFICATION NO. P1.16

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 125 PSIG @ 150 DEG. F

CONSTRUCTION: 2" AND UNDER - SCREWED; 2-1/2" AND OVER - FLANGED AND COUPLED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		10" AND UNDER	P12	GALV. C.S. A120, SCH. 40
FITTINGS		2" AND UNDER 2-1/2" TO 10" INCL.	FTG620 FTG611	GALV. M.I. SCREWED, 300 LB SSP. GALV. M.I. VICTAULIC GROOVED TYPE
UNIONS & FLANGES		2" AND UNDER 2-1/2" TO 10" INCL.	UN68 MC8	GALV. M.I. UNION SCREWED, 300 LB. SSP M.I. STYLE 77 VICTAULIC COUPLING
VALVES	SHUT-OFF	2" AND UNDER 2-1/2" TO 10" INCL.	VGA41 VGA62	BRONZE GATE, INSIDE-SCREW, RISING STEM, SCREWED 125 LB. SSP. C.I. GATE, IBBM, O.S. & Y., FLANGED 125 LB. ANSI B16.1.
	THROTTLE			
	CHECK			
JOINT MAT'L.		FOR SCREWED JOINTS	JT11	CYL-SEAL OR EQUAL.
GASKETS			G8	RED RUBBER, 1/8" THICK
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS A307 GR. B.

NOTES: 1) USE ITEM N19, GALV. A120 SCH. 80 NIPPLES, AT INSTRUMENT CONNECTIONS.

TR CST DR
STS SSS SFW
SP CTC
SR

Piping Materials

STANDARD SPECIFICATION NO. P1.20

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 100 PSIG @ 200 DEG. F

CONSTRUCTION: 2" AND UNDER - SCREWED; 2-1/2" AND OVER - FLANGED AND WELDED.

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1-1/2" AND UNDER 2" SIZE 2-1/2" TO 10" INCL.	P114 P16 P15	C.S. A106 GR. A OR B, SEAMLESS, SCH. 80 C.S. A53 TYPE S OR E, SCH. 80 C.S. A53 TYPE S OR E, SCH. 40
FITTINGS		2" AND UNDER 2-1/2" TO 10" INCL.	FTG617 FTG11	M.I. SCREWED, 300# SSP. C.S. BUTT WELD, SCH. 40
UNIONS & FLANGES		2" AND UNDER 2-1/2" TO 10" INCL.	UN63 FS011 FS012	M.I. SCREWED UNION, 300# SSP. C.S., 150 LB. SLIP-ON, ANSI B16.5 R.F. C.S., 150 LB. SLIP-ON, ANSI B16.5 F.F.
VALVES	SHUT-OFF	2" AND UNDER 2-1/2" TO 10" INCL.	VGA61 VGA63	C.I. GATE VALVE, ALL IRON TRIM, CLAMP BONNET, WEDGE DISC, 150# SWP. C.I. GATE VALVE, ALL IRON TRIM, WEDGE DISC, O.S. & Y., FLANGED 125#.
	THROTTLE	2" AND UNDER 2-1/2" TO 6" INCL.	VGL610 VGL64	C.I. GLOBE VALVE, ALL IRON TRIM UNION BONNET, SCREWED, 150# SWP. C.I. GLOBE VALVE, ALL IRON TRIM, PLUG DISC, O.S. & Y., FLANGED 125#.
	CHECK	2" AND UNDER 2-1/2" TO 10" INCL.	VCH615 VCH64	C.I. CHECK VALVE, ALL IRON TRIM, SWING TYPE, SCREWED, 125# SWP. C.I. CHECK VALVE, ALL IRON TRIM, SWING TYPE, FLANGED 125#.
JOINT MAT'L. GASKETS BOLTS				

NOTES:

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VAC - VACUUM
CG-(DRY)

Piping Materials

STANDARD SPECIFICATION NO. P1.21

REV.

FULL VACUUM @ 300 DEG. F.

PRESSURE AND TEMPERATURE LIMITATIONS: 150 PSIG @ 200 DEG. F

CONSTRUCTION: 2" AND UNDER - SCREWED; 2-1/2" AND OVER - FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1-1/2" AND UNDER 2" SIZE 2-1/2" TO 10" INCL.	P114 P16 P15	C.S., A106 GR. A OR B SEAMLESS SCH. 80. C.S., A53 TYPE S OR E, SCH. 80. C.S., A53 TYPE S OR E, SCH. 40
FITTINGS		2" AND UNDER 2-1/2" TO 10" INCL.	FTG617 FTG11	M.I. SCREWED, 300 LB. SSP C.S., BUTT WELD, SCH. 40
UNIONS & FLANGES		2" AND UNDER 2-1/2" TO 10" INCL.	UN63 FS011 FS012	M.I. SCREWED UNION, 300 LB. SSP C.S., 150 LB., SLIP-ON ANSI B16.5 R.F. C.S., 150 LB., SLIP-ON ANSI B16.5 F.F.
VALVES	SHUT-OFF	2" AND UNDER 2-1/2" TO 6" INCL.	VPL615 VPL616	D.I. NON-LUBRICATED PLUG, WRENCH OPERATED, SCREWED 150 LB. RATING D.I. NON-LUBRICATED PLUG, WRENCH OPERATED 3" AND SMALLER, GEAR OPERATED 4" AND LARGER, FLANGED 150 LB. ANSI B16.5 AND B16.10.
	THROTTLE	2" AND UNDER	VGL61	M.I. GLOBE, INSIDE-SCREW RISING STEM, SCREWED 300 LB. SSP.
	CHECK	2" AND UNDER 2-1/2" TO 6" INCL.	VCH61 VCH67	C.I. CHECK, BALL TYPE, SCREWED, 125 LB. SSP. C.I. CHECK, WAFER TYPE, SPRING LOADED, RATED 125#.
JOINT MAT'L.		FOR SCREWED JOINTS	JT11	CYL. - SEAL OR EQUAL
GASKETS			G1	COMPRESSED WHITE ASBESTOS, 1/16" THICK
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS A307 GR. B

NOTES: 1) USE ITEM N16, C.S. A106 SCH. 80 NIPPLES, AT INSTRUMENT CONNECTIONS.

FG

STANDARD SPECIFICATION NO. P1.22

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 5 PSIG @ 1400 DEG. F

CONSTRUCTION: 1-1/2" AND UNDER SOCKETWELD; 2" AND OVER FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE (SEE NOTE 2)		1/2" TO 1-1/2" INCL	P235	S.S. A312 TP304 SMLS., SCH. 40S.
		2" TO 16" INCL	P23	S.S. A312 TP304 SMLS., OR WLD., SCH. 10S.
		18" TO 24" INCL	P241	S.S. A312 TP304 SMLS., OR WLD., 0.250" WALL.
		30" AND 36" SIZES	P242	S.S. A312 TP304 SMLS., OR WLD., 0.312" WALL.
FITTINGS		1/2" TO 1-1/2" INCL	FTG262	S.S. A182 GR. F304, SOCKETWELD, 3000#.
		2" to 16" INCL	FTG25	S.S. A403 GR. WP304 BUTT WELD, SCH. 10S.
		18" TO 24" INCL	FTG259	S.S. A403 GR. WP304, BUTT WELD, 0.250" WALL.
		30" AND 36" SIZES	FTG263	S.S. A403 GR. WP304, BUTT WELD, 0.312" WALL.
UNIONS & FLANGES		1/2" TO 1-1/2" INCL	UN211	S.S. UNION A182 GR. F304 SOCKETWELD, 3000#.
		1/2" TO 1-1/2" INCL	FSW26	S.S. A182 GR. F304, SOCKETWELD 300# ANSI B16.5 RF
		2" TO 24" INCL	FSO22	S.S. A182 GR. F304, SLIP-ON, 300# ANSI B16.5 R.F.
		30" AND 36" SIZES	FSO220	S.S. A182 GR. F304, SLIP-ON 300# MSS-SP-44 DRILLING RATED 740# @ AMB. TEMP.
VALVES	GATE	3" TO 12" INCL	VGA261	CAST STAINLESS GATE A351 GR. CF8M, O.S. & Y., 300# RATED, BUTT WELD ENDS BORED SCH. 10S, GEAR OPERATED, WITH PURGE CONNECTIONS IN BODY AND BONNET.
	THROTTLE	2" AND UNDER	VGL229	FORGED STAINLESS STEEL GLOBE FOR HIGH TEMPERATURE SERVICE, A182 GR. F316, O.S. & Y., SOCKETWELD, RATED 500# @ 1500°F.
	CHECK			
JOINT MAT'L.				
GASKETS			G23	STAINLESS STEEL SPIRAL WOUND ASBESTOS FILLED, 3/16" THICK.
BOLTS			B19	STAINLESS STEEL STUD BOLTS WITH HEX NUTS, A193 GR. B8M (316) CLASS 1.

NOTES:
1) IN GENERAL, FLANGED JOINTS IN THIS SERVICE ARE TO BE USED ONLY WHERE NECESSARY FOR CONNECTIONS TO EQUIPMENT, CONTROL VALVES ETC.
2) PIPE WALLS INCLUDE A MINIMUM CORROSION ALLOWANCE OF 0.03".
3) USE ITEM N25 TP304 SCH. 80 NIPPLES AND ITEM VGL229 GLOBE VALVES AT INSTRUMENT CONNECTIONS.

Piping Materials

STANDARD SPECIFICATION NO. P1.23

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 100 PSIG @ 100 DEG. F

CONSTRUCTION: 3/4" AND UNDER-SCREWED; 1" AND OVER-FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1-1/2" AND UNDER 2" TO 4" INCL.	P114 P16	C.S., A106, GRADE B SEAMLESS, SCH. 80 C.S., A53 TYPE S OR E, SCH. 80
FITTINGS		3/4" AND UNDER 1" TO 4" INCL.	FTG19 FTG12	F.S., A105 SCREWED, 3000 LB. WOG C.S., BUTT WELD, SCH. 80
UNIONS & FLANGES		3/4" AND UNDER 1" TO 4" INCL.	UN12 FS011	F.S., A105 SCREWED UNION 3000 LB. WOG C.S., 150 LB. SLIP-ON ANSI B16.5 R.F.
VALVES	SHUT-OFF	3/4" AND UNDER 1" TO 4" INCL.	VPL615 VPL616	D.I. NON-LUBRICATED PLUG WRENCH OPERATED SCREWED, 150 LB. RATING D.I. NON-LUBRICATED PLUG, FLANGED 150 LB. ANSI B16.5 & B16.10 WRENCH OPERATED 3" & UNDER, GEAR OPERATED 4" AND LARGER
	THROTTLE			
	CHECK			
JOINT MAT'L.		FOR SCREWED JOINTS	JT12	TEFLON TAPE, SCOTCH #48
GASKETS			G4	COMPRESSED BLUE ASBESTOS, 1/16" THICK
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS A307 GR. B

NOTES: 1) USE ITEM N16 C.S. A106 SCH. 80, NIPPLES AT INSTRUMENT CONNECTIONS.

Piping Materials

STANDARD SPECIFICATION NO. P1.24

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 60 PSIG @ 325 DEG. F

CONSTRUCTION: FLANGED AND WELDED (JACKETED)

ITEM		SIZE	ITEM	DESCRIPTION
PIPE (SEE NOTE 1)		2" AND UNDER 3" TO 8" INCL.	P114 P15	C.S. A106 GR. A OR B SMLS, SCH. 80. C.S. A53 TYPE S OR E, SCH. 40.
FITTINGS		2" AND UNDER 3" TO 8" INCL.	FTG11 FTG12	C.S. BUTT WELD, SCH. 80. C.S. BUTT WELD, SCH. 40.
UNIONS & FLANGES (SEE NOTE 2)		8" AND UNDER	FS011	F.S. SLIP-ON, 150# ANSI B16.5 R.F.
VALVES	SHUT-OFF	3/4" TO 6" INCL.	VBL210	S.S. BALL, A351 GR. CF8M, JACKETED BODY, TEFLON SEATS AND SEALS, FLANGED 150# ANSI B16.5, FLANGE SIZE TO BE ONE SIZE LARGER THAN BODY.
	THROTTLE	3/4" TO 6" INCL.	VGL211	S.S. GLOBE, A351 GR. CF8M, JACKETED BODY O.S. & Y., FLANGED 150# ANSI B16.5 FLANGED SIZE TO BE ONE SIZE LARGER THAN BODY.
	CHECK	3/4" TO 6" INCL.	VCH210	S.S. CHECK, A351 GR. CF8M, JACKETED BODY, O.S. & Y., LIFT TYPE, FLANGED 150# ANSI B16.5, FLANGE SIZE TO BE ONE SIZE LARGER THAN BODY.
JOINT MAT'L.				
GASKETS			G1	COMPRESSED WHITE ASBESTOS, 1/16" THICK.
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS, A307 GR. B.

NOTES:

1) ALL PIPE SHALL BE JACKETED; JACKET/CORE SIZE COMBINATIONS TO BE AS FOLLOWS: 1-1/2" WITH 3/4", 2" WITH 1", 2-1/2" WITH 1-1/2", 3" WITH 2", 4" WITH 3", 6" WITH 4", AND 8" WITH 6". FITTINGS SHALL BE JACKETED TO MATCH PIPE.

2) FLANGES SHALL BE SLIP-ON REDUCING TYPE, NOMINAL SIZE SAME AS JACKET, REDUCED BORE TO MATCH CORE PIPE OR FITTING.

3) ALL FITTINGS SHALL BE JACKETED WITH LARGER SIZE FITTINGS; WHEREVER POSSIBLE, PIPING SHALL BE DESIGNED SUCH THAT PIPE AND FITTING JACKETS ARE CONTINUOUS. FLANGED JOINTS ARE TO BE AVOIDED AT FITTINGS UNLESS ABSOLUTELY NECESSARY.

SS
SCF

Piping Materials

STANDARD SPECIFICATION NO. P1.25

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 100 PSIG @ 130 DEG. F

CONSTRUCTION: 2" AND UNDER-SCREWED; 3" AND OVER-FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1-1/2" AND UNDER	P114	C.S., A106 GR. A OR B SEAMLESS, SCH. 80
		2" SIZE	P16	C.S. A53 TYPE S OR E, SCH. 80.
		3" TO 10" INCL.	P15	C.S. A53 TYPE S OR E, SCH. 40.
		12" SIZE	P17	C.S. A53 TYPE S OR E, 0.375" WALL.
FITTINGS		2" AND UNDER	FTG19	F.S. A105 SCREWED, 3000# WOG.
		3" TO 10" INCL.	FTG11	C.S. BUTT WELD, SCH. 40.
		12" SIZE	FTG13	C.S. BUTT WELD, 0.375" WALL.
UNIONS & FLANGES		2" AND UNDER	UN12	F.S. UNION, A105, SCREWED, 3000#
		3" TO 12" INCL.	FS011	F.S. SLIP-ON, 150#, ANSI B16.5 R.F.
			FS012	F.S. SLIP-ON, 150#, ANSI B16.5 F.F.
VALVES	SHUT-OFF	2" AND UNDER	VPL615	D.I. NON-LUBRICATED PLUG, A395, WRENCH OPERATED, SCREWED, 150# RATING.
		3" TO 12" INCL.	VPL616	D.I. NON-LUBRICATED PLUG, A395, WRENCH OPERATED 3" AND SMALLER, GEAR OPERATED 4" AND LARGER. FLANGED 150# ANSI B16.5.
	THROTTLE			
	CHECK			
JOINT MAT'L.		FOR SCREWED JOINTS	JT11	CYL-SEAL OR EQUAL.
GASKETS			G1	COMPRESSED WHITE ASBESTOS, 1/16" THICK.
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS A307 GR. B.

NOTES:
1) USE ITEM FS012 AT CAST IRON VALVES AND EQUIPMENT.
2) USE ITEM N16, A106 SCH. 80 NIPPLES AT INSTRUMENT CONNECTIONS.

Piping Materials

STANDARD SPECIFICATION NO. P1.26

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 150 PSIG @ 500 DEG. F

CONSTRUCTION: 1-1/2" AND UNDER-SOCKETWELD; 2" AND-FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1-1/2" AND UNDER 2" TO 10" INCL.	P118 P19	C.S. A106 GR. B SMLS., SCH. 80. C.S. A53, GR. B SMLS, SCH. 40.
FITTINGS		1-1/2" AND UNDER 2" TO 10" INCL.	FTG17 FTG11	F.S. A105 SOCKETWELD, 3000#. C.S. BUTT WELD, SCH. 40.
UNIONS & FLANGES		1-1/2" AND UNDER 2" TO 10" INCL.	UN13 FWN146	F.S. SOCKETWELD, 3000# WOG B16.5 R.F. F.S. WELD NECK, A105, 150# ANSI B16.5 R.F., BORED SCH. 40.
VALVES	SHUT-OFF	2" AND UNDER 2-1/2" TO 10" INCL.	VGA142 VGA143	F.S. GATE, A105, O.S. & Y., SOCKETWELD, 800#. C.S. GATE A216 GR. WCB, O.S. & Y., FLANGED 150# ANSI B16.5 AND B16.10
	THROTTLE	2" AND UNDER 2-1/2" TO 6"	VGL144 VGL145	F.S. GLOBE, A105, O.S. & Y., SOCKETWELD, 800#. C.S. A216 GR. WCB. O.S. & Y., FLANGED 150# ANSI B16.5 AND B16.10.
	CHECK	2" AND UNDER 2-1/2" TO 10" INCL.	VCH148 VCH151	F.S. CHECK, A105, SPRING LOADED PISTON TYPE, SOCKETWELD, 600#. C.S. CHECK, A216 GR. WCB, SWING TYPE, FLANGED 150# ANSI B16.5 AND B16.10.
JOINT MAT'L.		FOR SCREWED JOINTS	JT11	CYL-SEAL OR EQUAL
GASKETS			G1	COMPRESSED WHITE ASBESTOS, 1/16" THICK.
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS A307 GR. B.

NOTES: 1) USE ITEM N16 A106 SCH. 80 NIPPLES AT INSTRUMENT CONNECTIONS.

CGW (WET) COA
WCG FA

Piping Materials

STANDARD SPECIFICATION NO. P1.28

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 50 PSIG @ 100 DEG. F

CONSTRUCTION: 1-1/2" AND UNDER-SCREWED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1/2" TO 1-1/2" INCL.	P810	CPVC, TYPE IV GRADE 1 SCH. 80
FITTINGS		1/2" TO 1-1/2" INCL.	FTG84	CPVC, TYPE IV GRADE 1, SCREWED, SCH. 80
UNIONS & FLANGES		1/2" TO 1-1/2" INCL.	UN81	CPVC UNION, TYPE IV GRADE 1, SCREWED, SCH. 80
VALVES	SHUT-OFF	1/2" TO 1-1/2" INCL.	VBL87	CPVC BALL VALVE, SCREWED, 150 PSI
	THROTTLE			
	CHECK	1/2" TO 1-1/2"	VCH83	CPVC BALL CHECK, SCREWED, 100 PSI
JOINT MAT'L. GASKETS BOLTS		FOR SCREWED JOINTS	JT12	TEFLON TAPE

NOTES:

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CS GCP FLG
GQ ESP LBG

Piping Materials

STANDARD SPECIFICATION NO. P1.29

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 150 PSIG @ 200 DEG. F

CONSTRUCTION: 1" AND UNDER - SCREWED; 1-1/2" TO 4" FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1" AND UNDER	P210	S.S., A312 TP 316, SEAMLESS OR WELDED, SCH. 40
		1-1/2" TO 4" INCL.	P212	S.S., A312 TP 316L, SEAMLESS OR WELDED, SCH. 10S.
FITTINGS		1" AND UNDER	FTG221	S.S., A182 GR. F316 SCREWED, 150 LB. SSP.
		1-1/2" TO 4" INCL	FTG214	S.S., A403 GR. 316L, BUTT WELD, SCH. 10S.
UNIONS & FLANGES		1" AND UNDER	UN23	S.S., UNION GR. A403 316, SCREWED, 150 LB. SSP
		1-1/2" TO 4" INCL	FS0210	S.S., 150 LB. SLIP-ON, A182 F316L, ANSI B16.5 R.F.
VALVES	SHUT-OFF	1" AND UNDER	VPL21	S.S., PLUG A351 GR. CF8M (316), SCREWED, 150 LB
		1-1/2" TO 3" INCL	VPL22	S.S., PLUG A351 GR. CF8M (316), FLANGED, 150 LB ANSI B16.5 AND B16.10.
	THROTTLE	1" AND UNDER	VGL21	S.S. GLOBE, A351 GR. CF8M (316), RISING STEM, SCREWED, 200 LB. AT 500°F.
		1-1/2" TO 4" INCL	VGL26	S.S., GLOBE, A351 GR. CF8M (316), RISING STEM, FLANGED 150 LB AND B16.5 AND B16.10.
	CHECK	1" AND UNDER	VCH21	S.S., CHECK A351 GR. CF8M (316), SWING TYPE, SCREWED, 150 LB. SSP.
		1-1/2" TO 4" INCL	VCH23	S.S., CHECK, A351 GR. CF8M (316), SWING TYPE, FLANGED 150 LB, ANSI B16.5 AND B16.10.
JOINT MAT'L.		FOR SCREWED JOINTS	JT12	TEFLON TAPE
GASKETS			G1	COMPRESSED WHITE ASBESTOS 1/16" THICK
BOLTS			B1	MACHINE BOLTS WITH HEX NUTS A307, GR. B.

NOTES: 1) USE ITEM N23, S.S. SCH. 40 NIPPLES, AT INSTRUMENT CONNECTION.

Piping Materials

STANDARD SPECIFICATION NO. P1.30

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 150 PSIG @ AMB DEG. F

CONSTRUCTION: ALL SIZES - FLANGED (NOTES 1 & 2)

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1" TO 3" INCL.	P77	C.S., SCH. 40 POLYPROPYLENE LINED F492 WITH 150# D.I. LAP JOINT FLANGE EACH END.
FITTINGS		1" TO 3" INCL.	FTG76	D.I. POLYPROPYLENE LINED F492 FLANGED 150#.
UNIONS & FLANGES				
VALVES	SHUT-OFF	1" TO 3" INCL.	VPL73	D.I. NON-LUB PLUG VALVE, POLYPROPYLENE LINED BODY AND PLUG, WRENCH OPERATED, FLANGED 150#.
VALVES	THROTTLE			
VALVES	CHECK	1" TO 3" INCL.	VCH74	C.I. CHECK VALVE, BALL TYPE, POLYPROPYLENE LINED, FLANGED 125#.
JOINT MAT'L.				
GASKETS				
BOLTS		ALL SIZES	B3	ALLOY STEEL STUD BOLTS WITH HEX NUTS A193 GR. B7.

NOTES:
1) MINIMUM LINE SIZES TO BE 1".
2) THE USE OF SCREWED INSTRUMENTS SHALL BE PROHIBITED.

BI
BR
CLS
PFB

Piping Materials

STANDARD SPECIFICATION NO. P1.31

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 125 PSIG @ 200 DEG. F

CONSTRUCTION: 2" AND UNDER-SCREWED; 2-1/2" AND OVER-FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		1-1/2" AND UNDER 2" SIZE 2-1/2" TO 10" INCL.	P114 P16 P15	C.S., A106 GR. A OR B, SEAMLESS, SCH. 80. C.S., A53 TYPE S OR E, SCH. 80. C.S., A53 TYPE S OR E, SCH. 40.
FITTINGS		2" AND UNDER 2-1/2" TO 10" INCL.	FTG617 FTG11	M.I. SCREWED, 300 LB. SSP. C.S., BUTT WELD, SCH. 40.
UNIONS & FLANGES		2" AND UNDER 2-1/2" TO 10" INCL.	UN63 FS011 FS012	M.I. SCREWED UNION, 300 LB, SSP. C.S., 150 LB, SLIP-ON, ANSI B16.5 R.F. C.S., 150 LB, SLIP-ON, ANSI B16.5 F.F.
VALVES	SHUT-OFF	2" AND UNDER 2-1/2" TO 10" INCL.	VPL610 VPL611	C.I. NON-LUBRICATED ECCENTRIC PLUG VALVE, WRENCH OPERATED, SCREWED, 175 LB. WOG C.I. NON-LUBRICATED ECCENTRIC PLUG VALVE, WRENCH OPERATED, FLANGED 125 LB ANSI B16.1.
	THROTTLE			
	CHECK	2" AND UNDER 2-1/2" TO 10" INCL.	VCH615 VCH64	C.I. CHECK VALVE, ALL IRON TRIM, SWING TYPE, SCREWED 150 LB. SWP. C.I. CHECK VALVE, ALL IRON TRIM, SWING TYPE, FLANGED 125 LB.
JOINT MAT'L. GASKETS BOLTS				

NOTES:

Piping Materials

STANDARD SPECIFICATION NO. P1.32

REV.

PRESSURE AND TEMPERATURE LIMITATIONS: 150 PSIG @ 100 DEG. F

CONSTRUCTION: 2" AND OVER - FLANGED AND WELDED

ITEM		SIZE	ITEM	DESCRIPTION
PIPE		2" TO 10" INCL.	P150	C.S. A53 TYPE S OR E, SCH. 40 COATED AND WRAPPED
FITTINGS		2" TO 10" INCL.	FTG11	C.S. BUTT WELD, SCH. 40
UNIONS & FLANGES		2" TO 10" INCL.	FS012	C.S. 150 LB. SLIP-ON, ANSI B16.5 R.F.
VALVES	SHUT-OFF			
	THROTTLE			
	CHECK			
JOINT MAT'L. GASKETS BOLTS				

NOTES:

1) ALL COATING AND WRAPPING OF PIPING SHALL BE IN ACCORDANCE WITH AWWA C-203 SECTION A1.2.

1.0 SCOPE

1.1 Thermal insulation shall be provided on piping, vessels, ducts, and equipment in accordance with the Mechanical Flow Diagrams and the following specifications.

1.2 Insulation of building is not included in this specification.

2.0 PRIMARY INSULATING MATERIALS ARE IDENTIFIED AS FOLLOWS:

2.1 CLASS "A": Calcium Silicate ASTM G533 molded pipe insulation and segmental or flat block insulation (for service on piping and equipment, for temperatures of 1200 deg. F).

2.2 CLASS "B": Fiberglas ASTM C547 molded pipe insulation, 6 pcf density (for service on piping and circular equipment 30" diameter and under, for temperatures to 450 def. F).

2.3 CLASS "C": Fiberglas rigid board equipment insulation, 3 pcf density (for service on piping and circular equipment over 30" diameter and flat equipment, for temperatures to 450 deg. F).

3.0 JACKET AND FINISH MATERIALS ARE IDENTIFIED AS FOLLOWS:

3.1 CLASS "1": Aluminum jacket 0.010", corrugated, with integral moisture barrier (for service on Class "A" and "B" piping and circular equipment 30" diameter and under).

3.2 CLASS "2": Aluminum jacket 0.016", corrugated, with integral moisture barrier (for service on vessel shells and piping over 30" diameter).

3.3 CLASS "3": Weather coating, 1/8" dry film thickness, aluminum colored vinyl acrylic mastic reinforced with glass fabric (for service or Class "A", "B" and "C" pipe fittings and vessel heads).

4.0 GENERAL

4.1 Valves and flanges are to be insulated for lines in steam or traced services. Personnel protection for exposed hot valves and flanges is not required.

4.2 All banding shall be stainless steel.

4.3 Weatherproofing shall be applied at each junction of insulated and uninsulated surfaces. All aluminum shall be sealed with a weather and heat resisting coating.

5.0 INSULATION FOR PERSONNEL PROTECTION

Insulation for protection of personnel against burns of bodily contact with heated surfaces shall extend at least 7 feet above working level of operating floors, platforms and walkways.

6.0 THICKNESS SCHEDULE

6.1 CLASS "A" (CALCIUM SILICATE)

6.1.1 Piping

NOMINAL PIPE SIZE (INCHES)	PIPE SURFACE TEMPERATURE (DEG. F) 1200 INSULATION THICKNESS (INCHES)
1/2	2-1/2
3/4	2-1/2
1	3
1-1/2	3
2	3-1/2
3	3-1/2
4	4
6	4-1/2
8	5
10	5
12	5-1/2
14	5-1/2
16	6
18	6
20	6-1/2
24	6-1/2
30	7
36	7-1/2

6.1.2 Equipment

SURFACE TEMPERATURE (DEG. F)	INSULATION THICKNESS (INCHES)
1200	8

6.2 CLASS "B" (FIBERGLAS)

6.2.1 Piping

NOMINAL PIPE SIZES (INCHES)	PIPE SURFACE TEMPERATURE RANGE (DEG. F) 71 TO 250	251 TO 350	351 TO 450
	INSULATION THICKNESS (INCHES)		
1/2	1	1	1
3/4	1	1	1
1	1	1	1
1-1/2	1	1	1
2	1	1	1
3	1	1-1/2	1-1/2
4	1	1-1/2	1-1/2
6	1	1-1/2	1-1/2
8	1	1-1/2	2
10	1-1/2	1-1/2	2
12	1-1/2	1-1/2	2
14	1-1/2	1-1/2	2
16	1-1/2	2	2-1/2
18	1-1/2	2	2-1/2
20	1-1/2	2	2-1/2
24	1-1/2	2	2-1/2
30	2	2	2-1/2

6.3 CLASS "C" (FIBERGLAS)

6.3.1 Equipment

SURFACE TEMPERATURE RANGE (DEG. F)	INSULATION THICKNESS (INCHES)
70 to 150	1
151 to 250	1-1/2
251 to 350	2
351 to 450	2-1/2

6.2 Electrical

Appendix A - Electrical Motor List

1.0 GENERAL

This general specification contains information related to the preparation of electrical design documents for the subject project.

1.1 Design Methods

The electrical design for this project utilizes Dravo Engineers and Constructors design methods, calculation techniques and electrical symbols.

1.2 Codes and Standards

1.2.1 Codes: Design and installation will comply with the National Electrical Code (NEC), National Electrical Safety Code (NESC), National Fire Protection Association (NFPA) & Local Codes.

1.2.2 Standards: Where applicable, equipment and installation shall conform to the requirements of the American National Standards Institute (ANSI), National Electrical Manufacturers Association (NEMA), Occupational Safety and Health Act (OSHA) Insulated Power Cable Engineers Association (IPCEA), American Petroleum Institute (API), Institute of Electrical & Electronic Engineers (IEEE), and Underwriters' Laboratories, Inc. (UL) list of inspected equipment. (Where UL approved is not available, the material or equipment will conform to other recognized established standards).

1.3 Hazard Classification

For electrical hazard classification see the Hazard Specification C-10 which can be found in Section 6.6.

1.4 Voltage Levels

1.4.1 The incoming power line at 66 KV, 3 phase, 60 hertz shall be furnished and terminated at customer's pedestal mounted circuit switcher by Union-Light, Heat and Power Company (utility company). The utility company shall provide new metering for the Coal Gasification Plant.

1.4.2 Plant Power Utilization

Motors sized 250 HP thru 1000 HP shall be 4.16 KV, 3 phase, 60 hertz. Motors sized 1/4 HP thru 200 HP (Process) shall be 460 volt, 3 phase, 60 hertz unless otherwise noted. Motors sized 1/2 HP and below (non-process) shall be 120 volt, 1 phase, 60 hertz unless otherwise noted.

Indoor HID lighting shall be 277 volt, 1 phase, 60 hertz. Floodlighting and roadway lighting shall be 480 volt, 1 phase, 60 hertz. The lighting fixtures shall be fed from 480/277 volt, 3 phase, 60 hertz, 4 wire solidly grounded neutral lighting panels located at the various locations.

Motor control system shall be 120 volt, 1 phase, 60 hertz via separate control power transformer for each motor starter. Instrumentation system shall be 120 volt, 1 phase, 60 hertz fed from 208/120 volt, 3 phase, 60 hertz power panels.

1.5 66 KV Primary Sub-Station

One primary sub-station shall be furnished, rated 66 KV-4.16 KV and shall consist of an incoming line section with 1200 amps, unfused, out-door, air, pedestal mounted circuit switcher, 7500 KVA, oil filled, $55^{o}/65^{o}C$ temp. rise, 7% impedence, 66 KV-4.16 KV, 3 phase, 60 hertz Delta-Wye connected with resistance grounded neutral transformer. The protective relaying shall be provided as indicated on the master single line diagram (drawing # 2994-900-111 Rev. A). 125 VDC power source shall be provided for the circuit switcher.

1.6 Metalclad Switchgear

4.16 KV 3 phase, 60 hertz switchgear shall be located out-door and shall consist of an incoming line section with metering as shown on the master single line diagram, & four (4) 600 amps electrically operated fusible load break switches with ground fault protection assembled in NEMA-3R enclosure.

1.7 480 Volt Load Center Unit Substations

1.7.1 Two (2) unit substaions shall be furnished outdoors, rated 4.16 KV-480 volt and shall consist of the following major components assembled in NEMA 3R enclosure:

2000 KVA, oil filled, 5.75% impedance transformer, 4.16 KV-480 volt, 3 phase, 60 hertz, Delta-Wye connected, with solidly grounded neutral.

Metal-enclosed switchgear close coupled to the transformer, consisting of feeder breakers with solid-state protective devices and metering as shown on the Master-single line diagram. Each feeder breaker will have shunt trip operable from the corresponding motor control center.

1.8 4.16 KV Motor Control Centers

1.8.1 Medium voltage motor controllers shall be 4.16 KV, magnetic full voltage high interrupting capacity, units completely assembled and wired in rigid, free standing, NEMA Type I enclosures. The controllers shall be no more than two-high construction. Controllers shall be used to control motors 250 horsepower and larger and shall be located indoor.

1.9 480 Volt Motor Control Centers

1.9.1 Low voltage starters for 460 volt, 3 phase, 60 hertz induction motors shall be fusible switch combination type with 3 thermal overload devices and shall be for full-voltage starting. Starters shall be NEMA size one minimum and provided with individual 120 volt control power transformers with primary unfused and with secondary having one side fused and the other side grounded. Starters shall be front mounted and back-to-back mounted. The centers shall be free standing NEMA type 1A enclosures. Design shall be NEMA Class I with NEMA wiring type B. Horizontal main bus shall be copper rated 800 amps continuous and braced for 42000 amps RMS symmetrical short circuit current. The motor control centers shall also contain fusible switches for power feeders and relay sections as required.

1.10 Motors

1.10.1 Motors shall be as described in Mechanical Equipment Specification. See Appendix A for Electrical Motor List.

1.11 Lighting

1.11.1 Average maintained lighting levels shall be as follows:

Area	Footcandles	Maintenance Factor
Control Rm. (Process)	50	0.75
Control Rm. (Elect. Equip.)	30	0.75
Office & Change Hse.	50	0.75
Sulfur Bldg.	30	0.75
Gasifier Bldg.	30	0.75
Waste Water Treatment Bldg.	30	0.75
Coal Storage	10	0.75
General Yard Areas	1	0.75

1.11.2 Lighting fixtures for the process areas shall be high pressure sodium vapor with integral ballast. The lighting fixtures for the electrical equipment rooms, control rooms, offices and toilets shall be fluorescent. Outdoor area floods lighting at open coal pile area, gas quench, tar removal, sulfur removal area and out-door sub-station shall be high pressure sodium vapor fixtures controlled by photocell. Roadway lighting shall be provided at new 20 ft. concrete roadway and shall be high pressure sodium vapor fixtures controlled by photocell.

1.11.3 Egress lighting shall be provided by the rechargeable battery type industrial unit in the electrical equipment rooms, control room and office.

1.11.4 Power for 120 V, 1 phase lighting, receptacles and instrument systems shall be obtained from panelboards fed by wall and/or floor mounted dry type transformers located in various locations.

1.11.5 Exit sign with lighting fixture shall be provided as required.

1.12 Receptacles

1.12.1 120 volt convenience receptacles shall be provided in each office, toilet, laboratory, control room and equipment room.

In addition, receptacles shall be located in the process areas such that any point can be serviced by a 100 foot extension cord.

480 volt power receptacles shall be located in the process areas such that any point can be serviced by a 100 foot extension cord.

1.13 Control Locations

1.13.1 Motor control stations shall be located on the control panel in the control room as indicated on the engineering flow diagrams and locally near the motors. (Stop pushbutton shall be lock-out type.)

1.14 Grounding

1.14.1 Grounding system shall include grounding for buildings, equipment and electrical systems. Building grounding shall be via ground rods. The grounding conductor main loop shall be #4/0 AWG and tap conductor shall be #2 AWG. The grounding conductor shall be stranded, soft drawn, bare copper. The grounding resistance shall be 10 ohms or less. Underground connections shall be made by exothermic process.

1.14.2 Equipment grounding shall be accomplished by the conduit system and building steel. Compression type lugs shall be used for grounding electrical equipment.

1.14.3 The building grounding system shall be connected to the existing plant grounding system where applicable.

1.15 Wiring Methods

1.15.1 Wire and cable shall be installed in rigid galvanized steel conduit and/or galvanized steel cable trays. The exposed conduit shall be 3/4" minimum. Underground conduit shall be galvanized steel and 1" minimum encased in red dyed concrete.

1.15.2 4.16 KV feeder cable to sub-stations and medium voltage starters shall be three conductors with ground conductor, copper, shielded, EPR 133% insulation, interlocked aluminum armor and overall PVC jacket. 4.16 KV feeders to medium voltage motors shall be single conductors, copper, shielded, XLP insulation and overall jacket.

1.15.3 600 volt feeder and power cable shall have stranded copper conductor and be single conductor suitable for cable tray installation, type-TC and suitable for conduit installation, insulation type THWN. The minimum wire size shall be #12 AWG.

1.15.4 600 volt single conductor cable for miscellaneous power, lighting, control etc. shall be insulation type THWN. The minimum wire size shall be #12 AWG for power & lighting and #14 AWG for control. The lighting fixture wire shall be type SF-2.

1.15.5 Instrument cable shall be No. 16 AWG minimum, stranded copper 300 volt insulation and shielded twisted pairs as required. The instrument cable shall be installed in conduit.

1.16 Lightning Protection

1.16.1 Lightning protection shall consist of grounding necessary structural steel.

1.17 Power Factor Correction

1.17.1 Power factor correction capacitors shall be provided for 25 HP and larger size motors. The capacitors shall be connected at the starters. In addition, one 60 KVAR or smaller capacitors shall be provided for each motor control center and shall be connected to the MCC bus. The capacitors shall be installed in the electrical equipment room.

1.18 Aircraft Warning Lighting

1.18.1 Aircraft warning lighting will be furnished on two gasifier absorber columns.

1.19 Work Not Included

1.19.1 The following work denoted with an X is not included as a part of the feasibility study.

( ) roadway lighting

(X) communication system

(X) security system

(X) electric heat tracing system

(X) power factor correction except as noted in the Paragraph No. 6.2.17.1.

(X) cathodic protection

( ) aircraft warning lighting

(X) emergency power

(X) high resistance grounding system

APPENDIX A - ELECTRICAL MOTOR LIST

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	Remarks
Existing	Expander No. 1 Comb. Air Fan	20	460	2	Located in Exist. Insulation - Board Plant
Existing	Expander No. 2 Comb. Air Fan	20	460	2	Insulation Board Plant
Existing	Expander No. 3 Comb. Air Fan	20	460	2	Insulation Board Plant
Existing	Expander No. 4 Comb. Air Fan	20	460	2	Insulation Board Plant
Existing	Dryer Zone 1 Comb. Air Fan	60	460	2	Insulation Board Plant
Existing	Dryer Zone 2 Comb. Air Fan	60	460	2	Insulation Board Plant
Existing	Dryer Zone 3 Comb. Air Fan	60	460	2	Insulation Board Plant
33001-1C	Air Blower	50	460	1	Gasifier Building
33001-2C	Air Blower	50	460	1	Gasifier Building
33001-3C	Air Blower	50	460	3	Gasifier Building
33001-4C	Air Blower	50	460	3	Gasifier Building
33001-5C	Air Blower	50	460	3	Gasifier Building
33001-6C	Air Blower (Stand-By)	50	460	1	Gasifier Building
33001-1D	Gasifier #1 Grate Drive	1-1/2	460	1	Gasifier Building
33001-1E	Gasifier #1 Agitator Drive	3	460	1	Gasifier Building
33001-1F	Gasifier #1 Coal Valve Drive	2	460	1	Gasifier Building
33001-2D	Gasifier #2 Grate Drive	1-1/2	460	1	Gasifier Building

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	Remarks
33001-2E	Gasifier #2 Agitator Drive	3	460	1	Gasifier Building
33001-2F	Gasifier #2 Coal Valve Drive	2	460	1	Gasifier Building
33001-3D	Gasifier #3 Grate Drive	1-1/2	460	3	Gasifier Building
33001-3E	Gasifier #3 Agitator Drive	3	460	3	Gasifier Building
33001-3F	Gasifier #3 Coal Valve Drive	2	460	3	Gasifier Building
33001-4D	Gasifier #4 Grate Drive	1-1/2	460	3	Gasifier Building
33001-4E	Gasifier #4 Agitator Drive	3	460	3	Gasifier Building
33001-4F	Gasifier #4 Coal Valve Drive	2	460	3	Gasifier Building
33001-5D	Gasifier #5 Grate Drive	1-1/2	460	3	Gasifier Building
33001-5E	Gasifier #5 Agitator Drive	3	460	3	Gasifier Building
33001-5F	Gasifier #5 Coal Valve Drive	2	460	3	Gasifier Building
39001-1	2 Gasifier Slurry Mixer	10	460	6	Waste Water Building
39001-2	2 Gasifier Slurry Mixer	10	460	6	Waste Water Building
39002-1	3 Gasifier Slurry Mixer	10	460	6	Waste Water Building
39002-2	3 Gasifier Slurry Mixer	10	460	6	Waste Water Building
39003	Reagent Mixer	10	460	6	Waste Water Building
41001-1	Coal Receiving Sump Pump	2	460	1	Gas Quench & Tar Removal Area
41001-2	Coal Receiving Sump Pump (Stand-By)	2	460	1	Gas Quench & Tar Removal Area

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	Remarks
41002-1	Coal Reclaiming Sump Pump	1/2	460	1	Gasifier Building
41002-2	Coal Reclaiming Sump Pump (Stand-By)	1/2	460	1	Gasifier Building
41003-1	Tar Loading Pump	20	460	6	Waste Water Building
41003-2	Tar Loading Pump (Stand-by)	20	460	6	Waste Water Building
41004	2 Gasifier Recycle Pump	40	460	1	Gas Quench & Tar Removal Area
41005-1	3 Gasifier Recycle Pump	40	460	3	Gas Quench & Tar Removal Area
41005-2	3 Gasifier Recycle Pump (Stand-by)	40	460	3	Gas Quench & Tar Removal Area
41006-1	2 Gasifier Tar Pump	1	460	1	Gas Quench & Tar Removal Area
41006-2	2 Gasifier Tar Pump (Stand-by)	1	460	1	Gas Quench & Tar Removal Area
41007	3 Gasifier Tar Pump	1	460	3	Gas Quench & Tar Removal Area
41008-1	Gasifier Building Sump Pump	5	460	1	Gasifier Building
41008-2	Gasifier Building Sump Pump (Stand-by)	5	460	1	Gasifier Building
41018-1	2 Gasifier Liquor Pump	125	460	4	Sulfur Recovery
41018-2	2 Gasifier Liquor Pump (Stand-by)	125	460	4	Sulfur Recovery
41019-1	3 Gasifier Liquor Pump	200	460	5	Sulfur Recovery
41019-2	3 Gasifier Liquor Pump (Stand-by)	200	460	5	Sulfur Recovery
41020-1	Effluent Purge Pump	2	460	4	Sulfur Recovery
41020-2	Effluent Purge Pump (Stand-by)	2	460	4	Sulfur Recovery
41022-1	Reagent Pump	5	460	4	Sulfur Recovery
41022-2	Reagent Pump (Stand by)	5	460	4	Sulfur Recovery

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	Remarks
41024-1	2 Gasifier Slurry Pump	3/4	460	4	Sulfur Recovery
41024-2	2 Gasifier Slurry Pump (Stand-by)	3/4	460	4	Sulfur Recovery
41025-1	3 Gasifier Slurry Pump	3/4	460	5	Sulfur Recovery
41025-2	3 Gasifier Slurry Pump (Stand-by)	3/4	460	5	Sulfur Recovery
41030-1	2 Gasifier Filtrate Pump	3	460	4	Sulfur Recovery
41030-2	2 Gasifier Filtrate Pump (Stand-by)	3	460	4	Sulfur Recovery
41031-1	3 Gasifier Filtrate Pump	5	460	5	Sulfur Recovery
41031-2	3 Gasifier Filtrate Pump (Stand-by)	5	460	5	Sulfur Recovery
41032-1	2 Gasifier Wash Pump	3	460	4	Sulfur Recovery
41032-2	2 Gasifier Wash Pump (Stand-by)	3	460	4	Sulfur Recovery
41033-1	3 Gasifierier Wash Pump Pump (Stand-by)		460	5	Sulfur Recovery
41033-2	3 Gasifier Wash Pump (Stand-by)	5	460	5	Sulfur Recovery
41034-1	Liquid Sulfur Loading Pump	2	460	6	Waste Water Building
41034-2	Liquid Sulfur Loading Pump (Stand-by)	2	460	6	Waste Water Building
41035-1	Tar Separator Sump Pump	1/2	460	1	Gas Quench and Tar Removal Area
41035-2	Tar Separator Sump Pump (Stand-by)	1/2	460	1	Gas Quench and Tar Removal Area
41036-1	2 Gasifier Liquid Sulfur Transfer Pump	5	460	4	Sulfur Recovery
41036-2	2 Gasifier Liquid Sulfur Transfer Pump (Stand-by)	5	460	4	Sulfur Recovery
41037-1	3 Gasifier Liquid Sulfur Transfer Pump	5	460	5	Sulfur Recovery

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	Remarks
41037-2	3 Gasifier Liquid Sulfur Transfer Pump (Stand-by)	5	460	5	Sulfur Recovery
41038-1	2 Gasifier Equipment Cooling Water Pump	300	4160	MVS-3	Waste Water Building
41038-2	2 Gasifier Equipment Cooling Water Pump (Stand-by)	300	4160	MVS-3	Waste Water Building
41039	3 Gasifier Equipment Cooling Water Pump	300	4160	MVS-4	Waste Water Building
41040-1	Condensate Pump	3	460	6	Waste Water Building
41040-2	Condensate Pump (Stand-by)	3	460	6	Waste Water Building
41041-1	Boiler Feed Water Pump	15	460	6	Waste Water Building
41041-2	Boiler Feed Water Pump (Stand-by)	15	460	6	Waste Water Building
41042-1	Chlorinator Water Booster Pump - 1	15	460	6	Cooling Tower
41042-2	Chlorinator Water Booster Pump - 2	15	460	6	Cooling Tower
41043-1	Carbon Absorber Feed Pump - 1	15	460	7	Waste Water Bldg.
41043-2	Carbon Absorber Feed Pump - 2	15	460	7	Waste Water Bldg.
41044-1	Spent Water Disposal Pump - 1	5	460	7	Waste Water Bldg.
41044-2	Spent Water Disposal Pump - 2	5	460	7	Waste Water Bldg.
41045-1	Boiler Make-Up Water Pump - 1	5	460	7	Waste Water Bldg.
41045-2	Boiler Make-Up Water Pump - 2	5	460	7	Waste Water Bldg.
41046-1	Cooling Water Make-Up Pump - 1	15	460	7	Waste Water Bldg.
41046-2	Cooling Water Make-Up Pump - 2	15	460	7	Waste Water Bldg.

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	Remarks
41047-1	Cooling Water Acid Pump - 1	1	460	7	Waste Water Bldg.
41047-2	Cooling Water Acid Pump - 2	1	460	7	Waste Water Bldg.
41048-1	Boiler Water Acid Pump - 1	1	460	7	Waste Water Bldg.
41048-2	Boiler Water Acid Pump - 2	1	460	7	Waste Water Bldg.
41049-1	Caustic Metering Pump - 1	1	460	7	Waste Water Bldg.
41049-2	Caustic Metering Pump - 2	1	460	7	Waste Water Bldg.
41050-1	Centrifuge Feed Pump - 1	1	460	7	Waste Water Bldg.
41050-2	Centrifuge Feed Pump - 2	1	460	7	Waste Water Bldg.
41051-1	Dilution Recycle Pump - 1	5	460	7	Waste Water Bldg.
41051-2	Dilution Recycle Pump - 2	5	460	7	Waste Water Bldg.
41052-1	Bio Sludge Pump - 1	1	460	7	Waste Water Bldg.
41052-2	Bio Sludge Pump - 2	1	460	7	Waste Water Bldg.
41055-1	Aerobic Digester Feed Pump - 1	1	460	7	Waste Water Bldg.
41055-2	Aerobic Digester Feed Pump - 2	1	460	7	Waste Water Bldg.
41056-1	Phospheric Acid Feed Pump - 1	1	460	7	Waste Water Bldg.
41056-2	Phospheric Acid Feed Pump - 2	1	460	7	Waste Water Bldg.
41058-1	Emergency Storage Pump - 1	5	460	7	Waste Water Bldg.
41058-2	Emergency Storage Pump - 2	5	460	7	Waste Water Bldg.
41059-1	Coal Pile Run Off Acid Pump - 1	1	460	7	Waste Water Bldg.

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	REMARKS
41059-2	Coal Pile Run Off Acid Pump - 2	1	460	7	Waste Water Bldg.
41060-1	Aeration Feed Tank Pump - 1	1	460	7	Waste Water Bldg.
42012-1	2 Gasifier Vacuum Pump	25	460	4	Sulfur Recovery
42012-2	2 Gasifier Vacuum Pump (Stand-by)	25	460	4	Sulfur Recovery
42013-1	3 Gasifier Vacuum Pump	40	460	5	Sulfur Recovery
42013-2	3 Gasifier Vacuum Pump (Stand-by)	40	460	5	Sulfur Recovery
41060-2	Aeration Feed Tank Pump - 2	1	460	7	Waste Water Bldg.
41061-1	Biosludge Press Feed Pump - 1	1	460	7	Waste Water Bldg.
41061-2	Biosludge Press Feed Pump - 2	1	460	7	Waste Water Bldg.
41062	Waste Water Acid Pump	1	460	7	Waste Water Bldg.
41063-1	Filter Back Wash Water Pump - 1	5	460	7	Waste Water Bldg.
41063-2	Filter Back Wash Water Pump - 2	5	460	7	Waste Water Bldg.
42004	2 Gasifiers ESP Compressor	350	4160	MVS-1	Gas Quench & Tar Removal Area
42005	3 Gasifiers ESP Compressor	500	4160	MVS-2	Gas Quench & Tar Removal Area
42006	2 Gasifiers System Compressor	700	4160	MVS-1	Gas Quench & Tar Removal Area
42007	3 Gasifiers System Compressor	1000	4160	MVS-2	Gas Quench & Tar Removal Area
42008-1	2 Gasifier Air Blower	150	460	4	Sulfur Recovery
42008-2	2 Gasifier Air Blower (Stand-by)	150	460	4	Sulfur Recovery
42009-1	3 Gasifier Air Blower	200	460	5	Sulfur Recovery

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	REMARKS
42009-2	3 Gasifier Air Blower (Stand-by)	200	460	5	Sulfur Recovery
42014	Plant Air Compressor	125	460	6	Waste Water Bldg.
42015	Instrument Air Compressor	125	460	6	Waste Water Bldg.
42016-1	Aeration Blower - 1	150	460	7	Waste Water Bldg.
42016-2	Aeration Blower - 2	150	460	7	Waste Water Bldg.
43003	Vibrating Discharger	2	460	1	All in Open Coal
43004	Knife Gate	-	120	-	Pile Area Open Coal
43005	Vibrating Feeder	1	460	1	Pile Area Open Coal
43006	Coal Reclaim Conveyor	3	460	1	Pile Area Open Coal
43007	Coal Distribution Bucket Elevator	10	460	1	Outside Gasifier Building
43008	Coal Distribution Conveyor	20	460	1	Outside Gasifier Building
44003-1	2 Gasifier Equipment Water Cooling Tower	75	460	6	2 Speed Rev. Cooling Tower
44003-2	3 Gasifier Equipment Water Cooling Tower	75	460	6	2 Speed Rev. Cooling Tower
45002	2 Gasifier Electro-Static Precipitator	100KW	480	1	Gas Quench & Tar Removal Area
45003	3 Gasifier Electro-Static Precipitator	100KW	480	3	Gas Quench & Tar Removal Area
45018	2 Gasifier Sulfur Filter	2	460	4	Sulfur Recovery
45019	3 Gasifier Sulfur Filter	2	460	5	Sulfur Recovery
45020-1	Raw Water Carbon Absorber	-	120	FOR CONTROL PANEL	Waste Water Bldg.
45020-2	Raw Water Carbon	-	120	FOR CONTROL PANEL	Waste Water Bldg.

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	REMARKS
45022	Primary Sludge Centrifuge	20	460	7	Waste Water Bldg.
45023-1	Biosludge Clarifier - 1	1-1/2	460	7	Waste Water Bldg.
45023-2	Biosludge Clarifier - 2	1-1/2	460	7	Waste Water Bldg.
45024-1, 2	Pressure Filters	-	120	FOR CONTROL PANEL	Waste Water Bldg.
45025-1, 2	Pressure Filters	-	120	FOR CONTROL PANEL	Waste Water Bldg.
45026	Digestor Aerator	100	460	7	Waste Water Bldg.
45027	Biosludge Press	5	460	7	Need 120 V, 1 Ph. For Control Panel Waste Water Bldg.
47003A	Reductive Incineration Sys.	30	460	6	Incinerator
47003B	Reductive Incineration Sys. Control Panel	-	120	6	Incinerator
47003E	Reductive Incineration System Circulation Pump	5	460	6	47003C, D, E, F Non-Electric
47003G	Reductive Incineration System - Recirculation Pump	5	460	6	Incinerator
47004	Boiler	40	460	6	Boiler Package has 120V Control Panel
47005C	Boiler Feed Water Treatment Plant	3/4	460	6	Boiler
47005D	Boiler Feed Water Treatment Plant	3/4	460	6	Boiler
47005E	Boiler Feed Water Treatment Plant	1	460	6	Boiler
47005F	Boiler Feed Water Treatment Plant	1	460	6	Boiler

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	REMARKS
47008	Deaerator	-	-	-	120V for Solenoid Valve
47009	Cation Exchanger	-	120	FOR CONTROL PANEL	Waste Water Bldg.
47010-1	Primary Sludge Conditioning System Agitator	3/4	460	7	Waste Water Bldg.
47010-2	Pump - 1	1	460	7	Waste Water Bldg.
47010-3	Pump - 2	1	460	7	Waste Water Bldg.
47011-1	Biosludge Thickener Float Scraper	1	460	7	Waste Water Bldg.
47011-2	Sludge Scraper	1	460	7	Waste Water Bldg.
47011-3	Electrodes	24KW	480	7	Waste Water Bldg.
47012-1	Tube Setler Feed Conditioning System Agitator	3/4	460	7	Waste Water Bldg.
47012-2	Pump - 1	1	460	7	Waste Water Bldg.
47012-3	Pump - 2	1	460	7	Waste Water Bldg.
47013-1	Coagulant Aid System Agitator	3/4	460	7	Waste Water Bldg.
47013-2	Pump - 1	1	460	7	Waste Water Bldg.
47013-3	Pump - 2	1	460	7	Waste Water Bldg.
47014-1	Filter Aid System Agitator	3/4	460	7	Waste Water Bldg.
47014-2	Pump - 1	1	460	7	Waste Water Bldg.
47014-3	Pump - 2	1	460	7	Waste Water Bldg.
47015-1	Biosludge Condition-ing System - Agitator	3/4	460	7	Waste Water Bldg.
47015-2	Pump - 1	1	460	7	Waste Water Bldg.
47015-3	Pump - 2	1	460	7	Waste Water Bldg.
48001	Weigh Scale	-	120	-	At Weigh Scale - House

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	REMARKS
48002	Weigh Belt	-	120	-	At Weigh Scale - House
48005-1	Flame Front Generator	-	120	PP	Gasifier Building
48005-2	Flame Front Generator	-	120	PP	Gasifier Building
48005-3	Flame Front Generator	-	120	PP	Gasifier Building
48005-4	Flame Front Generator	-	120	PP	Gasifier Building
48005-5	Flame Front Generator	-	120	PP	Gasifier Building
48008	Cooling Tower Chlor-inator	-	120	PP	Gasifier Building
50001	Dust Collector Exhaust Fan	15	460	1	Gasifier Building
50002	Dust Collector	1/2	120	PP	Gasifier Building
50003	Bag House - Exhaust Fan	15	460	1	Gasifier Building
50004	Bag House	1/2	120	PP	Gasifier Building
51053-1	Pressure Filter Feed Pump - 1	1	460	7	Waste Water Bldg.
51053-2	Pressure Filter Feed Pump - 2	1	460	7	Waste Water Bldg.
51101	Gasifier Building Make-Up Air Unit	5	460	1	Gasifier Building
51102	Sulfur Building Make-Up Air Unit	5	460	4	Sulfur Building
51103	Gasifier Building Elect. Room H & V Unit	3/4	460	1	Gasifier Building
51104	Gasifier Building Control Rm. A/C Unit Condenser (3.2KW)	1/2	240	PP	Gasifier Building
51105	Gasifier Building H & V Rm. Unit Heater	1/25	120	PP	Gasifier Building
51106	Change House Make-Up Air Unit	1	460	4	Change House
51106-1	Sulfur Recovery Unit Heater	1/20	120	PP	Sulfur Building

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	REMARKS
51106-2	Sulfur Recovery Unit Heater	1/20	120	PP	Sulfur Building
51106-3	Sulfur Recovery Unit Heater	1/20	120	PP	Sulfur Building
51106-4	Sulfur Recovery Unit Heater	1/20	120	PP	Sulfur Building
51106-5	Sulfur Recovery Unit Heater	1/20	120	PP	Sulfur Building
51106-6	Sulfur Recovery Unit Heater	1/20	120	PP	Sulfur Building
51108	Change House A/C Unit	5.2KW	240	PP	Sup. Office Change House
51109	Change House A/C Unit	3.6KW	240	PP	Receptionist Change House
51110	Coal Tunnel H & V Unit	1	460	1	Gasifier Building
51111-1	Waste Water Building Unit Heater	1/20	120	-	Waste Water Building
51111-2	Waste Water Building Unit Heater	1/20	120	-	Waste Water Building
51113	Make-Up Air Unit Elect. Room-Waste Water Building	3	460	7	Waste Water Building
51201	Change House Base-board Heater	1250 Watts	240 1-Ph	PP	Pipe Chase Change House
51202	Change House Base-board Heater	1250 Watts	240 1-Ph	PP	Pipe Chase Change House
51203	Change House Base-board Heater	1250 Watts	240 1-Ph	PP	Pipe Chase Change House
51204	Gasifier Building Unit Heater	16KW	480 3-Ph	1	Stairwell - West 1st Fl. Gasifier Building
51205	Gasifier Building Unit Heater	12KW	480 3-Ph	1	Stairwell - East 1st Fl. Gasifier Building
51500	Toilet Room Exhaust Fan	1/80	120	PP	Gasifier Building

ITEM NO.	DESCRIPTION	H.P.	VOLTS	MCC NO.	REMARKS
51501	Gasifier Building Supply Air Fan	7-1/2	460	1	Gasifier Building
51502	Sulfur Building Wall Fan	1/4	120	PP	Sulfur Building
51503	Sulfur Building Wall Fan	1/4	120	PP	Sulfur Building
51504	Sulfur Building Exhaust Fan	3/4	460	4	Sulfur Building
51505	Waste Water Building Exhast Fan	1/4	120	PP	Waste Water Building
51603	Change House Exhaust Fan	1/4	120	PP	Change House
51604	Change House Exhaust Fan	1/4	120	PP	Change House
51606-1	Sulfur Building Roof Vent.	3/4	460	4	Sulfur Building
51606-2	Sulfur Building Roof Vent.	3/4	460	4	Sulfur Building
51607-1	Sulfur Building Roof Vent.	3/4	460	5	Sulfur Building
51607-2	Sulfur Building Roof Vent.	3/4	460	5	Sulfur Building
51608	Waste Water Building Roof Vent.	1	460	6	Waste Water Building
51609	Waste Water Building Roof Vent.	1/4	120	PP	Waste Water Building

6.3 Civil and Architectural

1.0 GENERAL

This General Specification contains information related to the preparation of the Civil and Architectural Design Documents for the subject project.

2.0 DESIGN METHODS

All work will be performed in accordance with Dravo Engineers and Constructors' Standards.

3.0 DESIGN DATA

The following soils data has been assumed for this report and will have to be verified by conducting a soils investigation:

Bearing Value: 4000 psf at a depth of 2-1/2 feet
Active Lateral Soil Pressure: 30 pcf liquid equivalent
Water Table: 10 feet below grade

4.0 GEOGRAPHIC DATA

A maximum frost penetration of 20 inches is applicable for this plant site as determined from U.S. Dept. of Commerce weather charts. The Kentucky Building Code dictates a 15 psf ground snow load and an 80 mph basic wind speed be used in design considerations both based on a 50 year mean recurrence interval. The following wind pressures (qF) are to be considered in the design of ordinary buildings and structures:

Height Zone (Feet)	Wind Pressure (qF) (psf)
0-30	10
30-40	14
40-75	15

A maximum rainfall intensity of 7 inches per hour for a 5 minute duration based on a 10 year frequency is applicable for this plant site as determined from U.S. Dept. of Commerce weather charts.

The Kentucky Building Code indicates that the plant site is in Seismic Risk Zone #1 in which the following should be considered:

Z = 0.25
I = 1.0
S = 1.5 site characteristic period

5.0 LIVE LOADS

Floors at grade shall be designed for a 500 psf uniform load except in the Gasifier Building the floor shall be designed for a 36,000 pound dumpster having a wheel load of 9,000 pounds.

Elevated floors shall be designed for a uniform load of 125 psf plus a pipe load of 15 psf and stairs, platforms and walkways designed for a uniform load of 100 psf.

Roofs shall be designed for a uniform load of 20 psf on the horizontal projection plus a pipe load of 10 psf.

6.0 DEAD LOADS

Dead loads are defined as the weight of the supporting structure including all elements of the floor or roof system.

7.0 EQUIPMENT LOADS

Equipment loads are defined as the greater of the operating, test or impact loads.

8.0 LOAD COMBINATIONS

A probability factor of one (1) shall be used for dead load only, dead load plus live load or dead load plus wind or earthquake load.

A probability factor of 0.75 shall be used for dead load plus live load plus wind or earthquake load.

9.0 MATERIALS OF CONSTRUCTION

Concrete design shall be based on American Concrete Association Manual AGI 318 and construction based on AGI 301 utilizing concrete for foundations and walls having a 3,000 psi strength at 28 days and concrete for all other elements having a 4,000 psi strength at 28 days. Concrete embedments shall consist of

ASTM A315, Grade 60 reinforcing bars; ASTM A185 welded wire fabric; ASTM A36 or AISI 1020 anchor bolts having a minimum yield of 30 KSI; ASTM A36 fabricated steel; ASTM A53, Grade "B" pipe sleeves and ribbed vinyl water stops with a center bulb.

Unexposed or below grade concrete shall be rough form finish. Exposed vertical concrete shall be smooth form finish. Horizontal surfaces of basins, sumps and curbs, roof decks and interior floors shall be trowel finished and liquid hardener applied on floors receiving no other surface treatment. Horizontal surfaces of equipment bases or pads, steps and exterior platforms shall be wood float finish.

10.0 STRUCTURAL STEEL

10.1 Structural and miscellaneous steel shall be designed fabricated and erected in accordance with the American Institute of Steel Construction's Manual of Steel Construction. Steel shall be in accordance with ASTM A36 with welded connections utilizing E70XX electrodes and major bolted connection's utilizing ASTM A325 bolts and minor bolted connections - i.e. handrails, toe plates, ladders, cages, purlins, girts, lintels, stairs and access platforms utilizing ASTM A307 bolts.

10.2 Handrails shall be bar and rod Dravo standard Type "G" conforming to OSHA requirements.

10.3 Grating shall be 1 x 3/16 inch plain steel bar Type W-19-4 conforming to the National Association of Architectural Metals Manufacturers Standards finished in manufacturer's standard black paint with galvanized clips to retain removable areas.

10.4 Enclosed stairs shall be steel framed with figured plate treads and plain plate risers open and access stairs shall be steel framed with grating treads with figured plate nosings.

11.0 CONCRETE MASONRY

Concrete masonry shall be smooth faced lightweight concrete units, fire rated where required, laid in running bond utilizing Type "M" or "S" mortar, as required and horizontally reinforced and joints concave tooled.

12.0 INSULATION

Insulation shall be rigid mineral board providing a minimum "K" of 0.36 on roof decks; water resistant expanded mineral in cores of concrete masonry walls and vinyl faced fiberglass blankets on interior of metal sheeted roofs and walls.

13.0 METAL FORM CENTERING AND ROOF DECKING

Metal form centering and roof decking shall be 1-1/2 inch nominal depth intermediate ribbed primed painted 18 gage minimum steel.

14.0 ROOF HATCHES

Roof hatches shall be manuafacturer's standard prefabricated prime painted steel units of size and type required.

15.0 SEALANTS

Sealants shall be a gun grade single component polyurethane.

16.0 ROOFING

Roofing shall be a smooth surface 3 ply built-up bitumen system.

17.0 COLD FLASHINGS

Cold flashings shall be 1/16 inch nominal thickness uncured neoprene and hot flashings shall be prefinished galvanized steel of gages required by girth.

18.0 FASCIAS, GUTTERS, SCUPPERS AND DOWNSPOUTS

Fascias, gutters, scuppers and downspouts shall be prefinished galvanized steel of gages required by girth and configuration.

19.0 METAL ROOF AND WALL SHEETING

Metal roof and wall sheeting shall be manufacturer's standard uniform ribbed panels of 24 minimum gage prefinished galvanized steel.

20.0 FRP SHEETING

FRP sheeting shall be a fiberglass reinforced polyester panel having an 8 ounce per square foot minimum weight and matching the configuration of the metal sheeting.

21.0 WALL LINERS

Wall liners shall be manufacturer's standard nominal one foot wide channel shaped panels of 24 minimum gage prefinished galvanized steel.

22.0 PRESSED METAL FRAMES

Pressed metal frames shall be combination type of 16 minimum gage steel.

23.0 HOLLOW METAL DOORS

Hollow metal doors shall be constructed of 16 minimum gage steel face sheets bonded to a paper honeycomb core and reinforced for hardware.

24.0 ROLLING SERVICE DOORS

Rolling service doors shall be constructed with an interlocking steel slat curtain with weatherstripping power operator and weather hood for outside mounting.

25.0 HARDWARE

25.1 Full mortice steel hinges prime painted with ball bearings where closers are required and plain bearings for all other applications.

25.2 Lock sets shall be mortise type of required function in dull bronze finish with 5 tumbler interchangeable core cylinder locks.

25.3 Latch sets shall be heavy duty cylindrical type in dull bronze finish.

25.4 Closers shall be narrow close projection type with parallel arms of sizes required.

25.5 Head and foot bolts shall be surface mounted japanned finished steel.

25.6 Weatherstripping shall be bulb type of solid vinyl.

25.7 Thresholds shall be saddle type of cast iron.

26.0 GLAZING IN DOORS

Glazing in doors shall be 1/4 inch tempered glass.

27.0 SUSPENDED CEILINGS

Suspended ceilings shall have an exposed painted steel grid with fissured mineral board lay-in acoustical panels.

28.0 VINYL COMPOSITION TILE

Vinyl composition tile shall be 1/8 inch thick in a marbelized pattern.

29.0 VINYL BASE

Vinyl base shall be a 4 inch high set-on type in a solid color.

30.0 CERAMIC TILE BASE

Ceramic tile base shall be a 6 inch high sanitary cove type in a solid colored matt glaze.

31.0 TOILET ROOM ACCESSORIES

31.1 Mirrors shall be 1/4 inch thick silver backed float glass in a stainless steel frame with an integral shelf.

31.2 Towel dispenser and receptacle shall be a stainless steel combination type for multifold paper towels designed for surface mounting.

31.3 Toilet tissue dispensers shall be single roll friction type of chrome plated cast alloy.

32.0 LABORATORY FURNITURE

Laboratory furniture shall be prefinished steel casework with resin rich tops.

33.0 LOCKERS

Lockers shall be nominal 12 x 15 x 72 inch flush panel ventilated units with sloping top designed for base mounting.

34.0 LOCKER ROOM BENCHES

Locker room benches shall be prefinished hardwood mounted on flanged steel pedestals.

35.0 PAINTING

35.1 Carbon steel building components and framing, vessels, equipment and piping is to receive a three coat alkyd coating system.

35.2 Concrete masonry is to receive a block filler and a two coat acrylic latex coating system.

35.3 Concrete roof slabs where designated will receive a two coat butryl resin coating system.

35.4 Concrete floors where designated will receive a two coat epoxy system with a non-slip finish.

36.0 DESCRIPTION OF STRUCTURES

36.1 The Gasifier Building

The Gasifier Building will have reinforced concrete spread footings and a reinforced concrete grade slab over granular fill; a steel superstructure with prefinished metal siding with FRP light panels and concrete masonry exterior walls; prefinished metal roofing over batt insulation and built-up roofing, insulation and vapor barrier on metal decking; prefinished metal fascias, scuppers, gutters and downspouts; prefinished metal and elastic flashings; concrete masonry partitions; reinforced concrete and grating floors; hollow metal personnel doors in pressed metal frames and motor operated rolling steel service doors. Office, laboratory and control room and toilet room will have suspended acoustical ceilings. Office and laboratory and control rooms will have vinyl flooring and base. Toilet room will have a sanitary cove base. Structural framing, doors, door frames and exterior masonry are to be painted as well as the interior walls of the office, laboratory and control room and toilet room.

36.2 The Waste Water Treatment Building

The waste water treatment building will have a thickened edge reinforced concrete slab over granular fill; a steel superstructure with prefinished metal wall and roof sheeting over butt insulation and a 4 foot high prefinished metal wainscot on the interior; prefinished metal gutters and downspouts; prefinished metal and elastic flashings; concrete masonry partitions; reinforced concrete elevated slabs; hollow metal personnel doors and hollow metal and manually operated rolling steel service doors. Structural framing, doors and door frames are to be painted.

36.3 The Office and Change House

The office and change house will have reinforced concrete spread footings, a reinforced concrete grade slab over granular fill; a pre-engineered steel superstructure with prefinished metal wall and roof sheeting over batt insulation and a full height prefinished metal wall liner on the interior; prefinished metal gutters and downspouts; prefinished metal fascia, gutters and downspouts; prefinished metal and elastic flashings; concrete masonry partitions; hollow metal doors in pressed metal frames; suspended acoustical ceilings; metal toilet partitions and urinal screens. Office, reception and

lunch room will have composition tile floors with vinyl base. Toilet and locker rooms will have ceramic tile base. Locker rooms will have metal pass-thru and personnel lockers and wood benches. Plastic laminate surfaced counters will be provided in women's clean locker room and lunch room. Hat shelf and clothes rod will be provided in reception closet.

Exposed structural framing, doors, door frames, concrete masonry walls and vestibule, locker room, toilet, shower area, clean clothing room floors will be painted.

36.4 Sulfur Removal and Recovery Building

Sulfur removal and recovery building will have reinforced spread footings and a reinforced concrete grade slab over granular fill including insulating refractory lined reinforced concrete sumps with steel framed plate covers; steel superstructure; with metal wall sheeting over batt insulation and FRP lightpanels with a prefinished metal wainscot on the interior; reinforced concrete elevated slabs over metal form centering; built-up roofing over insulation and metal deck; prefinished metal and elastic flashing; prefinished metal fascias, scuppers and downspouts; prefabricated roof hatch; concrete masonry partitions; hollow metal doors and transoms in pressed metal frames. Exposed structural framing, doors, transoms and door frames will be painted.

37.0 SITE DEVELOPMENT

Site development will include protection to minimize siltation of waterways. The storm drainage system will be open ditches with culverts under roadways with catch basins and piping in restricted areas only. The sanitary sewers are to be vitrified clay and process sewers are to be cast iron. Service racks are to be structural steel of design required with reinforced concrete foundations. Coal conveyor tunnel equipment foundations and pads and sumps and pits are to be reinforced concrete.

6.4 HVAC Systems

1.0 HEATING, VENTILATING AND AIR CONDITIONING

1.1 GENERAL

This General Specification contains information related to the preparation of Heating, Ventilating, Air Conditioning and certain Process Design Documents for systems to be utilized to maintain acceptable environmental conditions at the subject plant.

1.2 DESIGN METHODS

Dravo Engineering and Constructors standard methods will be used for this project; they incorporate and/or are supplemented by the following design guides ASHRAE 1977 Fundamentals, ASHRAE Standard 90-75 (Energy Conservation in New Building Design), Industrial Ventilation manual of the American Conference of Governmental Industrial Hygienists.

1.3 EQUIPMENT AND MATERIALS

Temperature control systems shall be Honeywell, Johnson Service Co. or Powers Regulator. All equipment of the same catagory i.e. wall louvers, unit heaters, roof ventilators, etc. shall be of the same manufacturer. All motors to be TEFC. Building HVAC duct systems shall be galvanized steel of proper gage and specifications for the service. Process system ductwork shall be carbon steel.

1.4 DESIGN DATA

Coal dust collection and combustion air blowers will assist in the general building exhaust. All HVAC equipment will have automatic temperature controls.

1.5 SERVICE CONDITIONS

For hazardous conditions and treatment of them, see Hazard Specification in Section 6.6. Steam will be available at 30 psig for heating and condensate will be returned to boiler. For electric power see Electrical Specification 6.2. Motors which are integral and unique to the equipment as unit heaters, roof ventilators, duct fans, etc. may deviate from the Electrical Specifications in Section 6.2, as long as they comply with the requirements of the electrical classification.

1.6 DESIGN CRITERIA

Symbols and descriptions of this section are applicable to the tables. Any condition not designated (Blanks) in the table is an indication that the condition is not a basic control for design. Where a specific numerical value is not given an "X" in the space indicates that the condition must be considered as a possible basic control.

Temperature and Humidity: The tables indicate target temperatures and relative humidities to be attained by use of manufacturer's standard equipment and controls for normal heating and ventilating service. Systems or spaces requiring more accurate control shall be so indicated in the remarks column of the tables.

Ventilation: The tables indicate the basis to be used to establish minimum quantities of OUTSIDE AIR which must be introduced into a system. The designated basis shall govern unless there is a more stringent code or operational requirement in which case it shall govern.

Symbols and Descriptions: (Temperatures in Deg. F.) (R.H. in percent)

DB - Dry Bulb Temperature
WB - Wet Bulb Temperature
TR - Maximum average temperature rise above outdoor ambient.
RH - Relative Humidity
AC - Air changes per hour based upon the first eight feet of height above a solid floor.
TAC - Air changes per hour based upon total volume of the space.
SF - Quantity of air (CFM) per square foot based upon floor area.
PR - Quantity of air (CFM) required to maintain the space at a pressure above (indicated by a "P" in the table) or below (indicated by an "N" in the table) that of adjacent spaces. Where pressurization is required for reducing the Hazards classification, the "P" or "N" shall be accompanied by a "H" and the Remarks Column shall indicate the Type (X, Y or Z as defined by NFPA) or purging required. Where pressurization is to be provided as a general measure to minimize infiltration of dirt and/or corrosive elements from the surrounding atmosphere the "P" or "N" shall be followed by a "C".
PE - Quantity of air (CFM) to satisfy - equal to - any process user requirements.
OC - Quantity of air (CFM) per person in accordance with the recommendations of the ASHRAE Guide.

OUTSIDE

SUMMER 90 DB 72 WB WINTER 6 DB _____ WB

INSIDE

SPACE		TEMPERATURE					VENTILATION						REMARKS
NAME	AREA	SUMMER			WINTER		RATE						
	NO.	DB	RH	TR	DB	RH	AC	TAC	SF	PR	PE	OC	
GASIFIER BUILDING													
Electrical Equip. Room				14	60					Pc			
Control Room		78	50		72					Pc			
H & V Equip. Room				14	60				1				
Toilet Room					72				2				
Main Building				14	45				1				
East Stairwell				14	45								
West Stairwell				14	45								
COAL TRANSFER TUNNEL				14	45						X		
SULPHER RECOVERY BLDG				14	60						X		
WATER TREATMENT BLDG				14	60						X		
Electrical Equip. Room				14	60					Pc			

OUTSIDE

SUMMER 90 DB 72 WB WINTER 6 DB _____ WB

INSIDE

SPACE		TEMPERATURE					VENTILATION						REMARKS
NAME	AREA	SUMMER			WINTER		RATE						
	NO.	DB	RH	TR	DB	RH	AC	TAC	SF	PR	PE	OC	
OFFICE & CHANGE HOUSE													
Offices		78	50		72				1				
Toilet Rooms					72				2				
Locker Rooms					72				1				USE 7CFM1 LOCKER
Clean Clothing Room					72				1				

1.7 SERVICE OPERATION:

1.7.1 Gasifier Building:

Electrical Equipment Room shall be heated, ventilated and pressurized with a forced air supply system. Control Room shall be heated, air conditioned and pressurized with a forced air supply system. H & V Equipment Room shall be heated with steam unit heater. Toilet Room shall be ventilated via transfer air from H & V Room and exhausted by sidewall mounted powered exhaust fan. Stairwells shall be natural ventilation and heated with electric cabinet heaters. Main Building shall be ventilated and heated by forced air supply system. Air for process and coal dust collection shall be forced make up air system.

1.7.2 Coal Transfer Tunnel shall be ventilated and heated by forced air supply system. Ventilation air exhausted through coal dust collection system.

1.7.3 Sulpher Recovery Building:

Main Building shall be ventilated year round with a forced air supply system and exhausted through powered roof ventilators and process exhaust fans. Additional summer ventilation via wall louvers and power roof ventilators. Main Building to be heated by steam unit heaters. Compressor Rooms shall be ventilated via transfer air from Main Building and exhausted by wall mounted powered exhaust fans.

1.7.4 Water Treatment Building shall be ventilated in summer by wall louvers and power roof ventilators. Heating shall be by steam unit heaters. Air for process shall be by forced make up air system.

Electrical Equipment Room shall be heated, ventilated and pressurized with a forced air supply system.

1.7.5 Office & Change House:

. Offices shall be heated, ventilated, and air conditioned by through the wall packaged air conditioners.

. Toilet Rooms shall be ventilated and heated via air supplied by make up air unit and exhausted through powered roof ventilator. Locker Rooms to be ventilated and heated via air supplied by make up air unit and exhausted by powered roof ventilator. Clean Clothes Room to be heated and ventilated via air supplied by make up air unit and exhausted by power roof ventilator.

6.5 Instrument Piping Materials and Workmanship

All Areas

1.0 SCOPE

1.1 This specification establishes the quality and type characteristics of the materials and the quality of workmanship to be used in furnishing, fabricating, installing, cleaning and testing of the instrument piping and tubing work shown on the drawings.

1.2 This specification covers the piping of all instrument impulse and air lines after the process or utility block valve. Piping up to and including the block valve shall be per the "Specification for Piping".

2.0 MATERIAL

2.1 MATERIALS INDEX, PIPING AND TUBING

SERVICE	MATERIAL CODE	APPLICATION	ITEM	NO.
Instrument Air	XA	Supply branch header - 1/2" size		
			pipe	P11
			nipples	N14
			fittings	FTG616
			swages	SXX11
			unions	UN62
			tubing	P41 3/8 inch O.D.
			tubing fittings	FTG44
			valves	VBL42
Instrument Air	XB	Single supply, control and transmission lines		
			tubing	P820
			fittings	FTG44

			pipe nipples	P45
			pipe fitting	FTG46
			unions	UN45
			valves	VNE42
			vents	STR41
			thread dope	JT12
Instrument Air	XB	Single supply, control and transmission lines where proximity to high ambient temperatures prohibit using plastic.		
			tubing	P41
			fittings	FTG44
			pipe nipples	P45
			pipe fittings	FTG46
			unions	UN45
			valves	VNE42
			vents	STR41
			thread dope	JT12
Instrument Air	XC	Bundled tubing All multiple tube runs from instrument panel through tubing trays to field junction		
	XC-1 Bundled plastic			
XC-1.1	Plain		bundles	P815
			fittings	FTG44
			bushings	ISM72
Caustic Process, monel trimmed C.S. and S.S.	XMC	Caustic, Chlorine, etc. less than 1,000# cold, 250# @ 375°F, process		
			tubing	P240
			tubing fittings	FTG237
			valves & taps	VNE19
			manifolds	VSP31
			nipples	N117
			thread dope	JT11

Process Medium Pressure, 316 S.S.	XMS	Corrosive, less than 1,000# cold, 250# @ 500°F., process.		
			tubing	P240
			tubing fittings	FTG237
			valves	VND23
			ball valves	VBL22
			thread dope	JT11
			manifolds	VSP26
			manifolds	VSP12 or VSP13 (May be used for C.S. process pipe services.)
			nipples	N210
			orifice taps	VNE27
High Temperature C.S.	XH	Hot gases		
			pipe	
			pipe fittings	FTG19
			tubing	P240
			tubing fittings	FTG237
			valves	VNE111
			manifolds	VSP14
			nipples	N117
			unions	UN16
			orifice taps	VNE112
Corrosive, Kynar	XK	Less than 150#, 150°F., highly corrosive.		
			pipe	P88
			pipe fittings	FTG88
			pipe unions	UN88
			valves	VBL84
			pipe dope	JT15
			flanges	FTH84
Bundle Support	XSB-1	Galvanized steel, normal plant atmosphere		

			Single bundle support	ISM14
			Main run bundle support	ISM13
			Vert. support	ISM41
			Tyewraps	ISM81
			Bundle fittings	ISM72
Tubing Branch Support	XST-1	Galvanized channel, normal plant atmosphere	Channels	ISM11
			Supports	ISM14
			Markers	ISM83
			Tyewraps	ISM81
			Clamps	ISM61
Tubing Branch Support	XST-3	Thinwall conduit (EMT), normal plant atmosphere		
Use plain plastic tube only			conduit	ISM16
			fittings	ISM17
			supports	ISM18
			boxes	ISM19
			fasteners	B25
			rods & fittings	B22
			U-bolt	B23

2.2 MATERIALS SPECIFICATION

2.2.1 Pipe and Tubing

ITEM NO.

P11 MATERIAL: Welded or seamless steel pipe, ASTM-A120 Grade A
SCHEDULE: 40, ANSI B36.10

P240 MATERIAL: Seamless stainless steel tubing, ASTM A269, Grade TP-316, hardness not to exceed Rockwell B-90, as manufactured by Superior Tube or PATCO only.
SIZE: 1/2 inch O.D. x 0.035 inch wall

P41 MATERIAL: Soft annealed copper, ASTM B75 or B68, Type DHP
SIZE: 3/8 inch O.D. x 0.035 inch wall

P45 MATERIAL: Brass, ASTM-B43
SCHEDULE: Extra strong, ASTM-B251

P88 MATERIAL: "FLUOROFLEX-K" solid Kynar pipe
SCHEDULE: 80 or equivalent
SIZE: 1/2 inch
MODEL: Resistoflex KS3780-008 or equal

P815 MATERIAL: Bundled polyethylene tubes, black with number coding, melt index 0.3 to 0.5, ASTM D1238
SHEATH: Polyvinyl chloride
TUBE SIZE: 1/4 inch O.D. x 0.040 inch wall

P820 MATERIAL: Polyethylene tubing, melt index 0.3 to 0.5, aluminum reinforced, nylon lined.
SIZE: 1/4 inch O.D.
3/8 inch O.D. for all air supplies and to large valve actuators
MODEL: Samual Moore Dekabond, or equal.

FTG19 MATERIAL: Forged carbon steel, ASTM A105-71
RATING: 3,000 lbs. WOG
CONNECTIONS: Screwed ANSI B2.1

FTG44 MATERIAL: Standard weight brass
TYPE: Flareless, complete with nuts and ferrules
MODEL: Hoke "Gyrolok", or equal

FTG237 MATERIAL: Standard weight stainless steel, ASTM A276, Type 316
TYPE: Flareless, complete with nuts and ferrules
MODEL: Hoke "Gyrolok". or equal

FTG46 MATERIAL: Brass, ASTM B62
RATING: 250 lbs.
CONNECTIONS: Screwed NPT

FTG616 MATERIAL: Cast malleable iron, ASTM A-197
RATING: 150 lbs. ANSI B16.3
CONNECTIONS: Screwed ANSI-B2.1

2.2.2 Pipe and Tubing Fittings

ITEM NO.

FTG88 MATERIAL: Solid Kynar
SCHEDULE: 80 equivalent
CONNECTION: Screwed ANSI B2.1
MODEL: RESISTOFLEX KS -----T-008

SXX11 MATERIAL: Carbon steel, galvanized swage nipple

N14 MATERIAL: Carbon steel nipple, ASTM A120, seamless or welded, Schedule 80, ANSI B36.10

N117 TYPE: Extra heavy eccentric hex nipple for flange mounting manifold C-10.62
MATERIAL: Carbon steel, plated
SIZE: 1/2 inch NPT x 3 inch long, Schedule 160
MODEL: Anderson Greenwood 2-2517C, or equal.

N210 TYPE: Extra heavy eccentric hex nipple for flange mounting manifold C-10.65
MATERIAL: 316 stainless steel
SIZE: 1/2 inch NPT x 3 inch long, Schedule 160
MODEL: Anderson Greenwood 2-2517S, or equal

2.2.3 Pipe Unions

ITEM NO.

UN16 TYPE: 2-bolt ammonia flange
MATERIAL: Forged carbon steel, ASTM A105-71
CONNECTIONS: Threaded ANSI B2.1
BORE: To match Schedule 80 pipe, ANSI B36.10
SEAL: Tongue and groove facing with asbestos gaskets
STUDS: Alloy steel, ASTM A-193, Grade B7, threaded full length, Class A fit
NUTS: Semi-finished heavy series hex, ASTM A-194, Grade 2H, ANSI B1.1 and B18.2, Class 2B fit
MODEL: Vogt 330 or equal

UN45 MATERIAL: Brass, ASTM B62
RATING: 250 lbs.
CONNECTIONS: Screwed NPT

UN62 MATERIAL: Malleable iron, ASTM A197, brass to iron seat
RATING: 300 lbs.
CONNECTIONS: Screwed ANSI B2.1

UN88 MATERIAL: Kynar VF-2
RATING: 150 lbs. @ 150°F.
CONNECTIONS: Threaded
MODEL: Resistoflex KS3713T-008 or equal

2.2.4 Flanges

ITEM NO.

FTH84 MATERIAL: Kynar
RATING: 150 lbs.
CONNECTIONS: 150 lbs. full flat face, blind flange, drilled for FNPT

2.2.8 Needle Valves

VNE11 MATERIAL
Body & Bonnet: Carbon steel bar stock, ASTM A108, Grade B-1111
Stem: 12-13% chromium
PACKING: Graphite-asbestos or teflon
STEM & YOKE TYPE: Inside screw, rising stem
SEATS: Integral for 1/2 inch size and under
BONNET: Screwed
PRESSURE & TEMPERATURE RATING: 600 lbs. @ 850°F.
CONNECTIONS: Screwed ANSI B2.1
MODEL: Reading, Pratt & Cady #1040A, or equal

VNE19 TYPE: Barstock angle gage valve, short form, 3-outlet, monel trimmed.
MATERIAL
Body: Carbon steel
PACKING: Teflon
SEAT: Monel ball
RATING: 6,000 psi @ 200°F
SIZE: 1/2 inch MNPT x 1/2 inch FNPT
NOTE: Provide plugs for unused openings
MODEL: Anderson Greenwood M5VHC-44-SG

VNE111 TYPE: High temperature instrument valves
MATERIAL
Body: Carbon steel
Trim: Stainless steel
PACKING: Asbestos
SEATS: Metal to metal
RATING: 6,000 psi @ 200°F.
1,500 psi @ 850 F.
CONNECTIONS: Threaded ANSI B2.1
MODEL: Anderson Greenwood H7HC Series

VNE112 TYPE: O.S. & Y. extra heavy angle gage valve
MATERIAL
Body: Carbon steel
Trim: Stainless steel

PACKING: Asbestos
SEAT: Metal to metal
RATING: 1500 lbs. @ 850°F.
CONNECTION: 1/2 inch F x 1/2 inch F, threaded ANSI B2.1
MODEL: Anderson Greenwood M4YC-444

VNE23

MATERIAL
Body & Bonnet: Stainless steel, ASTM A276, TP-316
Stem: 12-13% chromium
PACKING: Graphite-asbestos or teflon
STEM & YOKE TYPE: Inside screw, rising stem
SEATS: Integral for 1/2 inch size and under
BONNET: Screwed
PRESSURE & TEMPERATURE RATING: 600 lbs. @ 850°F.
CONNECTIONS: Screwed ANSI B2.1
MODEL: Reading, Pratt & Cady #1070A, or equal

VNE27

TYPE: Barstock angle gage valve, short form 3-outlet
MATERIAL: 316 stainless steel
PACKING: Teflon
SEAT: 316 stainless steel
RATING: 6,000 psi @ 200°F.
SIZE: 1/2 inch MNPT x 1/2 inch FNPT
NOTE: Provide plugs for unused openings
MODEL: Anderson Greenwood M5VS-44

VNE42

MATERIAL
Body: Brass
Spindle: Stainless steel
PACKING: Dynapak
PRESSURE & TEMPERATURE RATING: 2,000 lbs. @ 100°F.
CONNECTIONS: 1/4 inch MNPT and 1/4 inch "Gyrolok"
MODEL: Hoke #321H4B

2.2.10 Special Valves

ITEM NO.

VSP 12

TYPE: Insert block and by-pass manifold, for installation between flanges and body of standard differential pressure transmitter
MATERIAL
Body: Carbon steel, plated
Trim: 316 stainless steel
PACKING: Teflon
SEATS: Stainless steel ball
PRESSURE & TEMPERATURE RATING: 6,000 psi @ 200°F.
MODEL: Anderson Greenwood M3BC, or equal

VSP13

TYPE: All angle 3-valve manifold for mounting differential pressure transmitter directly on orifice flange.
MATERIAL
Body: Carbon steel, plated
Trim: 303 and 316 stainless steel
PACKING: Teflon
SEATS: Stainless steel ball
PRESSURE & TEMPERATURE RATING: 5,000 psi @ 200°F.
CONNECTIONS
Inlet - 1/2 inch - 2 bolt flanges
Outlet - 1/2 inch FNPT (furnished plugs for unused openings)
MODEL: Anderson Greenwood M2VC, or equal

VSP14

TYPE: High temperature 3-valve manifold
MATERIAL
Body: Carbon steel
Trim: 303 stainless steel
PACKING
Shut-Off Valves: O.S. & Y., asbestos
By-Pass Valve: Ring, asbestos
SEATS: Metal to metal
RATING: 1500 psi @ 850°F.
CONNECTIONS
Inlet: Flange unions, threaded ANSI B2.1
Outlet: Threaded ANSI B2.1 (furnished plugs for unused openings).
MODEL: Anderson Greenwood M2HYC or equal

VSP26

TYPE: Insert block and by-pass manifold, for installation between flanges and body of standard differential pressure transmitter
MATERIAL
Body: 316 stainless steel
Trim: 316 stainless steel
PACKING: Teflon
SEATS: Stainless steel ball
PRESSURE & TEMPERATURE RATING: 6,000 psi @ 200°F.
MODEL: Anderson Greenwood M3BS or equal

VSP31

TYPE: All angle 3-valve manifold for mounting differential pressure tramsmitter directly on orifice flange, monel trimmed.
MATERIAL
Body: Carbon steel
PACKING: Teflon
SEATS: Monel ball
PRESSURE & TEMPERATURE RATING: 6,000 psi @ 200°F.
CONNECTIONS
Inlet - 1/2 inch - 2 bolt flanges
Outlet - 1/2 inch FNPT (furnish plugs for unused openings)
MODEL: Anderson Greenwood M2VS-SG

2.2.13 Ball Valves

ITEM NO.

VBL22 BALL VALVE
Body: Cast stainless steel AISI type 316
Ball & Stem: 316 stainless steel
Packing & Seats: Teflon
PRESSURE & TEMPERATURE RATING: 600 psi @ 150°F
MODEL: Jamesbury A36TT or equal

VBL42 STRAIGHT PATTERN BALL VALVE
MATERIAL
Body: Bronze
Ball: Chrome plated brass or stainless steel
Stem & Seal: Buna-N
PRESSURE & TEMPERATURE RATING: 150 lbs. @ 200°F.
CONNECTIONS: 1/2 inch FNPT
MODEL: Crane "GEM" No. 2180

VBL84 MATERIAL
Body: Kynar
Ball & Stem: Kynar
PACKING: Teflon
SEALS: Teflon
PRESSURE & TEMPERATURE RATING: 150 lbs. @ 150°F.
CONNECTION: Threaded
MODEL: Hills-McCanna P152-Ky-T-Ky, or equal

2.2.15 Strainers

ITEM NO.

STR41 MATERIAL: Exhaust vent screen
SIZE: 1/4 inch NPT, angle
MODEL: Fisher Govenor "Bugproof" or equal

2.2.16 Specialty Items

ITEM NO.

ISM11 TUBING CHANNEL
MATERIAL: Galvanized Steel
SIZE
1 inch x 7/8 inch
1-1/2 inch x 7/8 inch
MODEL: "P-W" Industries; 2501 Series

ACCESSORIES
Tubing Clips #DS-9004
Rod Hangers #1052-0355
Wall Hangers #1052-0358 and 9999-9364
Channel Fittings, 2501 Series
1/4" "Southco" pattern drive rivets

ISM13 TUBING LADDERS AND FITTINGS
MATERIAL: Galvanized Iron
MODEL: 3" deep P-W Industries, or equal

ISM14 TROUGH SUPPORTS AND FITTINGS
MATERIAL: 12 gage steel, painted
MODEL: Unistrut P-1000, or equal

ITEM NO.	DESCRIPTION	SIZE	STEEL CITY NUMBER
ISM16	Galvanized thinwall conduit (EMT)	1/2 in.	-
	Galvanized thinwall conduit (EMT)	3/4 in.	-
	Galvanized flexible conduit (Greenfield)	1/2 in.	-
	Galvanized flexible conduit (Greenfield)	3/4 in.	-
ISM17	EMT Coupling, Setscrew	1/2 in.	TK-121
	EMT Coupling, Setscrew	3/4 in.	TK-122
	EMT Connector, Setscrew w/locknut	1/2 in.	TC-121
	EMT connector, Setscrew w/locknut	3/4 in.	TC-122
	Plastic Bushing	1/2 in.	BU-501
	Plastic Bushing	3/4 in.	BU-502
	Flexible Conduit connector (Greenfield connector)	1/2 in.	XC-401
	Flexible Conduit connector (Greenfield connector)	3/4 in.	XC-402
	Thinwall to Flexible adapter coupling	1/2 in.	TX-221
	Thinwall to Flexible adapter coupling	3/4 in.	TX-222

ISM18	One-hole strap	1/2 in.	TX-101
	Spacer	1/2 in.	CB-201
	One-hole strap	3/4 in.	TX-102
	Spacer	3/4 in.	CB-202
	Right angle beam clamp	1/2 in.	RCS-1/2
	Right angle beam clamp	3/4 in.	RCS-3/4
	Parallel bar clamp	1/2 in.	PC-1/2
	Parallel bar clamp	3/4 in.	PC-3/4
	Edge beam clamp	1/2 in.	EC-1/2
	Edge beam clamp	3/4 in.	EC-3/4
ISM19	Square box, 4-11/16 x 2-1/8 deep, with 3/4 and 1/4 inch knockouts.	-	72171-1/2 & 3/4
	Plain lid, 4-11/16 in.	-	72-C-1

ISM41 WOVEN WIRE RISER GRIP, SINGLE EYE
MATERIAL: Plated Bronze
MODEL: Kellems 022-01-005
Kellems 022-03-005

ISM 61 SPLIT RING PIPE CLAMP, WITH SCREW AND NUT
MATERIAL: Malleable Iron, Galvanized
SIZE: 1/2 inch pipe x 3/8 inch rod
MANUFACTURER: Grinnell, or equal

ISM72 CONNECTOR FITTINGS FOR TUBING BUNDLE, WATERTIGHT COMPRESSION FORM
MATERIAL: Galvanized Iron and Synthetic Rubber
MODEL: Dekoron Part No. 1503 Series, or equal

ISM81 CABLE TIES, NYLON
MANUFACTURER: Thomas & Betts "TYEWRAP", no substitute

ISM83 TUBE MARKER
TYPE: 3/4 inch blank writing space with clear Vinyl wraping end
MANUFACTURER: Brady SLFW-500, for individual tubes
Brady PWC-PK-6, for bundles

2.2.20 Joint Compound

ITEM NO.

JT11 Cyl-Seal

JT12 Teflon Tape

JT15 Teflon Paste, John Crane #JC-30, or equal.

2.2.21 Threaded Products

ITEM NO.

B22 MATERIAL: Galvanized Steel
THREAD SIZE: 3/8-16
ITEM: All-thread rod
ITEM: Medium "C" beam clamp, thd'd both sides, with hard-pointed set screw.
ITEM: Hex bar coupling

B23 MATERIAL: Zinc Chromated Steel
SIZE: 3/8-16 x 2-1/2 inside
ITEM: U-Bolt with plate and nuts, for 2-inch pipe.

B25 MATERIAL: Steel, zinc chromated or galvanized
SIZE: 3/8-16, full threaded.
ITEM: 1/2 in. long R.H. Machine Screw
ITEM: 1 in. long R.H. Machine Screw
ITEM: 2 in. long R.H. Machine Screw
ITEM: Semi-finished hex. nut.
ITEM: Washer
ITEM: Lockwasher

3.0 FABRICATION AND INSTALLATION

3.1 All piping shall be fabricated and installed in accordance with American Standard Code for Pressure Piping, ANSI B31.1, latest edition.

3.2 All pipe shall have the ends reamed and shall be thoroughly cleaned of all internal scale, oil and dirt before assembly.

3.3. Pipe shall be assembled using a minimum of thread compound.

3.4 Where not covered by this specification, pipe joints shall be made up in accordance with "Specification for Piping".

3.5 The use of couplings shall be kept to a minimum.

4.0 CLEANING

4.1 In accordance with "Specification for Piping".

5.0 TESTS

5.1 Process and Utility Piping shall be in accordance with "Specification for Piping". Test pressure in instrument systems shall be the same as that used for the connecting process piping, wherever possible. Instruments which can withstand the test pressure without being damaged (even if overranged by that pressure) shall be left connected and tested along with the main piping. Only instruments which could be damaged by testing shall be disconnected from the piping during testing. In any case, all field erected instrument piping and tubing, and as much as possible of sample systems, manifolds, and other pressure-resistant parts of instrument systems shall be included in the main test. Before testing, obtain a list of items that must be disconnected, from the engineer. When such an item is isolated from the test by a valve, open a vent or break a joint downstream of the valve so that a leak in the valve will not inadvertently overpressure the instrument during the test.

5.2 Testing of instrument air tubing shall be in accordance with the Instrument Society of America Recommended Practice ISA-RP-7.1.

6.6 Hazard Specification

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1.0 GENERAL

1.1 Scope

This document establishes the minimum safety requirements that must be considered in the design of the project in these basic areas:

1.1.1 Electrical classifications
1.1.2 Hazards
1.1.3 Means of reducing hazards

1.2 Codes and Regulations

1.2.1 All Local, State and Federal Regulations and Codes shall apply as appropriate to the work and area location. The most recent available edition of these documents at the start of the contract shall be used.

1.2.2 The National Electrical Code will be applied.

1.3 PLANT DESCRIPTION

This industrial fuel gas facility consists of coal handling and storage equipment, a gasification system, coal tar and sulfur removal systems, waste water treatment, a flare and various auxiliary areas for utilities.

1.4 BASIC CONSIDERATIONS

1.4.1 Containment of toxic and volatile flammable fluids and particulate matter must be the primary concern. As the maximum allowable concentrations of the process materials are generally well below their lower explosive limits it is not permissible to use a higher electrical hazard classification (Division 1) in lieu of containment.

1.4.2 The noise levels in occupied parts of the plant must be made to meet OSHA 1910.95 standards.

0) 1.4.3 An electrical area classification plot plan, based on Section 2.0 of this specification shows some of the classifications described in Section 2.0. Refer to Drawings No. 2994-600-801 and 2994-600-802.

1.4.4 Self-contained breathing apparatus shall be available.

0)

0) 1.4.5 This specification makes no attempt to describe startup and plant operation, neither does it contain instructions on any construction procedures for expansion of the plant at a later date.

2.0 AREA CLASSIFICATIONS AND HAZARDS

2.1 Truck Weigh Scale, Coal Pile and Transfer Tunnel

2.1.1 Electrical Classification

Truck Weigh Scale: Nonhazardous

Coal Pile: Nonhazardous

Transfer Tunnel: Class II, Group F, Division 1

2.1.2 Hazards

Release of coal dust within the enclosed transfer tunnel.

2.1.3 Means of Reducing Hazards

Adequate housekeeping

Dust suppressant shall be available at the coal pile.

Ventilate the transfer tunnel

2.2 GASIFIER BUILDING

2.2.1 Electrical Classification

Coal Conveyor Area (above el. 974'-2"): Nonhazardous (dust will be contained within equipment).

Gasifier Agitator and Poke Holes: Class I, Group C, Division 2 for a 5-foot radius from agitator shaft seal and each poke hole (Ignition Limit, 932°F)

Pump Sump: Class I, Group C, Division 1 and 2 (Ignition Limit, 500°F)

Remainder of Building: Nonhazardous

0) NOTE: The Class I, Group C, Division 2 areas are extremely limited because the gases are to be contained within the equipment except as noted above. To minimize the hazard, the combustion air is drawn from within the building. Thus a continuous air change is assured.

2.2.2 Hazards

Accidental release of product gas from agitator seal, and poke holes, Section 2.2.1.

2.2.3 Means of Reducing Hazards

Adequate housekeeping

0) The coal conveyor and coal bins will be completely enclosed and under a negative draft through a dust collector.

0) Ventilate all parts of the building, and provide alarms for the ventilation system operation.

A carbon monoxide detector head shall be installed above the operating level (el. 944'-10") at each gasifier. Alarms shall sound in the control room within the building, and outside the building.

2.2.5 Venting Requirements

0) Explosion Relief at Coal Bins: Discharge will be outside of the gasifier building. A 5-foot radius spherical space at the exhaust is Class I, Group C, Division 1 enveloped by a 10-foot Class I, Group C, Division 2 sphere.

0) Explosion Relief at Gasifier (below and above coal bed, and in cyclone): Discharge will be outside of the gasifier building. A 5-foot radius spherical space at the exhaust is Class I, Group C, Division 1, enveloped by a 10-foot Class I, Group C, Division 2 sphere.

0) Vessel Pressure/Temperature Ratings: Design conditions for all equipment that will contain coal and/or fluids will be established to safely contain all normal operations. When required, relief systems will be provided for abnormal operation.

0)

2.3 GAS QUENCH, TAR REMOVAL AND TAR STORAGE TANK AREAS

2.3.1 Electrical Classification

0) ESP Compressors, 42004 and 42005: Class I, Group C, Division 2 (Ignition Limit 932°F)

0) Gasifier System Compressors, 42006 and 42007: Class I, Group C, Division 2 (Ignition Limit 932°F)

Miscellaneous Point Sources (ex. control and hand valves): Class I, Group C, Division 2 for a 3-foot radius from each source.

Remainder of Areas: Nonhazardous

2.3.2 Hazards

Accidental release of product gas, Section 2.3.1.

0) 2.4 FLARE/VENT

2.4.1 Electrical Classification

0) Flarehead: Class I, Group C, Division 1 for a 5-foot radius sphere surrounded by an enveloping 10-foot radius sphere.

Miscellaneous Point Sources (ex. valves) on gas line to the flare: Class I, Group C, Division 2 for a 3-foot radius from each source.

Remainder of Area: Nonhazardous

2.4.2 Hazards

Accidental release of product gas, Section 2.4.1.

Explosion because of air (excess oxygen) in the gas, could occur because of misoperation.

2.5 SULFUR REMOVAL AREA

2.5.1 Electrical Classification

0) Sulfur Removal and Recovery Building:

0) Class I, Group C, Division 2 (Ignition Limit 500°F) and Class II, Group G, Division 2 with a 5-foot radius Division I envelope around the sulfur filters and equipment vents..

0) Oxidizer Tanks and Liquor Tanks: Class I, Group C, Division 1 and Class II, Group G, Division I envelope surrounded by a similar Division 2 envelope.

0) Remainder of Area; Nonhazardous

2.5.2 Hazards

Accidental release of hydrogen sulfide will probably be the greatest hazard to personnel and property.

0) Release of hydrogen sulfide will be the greatest hazard to personnel and property.

0) 2.5.3 Means of Reducing Hazards:

0) Vent equipment to outside of building and elevated, incinerate Stretford solution blowdown.

2.6 LIQUID SULFUR STORAGE TANK

2.6.1 Electrical Classification

Class I, Group C, Divisions 1 & 2 (Ignition Limit 500°F)

2.6.2 Hazards

Release of hydrogen sulfide will be the greatest hazard to personnel and property.

0) 2.7 INCINERATOR

2.7.1 Electrical Classification

0)

0) Nonhazardous

0) 2.7.2 Hazards

0) Fired incinerator

0) 2.7.3 Means of Reducing Hazards

0) Locate incinerator adequate distance from other equipment.

2.8 WASTE WATER TREATMENT, COOLING TOWER, BOILER AND SUBSTATION

2.8.1 Electrical Classification

Nonhazardous

2.8.2 Hazards

The waste, cooling and boiler water will require treatment chemicals that have various degrees of toxicity. Safety showers probably will not be required, but eye sprays are proposed for each area (except the substation) if drummed chemicals are to be handled.

Danger of fire is slight.

2.9 OFFICE AND CHANGE HOUSE

2.9.1 Electrical Classification

Nonhazardous

2.9.2 Hazards

Proper design of the Change House will minimize health problems, and must be considered part of a personal hygiene program. The Change House shall consist of a "clean side" for street clothes, lockers, showers, and a "contaminated side" for work clothes.

Danger of fire is slight.

3.0 PRINCIPAL CHARACTERISITICS OF MATERIALS

3.1 Bituminous Coal

3.1.1 Composition

	% (wt.)
Carbon	64.0
Hydrogen	6.2
Oxygen	14.3
Nitrogen	1.2
Sulfur	4.1
Ash	10.2

3.1.2 OSHA Limits for Coal Dust (Table Z-3 in OSHA 1910.1000)

Respirable fraction (particles smaller than about 10 microns) of silicon oxide in coal dust:

Less than 5%: 2.4 mg/cu in

More than 5%: 10 mg/cu in

3.2 RAW PRODUCT GAS

3.2.1 Composition of Gas Fraction

Flammables	% (vol.)
Carbon monoxide	17.4
Hydrogen	13.5
Methane	1.3
Ethylene	0.2
Ethane	0.1
Hydrogen Sulfide	0.66
Ammonia	0.026
Carbon oxysulfide	0.013
Hydrogen cyanide	0.009

Noncombustibles	
Nitrogen	46.1
Water vapor	13.7
Carbon dioxide	7.1
Sulfur dioxide	0.002

NOTE: The gas stream contains 2.3% (by wt.) tar.

3.2.2 Composition of Solids Fraction

Total Solids	% (wt.)
Carbon	66.4
Hydrogen	0.8
Oxygen	3.7
Nitrogen	1.1
Sulfur	3.6
Ash	24.4

3.2.3 OSHA Concentration Limit

Based on major constituent, carbon monoxide; 50 ppm

3.2.4 Flammability

Principal flammable components are carbon monoxide and hydrogen.

Class I, Group C has been selected for this mixture because the hydrogen content is below the 30% (by volume) specified in Table 500-2 of the National Electrical Code.

3.3 FILTERED RAW PRODUCT GAS

This stream is the same as that described in Section 3.2.1 except for total solids which have been reduced by 40% from 292.4 to 117 lb/hr.

3.4 QUENCHED PRODUCT GAS

Essentially all of the remaining solids and the tar will be removed from the gas leaving the quench tank. The remaining flammables and noncombustibles will be very close to the volume percentages listed in Section 3.2.1.

0) 3.5 STRETFORD SOLUTION

0) 3.5.1 Constituents

0) Anthraquinone Disulphonic Acid
0) Sodium Metavanadate
0) Sodium Citrate
0) Sodium Carbonate
0) Water

0) 3.5.2 OSHA Concentration Limit

0) OSHA has no established limit for Stretford solution.

0) 3.5.3 Characteristics

0) Stretford solution is a nonflammable aqueous solution of the above components. Solution is considered nonhazardous and of low toxicity.

0) 3.6 STRETFORD SOLUTION BLOWDOWN

0) 3.6.1 Constituents

0) Anthraquinone Disulfonic Acid
0) Sodium Metavanadate
0) Sodium Citrate
0) Sodium Carbonate
0) Sodium Thiosulfate
0) Sodium Thiosulfite
0) Sodium Thiocymate
0) Sodium Sulfate
0) Sulfur
0) Vanadium Salts
0) Water

0) 3.6.2 OSHA Concentration Limit

0) OSHA has no established limit for this solution.

0) 3.6.3 Characteristics

0) The Stretford solution blowdown is a nonflammable aqueous solution which has accumulated insoluable salts. Some of these salts and the intermediate reaction compounds consist of vanadium compounds in the various vanadium valence states. This blowdown will be incinerated for safe disposal.

3.7 TAR

3.7.1 Characteristics

Coal tar contains many volatile aromatics, including benzene.

Moderate fire hazard when exposed to heat. Explosion hazard when vapors (if any are produced) are exposed to heat or flame

Recognized as a carcinogen

3.7.2 OSHA Limit For Coal Tar Pitch Volatiles (Table Z-1 in OSHA 1910.1000)

For benzene soluble fraction: 0.2 mg/cu m

3.8 SULFUR

3.8.1 Characteristics

Melting Point: 234°F
Flash Point: 405°F
0) Ignition Temperature: 450°F

NOTE: Flash point of impure sulfur may be as low as 335°F.

Recovered sulfurs often contain dissolved hydrogen sulfide which can be liberated rapidly if liquid sulfur is agitated. At the transportation temperature (250-310°F), the lower explosive limit for hydrogen sulfide is about 3.4% instead of 4.3% by volume in air at room temperature.

Solid and liquid sulfurs are considered to be combustibles.

Sulfur dust requires use of Class II, Group G electrical equipment.

3.8.2 OSHA Limits for Nuisance Dust (Table Z-3 in OSHA 1910.1000).

Respirable fraction: 5 mg/cu m

Total dust: 15 mg/cu m

Toxicity of sulfur dust itself is very low. Chronic exposure can cause irritation of the mucus membranes.

3.9 CARBON MONOXIDE

Boiling Point: -314°F
Gas Density (Air = 1): 0.97
Ignition Temperature: 1128°F
Explosive Range (% Vol. in Air):
Low Limit: 12.5
Upper Limit: 74

OSHA Concentration Limit (Maximum allowable exposure on an 8-hour weight average basis): 50 ppm

Effect on body is predominently one of asphyxia.

3.10 HYDROGEN

Boiling Point: -422°F
Gas Density (Air = 1): 0.1
Ignition Temperature: 932°F
Explosive Range (% Vol. in Air):
Lower Limit: 4.0
Upper Limit: 75

Nontoxic, however it can cause asphyxiation.

3.11 HYDROGEN SULFIDE

Boiling Point: -76°F
Gas Density (Air = 1): 1.2
Ignition Temperature: 500°F
Explosive Range (% Vol. in Air):
Lower Limit: 4.0
Upper Limit: 44

OSHA Concentration Limit (Maximum allowable exposure on an 8-hour weigh average basis): 20 ppm

High concentrations cause almost immediate death.

3.12 OTHER MATERIALS IN THE PRODUCT GASES

The product gases contain, in addition to hydrogen and carbon monoxide, other flammable gases; however, they will be in rather low concentrations. Refer to Section 3.2.1.

Of the other components, such gases as hydrogen sulfide, carbon oxysulfide, hydrogen cyanide and sulfur dioxide are much more toxic than carbon monoxide and hydrogen. They will be in low concentrations in most streams; however, hydrogen sulfide is expected to be in high concentrations within the sulfur removal area.

The hazard to personnel from a major accidental release of gas would be asphyxiation. A small leak of product gas could result in an excessive concentration of carbon monoxide.

7.0 Environmental Considerations

Introduction

The purpose of this chapter is to identify the permits and licenses which may be required to construct or operate the gasification plant and to combust synthetic low-Btu gas at the existing board plant. Those permits which appear to be required are discussed in Section 7.1.

In addition, this chapter will present other environmental factors which may impact the construction or operation of the gasification plant. Factors to be discussed include: air quality, seismicity, and rare, threatened, or endangered species.

7.1 Permits and Licenses

7.1.1 Air Quality

7.1.1.1 Federal Permits

Preconstruction Permits(1)

An air obstruction permit is not required unless some structure exceeds 200 ft in height.

Preoperation Permits

No Federal air quality permits are required.

7.1.1.2 State Permits

Preconstruction Permits

Kentucky Department of Natural Resources and Environmental Protection (KY DNREP) - Prevention of Significant Deterioration of Air Quality (PSD) and New Source (Air Quality) Permits

PSD and new source (air quality) permits may be required by the KY DNREP prior to the start of construction of any new air contaminant source (see Attachment A at the end of Section 7.1).

If it is determined that preconstruction ambient air quality monitoring is necessary, General Refractories may be required to collect ambient monitoring data for one year prior to submitting a construction permit application. A public hearing may also be held. (The air quality permits fall under Federal regulations for PSD and New Source Performance Standards (NSPS) and are reviewed by the U.S. Environmental Protection Agency (USEPA) - Region IV.)

Further information on air quality permits is given in Appendix 7A, "Permit Information Required for Kentucky Air and Water Construction Permits," and Appendix 7B, "Prevention of Significant Deterioration of Air Quality Regulatory Outline."

Preoperation Permit

KY DNREP - Operation of Air Contaminant Source Permit

The KY DNREP issues a permit for operating an air contaminant source prior to the startup of a coal conversion facility. This permit differs from the permit obtained during the construction phase of the cycle in that it applies to an ongoing continuous air contamination source.

7.1.2 Water Quality

7.1.2.1 Federal Permits

Preconstruction Permits

No Federal water quality permits are required.

Preoperation Permit(2)

USEPA - National Pollutant Discharge Elimination System (NPDES) Permit

During the operating stage of the facility, a Federal water discharge or NPDES permit must be obtained from USEPA - Region IV for a non-"zero discharge" coal conversion facility.

7.1.2.2 State Permits

Preconstruction Permits

KY DNREP - New Source Construction Permit

The KY DNREP Division of Water Quality issues a permit for construction of any new source of wastewater discharge.

Preoperation Permits

KY DNREP - Water Withdrawal, New Individual Water Supply and Discharge of Treated Wastewater Permits

The KY DNREP issues (through its Division of Water Resources) a water withdrawal permit for any facility withdrawing more than 10,000 gal daily from existing water supplies.

Another KY DNREP permit must be obtained if the facility constitutes a new individual water supply (i.e., if it does not receive flow from existing water lines). This permit consists of the approval of plans submitted by a professional engineer on behalf of the applicant to the Division of Sanitary Engineering. Such plans must cover the water supply source and its distribution, fire reserve tanks, and firefighting and process systems.

The KY DNREP Division of Water Quality issues a permit for the discharge of treated wastewater from manufacturing facilities in accordance with the previously issued construction permit.(3)

7.1.3 Land Quality (Disposal of Solid/Hazardous Wastes)

7.1.3.1 Federal Permits

Preconstruction Permits

No Federal land quality permits are required.(4)

Preoperation Permits

USEPA - Resource Conservation and Recovery Act (RCRA) Permit

A RCRA permit will be required from USEPA - Region IV for offsite disposal of solid wastes, unless the disposal site has a RCRA permit.

7.1.3.2 State Permits

Preconstruction Permits

KY DNREP - Solid/Hazardous Waste Storage Permit

This permit allows solid and hazardous waste storage and is issued by the Division of Hazardous Materials and Waste Management.

Preoperation Permits

KY DNREP - Kentucky Landfill Operation Permit for Solid/Hazardous Wastes

The KY DNREP Division of Hazardous Materials and Waste Management issues a permit for operation of a landfill for solid and hazardous wastes disposal.

7.1.4 Environmental Quality

7.1.4.1 Federal Permits

Preconstruction Permits

"Lead Agency" - Environmental Impact Statement Approval

An Environmental Impact Statement may be required. This determination will be made by the "lead agency" (USEPA or KY DNREP).(5)

Preoperation Permits

No Federal environmental quality permits are required.

7.1.4.2 State Permits

Preconstruction Permits

Kentucky Department of Transportation (KY DOT) - Kentucky Air Obstruction Highway Encroachment Permits

Various divisions of the KY DOT issue construction permits. An air obstruction permit is issued by the Kentucky Airport Zoning Commission for any structure over 200 ft high; the Bureau of Highways issues an encroachment permit for any encroachment on its right-of-way (above, on, or below ground).

In addition, a building permit must be secured from the local building inspectors office before construction commences. A joint state review of building plans is handled by the Division of New Construction and the Division of Plumbing, Kentucky Department of Housing, Buildings and Construction (KY DHBC), and is concerned mainly with fire prevention and personal safety. (Plumbing plans for building permits are also reviewed by the local Board of Health prior to final approval by the Division of Plumbing, KY DHBC.)

Kentucky Energy Regulatory Commission (KY ERC) - Certificates of Convenience and Necessity and Environmental Compatibility

The KY ERC, formerly the Public Service Commission (PSC), issues authorization to construct energy facilities for specific sites. If a conversion facility will serve as an energy source, authorization from KY ERC will be required. KY ERC issues a Certificate of Convenience and Necessity and a Certificate of Environmental Compatibility after a public hearing, and after it has received a recommendation from KY DNREP concerning the

environmental compatibility of the proposed facility. These certificates are needed to start construction.

KY DHBC(6) - Electrical, Building and Plumbing Plans Approval; and Boiler/Pressure Vessel Installation Permit

The KY DHBC issues permits through three different divisions: (1) the Division of New Constructions approval is required for the electrical and building plans (prepared by a certified engineer); (2) the Division of Plumbing issues a permit after a review of the plumbing plans, prior to the commencement of construction; and (3) the Bureau of Boiler and Pressure Vessel Inspection of the Office of the State Fire Marshall, KY DHBC, issues a permit for the installation of boilers or other pressure vessels. (Evidence of boiler inspection must be present at the plant.)

Kentucky Department of Labor (KY DOL)(7) - Elevator Installation Permit

The Division of Labor Standards of KY DOL issues an elevator installation permit.

Preoperation Permits

KY DOT - Truck Cab Registration (for Hazardous Liquids Transportation) and Industrial Hauling Permit; plus Apportionment License, Motor-Fuel-Use-Tax License (or Trip permit), and Exempted Commodity/Irregular Truck Route Certificate

The truck cab used for transport of hazardous liquids must be registered with the KY DOT. In addition, the Division of Motor Carriers issues an Industrial Hauling Permit for the transport of materials over public roads whenever the gross weight of the truck exceeds road weight limitations.

A $20 permit fee is assessed for all vehicles, and a maximum allowable weight is set, depending on the number of axles per vehicle.(8)

An Apportionment License Tag must also be acquired (fees range from $11.50 for pickup trucks to $840 for the largest motor carriers); any motor vehicle with three or more axles must obtain from the Motor Vehicle Tax Division of the KY DOT a Highway-Motor-Fuel-Users license (for the purpose of paying a 2-percent highway users tax).(9)

In lieu of a motor-fuel-users license, it is possible for a motor vehicle operator to purchase a trip permit. (Upon payment of $10, the Bureau of Vehicle Regulation issues a permit which entitles the holder to operate for ten consecutive days.)

The Bureau of Vehicle Regulation of the KY DOT issues special Irregular Route Truck Certificates. A fee is assessed for the certificate with the rate depending upon the type of commodity being hauled.(10)

If the commodity is on the exempted commodity list, such as coal, then it could be hauled under an Exempted Commodity Certificate, which is issued for a $25 fee and may be renewed each year for an annual renewal fee of $25.

KY DHBC - Certificates for Boiler/Pressure Vessel Operation and Flammable/Combustible Liquids Storage and Use; and Tank Vehicle Permit

Through its Bureau of Boiler and Pressure Vessels Inspection, the DHBC issues an Operation Certificate which shows that the boiler or pressure vessel has been inspected and found to be in safe working order. A new certificate must be obtained annually (unless a low-pressure boiler is involved, in which case a biannual inspection suffices).

The KY DHBC, through its Division of Fire Prevention, Hazardous Material, also issues a Certificate of Condition for Flammable and Combustible Liquids; and a Tank Vehicle Permit, approving the transport of hazardous liquids.

KY DOL - Industrial Plant/Office Elevator Safety Certificate

All industrial plant and office elevators must be certified safe each year by the Division of Labor Standards within the KY DOL.

References for Section 7.1

1. The U.S. Environmental Protection Agency (USEPA), although not directly responsible for issuing air quality permits, does have veto power over the Kentucky Prevention of Significant Deterioration of Air Quality (PSD) and new source (air quality) permits per the Clean Air Act Amendments of 1977. (Kentucky has been delegated all air quality permitting authority, and air quality permits are therefore discussed under "State Permits.")

   Air quality regulations regarding PSD are discussed in detail in Appendix 7A; state air quality permit requirements are outlined in Appendix 7B.

2. A plant radio permit may also be required from the Industrial Radio Service of the Federal Communications Commission (FCC) for the use of mobile service radio communication system. The transport of coal or any other materials across state

boundaries in for-hire vehicles may require certification from the Interstate Commerce Commission (ICC). Private carriers and intrastate transport do not require ICC certification.

3. New Source Construction Permit requirements are outlined in Appendix 7B.

4. USEPA - Region IV must be notified if the plant wastes may be hazardous.

5. If Kentucky has a "mini-NEPA," the USEPA may delegate its "lead agency" status to KY DNREP.

   In addition, if the proposed site for the location of the conversion facility is at variance with local zoning ordinances, it may be necessary to apply to the local Planning Commission for a zoning ordinance amendment.

6. The Radiation Control Branch of the Department for Human Resources issues a permit for the handling of radioactive materials whenever such materials are in use in gauges, scales, and so on. Such a permit or license must be obtained initially during the construction phase when installation takes place and continues to apply as long as such radioactive materials are utilized in the area.

7. These permits are usually obtained by firms to which the installation has been subcontracted rather than by the coal conversion facility itself.

8. The KY DOT Bureau of Highways also issues, upon request, a special permit for overweight or overdimensioned vehicles. This permit is applicable only to indivisible loads, that is, loads which must be shipped intact, as an entity, but which exceed size or weight regulations. (It is unlikely that a conversion facility would need to obtain this type of permit more than occasionally.) KY DOT also issues a certificate that verifies that the carrier has purchased bodily injury and property damage liability insurance.

9. In addition, carriers must file (with their permit application) a corporate surety bond in the maximum amount of four months anticipated liability for the highway users tax, not to exceed $50,000, and in a minimum amount of $1,000. (The Division of Motor Carriers issues an annual Uniform Vehicle Identification Card for a nominal fee to any private carrier or for-hire carrier to provide evidence that the carrier has a Kentucky motor-fuel-use-tax license number.)

10. If the commodity is regulated, a Certificate of Public Convenience and Necessity would first have to be obtained from the KY DOT Division of Hearings to haul the commodity legally. A Public Convenience and Necessity Certificate is renewable each year for a $25 fee.

    Both exempt and regulated commodity certificates apply to Kentucky intrastate for-hire motor carrier operations only. A private carrier hauling its own commodities does not have to have either of these two types of certificates.

7.2 Terrestrial Ecology

7.2.1 Existing Conditions

The site lies near the eastern boundary of Boone County. Physiographically this area is known as the Outer Bluegrass. The principal trees supported by this area are sugar maple, ash, black walnut, beech, wild cherry, and black locust. The majority of the original forest was cleared to make room for agricultural uses of the land.

The site area was probably cleared for such agricultural uses but was abandoned. This abandonment allowed weeds and shrubs to begin growing before it was once again cleared for use as the Northern Kentucky Industrial Park.

The GREFCO plant site is currently maintained by cutting grass-covered areas so that the vegetation does not exceed 3 in. in height. This type of habitat could support reptiles, amphibians, small mammals and birds. The U.S. Department of Agriculture estimates that 34 species of mammals, 33 species of reptiles and amphibians, and 110 species of breeding birds inhabit Boone County. In addition, approximately 200 other species of birds visit the county during migratory movements. Only a few of these species actually use the GREFCO site.

According to the Kentucky Nature Preserves Commission, the only rare, threatened, or endangered species appearing in Boone County near the project site are the Redback Salamander (*Plethodon cinereus*) and Yellow-Wood (*Cladrastis kentuckea*). It is very unlikely that either of these species inhabit the site because both are found in woodland habitats which are much different from the grassy habitat onsite.

The Kentucky Nature Preserves Commission identified six environmentally sensitive areas in Boone County. The closest of these are approximately 5 miles south-southwest (Bald Point - 1-1/2 miles west of Hueys Corners) and 5 miles north-northwest (Conrad Lane, beech-maple forest - 1 mile northeast of Burlington) of the site. None of these six areas will be directly modified by the proposed project.

7.2.2 Impacts on Terrestrial Ecology

Construction and operation of the GREFCO project will have minor impacts on the terrestrial ecology of the area. Surrounding habitats are very similar to the one composing the proposed site; therefore, fauna will be able to relocate to these areas.

Neither rare, threatened, or endangered species nor environmentally sensitive areas will be disturbed during construction or operation.

7.3 Physiography, Geology, and Soils

7.3.1 Physiography

The proposed site lies in the Interior Low Plateaus Province. This regional physiographic province is bounded on the east, in Kentucky and Tennessee, by the west-facing escarpment of the Appalachian Plateaus and on the southwest by the Tennessee River. The northern boundary, although less defined because of glaciation, runs along the Ohio River.(1)

The Interior Low Plateaus includes the Blue Grass region of Kentucky, which in turn consists of four physiographic subdivisions: Inner Blue Grass, Eden Shale Belt, Outer Blue Grass, and Knobs. The proposed site is located in the northern part of the Outer Blue Grass subdivision (see Figure 7-1).

7.3.2 Geology

Bedrock of the Blue Grass Region ranges in age from Ordovician to Pennsylvanian.(2) Over 90 percent of this Region including the proposed site consists of near-surface rocks are of the Ordovician Period. The site itself rests on the Bull Fork Formation, which is part of the Maysville group(3) (see Figure 7-2).

The Bull Fork Formation is approximately 105 ft thick and consists of interbedding limestone and shale. Resting beneath the Bull Fork Formation are, from the top, the Grant Lake Limestone (6 to 20 ft in thickness), the Fairview formation (interbedded limestone and shale 90 to 120 ft thick), and the Kope Formation (layers of shale and limestone, over 220 ft thick). The latter formation is part of the Lower-Ordovician Eden Group.

The major structural feature of the site region is the Cincinnati arch. The axis of this arch extends from central Tennessee northeastward to the central part of the Blue Grass region. Here it splits, one branch extending northwestward through Boone County and one extending northward through Pendleton County.(3) The site lies approximately 6 miles east of the northwestern branch (see Figure 7-1).

Historically, the site region was exposed to a continuous depositional period from the Middle Cambrian to the Pennsylvanian Period (535 to 300 million years ago (mya)). During the Late Mississippian and Early Pennsylvanian Periods

(315 to 305 mya), the area underwent two main periods of arching forming the Cincinnati arch. During the late Paleozoic Era (300 to 225 mya), fault systems developed (such as the Rough Creek, the Hickman, and the Kentucky fault systems) which control in part the direction of the Kentucky River.(4)

The Mesozoic Era (225 to 65 mya) was characterized by erosion, which was followed by uplifting during Early Tertiary (65 to 60 mya) and resulted in the formation of the Lexington Plain. Uplifting continued into the Late Tertiary (5 to 10 mya) causing dissection of the Lexington Plain and entrenchment of major streams.(4)

The Pleistocene (1,500,000 to 10,000 years ago) brought two glacial episodes, Illinoian and Wisconsin, which scoured present-day landscapes and left behind glacial till on the hills and glacial outwash deposits along the Ohio River in northern Kentucky.(4)

Blanketing the site area are unconsolidated sediments of glacial and alluvial origin. Alluvial deposits are found along the Ohio and Licking Rivers, as well as their tributaries. Alluvium along the Ohio River Valley is predominantly weathered silty clay and clayey silt with fine sand with local lenses of gravel and coarse sand. The Licking River Valley is blanketed by silt and fine sand and some coarser material, as much as 95 ft thick downstream and thinning out upstream. Tributary stream deposits consist mainly of silt and clay with variable amounts of sand and gravel. Locally, permanent and intermittent streams in Boone and Kenton Counties are actively downcutting and generally expose as much as several feet of bedrock beneath terrace deposits of silt and clay.

North and northwest of the site are deposits of glacial drift and glacial outwash. Glacial drift deposits consist of clay, silt, sand, and mixtures in varying percentages. Cobbles and boulders are rare and consist of conglomerates, sandstone, igneous, and metamorphic rocks up to 5 or 6 feet in diameter.

Glacial outwash deposits, consisting of silt, clay, crossbedded sand, and gravel interfingering with one another, are found along the Ohio River. Unconsolidated materials at the site consist of fine sand and silt at the surface with silt and clay beneath, both of glacial origin.

7.3.3 Seismology

Kentucky has two fault zones which trend eastward; they are the Kentucky River fault zone, in eastern Kentucky, and the Rough Creek fault zone, in western Kentucky.(5) Branching off the Kentucky River fault zone in Jessamine County, and running northeastward into Mason County, is the smaller Hickman fault

zone.(2) The proposed site is approximately 25 miles northwest of the Hickman fault at its closest point (see Figure 7-1).

Historically, seismic frequency for the proposed site area is less than 8 per 10,000 square kilometers (4,000 square miles) during the period 1800 to 1972.(5) Intensities for epicenters located within a 100-mile radius of the site during this period varied from III to VIII on the Modified Mercalli (MM) scale (see Table 7.3.3-1).(6,7) The largest recorded earthquakes in the United States took place on December 16, 1811, January 23, 1812, and February 7, 1812 in New Madrid, Missouri, some 330 miles southeast of the site. In all three seismic events, an intensity of X-XII MM was felt within the epicenter area. The resultant site intensities from these seismic episodes may be estimated as VI-VII MM (see Table 7-2).

7.3.4 Soils

The soil of the proposed site consists of Rossmoyne silt loam, which is part of the Rossmoyne soil series. This series consists of deep, strongly acidic, moderately well-drained silt loam soils that rest on a fragipan. Lying beneath the fragipan, which lies 18 to 22 in. from surface and is approximately 30 in. thick, is 60 in. or more of low-permeable mottled silty clay.

The Rossmoyne silt loam at the site slopes from 0 to 6 percent, is considered to be subject to moderate erosion, and is found on broad ridgetops.(6)

7.3.5 Potential Impacts

7.3.5.1 Construction

During the construction phase, there should be no adverse impacts imposed either on the local or regional physiography or on the general geology.

Because of the low seismic frequency and intensity characteristics of the site area, seismic activity should not be a factor in preventing the construction of the coal gasification plant at the proposed site.

Construction activities will call for a certain disturbance of site soils. Although the Rossmoyne silt loam is considered to be subject to moderate erosion,(8) erosion can be minimized by proper control techniques.

7.3.5.2 Operation

There should be no impacts on the physiography, geology, or seismicity of site region.

The coal pile will be lined and runoff treated; therefore any impact on site soils will be contained within the plant area.

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8. U.S. Dept. of Agriculture, Soil Conservation Service, Aug. 1973, Soil Survey of Boone, Campbell, and Kenton Counties, Kentucky.

9. Gupta, I.N. and Nutti, D.W., 1976, Spatial Attenuation of Intensities for Central U.S. Earthquakes, Bull. Seism. Soc. Am. Vol. 66, No. 3, pp. 743-751.

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Table 7-1

Earthquake History of Site Area - 50-Mile Radius (6)
1800 - 1970

Year	Date	(CST) Time	Locality	N Lat.	W Long.	Area	Epicenter Intensity
1779	unknown		Northern Kentucky	----	----	----	----
1791 or 1792	April or May	07:00	Northern and eastern Kentucky	----	----	----	----
1834	Nov 20	13:40	Northern Kentucky	----	----	----	V
1897	May 28	10:10	Maysville, Kentucky	38.7	83.7	6.00	V
1933	Apr. 30	22:00	Tennessee Illinois, Indiana, and Kentucky	----	----	----	IV-V

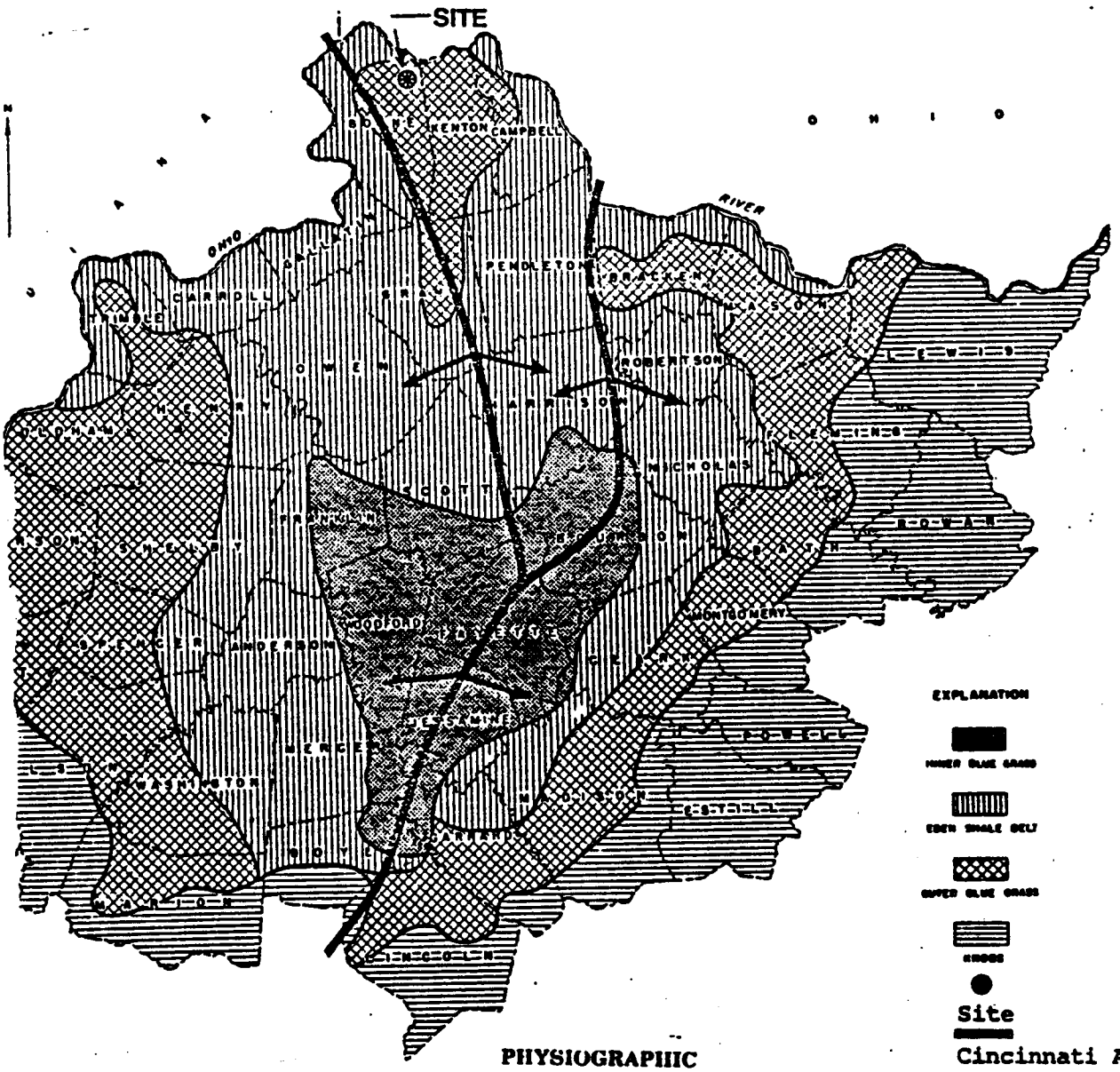
Source: Gibbs & Hill, Inc.

Table 7-2

Estimated Site Intensities of Major Historical Earthquakes in the Region (1800-1980 Data) (6,7)

Year	Date	Location of Epicenter	Distance from sites (miles)	Epicentral Intensity	Estimated site Intensities (9-10)
1811	Dec. 16	New Madrid, Missouri	330	X-XII	VI-VII
1812	Jan. 23	New Madrid, Missouri	330	X-XII	VI-VII
1812	Feb. 7	New Madrid, Missouri	330	XII	VI-VII
1937	Mar. 8	Western Ohio	80	VII-VIII	V
1968	Nov. 9	Central South Illinois	220	VII	II-IV
1972	Sept. 14	Central Illinois	450	VI	I-II
1980	July 27	Sharpburg, Kentucky	70	VI-VII	III-V

Source: Gibbs & Hill, Inc.



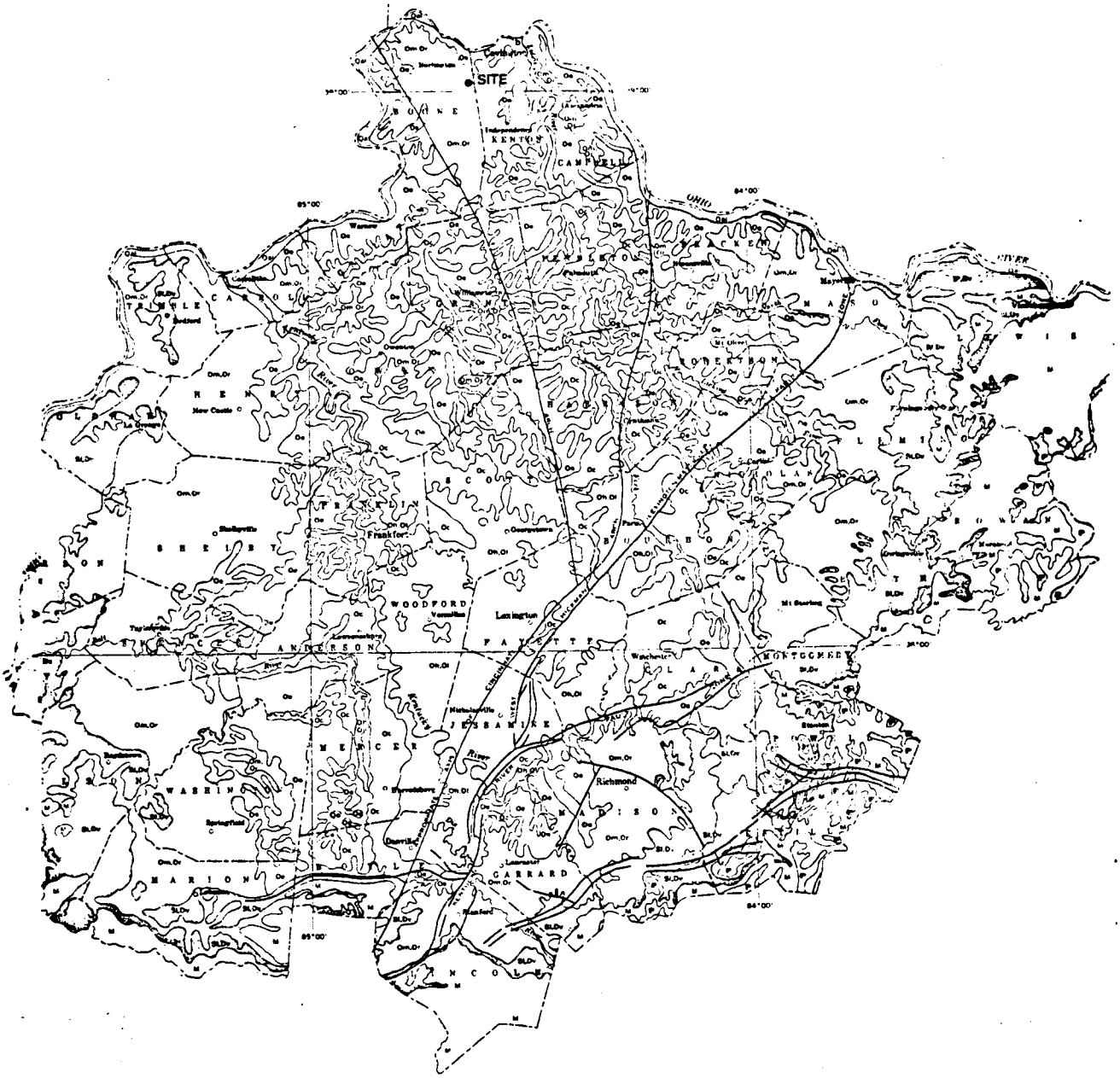
PHYSIOGRAPHIC SUBDIVISIONS OF THE BLUE GRASS REGION, KENTUCKY (AFTER McFARLAN, 1943)

Source: (2)

GREFCO INC.
FLORENCE, KENTUCKY

Dravo
Engineers & Constructors

Figure 7-1



GEOLOGIC MAP OF THE BLUE GRASS REGION, KENTUCKY

Source (2)

GREFCO INC.
FLORENCE, KENTUCKY

Dravo
Engineers & Constructors

Figure 7-2

7.4 Surface Water and Groundwater

7.4.1 Surface Water

The proposed site is located on a crest of a watershed divide which separates Gunpowder Creek to the west and Licking River to the east. Along this divide and within the site area, numerous small intermittent streams drain into South Fork (a tributary of Gunpowder Creek) or into Bullock Pen Creek (a tributary to the Licking River). Within a 1/2-mile radius of the proposed site are 14 ponds, one of which is manmade.

The proposed site is situated approximately 2-3/4 miles west of the nearest flood-prone area. The flood-prone area is characterized as having a 1 in 100 chance on the average of being inundated during any year. The elevation of the site of 900 ft places it 200 ft above the flood-prone area.(1)

7.4.2 Groundwater

Two broad classes of aquifers are present within the site area. They are:

- Unconsolidated material along the Ohio River and its tributaries, primarily glacial and alluvial in origin.

- Bedrock deposits of Ordovician limestone interbedded with shale.

Unconsolidated alluvial materials consist of gravel, sand, silt, and clay of valley train deposits, channel alluvium, and tributary alluvium. Valley train deposits generally are 5 to 8 ft thick but can exceed 20 ft; channel and tributary deposits are up to 25 ft thick.(3)

Glacial deposits (till), which consist of clay, silt, sand, and gravel, are up to 15 ft thick. Northwest of the site near Burlington and north of Cincinnati Airport, thickness of the glacial deposits is up to 175 ft.(3)

The closest spring to the site lies approximately 9 miles southwest of the site near Big Bone. Water from this spring is discharged from the Eden group and the Cynthiana Formation, both of Ordovician Period (435 to 500 mya).(4)

Almost everywhere, alluvium of the Ohio Valley will yield sufficient quantities of water for domestic use, and in many places it will yield several hundred to over one thousand gallons per minute (gpm). Alluvial deposits along major tributaries of the Ohio River have yields ranging from 8 to 100 gpm.(5)

Beneath the unconsolidated deposits are the bedrock units. The site area is underlain by the Bull Fork Formation of Upper Ordovician Period, consisting of interbedded limestone and shale. Resting beneath this formation are the Grant Lake Limestone and the Fairview and Kope Formations (see Section 7.3.2). Groundwater generally moves through the bedding planes, joints, and solution cavities of these formations. Locally, wells in bedrock yield small quantities of water. This is a result of the relatively impermeable shale beds in the upper Bull Fork Formation, which prevent large quantities of water from percolating downward.(4)

Groundwater quality of wells which tap the Maysville group (Bull Fork being part of this group) is given in Table 7-3. Generally, groundwater is high in hardness, iron, sulphate, chlorides, and calcium carbonate.

7.4.3 Potential Impacts

7.4.3.1 Construction

The site is located on a broad flat-lying watershed divide where streams are intermittent. Effects of discharge of construction wastes via surface runoff to any nearby surface water body should be temporary. Because of this, the potential impact on surface water quality from construction runoff should be negligible.

The site area is underlain by 30 in. of fragipan and, below this, by 60 in. of silty clay. Due to their low permeability, these materials will prevent and minimize any potential contamination of groundwater from construction wastes.

7.4.3.2 Operation

During operation, four waste byproducts will be generated from coal storage and coal gasification processes. These waste byproducts are:

- Coal Leachate
- Bottom Ash
- Liquid Sulfur
- Liquid Tar

The coal pile area will be lined, and all leachate will be collected, treated, and discharged to the city sewer line. Bottom ash will be collected in dumpsters, sold and trucked off site. Liquid sulfur and liquid tar will be stored in steel tanks and also sold and trucked off site. Because all waste byproducts

will be trucked off site or treated and discharged into a sewer line, there should be no impacts on the groundwater or surface water quality in the site vicinity.

References for Section 7.4

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Table 7-3

Summary of Chemical Analysis of the Maysville Group Aquifer[4]

	Silica	Iron	Manganese	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate	Dissolved Solids	Hardness as CaC03		Specific Conductance	pH
														Total	Non-Carbonate		
No. of Analysis	4	16	2	4	4	3	3	16	16	16	9	14	4	16	3	16	4
Maximum	9.4	8.9	0.26	97	35	230	15	428	1,086	8,900	1.8	55	761	2,810	117	23,500	7.7
Average	6.5	1.4	0.17	77	23	124	10.2	275	173	900	0.5	19.1	576	506	56	3,081	---
Low	2.4	0.14	0.09	31	12	16	7.4	132	3.3	7	0.1	1.2	364	164	8	476	7.2

Note: Units for Specific Conductance are umhos/cm, pH are standard units, all others are mg/l

7.5 Meteorology and Air Quality

7.5.1 Existing Conditions

7.5.1.1 Meteorology

The importance of describing the climate of the site vicinity and quantifying the associated parameters lies primarily in the role of weather in transporting and dispersing atmospheric emissions. The climate in the vicinity of the site is described well by the hourly surface observations made by the National Weather Service (NWS) at the Greater Cincinnati Airport, 6 miles (9 km) north-northwest of the site in Erlanger, Kentucky, and by the twice daily upper-air observations made by the NWS at the Dayton Municipal Airport, 67 miles (107 km) north-northeast of the site in Vandalia, Ohio. The upper-air observations are made by radiosonde balloon.

The Climate is of the continental type, and is thus characterized by large seasonal differences in weather conditions. Winters are moderately cold with frequent periods of cloudy skies and relatively warm temperatures separated by clear, cold spells; summers are warm and moderately humid, and on the whole less cloudy. The dominant air masses are polar continental (cP), which bring cold, dry air south from Canada, and tropical maritime (mT), which bring warm, moist air north from the Gulf of Mexico. The alternating advance of these air masses produces the changeable weather typical of the region. The heaviest precipitation during the cooler half of the year, as well as the precipitation of longest duration, is usually associated with large low-pressure disturbances moving in a general southwest to northeast direction along the polar front which separates polar from tropical air masses. The heaviest precipitation during the warmer half of the year usually results from short duration shower and thunderstorm activity.

The most important meteorological variables for air quality concerns are those that describe the transport and dispersion processes: wind speed and direction, atmospheric stability, and mixing height. Also of importance are temperature (which along with the above parameters determines the height to which a plume will rise) and moisture (which affects plume visibility and can alter the chemical form of certain emissions). In the following paragraphs, the meteorological variables listed above are described in more detail for the site vicinity.

Temperature

The relatively large contrast between winter and summer is apparent in the range of temperatures. The average monthly surface temperatures for January and July, respectively, are 31.1 F (-0.5 C) and 75.6 F (24.2 C). Surface temperature data for the Greater Cincinnati Airport are summarized in Table 7-4.

Upper-air temperatures are obtained from the Dayton upper-air observations. The vertical temperature profile is analyzed to approximate mixing heights, which are discussed later in this section.

Moisture

Annual precipitation averages 40.7 in. (103 cm) and is fairly well distributed among the seasons. A weak maximum occurs during spring and early summer with a minimum occurring in late summer and fall. Rainfall data for Cincinnati are summarized in Table 7-4.

Heavy fog, defined as fog which reduces visibility to 1/4 mile or less, occurs approximately two dozen times per year. The frequency of heavy fog is highest in the fall and lowest in the spring.

Wind

Surface winds are predominantly from the south, southwest, and west during all seasons. The annual wind rose for the Greater Cincinnati Airport, where wind measurements are made at 20-ft elevation, is shown on Figure 7-3; the average speed is 9.1 mph (4.1 m/sec). Average speeds are higher in winter and spring, at 10.5 mph (4.7 m/sec) and 10.3 mph (4.6 m/sec), than in summer and fall, at 7.2 mph (3.2 m/sec) and 8.4 mph (3.8 m/sec). Surface wind data for Cincinnati are summarized in Table 7-4.

Upper-air wind measurements are made during the twice daily upper-air observations taken at Dayton Municipal Airport. These wind measurements were not utilized for this study. Wind speed at stack height is discussed below in the section entitled "Meteorological Input to Dispersion Modeling."

Atmospheric Stability

Atmospheric stability is a measure of the ability of the atmosphere at a given time and place to inhibit or enhance vertical motion. Unstable conditions, which result from a sharp decrease in temperature with height, promotes vertical motion and enhances despersion. Stable conditions, which result from a small decrease in temperature with height, or in the case of an inversion an increase in temperature with height, dampens vertical motion and inhibits dispersion.

The frequency of unstable, neutral, and stable conditions in the Cincinnati area is similar to that for most other Ohio Valley locations. On the basis of 5 years (1970-74) of Cincinnati hourly surface data which approximate stability by means of wind speed, cloud cover, and solar declination using the Pasquill-Gifford method, unstable conditions exist 15.8 percent of the time, neutral conditions 53.5 percent, and stable conditions 30.7 percent. Unstable conditions are most frequent during the summer (June-August) at 29.1 percent of the time, and least frequent in

winter (December-February) at 5.1 percent. Stable conditions occur most frequently in summer and fall at 36.1 percent and 38.3 percent, respectively, of all stable cases, and least frequently in winter at 16.7 percent of all stable cases. These figures show the tendencies toward stability extremes (i.e. very unstable or very stable conditions) in summer and neutral conditions in winter.

Mixing Height

The mixing height is the height to which the atmosphere is well mixed. Mixing heights vary on an hourly, daily, and seasonal basis. The mixing results from thermal turbulence, i.e., atmospheric instability, and mechanical turbulence, i.e., wind and terrain interactions. The morning and afternoon mixing heights are approximated by analysis of the morning vertical temperature profile (obtained by upper-air observation) in conjunction with the morning minimum and afternoon maximum surface temperatures. The annual average morning mixing height is 1,600 ft. (490 m); seasonally, it is as follows: winter 1,800 ft., spring 2,100 ft., summer 1,300 ft., and fall 1,300 ft. The annual average afternoon mixing height is 4,700 ft., (1,430 m) or by season: winter 3,100 ft., spring 5,700 ft., summer 5,700 ft., and fall 4,500 ft.

Meteorological Input to Dispersion Modeling

Meteorological input to the air quality dispersion model, which is discussed in Section 7.5.2, Air Quality Impacts, consists of one year (1964) of hourly surface data from Cincinnati and twice daily upper-air data from Dayton. The year 1964 was used because it is the most recent year for which the National Climatic Center has hourly digitized data.

The hourly data include wind speed and direction, cloud cover, and temperature. Wind speed at stack height is approximated in the dispersion model by multiplying the 20 foot wind speed by an exponential factor that is dependent on atmospheric stability. The twice daily data consist of morning and afternoon mixing heights.

7.5.1.2 Ambient Air Quality

General

In terms of air quality, the feasibility of the proposed modification is determined both by the existing ambient air quality in the vicinity of the plant and by the impacts of the plant emissions on this air quality. This section focuses on the existing conditions in the site vicinity. Due to the relatively limited distance to which impacts occur (see Section 7.5.2), the discussion is limited to the area within 25 km of the plant (Figure 7-4).

The plant is located in Boone County, 100 m west of the Kenton County line. Boone County and Kenton County are in the Kentucky portion of the Metropolitan Cincinnati Interstate Air Quality Control Region, AQCR 79. AQCR 79 includes 14 counties in Kentucky, Ohio, and Indiana. Eight counties are in Kentucky, 4 of which, other than Boone and Kenton, have sections within 25 km of the site: Campbell, Gallatin, Grant, and Pendleton. Four counties are in Ohio, only one of which, Hamilton, is within 25 km; Hamilton County, which includes the city of Cincinnati is, at its closest, 10.5 km from the site. The remaining two counties in AQCR 79, Dearborn and Ohio, are in Indiana, and both have portions within 25 km of the site. In addition, the Indiana county of Switzerland, in the Southern Indiana AQCR, AQCR 83, is within 25 km of the site.

Kentucky is in USEPA Region 4; Indiana and Ohio are in USEPA Region 5.

Standards

The Ambient Air Quality Standards (AAQS) for Kentucky are identical to the National AAQS for the criteria pollutants, i.e., total suspended particulates (TSP), sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), ozone (O3), non-methane hydrocarbons (NMHC), and lead. In addition, Kentucky has standards for hydrogen sulfide (H2S), gaseous fluorides, total fluorides, and odors. The Kentucky and National AAQS are summarized in Table 7-5. The annual standards are given as arithmetic or geometric means which are not to be exceeded. The short term standards are given as concnetrations that can be exceeded once per year.

Monitoring Networks

There are a total of 30 air quality monitoring stations within 25 km of the site which measure one or more of the criteria pollutants. As such, the air quality in the general site vicinity is well described. The large majority of these stations, however, are at least 10 km north of the site in and near Covington on the Kentucky side of the Ohio River and

Cincinnati on the Ohio side. Of the 30 stations within 25 km, 13 are in Kentucky and are administered by the KY DNREP, and 17 are in Ohio and are administered by the Ohio Environmental Protection Agency (OEPA). There are no air quality monitoring stations in Indiana that are within 25 km of the site.

Although there are only two stations within 10 km of the site, these are only 2.0 km northwest in Florence and 4.9 km north in Erlanger. Each station measures TSP, SO2, NO2, and lead. The closest stations that measure O3 and CO2 are in Covington, and are 12.7 and 14.7 km northeast of the site, respectively. Measurements of NM-HC are not routinely taken in the Greater Cincinnati Metropolitan Area.

Total Suspended Particulates (TSP)

The immediate site vicinity is designated attainment with respect to the primary and secondary standards. At the Florence monitoring station for the period 1978 through 1979, the annual geometric mean and the second maximum 24-hr average were approximately 89 percent and 65 percent of the respective secondary standards. At Erlanger, the annual mean exceeded the secondary standard in both 1979 and 1980 and was approximately 90 percent of the primary standard. The second maximum 24-hr average was 87 percent of the secondary standard in 1979, and it was 66 percent of the primary standard, exceeding the secondary standard, in 1980. The 1979 and 1980 TSP measurements at Florence and Erlanger are given in Table 7-6.

The closest area that is non-attainment for TSP is in Cincinnati in Hamilton County, 10.4 km north of the site; this area is non-attainment with respect to the secondary standards. The closest area that is non-attainment with respect to the primary standards is also in Cincinnati at a distance of 12.9 km. These areas are more urban and industrial in character than the immediate site vicinity. Other than Hamilton County, the only areas that are non-attainment within 25 km are the southeastern tip of Dearborn County in Indiana, 23 km to the northwest, and the City of Newport in northern Campbell County in Kentucky, 15 km to the northeast; both these areas are non-attainment with respect to the primary standards.

Sulfur Dioxide

The immediate site vicinity is designated attainment with respect to the primary and secondary standards. In Florence in 1980 (there were no 1979 measurements), the annual arithmetic mean and second maximum 24-hr average were only 7 percent and 2 percent of the respective primary standards (there are no secondary standards for these averaging times). These figures are based on an incomplete sampling schedule for the year. In Erlanger, the annual mean and 24-hr concentrations for 1979 and 1980 were approximately 21 percent and 34 percent of the respective standards. No 3-hr

measurements were taken at either Florence or Erlanger, and as such the 3-hr secondary standard is not addressed. The 1979 and 1980 SO2 measurements at these two stations are given in Table 7-6.

The only area within 25 km that is non-attainment for SO2 is Whitewater Township in western Hamilton County, approximately 20 km to the north-northwest of the site. This area is non-attainment with respect to the primary standards.

Nitrogen Dioxide

The entire area within 25 km of the plant is designated attainment for NO2. In Florence the annual arithmetic mean for 1980 (there were no measurements in 1979) was 38 percent of the primary standard (same as the secondary standard). In Erlanger the mean for 1979 and 1980 was approximately 37 percent of the standard (see Table 7-6).

Carbon Monoxide

The immediate site vicinity is attainment with respect to the primary standards (same as the secondary standards). The closest station that measures CO, although representative of a more urban setting than the immediate site vicinity, is in Covington, 14.7 km to the northeast. For 1979 and 1980, the second maximum 1-hr average was approximately 44 percent of the 1-hr standard. The 8-hr standard was violated in 1979; in 1980 the second maximum 8-hr average was 77 percent of the standard (see Table 7-6).

The only area within 25 km that is non-attainment is Hamilton County, 10.4 km to the north.

Ozone

The immediate site vicinity and most of the area within 25 km are non-attainment with respect to the primary standard (same as the secondary standard). The closest station that measures ozone, although in a more urban setting, is in Covington, 12.7 km to the northeast. The 1-hr standard was violated 3 times at this station in 1980 (there were no 1979 measurements). The second maximum 1-hour average was 9 percent above the standard. Ozone measurements for 1980 are given in Table 7-6.

Counties within 25 km are non-attainment for ozone are Boone, Kenton, and Campbell in Kentucky, and Hamilton in Ohio.

Non-Methane Hydrocarbons

Non-methane hydrocarbons (NM-HC), the measurement of which serves as a guide for the ozone standard, are not currently monitored within 25 km of the site.

There is no attainment status for NMHC.

Lead

Ambient concentrations of lead are measured at both Florence and Erlanger. For 1979 and 1980, the highest calendar quarter arithmetic means for these stations were approximately 23 percent and 37 percent, respectively, of the primary standard (same as the secondary standard). Lead measurements for 1979 and 1980 are given in Table 7-6.

There is no attainment status for lead.

Summary

The immediate site vicinity is attainment for all criteria pollutants except ozone. There are, however, attainment problems with TSP, SO2, and CO at distances beyond 10 km to the north. The attainment status of the five classifiable pollutants is summarized in Table 7-7.

The OEPA has indicated through informal discussions that the attainment status for TSP and SO2 might improve in the next few years, as there is a possibility that for portions of Hamilton County, the status of these pollutants might be redesignated to attainment. As of now, however, no requests to redesignate have been submitted to the USEPA .

SO2 and sulfuric acid mist (defined as H2SO4 and SO3 measured as H2SO4) are the pollutants of particular interest for the proposed modification. There are no ambient air quality standards for H2SO4, although it is subject to regulation under the Clean Air Act.

7.5.2 Impacts

7.5.2.1 Emissions to the Atmosphere

Construction

Emissions to the atmosphere during gasifier construction consist of fugitive dust generated by construction activity, and exhaust emissions produced by the operation of construction equipment.

Dust emissions vary substantially from day to day depending on soil conditions and the level of activity, but average 1.2 tons/acre/month. Assuming a 2-acre construction site of which half would be active in any given month, and a construction period of 8 months, total particulate matter (PM) emissions would be 9.6 tons. If activity is limited to a normal working schedule of 40 hr/week, PM emissions are 13.84 lb/hr. Watering can reduce this rate up to 50 percent.

Construction equipment includes bulldozers, backhoes, cranes, trucks, diesel generators, and similar equipment. An approximation of the emissions resulting from this equipment can be made by assuming these emissions to be equal to the continuous operation (40 hr/week) of two heavy-duty off-highway trucks, two bulldozers, and one generator. Using AP-42 (Compilation of Air Pollutant Emission Factors, USEPA, 1979), the resulting emissions are 0.99 lb/hr of PM, 1.74 lb/hr of sulfur oxides (SOx), 27.37 lb/hr of nitrogen oxides (NOx), 4.59 lb/hr of carbon monoxide (CO), and 1.50 lb/hr of hydrocarbons (HC). At 40 hr/week for 8 months, this amounts to 0.69 ton of PM, 1.21 tons of SOx, 18.98 tons of NOx, 3.18 tons of CO, and 1.04 tons of HC.

Operation

Emissions to the atmosphere during plant operation consist of gaseous and particulate emissions from the gasifier flares and stacks and the factory stacks, water vapor and drift droplets from the cooling tower, and fugitive dust from the coal pile.

The gasifier plant has six flares, including five gasifier flares and one absorber flare, and two stacks, including one reductive incinerator stack and one boiler stack. All of these sources rise 100 ft above grade. Emissions are more or less continuous in nature and amount to 5.01 tons/yr of PM and 60.23 tons/yr of sulfur dioxide (SO2). Smaller amounts of NO2, CO, and NM-HC are also emitted.

Associated with the gasifier plant are two additional sources, a two-cell mechanical draft cooling tower, and a coal pile. The tower rises 28.2 ft above grade and its emissions consist of approximately 41 tons/hr of evaporative loss (water vapor) and 1.5 tons/hr of drift loss (liquid water including dissolved and suspended impurities). The coal pile is 180 ft long, 120 ft wide, and 10 ft high. Approximately one-fifth of the pile will be active. The remainder will be inactive and will be sprayed with a water base organic polymer dust suppressant. Fugitive dust emissions result from wind erosion and coal handling on the active portion of the pile. Using emission factors in AP-42, which incorporate a precipitation-evaporation index, fugitive

dust emissions across the site boundary are estimated to be approximately 1 ton/yr.

The factory has several stacks, ranging in height from 30 to 60 feet. Emissions from these stacks are continuous. Factory emissions from burning natural gas include SO_2 and sulfuric acid. These sulfurous emissions result almost entirely from sulfur in the product board which is released when the board is dried. When low-Btu gas from the gasifier is used instead of natural gas, SO_2 emissions increase, but H_2SO_4 emissions do not change. Much smaller amounts of NO_2, CO, and NM-HC are also emitted.

Other PSD and non-attainment area requirements concern ground level impacts resulting from the above-summarized emissions. These aspects of air quality review are discussed in Section 7.5.2.3, Impacts on Air Quality.

7.5.2.2 Impacts on Meteorology

The only atmospheric emission that will have a measurable effect on the meteorology within the immediate plant vicinity will be the cooling tower evaporative and drift loss. The addition of vapor to the atmosphere will cause a slight increase in ground level humidity in the downwind direction during infrequent weather conditions at distances of up to 1 km from the tower. Also, drift loss will result in the deposition of small amounts of liquid water and suspended and dissolved solids on the site proper.

7.5.2.3 Impacts on Air Quality

Construction

The construction site is an area source. Impact concentrations resulting from emissions generated on the site can be estimated by employing the virtual point source method of D.B. Turner (Turner, 1970).

Assuming a wind speed of 9.1 mph (the average annual wind speed), neutral atmospheric stability, and a source height of 10 ft, the maximum annual impacts will be in the north-northeast and will be only a small fraction of the respective National Ambient Air Quality Standard (NAAQS) for each pollutant (PM, SO2, NO2, CO, and NMHC). The most significant emission, NOx, will produce a maximum offsite annual impacts of 5.4 ug/cubic meter at a distance of 1 km from the source; this is 5.4 percnet of the annual NOx standard of 100 ug/cubic meter. PM emissions will result in a maximum annual impact of 3.9 ug/cubic meter, or 65 percent of the annual secondary standard of 60 ug/cubic meter. Maximum impacts decrease to approximately 25 percent of these levels at a distance of 1 km.

Short-term impacts are also small. Assuming the same wind speed and stability as above and a constant wind direction, the maximum 24-hr impact for which there is an applicable 24-hr standard is 25 ug/cubic meter for PM, or 17 percent of the secondary 24-hr standard of 150 ug/cubic meter. As with annual impacts, short-term impacts decrease rapidly with distance.

Operation

Air quality impacts during operation were estimated using the USEPA-recommended CRSTER computer dispersion model. This model computes annual and short-term (i.e., 24-hr, 3-hr, and 1-hr) impacts. Input consists of receptor information, stack characteristics, emission rates, and meteorological data. Receptor information includes location (distance and direction) and elevation. Stack characteristics include height, exit diameter, exit velocity, and exit temperature. Emission rates are specified as either short-term or long-term and for one pollutant per computer run. Meteorological data consist of one year of hourly observations, including wind speed and direction, temperature, and sky cover, and one year of twice daily mixing heights (see Section 7.5.1, Existing Conditions-Meteorology a complete discussion on meteorological input).

A total of 16 computer runs were made using the emission rates and stack characteristics shown in Tables 7-9 and 7-10. These runs covered short and long term emission rates. Fifteen receptor distances were chosen between 0.1 and 25 km for the 36 compass directions. Plant elevation was assumed for all receptors; this

is a conservative assumption as the plant is at the highest elevation in the site vicinity and most receptors would therefore be below plant elevation and thus yield lower impact concentrations if actual elevations were input. Only PM, SO2, and H2SO4 were modeled as these are the pollutants of concern. Of these three, only SO2 and H2SO4 are significant emissions as defined in PSD.

Maximum SO2 and H2SO4 impacts are predicted to occur at distances of less than 1 km from the plant. The maximum annual SO2 impact is 4.5 ug/m^3 at a distance of 0.6 km to the north-northeast; this is 5.6 percent of the applicable annual standard. The second maximum 24-hour SO2 impact is 49 ug/m^3 at a distance of 0.7 km to the north-northeast; this is 13.4 percent of the applicable 24-hour standard. The second maximum 3-hour SO2 inpact is 143 ug/m^3 at a distance of 0.4 km to the east-northeast; this is 11.0 percent of the applicable 3-hour standard. Maximum H2SO4 impacts for the same time periods as above are 4.1, 50, and 140 ug/m^3, and occur at the same locations; as discussed earlier, there are no ambient air quality standards for H2SO4.

For each direction annual SO2 and H2SO4 impacts decrease at 5 km to between 20 and 25 percent of the maximum radial values and at 25 km to between 2 and 4 percent of the maximums. Twenty-four hour impacts decrease to between 25 and 50 percent of the maximum radial values at 3 to 4 km. A secondary maximum occurs at 5 km in the north-northeast sector; overall at 5 km, impacts are between 15 and 35 percent of the maximum radial values. At 25 km 24-hour impacts decrease to between 3 and 10 percent of the maximums. Three-hour impacts follow a pattern similar to that for the 24-hour impacts.

Maximum annual and second maximum short-term impacts are listed in Table 7-11 along with the respective standards. The plant contributions of SO2 and H2SO4 are graphed with distance on Figures 7-5 and 7-6 , respectively. In no case do the impacts cause a violation excedance of the NAAQS. In addition SO2 and PM impacts on non-attainment areas to the north are less than the respective significant impact levels (there is no attainment status for H2SO4). Sulfur dioxide impacts to consume a significant portion of the SO2 PSD increments in the immediate site vicinity: 22.5 percent of the annual increment, 53.8 percent of the 24-hr increment, and 27.9 percent of the 3-hr increment. Because ambient SO2 levels in the immediate vicinity of the plant are low, however, it is still large enough to accommodate the source. A detailed inventory and modeling study for existing sources would have to be performed to determine the exact available increments. It should be noted that the KY DNREP and the USEPA may decide that only a portion of the available increments can be used by any given proposed new source or modification. In addition, the portion of the available increment which can be used by a given source in any area across a state line is only half of the total available increment in that area.

The effects of aerodynamic stack downwash and building wake effect are not considered in the CRSTER Model. In general these phenomena cause occasionally higher ground level concentrations to occur close to the stack if the stack is relatively low in height, has a wide diameter and low exit velocity, and is adjacent to a structure of significant size. The exit velocity of the factory stack emissions and the height of the gasifier flares and stacks are sufficient to prevent the occurrence of these phenomena under most but not all meteorological conditions.

Factory stack impacts account for approximately 80 percent of total plant impacts for SO2 for all averaging times and distances, while gasifier sources account for 20 percent. This ratio is approximately the same as the ratio between annual SO2 factory and gasifier emissions (279.48 versus 60.23 tons/yr). In addition, facotry stack emissions account for all of the plant's H2SO4 impact. Because higher factory stacks would decrease the possibility of downwash, two model runs were made with the factory stacks raised 25 feet above existing heights to determine what reduction in maximum impacts would occur. For all averaging times and distances factory impacts decrease approximately 30 percent from those resulting with existing stack heights.

Table 7-4

Meteorological Data for the Greater Cincinnati Airport[1)]

	Temperature (°F)			Precipitation (inches) Water Equivalent			Wind (mph)			
Record span	1941 - 1970			1948 - 1979			1948 - 1979		1964 - 1979	
	Daily Maximum	Daily Maximum	Average	Normal	Maximum	Minimum	Mean Speed	Prevailing Direction	Fastest Mile[2)]	Direction
January	39.7	22.4	31.1	3.52	9.43	0.75	10.7	SSW	46	W
February	42.7	23.8	33.3	2.92	6.72	0.25	10.6	SSW	40	WNW
March	51.8	31.6	41.7	3.91	12.18	1.14	11.2	SSW	44	WSW
April	65.0	42.7	53.9	3.60	7.19	1.04	10.8	SSW	40	WSW
May	74.4	51.9	63.2	3.67	9.48	1.13	8.8	SSW	35	NW
June	83.2	61.0	72.1	4.15	7.36	0.95	7.9	SSW	40	WSW
July	86.5	64.6	75.6	4.25	8.36	1.18	7.1	SSW	35	NW
August	85.8	63.0	74.4	2.91	6.10	0.31	6.7	SSW	32	ENE
September	79.7	55.9	67.8	3.02	8.61	0.18	7.4	SSW	32	WSW
October	68.5	45.0	56.8	2.48	5.03	0.25	8.1	SSW	35	W
November	53.2	34.3	43.8	3.21	6.26	0.43	9.6	SSW	35	SSW
December	42.0	25.3	33.7	3.08	6.46	0.51	10.2	SSW	40	SSW
Annual	64.4	43.5	54.0	40.72	53.22	27.99	9.1	SSW	46	W

(1) From "Local Climatological Data, Annual Summary with Comparative Data, 1979, Cincinnati, Ohio", NOAA

(2) Speed of peak wind over time period needed for air to travel one mile past the point of measurement.

TABLE 7-5

AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	Criteria	Primary Standard ug/m^3	Primary Standard ppm by volume	Secondary Standard ug/m^3	Secondary Standard ppm by volume
		NATIONAL AND KENTUCKY				
Sulfur dioxide (SO_2)	Annual	Arithmetic mean - not to exceed	80	0.03	-	-
	24-hour	Not to exceed more than once per year	365	0.14	-	-
	3-hour	Not to exceed more than once per year	-	-	1,300	0.50
Total suspended particulates (TSP)	Annual	Geometric mean - not to exceed	75	-	60[1]	-
	24-hour	Not to exceed more than once per year	260	-	150	-
Nitrogen dioxide (NO_2)	Annual	Arithmetic mean - not to exceed	100	0.05	Same as	primary
Carbon Monoxide (CO)	8-hour	Not to exceed more than once per year	10,000	9	Same as	primary
	1-hour	Not to exceed more than once per year	40,000	35	Same as	primary
Ozone (O_3)	1-hour	Not to exceed more than once per year	235	0.12	Same as	primary
Lead	Calendar quarter	Arithmetic mean - not to exceed	1.5	-	Same as	primary
Non-methane hydrocarbons[2]	3-hour	Not to exceed more than once per year	160	0.24	Same as	primary
		KENTUCKY				
Hydrogen sulfide	1-hour	Not to exceed more than once per year	-	-	14	0.01
Gaseous fluorides (measured as HF)	Annual	Arithmetic mean - not to exceed	400	0.5	0.50	0.60 ppb
	1-month	Not to exceed more than once per year	-	-	0.80	0.97 ppb
	1-week	Not to exceed more than once per year	-	-	2.86	3.50 ppb
	24-hour	Not to exceed more than once per year	800	1.0	2.86	3.50 ppb
	12-hour	Not to exceed more than once per year	-	-	3.68	4.50 ppb
Total fluorides	Growing Season	Not to exceed more than once per year	-	-	-	40[3]
	2-month	Not to exceed more than once per year	-	-	-	60[3]
	1-month	Not to exceed more than once per year	-	-	-	80[3]
Odors	Undefined	No odor	-	-	When 1 volume ambient air mixed with 7 volumes of odorless air	

1) Used as a guide in achieving 24-hour standard
2) Used as a guide in achieving ozone standard
3) ppm by weight

TABLE 7-6

Ambient Air Quality in Immediate Site Vicinity

Station	Distance to site (Km)	Direction	Year	TSP Annual (ug/m³)	TSP 24-hour (ug/m³)	SO2 Annual (ug/m³)	SO2 24-hour (ug/m³)	SO2 3-hour (ug/m³)	NO2 Annual (ug/m³)	CO 8-hour (mg/m³)	CO 1-hour (mg/m³)	O3 1-hour (ug/m³)	Lead Calendar Quarter (ug/m³)
Florence	2.0	NW	1979	52	114/93	-	-	-	-				0.43
			1980	55	134/102	5.2	10/8	-	38.0				0.26
Erlanger	4.9	N	1979	63+	139/131	23.1	186/133	-	39.2				0.74
			1980	72+	191/171+	10.4	65/44	-	34.0				0.38
Covington	12.7	NE	1979									-	
			1980									284/255*	
Covington	14.7	NE	1979							11.3/11.3*	29.1/19.4		
			1980							7.7/6.9	12.6/11.4		

For Short-term averages, slash denotes: highest/second highest

* - Violation of Primary Standard
\+ - Violation of Secondary Standard

Source: Kentucky Department for Natural Resources and Environmental Protection Ohio Environmental Protection Agency.

Table 7-7

Attainment Status for Counties within 25 km of Site

State	County	Distance to Closest Boundary (km)	AQCR	TSP	SO2	NO2	CO	O3
Kentucky	Boone	-	79	1	1	1	1	3
Kentucky	Campbell	12.8	79	2a	1	1	1	3
Kentucky	Gallatin	20.5	79	1	1	1	1	1
Kentucky	Grant	19.8	79	1	1	1	1	1
Kentucky	Kenton	0.1	79	1	1	1	1	3
Kentucky	Pendleton	22.0	79	1	1	1	1	1
Ohio	Hamilton	10.4	79	2b	2c	1	3	3
Indiana	Dearborn	22.7	79	2d	1	1	1	1
Indiana	Ohio	18.7	79	1	1	1	1	1
Indiana	Switzerland	18.5	83	1	1	1	1	1

1 - Attainment for entire county

2 - Non-attainment for sections of the county

3 - Non-attainment for entire county

a - City of Newport does not meet primary standard (closest non-attainment section to site is 15 km NE).

b - Most of Cincinnati does not meet primary standard; most of remainder of county, with exception of NE quadrant, does not meet secondary standard (closest primary non-attainment section is 12.9 km N; closest secondary non-attainment section is 10.4 km N).

c - Whitewater Township does not meet primary standard (closest section to site is 20 km NNW).

d - Central third of County from east to west boundary does not meet primary standard (closest section to site is 23 km NW).

TABLE 7-8

Topographic Relief Within 25 Km of Site

Site elevation (above Sea Level): 920 ft

Radius (Km)	Maximum Elevation (ft)	Direction (ft)	Difference from Site Elevation (ft)	Minimum Elevation (ft)	Direction (ft)	Difference from Site Elevation (ft)
2.0	945	S, SW, W	+25	800	NE, E	-120
5.0	950	S, SW, W	+30	580	E	-340
10.0	960	S, SE	+40	460	N	-460
25.0	965	S, SE	+45	455	SW	-465

TABLE 7-9

Gasifier and Factory Source Characteristics[1)]

Source	Source Number	Height above grade (ft)	Height of supporting structures (ft)	Exit diameter (ft)	Exit temperature (°F)	Exit velocity (ft/sec)
Gasifier flares	1-5	100	72	1.5	2,500	2.64
Absorber flare	6	100	31[1)]	1.5	2,500	1.87
Reductive incinerator stack	7	100	0	2.0	120	2.36
Boiler stack	8	100	13	1.33	450	58.3
Expander and dryer stacks	9	60	31	4.0	350	65
Cooling tower	10	28.2	28.2	16.0	N/A	N/A

1) Height of nearest structure

N/A - Not available

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Table 7-11

Maximum Ground Level Impact Concentrations for PM, SO_2, and H_2SO_4

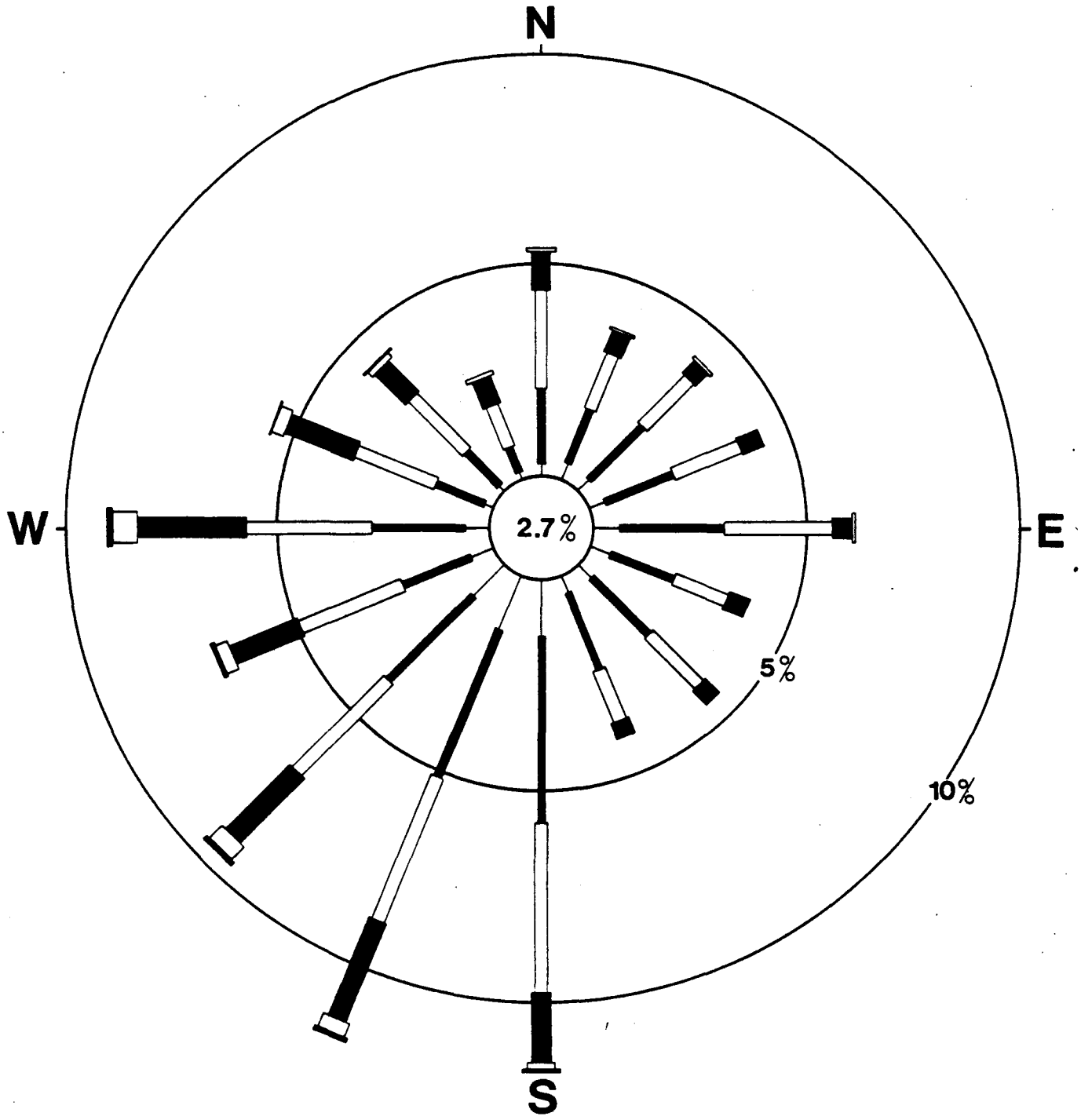
		Maximum Impact[1] (ug/m^3)	Distance	Direction	NAAQS[2] (ug/m^3)	Percent of NAAQS	Ambient Level[3] (ug/m^3)	Impact plus Ambient (ug/m^3)	PSD Increment[4] (ug/m^3)	Percent of PSD Increment
TSP	Annual	0.13	0.5	NNE	60	0.2	54	54	19	0.7
	24-hour	1.1	0.3	W	150	0.7	98	99	37	3.0
SO_2	Annual	4.5	0.6	NNE	80	5.6	17	22	20	22.5
	24-hour	49	0.7	NNE	365	13.4	89	138	91	53.8
	3-hour	143	0.4	NE	1,300	11.0	-	-	512	27.9
H_2SO_4	Annual	4.1	0.7	NNE	-	-	-	-	-	-
	24-hour	50	0.7	NNE	-	-	-	-	-	-
	3-hour	140	0.4	NE	-	-	-	-	-	-

(1) Maximum for annual and second-maximum for short-term

(2) Primary standard unless there is secondary standard, in which case secondary standard

(3) Closest station, Florence, is used for TSP; Erlanger used for SO_2 because of better data recovery - Data is for 1978-79.

(4) Class II



ANNUAL WIND ROSE FOR COVINGTON, KENTUCKY (1970-74)

calm — 1-3 — 4-6 — 7-10 — 11-16 — 17-21 — >21 knots

Source: NOAA/National Climatic Center

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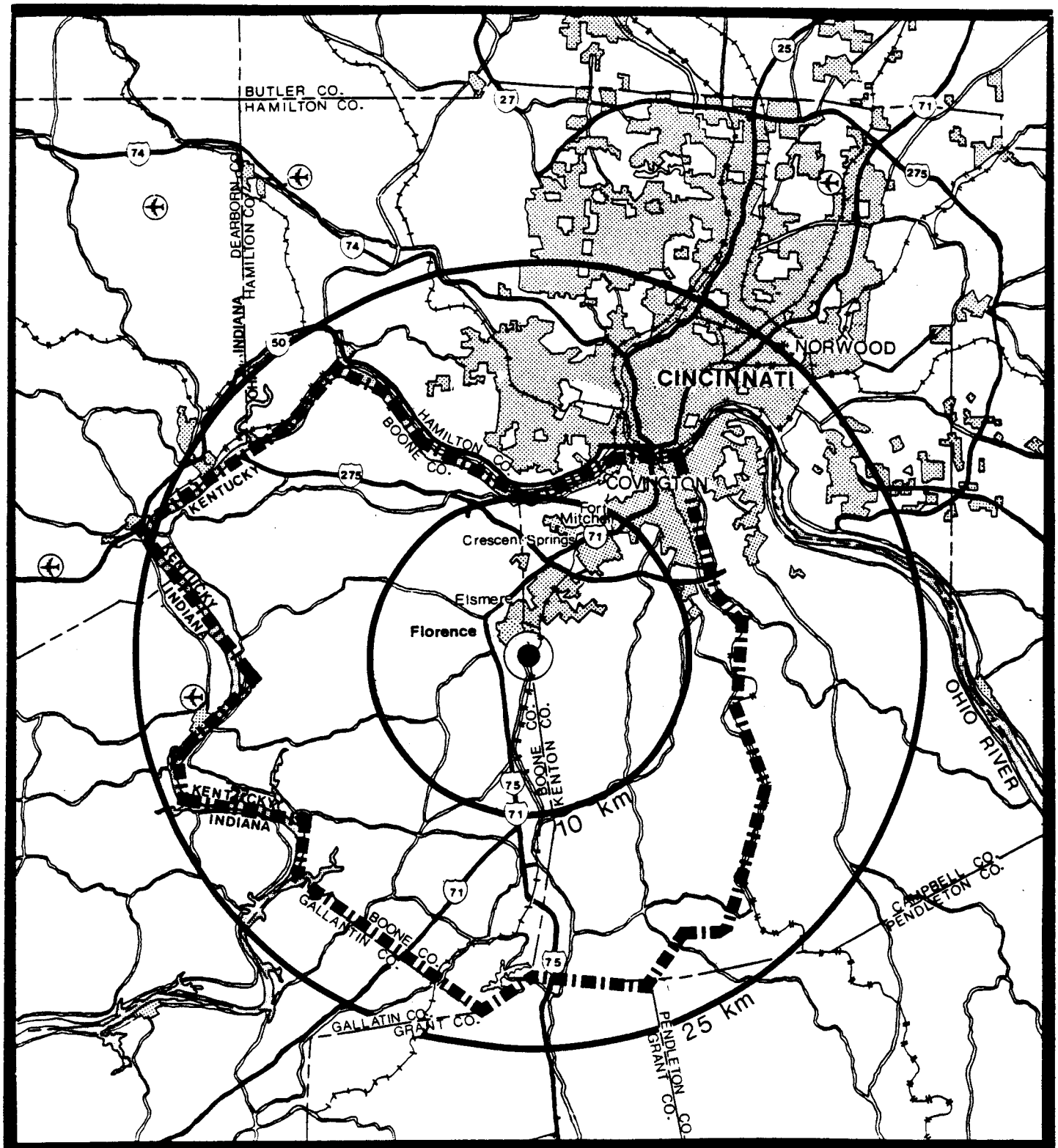
Figure: 7-3



THE SITE VICINITY

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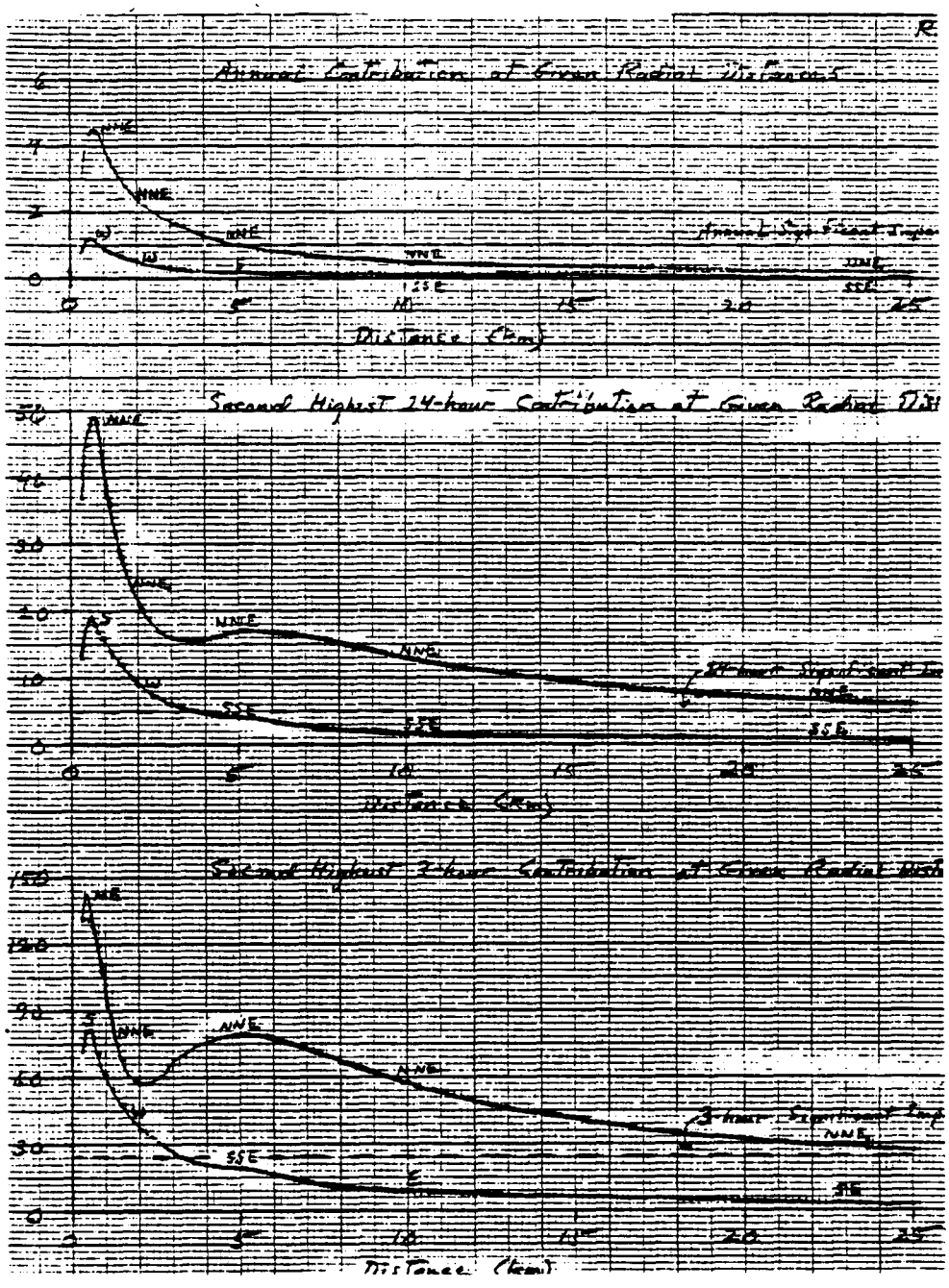
Figure: 7-4



Note: Meteorological input consisted of one year (1964) of hourly surface data from the Greater Cincinnati Airport and twice daily upper-air data from the Dayton Municipal Airport.

Figure 7.5-3 Sulfur Dioxide Impact Concentrations from 0.3 to 25 km

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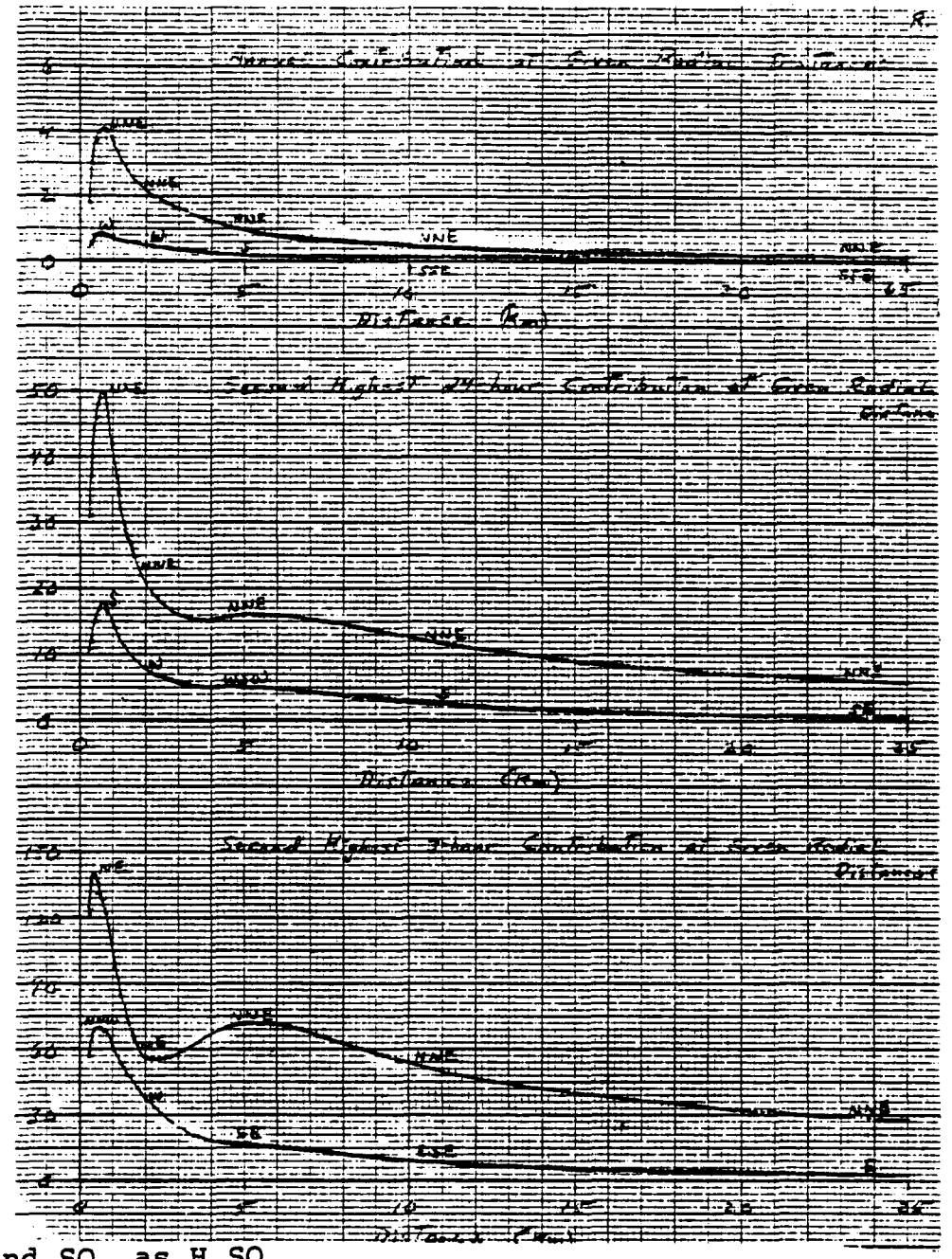
Figure: 7-5



1) H_2SO_4 and SO_3 as H_2SO_4

Note: Meteorological input consisted of one year (1964) of hourly surface data from the Greater Cincinnati Airport and twice daily upper-air data from the Dayton Municipal Airport.

Figure 7.5-4 Sulfuric Acid 1) Impact Concentrations from 0.3 to 25 km

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Figure 7-6

7A.2 Water Construction Permits

The following information is required for a construction permit from KY DNREP - Division of Water Quality:

- A U.S.G.S. 7-1/2-minute topographical map showing the plants exact location and the maps quadrangle name.

- A plot plan of the plant complex, including:

  - The location of all ponds; the capacity, sizing, and purpose for all ponds, and all associated ditches and berms; and the flow pattern of surface water to these ponds.
    (Suggested Scale: 1 in. = 40 ft to 1 in. = 100 ft.)

  - The location of all waste disposal areas (associated berms, ditches, and access areas, as well as the mode of transporting material to these areas).

  - All diversion ditches or berms which divert unaffected runoff away from stockpile areas.

- A complete flow sheet of the plant, including a material balance.

- The location, flow, and capacity of fresh water and makeup water sources (for impoundments, both a schematic and a cross-section of the dam).

- The method of sanitary waste disposal.

- The drainage (ditches and pipes) for onsite roads.

- The method and means of cleaning and maintaining all ponds, and the type of equipment (dragline, back hoe, front-end loader) to be used.

- A copy of any lease or rental agreement pertaining to the land to be utilized.

- Three complete sets of the application, along with a copy of the National Pollutant Discharge Elimination System application.

APPENDIX 7A

PERMIT INFORMATION REQUIRED FOR KENTUCKY AIR AND WATER CONSTRUCTION PERMITS

7A.1 Air Construction Permits

The following permit information is required for air construction permits from the Kentucky Department of Natural Resources and Environmental Protection (KY DNREP) - Division of Air Quality (includes the Prevention of Significant Deterioration of Air Quality (PSD) permit requirements):

7A.1.1 Engineering Information

- Site Plan (showing property lines, building heights, adjacent property, plant equipment, and fugitive emission points at an appropriate scale)
- Plant Flow Diagrams (including process fuel and waste handling flows)
- Coal Handling Plan
- Fugitive Emission Control Plan
- Air Monitoring Plan
- Air Emergency ("Episode Standby") Plan
- Analysis of Plant Impact on Local Visibility, Soils, Vegetation and Air Quality
- Demonstration of Compliance with National Ambient Air Quality Standards (NAAQS) and PSD Standards (See Appendix 7B for PSD analysis.)

7A.1.2 Administrative Information

- Cost of Pollution Control Equipment
- Cost of Coal Gasification Plant (including above equipment)
- Construction Schedule
- Typical Operation Schedule

APPENDIX 7B

PREVENTION OF SIGNIFICANT DETERIORATION OF AIR QUALITY (PSD) REGULATORY OUTLINE

7B.1 Introduction

The permitting of new stationary sources under the Federal Clean Air Act (CAA) comes within two categories:

- The regulation of new sources in attainment areas under Prevention of Significant Deterioration of Air Quality (PSD) standards

- The regulation of new sources in non-attainment areas under Non-attainment Area New Source Review.

On August 7, 1980 (45 Fed. Reg. 52676), the U.S. Environmental Protection Agency (USEPA) published revised final rules for PSD. These regulations apply to major stationary sources and major modifications that meet specific criteria for the following:

- Geographical location

- Type and amount of pollutants to be emitted

- Timing of proposed construction

7B.2 New Sources in Attainment Areas

PSD regulations apply to "major stationary sources" (40 CFR S. 52.21c). The definition of "source" under PSD regulations was expanded on August 7, 1980, to include the entirety of a "facility or installation."

A major source is defined as: (1) any source that falls within 28 industrial categories (including fuel conversion plants) listed in the CAA if it has the "potential to emit" over 100 tons of any air pollutant regulated by the CAA or (2) any source with the potential to emit over 250 tons per year of any air pollutant regulated by the CAA.

"Potential to emit" is based upon: (1) actual pollutant emissions; (2) potential emissions at maximum plant capacity, with designated pollution controls operating at "reasonably anticipated levels"; or (3) Federally enforceable restrictions on operations, including hours of operation and type or amount of material combusted, stored, or processed.

7B.3 Modified Sources

For existing sources, a "major modification" is subject to PSD regulations, and the appropriate emissions control technology per attainment and non-attainment areas. Unless the net increase for an entire facility ("bubble concept") is greater than the following significance threshold criteria, there is no "major modification."

Significance Criteria (Threshold)
(measured as net annual emissions)

CAA Regulated Pollutant	"Significant Increase Threshold"
Carbon Monoxide	100 tons per year (tpy)
Nitrogen Oxides	40 tpy
Sulfur Dioxide	40 tpy
Particulate Matter	25 tpy
Ozone	40 tpy of volatile organics
Lead	0.6 tpy
Asbestos	0.007 tpy
Beryllium	0.0004 tpy
Mercury	0.1 tpy
Vinyl Chloride	1 tpy
Fluorides	3 tpy
Sulfuric Acid Mist	7 tpy
Hydrogen Sulfide	10 tpy
Total Reduced Sulfur (including H2S)	10 tpy
Reduced Sulfur Compounds (including H2S)	10 tpy

"Major Modification" is thus defined by the "Significant Net Emissions" criteria for each designated pollutant. These

criteria replace USEPAs previous exemption of modifications which result in less than a 100 tpy increase from a designated category, or less than 250 tpy increase from all other source categories. In addition, these criteria define the threshold for the Best Available Control Technology (BACT) requirement for new sources in attainment areas and the Lowest Achievable Emission Rates (LAER) requirement for new sources in non-attainment areas.

7B.4 Air Quality Classifications and PSD Increments

Geographical-based air quality classifications can be summarized as follows:

- Class I - National Parks of over 6,000 acres and in existence on August 7, 1977.
- Class II - areas with air quality better than NAAQS. Certain Park lands may be redesignated only to Class II.
- Class III - "dirty" air areas around urban and industrial centers.

For each class, the CAA specifies increases in pollutant concentrations for particulate matter and sulfur dioxide that will be allowed above baseline levels. The allowable increment is smallest for Class I areas and greatest for Class III.

Increments over the "baseline" concentrations have been established only for sulfur dioxide and particulate matter as follows:

PSD Increments

Class I Area

Particulate matter:	5 ug/cubic meter annual mean
	10 ug/cubic meter 24-hr average
Sulfur dioxide:	2 ug/cubic meter annual mean
	5 ug/cubic meter 24-hr average
	25 ug/cubic meter 3-hr maximum

Class II Area

Particulate matter:	19 ug/cubic meter annual mean
	37 ug/cubic meter 24-hr average
Sulfur dioxide:	20 ug/cubic meter annual mean
	91 ug/cubic meter 24-hr average
	512 ug/cubic meter 3-hr maximum

Class III Area

Particulate matter:	37 ug/cubic meter annual mean
	75 ug/cubic meter 24-hr average
Sulfur dioxide:	40 ug/cubic meter annual mean
	182 ug/cubic meter 24-hr average
	700 ug/cubic meter 3-hr maximum

Increments are limited by the following National Ambient Air Quality Standards (NAAQS) :

National Ambient Air Quality Standards (NAAQS)[1] - in mg/m^3 and (ppm)

Air Pollutant	Observation Time	Primary Standard	Secondary Standard
Particulate Matter (PM)	1 yr.	75 (annual geometric average)	60[2] (annual geometeric averag
	24 hrs.	260	150
SO (Sulfur Dioxide)	1 yr.	80 (0.03) (annual arithmetic average)	None
	24 hrs.	365 (0.14)	None
	3 hrs.	None	1300 (0.5)
CO (Carbon Monoxide)	8 hrs.	10,000 (9)	Same
	1 hr.	40,000 (35)	Same
Ox (Ozone)	1 hr.	235 (0.12)	Same
HC (Hydrocarbons)	3 hr. (6-9 AM)	160 (0.24) (not enforceable)	Same (not enforceable)
NO_2 (Nitrogen Dioxide)	1 yr.	100 (0.05) (annual arithmetic average)	Same
Pb (Lead)	3 mos. (i.e., every calendar quarter; e.g., Jan-Mar, April-June, etc.)	1.5	Same

FOOTNOTES:

[1]Increments may not allow the NAAQS to be violated.

[2]This secondary standard applies as guidance to achieve the 24-hr. standard only.

[3]This primary standard may be revised to 28,630 ug/m^3 (25 ppm) in the near future.

Significant Impact Levels (ug/cubic meter)

Air Pollutant	Observation Time	"Significant Impact Level" Threshold
PM	1 yr.	1 (annual geometric average)
	24 hrs.	5
SO2	1 yr.	(annual arithmetic average)
	24 hrs.	5
	3 hrs.	25
NO2	1 yr.	1 (annual arithmetic average)
CO	8 hrs.	500
	1 hr.	2000

The "baseline" ambient air quality level (from which the increments must be measured) is the actual air quality existing at the time of the first application for a PSD permit in an "area" (generally, an Air Quality Control Region) with certain adjustments:

- The contribution of sources which "commenced construction" after January 6, 1975, must be subtracted from the increment, resulting in the "available increment."

- The estimated air quality impacts from sources which commenced construction before January 6, 1975, although not in operation by August 7, 1977, must be added to the actual baseline.

- The baseline includes emission increases allowed under state implementation plan (SIP) relaxations pending on August 7, 1977.

- The baseline will be determined by USEPA and the states from industrys required periodic reports covering emission increases and reductions, modeling estimates, etc., rather than by any ambient air monitoring networks. However, where ambient air data are sketchy, 1 ug/cubic meter of particulate matter and/or SO2 may be used as an assumed "ambient."

Thus, emissions that decrease the available increments are:

- Emissions from new sources after January 6, 1975

- Emission increases from existing sources that were included in the baseline

- Emission increases authorized by a relaxation in SIP requirements

However, events that will expand the available increments are:

- SIP revisions which reduce emissions from existing plants

- Enforceable emission offsets

7B.5 PSD Permits

To obtain a PSD permit, a source must meet all State Implementation Plan SIP, New Source Performance Standards (NSPS), National Emissions Standards for Hazardous Air Pollutants and Best Available Control Technology (BACT) requirements.

BACT is determined on a case-by-case basis, and is the maximum emission reduction achievable by the source taking into account technological, energy-related, environmental, and economic considerations. BACT cannot be less than NSPS. Also, USEPA can impose design, equipment, and operational standards or work practices as part of BACT requirements.

If a modified source can show that the net increase in its potential to emit a specific pollutant will be less than "significant", (see Section 7B.3, "Significance Criteria") BACT need not be required for that pollutant. If all pollutant increases associated with a modification meet this test, no PSD review need be performed.

For modified sources, BACT will only be required on the "emission unit" that causes a significant net increase in potential emissions. In determining whether a net increase in potential emissions from a modification will exceed the de minimis level, all "contemporaneous" intra-plant offsets are considered (see F.R. 52698-52705 and 40CFR 51.24(b)2, 52.21(b)2).

However, for all sources, the following "de minimis impacts" determine whether monitoring is required (even though the source may be a "Significant" modification per the "Significance Criteria"):

De Minimis Impacts

CAA-Regulated Pollutant	"De Minimis" Impacts (in ug/cubic meter) averaged over a 24-hr period - unless otherwise noted in parentheses
Carbon Monoxide	575 (8-hr average)
Nitrogen Oxides	14
Sulfur Dioxide	13
Particulate Matter	10
Ozone (measured as voc or "Volatile Organic Compounds"	100 (tons/yr)
Lead	0.1
Asbestos	None
Beryllium	0.0005
Mercury	0.25
Vinyl Chloride	15
Fluorides	0.25
Sulfuric Acid Mist	None
Hydrogen Sulfide (H2S)	0.04 (1 hr. avg.)
Total Reduced Sulfur (including H2S)	10 (1 hr. avg.)
Reduced Sulfur Compounds (including H2S)	10 (1 hr. avg.)

7B.6 Non-Attainment Areas and Offsets

In an "area" designated as non-attainment under CAA S.107(d)-(1), the Offset Ruling applies. The general S.110(a) (2) (D) State Program "attainment and maintenance requirements" are then superseded by the explicit requirements for offsets, "lowest achievable emission rate" and "reasonable further progress" towards attainment.

Any new source or any modification with the "potential to emit" 100 tpy or more of particulate matter, sulfur oxides, nitrogen oxides, volatile organic compounds, carbon monoxide, or lead, must be reviewed to determine compliance with applicable emission limitations, and with the Rulings air quality impact provisions.

Sources that come under USEPAs Offset Ruling (44 Fed. Req. 3274) are not subject to PSD review for the same pollutant unless they have a "significant impact" on a clean area in another state or any impact on Class I areas (see 13 ERC 2013, and 45 Red. Req. 52676). "Significant impact" levels are defined in the following table.

A specific source may be subject to PSD requirements for some pollutants and non-attainment review requirements for others.

For non-attainment areas, there must be emissions offsets (reductions) from sources in the same vicinity sufficient to provide reasonable progress towards NAAQS attainment. Further, the offset must be shown to produce a "net air quality benefit" in the area of the new source.

Emissions offsets must be enforceable and accomplished by the date of startup of the source. For offsets obtained from facilities other than those operated by the applicant, the offset must be incorporated into an enforceable SIP revision. State and local governments may also initiate and obtain offsets for a new source.

Offsets may be "banked." Reductions in emissions which go beyond present offset requirements and which are banked can be used to offset emission increases at a later date. The reviewing authority must establish procedures for identifying what emissions can be and have been banked, and how new sources may use them for offsets.

Under the stay order issued May 13, 1980, at 45 Fed. Reg. 31304, USEPA exempts from the Offset Ruling (and from the Restriction on Construction) sources which are not "major" where: (1) intra-plant offsets are considered; or (2) "potential to emit" is defined to consider the effects of control equipment and/or operating limitations.

The new source in a non-attainment area must meet an emission limit which is the "lowest achievable emission rate" (LAER) for its source category as listed in the State Implementation Plan. LAER is defined as the lower of either the most stringent emission limitations for that source category or the lowest actually achieved in practice. In no event can any pollutant be emitted from the source in excess of that allowable under NSPS. In determining LAER, USEPA will consider "technology-transfer" and establish levels based on the performance of technology in another industry category with comparable pollutants and operating conditions.

The applicant must certify that all existing major sources owned or operated by the applicant--or by any entity controlling, controlled by, or under common control with the applicant--in the same state are in compliance with applicable standards or a Federally enforceable schedule of compliance.

8.0 SOCIOECONOMICS

GREFCO, a division of General Refractories Corporation, has proposed to construct a coal gasification plant on its premises in the Northern Kentucky Industrial Park in Florence, Kentucky, located approximately 15 miles southwest of Cincinnati, Ohio.

The construction of the proposed gasification plant is expected to take 19 months at a cost of approximatly $33 million. The net operating expense is estimated at $5.1 million per year.

For the purposes of this socioeconomic analysis, a regional impact area has been defined. For ease of calculation, it has been defined as Boone and Kenton Counties and includes most of the land within 15 miles of the project site. Most of the construction workers and operations and maintenance staff would be recruited from that area, and therefore, the economic and social impacts would be most significant in this area (See Figure 8-1).

The socioeconomic analysis is presented in four sections, a baseline description of the regional and local socieconomic environments and construction and operation impacts. The baseline description includes Section 8.1 (land use, economy, and population in the regional impact area) and Section 8.2 (land use and circulation in the site vicinity). The major construction and operational impacts, Sections 8.3 and 8.4, focus on land use and circulation impacts on the site vicinity and economic impacts on the regional impact area.

8.1 Regional Impact Area

8.1.1 Land Use

The regional impact area includes 264,000 acres or about 413.6 square miles. Most of the area is cropland and grassland and other non-urban uses. Only 11,757 acres, or 4.4 percent, of the area has housing, and 31,098 acres, or 11.7 percent, is urbanized. The urbanized area is located in the northern part of the region, between the project site and Cincinnati (Table 8-1).

8.1.2 Economy

In 1980, there were 49,318 nonagricultural jobs in the regional impact area. There were 10,862 manufacturing jobs, 15,776 in trade, and 15,024 in services. (See Table 8-2).

8.1.3 Population

In 1980, the population of the regional impact area was 181,710. The largest municipality is Covington, with a population of 47,162 and located in the northernmost part of the impact area, on the southern shore of the Ohio River, opposite Cincinnati. The second largest municipality is Florence, with a population of 26,365 and located at the project site,

about 10 miles southwest of Covington. Between Covington and Florence are several smaller municipalities which together form the only major concentration of population in the impact area (Figure 8-1, Table 8-3).

Much of the recent growth is found in the suburban fringe area adjacent to the site. The older industrial areas closer to the center of the metropolitan area, such as Covington, have lost population in recent years (Table 8-3).

According to local public agencies, population is expected to grow from 181,710 in 1980 to 199,000 by the end of the century. The average annual growth rate is estimated at 1.36 percent (Table 8-4).

In 1980, the impact area labor force included 83,632 persons, or 48.7 percent of the population. The unemployment rate was 6.0 percent, slightly above the average for the state (Table 8-5).

There is a net out-migration of residents to jobs located outside the impact area in center city and other parts of the metropolitan area (Tables 8-5 and 8-2).

Total personal income by place of residence was $1.3 billion, or about $15,550 for every member of the labor force. Per capita income was $7,480, about the same as the average for the state (Table 8-6).

8.2 Site Vicinity

8.2.1 Land Use

The project site is within a two square mile industrial zone which contains 62 firms employing 7,660 persons. The site is in the Northern Kentucky Industrial Park, which is the focus of industrial development in the site vicinity. (See Figure 8-2 and Table 8-7).

The Northern Kentucky Industrial Foundation was incorporated in 1959 and began to develop 1200 acres of land just south of Florence, Kentucky. In 1962, GREFCO was the first industry to begin operation in the park. In 1972, the Northern Kentucky Industrial Park Company (NKIP) assumed management of the Park. About 200 of the original 1200 acres now remain for development purposes, and a 70-acre tract to the south has also recently been purchased for future expansion. It is probable that more southern property will be acquired.

There are now about 52 industries located in the park, employing an estimated 7,100. According to local sources, the majority of those working in the Park live in the immediate Northern Kentucky region (within a 10-mile radius).

To the east of the NKIP and contiguous to it are the Gates Industrial Park and the One Twenty Industrial Park. Together with the NKIP, they comprise the large industrial zone mentioned above.

In summary, no major traffic problems are expected to be caused by construction or operation of the GREFCO gasification plant. Traffic near the site is light, and no impact will be noticeable on area roads.

References for Section 8.2

1. Road information from telephone conversation with Ms. Thurmond, K.D.O.T., 8/3/81. Road capacities are estimated using the Highway Capacity Manual, Special Report No. 67.

2. Telephone conversation with George Hoffman of K.D.O.T., Boone County, 8/4/81.

3. Telephone conversation with Pearson Van-Norman of K.D.O.T., Frankfort, 8/4/81.

4. Telephone conversation with Paul Hemmer of N.K.I.P., 7/30/81.

5. Traffic counts through the intersection were not available. These would be useful to more accurately assess the impact of project traffic on delays at the light.

6. Telephone conversation with Bob Benge, Project Mgr., Dravo, 7/29/81.

8.3 Construction Impacts

Construction of the coal gasification plant is expected to be completed within 19 months. The construction activity will take place on property owned by GREFCO within the NKIP and adjacent to the existing plant structure. It will take approximately 143 person-years to complete the facility with most, if not all, of the labor and materials acquired locally.

More than 150 persons will be employed during the construction phase of the project, with about 18 expected to be from out-of-state. These 18 will form a supervisory team which will remain for the duration of the construction period.

The nonsupervisory personnel are expected to live in the metropolitan area and commute daily to the job site. Almost all are expected to live in the regional impact area. There are 2800 males in the construction industry labor force of the impact area. The number unemployed varies considerably from month to month, but if it is 10 percent, then 280 would be available. During the peak month of construction on the project, 150 nonsupervisory workers are needed. The area is 85 percent non-union; and the prevailing practice is to hire local residents. It is reasonable to expect almost all to be drawn from the local labor pool, and for almost no in-migration to occur to fill these jobs. The resulting impact is a reduction in local unemployment without any changes in residence.

The direct economic potential 143 person-years of employment and a construction payroll of $4.3 million. This activity will generate secondary employment and earnings which could add at least 50 percent to the direct impacts. The total potential is therefore, a possible 215 person-years of employment and $6.5 million total payroll.

The impact of this expenditure will be distributed over a large population. Regional earnings will increase by 0.5 percent, and the general unemployment rate will be reduced by almost 0.2 percent (Table 8-12).

As it is anticipated that the construction workers would be recruited locally, the extra demands placed on community services are expected to be minimal. Similarly, even accounting for the temporary in-migration of the supervisory team personnel and their families, there would be a negligible increase in demands placed on community services.

8.4 Impacts During Operation

At full capacity, the plant would require 27 trucks per day. The plant would use approximately 390 tons of coal/day, probably transported in about 22 trucks/day from either eastern Kentucky or northeastern Ohio. Other catalysts and chemicals would be imported monthly. Besides the gas, the plant would produce significant coal byproducts, including about 14 tons of sulphur/day (the equivalent of one truck load) which, it is expected, would be sold in the local Cincinnati area. Approximately 41 tons of ash/day (two truck loads) would either be sold in Cincinnati or disposed of in nearby landfills. In addition, two tank trucks for tar will leave the site each day.

The traffic generated as a result of the plant's operation would be noticeable, at least in the immediate environment of the NKIP. To avoid backloading the streets, careful consideration has been given to the design of the plant, ensuring that necessary provisions be made for truck parking and unloading. As noted earlier, the site is designed to accommodate delivery trucks on a long approach road onsite (see Section 8.2.2).

During peak operation it is expected that there would be a maximum of 12 operators and maintenance employees at any one time. It is anticipated that all new personnel would be recruited from the surrounding areas. The population increase due to any hiring for new positions would, as a result, be negligible.

As the coal gasification plant is to be built on land now zoned industrial and situated within the confines of an existing industrial park, the plant activities would be consistent with the existing land use.

The total labor cost for operating the plant is anticipated to be more than $1,000,000 per year. The cost of purchasing the necessary coal is expected to amount to about $4 million per year, with all other incidental costs totaling about $2.1 million.

An expected total of 35 persons would be hired for operation and maintenance of the plant. In addition a maximum of about 27 truck drivers (depending on the distances involved) would be delivering the necessary coal daily; these individuals would not be directly associated with the plant, but rather employees or the coal companies or transportation subcontractors.

The 35 operations and maintenance personnel are expected to be hired locally. Taking into consideration the multiplier effect of the payroll, at least an additional 50 percent of 17 jobs would be created yielding a total increase of 52 local jobs.

Visual Impact

The gasifier building will be about six stories high and with stacks extending to about 8 stories, considerably higher than nearby industrial buildings. Such a structure is consistent with surrounding land uses. It would be visible from nearby roads and other locations in the industrial park. The residential area one mile east of the park is at a lower elevation than the site. Therefore, the gasifier building and exhaust stacks will be visible. To minimize these impacts, the building and smokestack will be designed to harmonize with the area.

Table 8-1

Existing Land Use, Regional Impact Area, 1978

Land Use	Acres	Percent of Total Land
Residential	11,757	4.4
Commercial	1,940	0.7
Industrial	1,599	0.6
Utilities & Transp.	7,808	2.9
Public/Semi-Public	5,354	2.0
Parks/Open Space	2,640	1.0
Cropland	32,023	12.1
Grassland	111,033	41.9
Woodland	84,176	31.8
Water Areas	6,391	2.4
Total Urban/Built-up	31,098	11.7
Total Rural Farm	233,623	88.3
Total Land Area	264,721 (413.6 sq. mi.)	100.0

Source: OKI Regional Water Quality Management Plan, 1977; Boone County Land Use Plan, KZF Environmental Design Consultants, Inc., Covington Kentucky, 1978; and Northern Kentucky Area Development District Land Use and Housing Plan, Northern Kentucky Area Development District, June 1978; NKAPC Northern Kentucky Future; A Comprehensive Plan Update, 1977; Northern Kentucky Area Development District, June 1978.

Table 8-2

Nonagricultural Employment by Industry, 1980
(by Place of Work)

	Boone County	Kenton County	Regional Impact Area	Percent
Mining and Quarrying	35	0	35	0.1
Contract Construction	746	2,041	2,787	5.7
Manufacturing	6,695	4,167	10,862	21.9
Transportation Communications & Public Utilities	1,582	1,098	2,680	5.4
Wholesale & Retail	6,842	8,934	15,776	32.0
Finance, Insurance & Real Estate	602	1,348	1,950	4.0
Services	3,865	11,159	15,024	30.5
Other	96	58	154	0.3
TOTAL	20,404	28,854	49,318	100.0

Source: Kentucky Department of Human Resources.

Table 8-3

Population Projections, Regional Impact Area, 1980-2000

	1980	1990	2000
Boone County	45,460	50,000	60,000
Kenton County	136,150	136,650	139,000
Impact Area	181,710	186,650	199,000
Kentucky	3,520,000	3,950,000	4,290,000

Source: Boone County Planning Commission, U.S. Bureau of the Census, Northern Kentucky Area Development District Land Use and Housing Plan. Northern Kentucky Area Development District, 1978

Table 8-4

Population, Incorporated Areas, Regional Impact Area: 1960, 1970, and 1980

	1960	1970	1980
Boone County			
Florence	5,837	11,661	26,365
Union	-	175	592
Walton	1,530	1,801	1,650
Total, Incorporated	7,367	13,637	28,607
Unincorporated	14,573	19,175	16,953
Total, County	21,940	32,812	45,560
Kenton County			
Convington	60,376	52,535	47,162
Erlanger	7,072	12,676	13,125
Edgewood	1,100	4,139	7,262
Fort Mitchell	-	4,819	7,147
All Other Incorporated Areas	21,707	35,249	33,278
Total, Incorporated	90,255	109,418	107,974
Unincorporated	30,445	19,982	28,176
Total, County	120,700	129,400	136,150
Total, Regional Impact Area	142,640	162,212	181,710

Source: 1980 Census of Population and Housing, U.S. Department of Commerce; and, Northern Kentucky Area Development District Land Use and Housing Plan, Northern Kentucky Area Development District

Table 8-5

Labor Force, 1980

	Civilian Labor Force	Employment	Unemployment	Unemployment Rate
Boone County	20,165	18,882	1,283	6.0
Kenton County	63,467	59,629	3,838	6.1
Regional Impact Area	83,632	78,511	5,121	6.1
Kentucky	1,563,000	1,476,000	87,000	5.6

Source: Northern Kentucky Development District

Table 8-6

Personal Income, 1979

	Total Personal Income	Per Capita
Boone County	302,012,000	7,226
Kenton County	999,410,000	7,568
Impact Area	1,301,422,000	7,480
Kentucky	26,066,000,000	7,390
Ratio	5.0%	101.3%

Source: Northern Kentucky Development District

Table 8-7

Economic Activity in Site Vicinity, 1981

Name	Purchase Date	Areas (acres)	Developed Area (acres)	Firms	Employees
Northern Kentucky Industrial Park	1959	1270	1000	52	7,100
Gates Industrial Park	1972	95	66	3	200
One Twenty Industrial Park	1967	70	65	7	360
Total, Site Vicinity		1,435	1,131	62	7,660

Table 8-8

Selected Residential Development in the Site Vicinity
(2-1/2-mile radius)

Development	Location (County)	Distance from Site (miles)	Type of Unit
Apartments			
Beechgrove Apts.	Kenton	1.5	1 & 2 bedroom apartments
Carriage House	Kenton	2	NA
Circle Apts.	Boone	1.5	1 bedroom apartments
Dixie Apts.	Boone	1	1 & 2 bedroom garden apartments
Shenandoah Square	Boone	1.5	1 & 2 bedroom garden apartments
Villages of Beechgrove	Kenton	1.5	NA
Single Family, Condominiums, Townhouses			
Arrowhead Estates	Kenton	2	NA
Covered Bridge	Kenton	2	Single Family
County Club Estates	Kenton	2	Single Family
Spring Meadows	Boone	1.5	NA
Spring Valley	Kenton	2.5	Single Family
Villages of Beechgrove	Kenton	1.5	Single Family and townhouses
Walnut Creek	Boone	2	Single Family

Source: Home Builders Association of Northern Kentucky.
A Guide to New Homes and Garden Apartments in Northern Kentucky.

Table 8-9

Estimated Capacity of Roads in Site Vicinity

Road	Lanes	Access	Speed (mph)	Capacity (Vehicles/hr)
I-75	6	Limited	55	6000
RT. 42	4	Unlimited	35	3400
RT. 1829	2	Unlimited	45	1500
RT. 25	2	Unlimited	45	1500

---

1. Kentucky Department of Transportation, Boone County.

2. Highway Capacity Manual p. 284, 302-3, for a level of service of "C" which indicates stable flow with some restrictions on operating speed or lane changing. A level of service of "D", indicating little freedom to maneuver and approaching unstable flow, would correspond to a higher road capacity.

TRAFFIC COUNTS, SELECTED LOCATIONS IN SITE VICINITY

LOCATION	DESCRIPTION	24 HOUR COUNT (VEHICLES)[2]	PEAK HOUR	COUNT (VEHICLES)[2]	ESTIMATED FUTURE TRAFFIC (VEHICLES/HOUR)[3]	ESTIMATED ROAD CAPACITY (VEHICLES/HOUR)[4]	ROAD UTILIZATION AT PEAK HOUR
A	I-75 N. of Rt. 42	52,000	4 pm	4120	8200	6000	69%
B	I-75 S. of Rt. 42	49,000	4 pm	3030	7344	6000	50%
C	Rt. 42 W. of Rt. 1829	32,500	5 pm	2570	2337	3400	75%
D	Rt. 42 E. of Rt. 1829	18,300	4 pm	1510	NA	3400	45%
E	Rt. 1829 S. of Rt. 42	18,500	3 pm	1350	1411	1500	90%
F	Rt. 1829 W. of Rt. 25	14,000	3 pm	1170	NA	1500	78%
G	Rt. 1829 E. of Rt. 25	6,200	3 pm	540	NA	1500	36%
H	Rt. 1829 W. of Rt. 1303	7,600	5 pm	710	NA	1500	47%
I	Rt. 25 N. of Rt. 1829	13,100	4 pm	1120	1208	1500	75%
J	Rt. 25 S. of Rt. 1829	12,900	3 pm	1120	1400	1500	75%

NA - Not Available
1. For locations, see Figure 3.
2. Kentucky D.O.T., Office of Transportation Planning: Portable Traffic Recorder Reports; A, B, C, D, J-1980, E, F-1978, G, H, I-1981.
3. Telephone Conversation with George Hoffman of Kentucky D.O.T., Boone County, 8/4/81.
4. Estimated Using Highway Capacity Manual, pp. 284, 302-3, See also footnote 5 of text.

TABLE 8-11

TRAFFIC COUNTS, HOURLY, SITE VICINITY

LOCATION[1]	A		B		C	D	E	F	G	H	I	J
YEAR COUNTED	1980		1980		1980	1980	1980	1978	1981	1981	1981	1980
DIRECTION	N	S	N	S	2-WAYS	2-WAYS	2-WAYS	2-WAYS	2-WAYS	2-WAYS	2-WAYS	2-WAYS
HOUR BEG.												
6 AM	1490	1190	1080	680	1290	460	-	700	460	460	640	730
7	1840	1130	1070	860	1630	830	1270	790	420	530	740	720
8	1490	1520	1230	1120	1580	920	850	690	290	340	610	580
9	1470	1500	1290	1300	1340	740	770	580	210	210	440	490
10	1460	1580	1450	1360	1500	870	870	620	220	250	510	580
11	1530	1590	1350	1380	1790	1080	1200	900	300	360	620	660
12 PM	1460	1390	1450	1340	2060	1180	1320	900	320	340	760	670
1	1680	1450	1550	1290	1890	1080	1150	840	310	330	660	740
2	1690	1600	1620	1340	1980	1140	1230	920	310	400	800	810
3	2060	1730	1560	1420	2530	1370	1350	1170	540	660	1080	1120
4	2010	2110	1470	1560	2450	1510	1280	1080	520	620	1120	1110
5	1810	1930	1470	1530	2570	1480	1290	1020	470	710	1090	930
6	1560	1500	1400	1160	2000	1240	1110	330	330	530	720	740
7	1160	1170	1190	1050	1680	1060	800	620	260	370	540	550

Note:

1. For locations, see Table 2 and Figure 3 (See also footnote 5 of text).

Source is Kentucky D.O.T., Office of Transportation Planning, Portable Traffic Recorder Reports.

Table 8-12

Construction Impact on Economic Indicators
(Construction year - in 1981 dollars)

	Without Gasification Plant	With Gasification Plant	Difference
Earnings	$1,300,000,000	1,306,500,000	6,500,000
Labor Force	84,000	84,018	18
Employment	78,950	79,121	161
Unemployment	5,040	4,897	143
Unemployment Rate (percent)	6.00	5.83	0.17

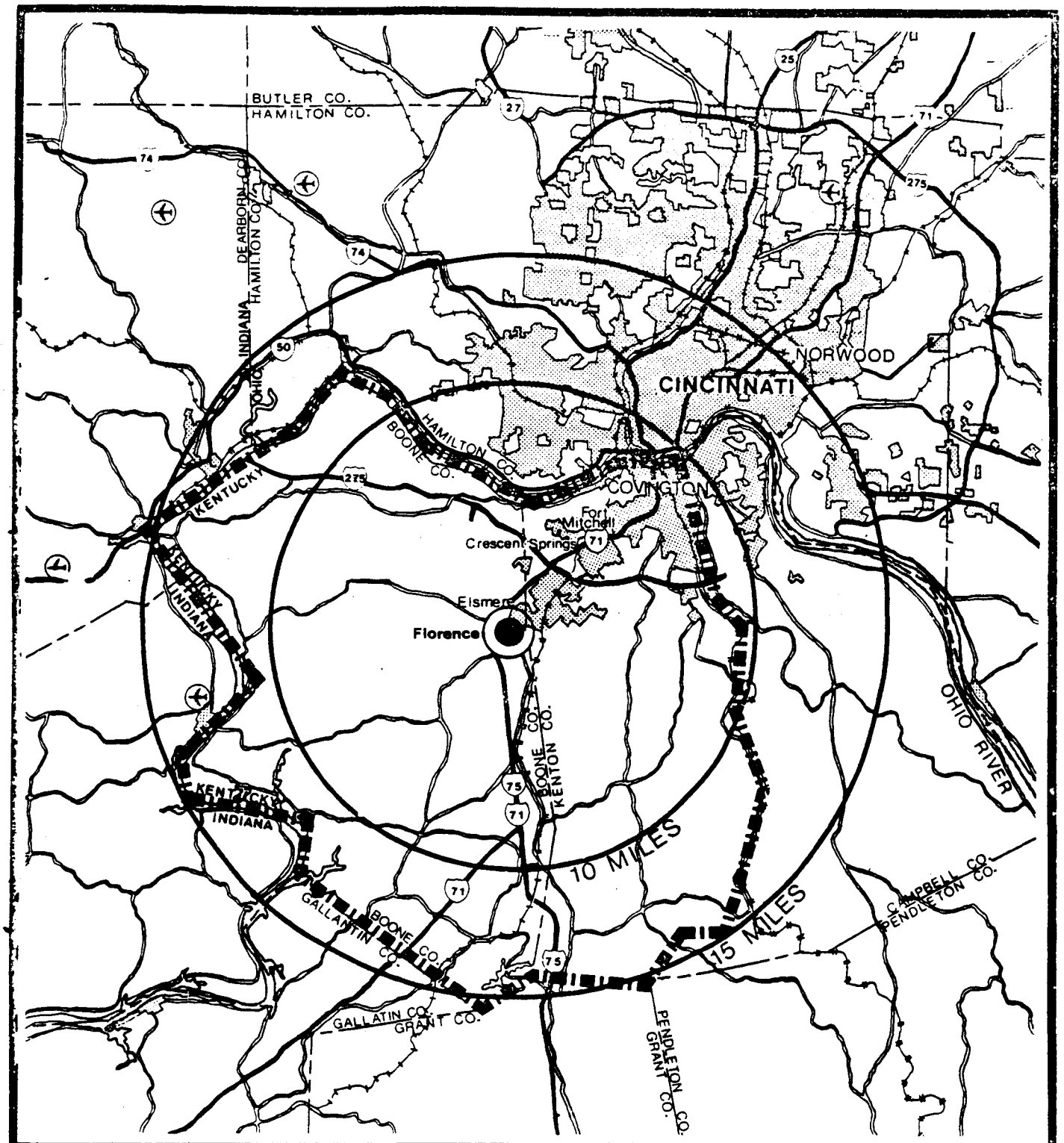
---

1. 1980 has been taken as the base year. See Table 8-4

2. 1980 average (rounded). See Table 8-3

3. In-migration of supervisory personnel

4. 215 person-years of employment over 16 months yields annual rate of 75 percent of 216 equals 161.



REGIONAL IMPACT AREA

Legend:

- GREFCO Site
- Impact Area

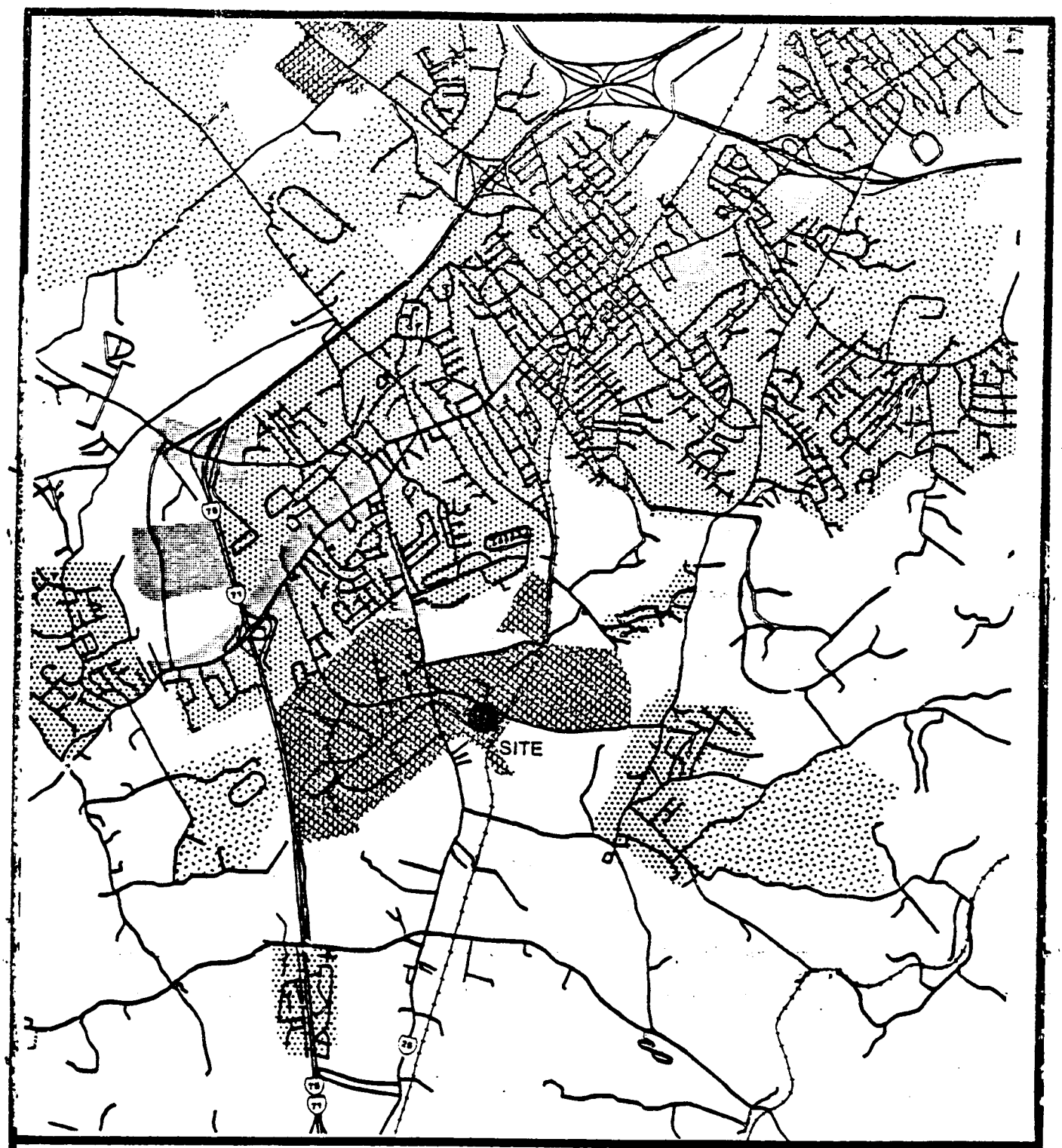
GREFCO INC.

FLORENCE, KENTUCKY

Dravo
Engineers & Constructors

1 0 2 6mi

Figure: 8-1



SITE VICINITY LAND USE

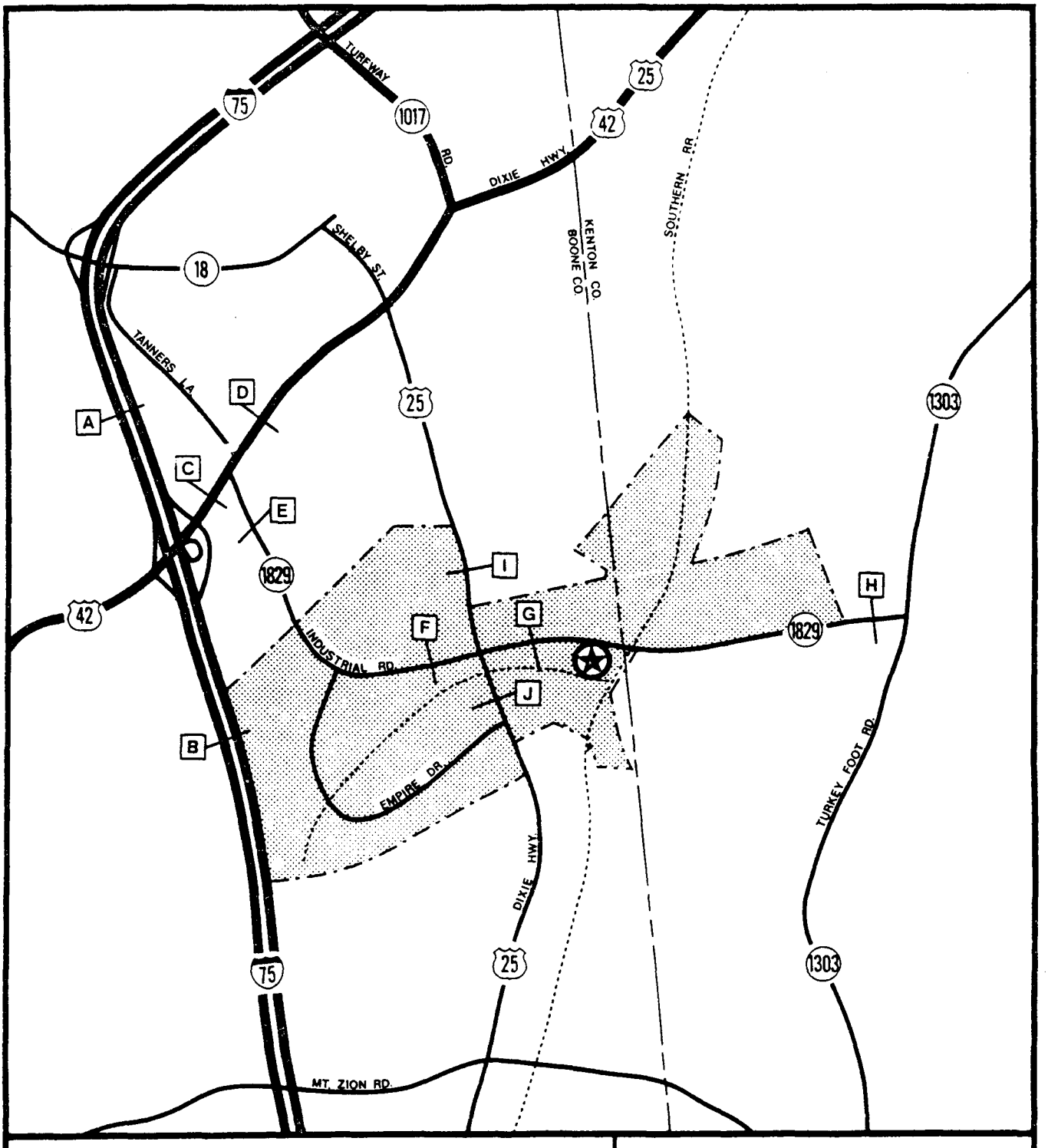
Legend:

- Residential
- Commercial
- Industrial
- Public/semi-public & Recreational

GREFCO INC.
FLORENCE, KENTUCKY

Dravo
Engineers & Constructors

Figure: 8-2



SITE VICINITY CIRCULATION

Legend:

- 2 Lane Road
- 4 Lane Road
- 6 Lane Highway
- Railroad Line
- ★ GREFCO Site
- A — Traffic Recorder
- County Line
- N. Kentucky Ind. Pk.

GREFCO INC.

FLORENCE, KENTUCKY

Dravo
Engineers & Constructors

500 0' 1000 2000

Figure 8-3

9.0 SAFETY AND HEALTH PROGRAM

9.1 Purpose

The purpose of this program is to provide information and guidance for organizations operating the Wellman-Galusha Gas Producer System. The program is intended as a guidance document for the operators and is not intended to dictate precisely how they should conduct their occupational safety and health or loss prevention programs.

9.2 Scope

The scope of this program covers the operational phases of the Wellman-Galusha® Gas Producer System. The program is applicable to the employees of the facility operator, subcontractors and visitors. The program does not cover construction or demolition activities. The program is applicable to chemical-plant-style coal conversion facilities, consequently it is not directly applicable to the board plant. The Program will address the following topics:

- Organization and administration
- Safety training and inspection
- Accident prevention
- Control systems
- OSHA compliance
- Personnel monitoring
- Evaluation of operations
- Clinical occupational medicine
- Carcinogenic safety and personnel protection
- Toxicological testing under TSCA

9.3 Objective

The primary objective of this program is to guide the operator in achieving adequate control of potentially hazardous activities associated with the operation of the facility and to assure the safety and health of the workforce and community.

9.4 Personnel Safety and Health

9.4.1 Organization and Administration

9.4.1.1 Policy

The most efficient and profitable way to operate a business is in a safe manner. Effective accident and loss prevention, and occupational health programs, are the best way to safeguard employees and the public from injury and illness, to conserve property and to protect business interests.

It should be the policy of the operating organization to perform all activities in a manner which recognizes the primary importance of accident prevention and safeguards the employees and the public from hardships caused by injuries or illnesses related to their operations.

9.4.1.2 Authority and Responsibility

The Occupational Safety and Health Act of 1970 requires all employers to provide a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm to employees and to comply with occupational safety and health standards promulgated under the Act.

The plant manager should have ultimate responsibility for occupational safety and health, loss prevention and public safety from all operations of the facility. The Plant Manager should have at his disposal an occupational safety and health organization composed of competent personnel whose primary responsibility is the implementation of accident and loss prevention, and occupational safety and health related programs. This is depicted in Figure 9-1. Attention to safety and health and the avoidance of losses are the responsibilities of all employees and particularly every line supervisor. Accountability for performance in this area should be fully observed.

All employees should be trained in hazard recognition and accident prevention. All employees should be required to comply with safety rules and procedures and given recognition for good performance or disciplined for non-compliance.

9.4.1.3 Administration

As depicted in Figure 9-1, ultimate responsibility for safety and health should reside with the plant manager. All levels of occupation in the organization should be charged with substantial safety and health responsibilities.

9.4.1.4 Program Evaluation and Revision Plan

The occupational safety and health program should be subject to periodic evaluation through objective and subjective performance measurement.

Dravo Engineers and Constructors

FACILITY DIRECTOR (Plant Manager)

1. HAS FULL RESPONSIBILITY FOR SAFETY AND HEALTH
2. HOLDS TOP MANAGEMENT RESPONSIBLE FOR SAFETY AND HEALTH
3. AUTHORIZES BUDGET
4. PARTICIPATES IN PROGRAM THROUGH INSPECTION AND AUDIT
5. PASSES ON SAFETY POLICIES AND PROGRAMS TO LINE SUPERVISOR

ENGINEERING and MAINTENANCE

1. PROMPT EXECUTION OF WORK ORDERS
2. MODIFICATION REVIEW
3. MAINTAIN A REGULAR MAINTENANCE SCHEDULE ON ALL EQUIPMENT FROM THE STANDPOINT OF SAFETY AND MAINTAIN RECORDS.
4. ASSIST IN ACCIDENT INVESTIGATION

SAFETY and HEALTH SUPERVISOR

1. SERVES AS STAFF CAPACITY WITHOUT LINE AUTHORITY
2. RESPONSIBLE FOR DAY-TO-DAY SAFETY AND HEALTH ACTIVITIES
3. KEEPS AND ANALYZES RECORDS
4. RESPONSIBLE FOR SAFETY AND HEALTH TRAINING
5. COORDINATES MEDICAL MONITORING PROGRAM
6. PERFORMS ACCIDENT INVESTIGATION AND PREPARES REPORTS
7. PERFORMS HEALTH HAZARD SURVEYS
8. PLANS AND DIRECTS A REGULAR PROGRAM OF SAFETY INSPECTIONS
9. ADMINISTERS PERSONAL PROTECTION PROGRAMS
10. SUPPLIES INPUT FOR ENGINEERING
11. REVIEWS MODIFICATION AND EXPANSION PLANS

LINE SUPERVISION

1. INSPECT FOR COMPLIANCE WITH SAFE WORK PRACTICES AND CONDITIONS
2. SUPERVISES ACTIVITIES FOR SAFETY
3. TRAINS PERSONNEL TO WORK SAFELY
4. RESPONSIBLE FOR A SAFE WORK PLACE AND HOUSEKEEPING
5. HOLDS SAFETY MEETINGS
6. PERFORMS ACCIDENT INVESTIGATIONS
7. RESPONSIBLE FOR PROVIDING OR OBTAINING FIRST AID

HOURLY EMPLOYEES

1. WORKS IN ACCORDANCE WITH ACCEPTED SAFE PRACTICES
2. REPORTS UNSAFE CONDITIONS AND PRACTICES
3. OBSERVES SAFETY RULES AND REGULATIONS
4. DOES NOT UNDERTAKE ACTIVITIES WITHOUT FULL UNDERSTANDING OF HAZARDS INVOLVED
5. MAKES SAFETY SUGGESTIONS

FIGURE 9-1

SAFETY AND HEALTH FUNCTION ORGANIZATIONAL CONFIGURATION

Objective performance measures are usually statistical data compiled from inspections and reports. Incidence rate per 100 full time workers (IR) is often used to measure Occupational Safety and Health (OSH) performance and is given by:

$$IR = \frac{\text{No. of disabling illnesses or injuries} \times 200{,}000}{\text{No. of manhours worked}} \; *$$

Additional insight into OSH performance may be provided by viewing specific aspects of illnesses and injuries. Severity rate (SR) and the Disabling Injury/Illness Index (DII) may be useful in gaining further insight into the nature of OSH performance.

$$SR = \frac{\text{No. of man-days lost} \times 200{,}000}{\text{No. of hours worked}}$$

$$DII = \frac{SR \times IR}{40}$$

An effective program should reduce these measures or maintain them at an acceptable rate. The data used for these measures should be collected and summarized monthly, quarterly and annually for comparison and trend analysis. Acceptable severity and incidence rates should be assessed against the objectives of the plan and against comparable industries. The following table gives some typical incidence-rate figures from selected industries.

Incidence Rates From Selected Industries

Industry	Incidence Rate 1979 **
Mining (overall)	11.2
Metal mining	10.0
Bituminous coal and lignite mining	10.2
Anthracite mining	18.3
Manufacturing (overall)	12.8
Chemicals and allied products	7.2
Petroleum and coal products	7.5
Primary metal products	16.9
Stone, clay, and glass products	16.3
Lumber and wood products	20.4

Another objective criterion for OSH performance is cost. One objective of the OSH program should be to reduce the costs associated with:

* 200,000 = base for 100 full-time equivalent workers (working 40 hrs/week, 50 weeks/year).

** U.S. Dept. of Labor, Bureau of Labor Statistics, 1979.

- Illness
- Injury
- Absenteeism
- Worker turnover
- Productivity
- Quality of Work

It is often difficult to assess cost savings in these areas, however measurable cost can be seen in items such as:

- Fewer and smaller insurance claims
- Fines and costs associated with handling citations
- Fewer lost hours
- Fewer training costs, or start-up costs or both associated with set backs from hiring new employees or operational mistakes.

Much of the economic impact of a well-run OSH program will be in costs never incurred such as fatalities, litigation and compensation from serious injuries or illnesses.

Subjective factors also come into play with OSH program evaluations. As a result of an effective program, employees should exhibit more awareness of safety and health and should provide visible feedback such as more effective evaluation of the workplace, reporting unsafe conditions, volunteering suggestions for program improvement and a general positive morale level.

Loss Prevention

Evaluation of losses from accidents should be of particular importance as they pose the greatest potential for capital and operating expenditure losses. A typical breakdown of losses caused by fires and explosions is given in the following table.

Causes of Loss from Fire and Explosion - Process Industries

Cause	Percent
Equipment failure*	31.1
Inadequate material evaluation	20.2
Operational failures	17.2
Chemical process problems	10.6
Ineffective loss prevention program	8.0
Material movement problems (logistics)	4.4
Plant site problems	3.5
Structures not in conformity with use requirements	3.0
Inadequate plant layout and spacing	2.0

The above losses are typically insured when resulting from fire or explosion. Another important loss which is normally uninsured is plant shutdown and downtime which can be substantial, particularly if make-up product provisions would be necessary.

Typically, loss prevention plans are reviewed by insurance underwriters who have specific criteria for estimating potential losses and assessing insurance premiums accordingly. Plant performance in relation to these factors should also figure prominently in the evaluation.

Program Revision Plan

In conjunction with the program evaluation, the safety and health department should revise the program to meet any new needs, improve areas of unsatisfactory performance and establish objectives reflecting the desired level of performance. The program revisions should update or redefine the standards, practices and responsibilities necessary to meet the desired objective and should establish an implementation program. The revised program should be approved by management staff to assure a clear understanding of the objectives, cooperation from other departments, and proper budgeting approval.

* May reflect poor maintenance, design, etc.

9.4.2 Safety and Health Training and Inspection

9.4.2.1 Safety and Health Training

An effective accident prevention and occupational health hazard control program is based on proper job performance. When work is done properly and with due regard for the associated hazards, it is done safely.

Safety and health training should be a continual, ongoing process. Supervisory personnel require training particularly in the technical aspects of safety, loss prevention and in safety training and motivation. Hourly personnel require training directed toward hazard recognition, task performance and procedures, the use of and location of safety equipment, and actions to be taken in particular situations.

The objective of safety and health training should be to provide workers with the knowledge and information to:

- Recognize the activities, process conditions and environmental conditions which may lead to hazardous conditions.
- Recognize hazardous conditions when they exist.
- Take effective evasive action.

Initial Training and Orientation

Orientation for new employees should emphasize the fundamental concept that each employee's first responsibility must be protecting himself and his fellow employees. Through the use of classroom lectures, training films, handout material, and demonstrations, and on-the-job training, the following information should be provided:

- Company policy.
- Plant rules.
- Individual responsibilities.
- The nature of the hazards (chemical, physical and ergonomic.)
- The specific nature of the operations which would could result in hazards.
- The necessary protective measures including the use of protective equipment to mitigate hazards.
- The purpose, proper use and limitations of, protective equipment and attire.

- Fire and explosion hazards.
- The purpose for, and a description of, the environmental monitoring and surveillance program, and the significance of findings.
- The need for, and proper use of, the change house, personal hygiene practice and activity restrictions.
- The purpose, description, and explanation of the medical monitoring program.
- Emergency procedures.

These topics can often be put into a pocket-sized booklet and distributed to employees for reference.

Supplemental Training

Further training in specific aspects should be provided as appropriate, depending upon trade or craft needs and maintenance and operations requirements. The safety and health supervisor should provide staff support for supplemental training which might include:

- Electrical safety
- Safe work permits
- Vessel and confined-space entry
- Safe use of hand tools
- Purge procedures and line breaking
- Start-up and shutdown operations
- Additional health hazard training
- Proper lifting techniques

Training in proper job performance should be regarded as an investment rather than an expense. An effective program of accident prevention and health hazard control can result in fewer illnesses, injuries, property damage and business interruptions as well as better morale and lower insurance premiums.

Monthly Safety and Health Meetings

Monthly, or more often if necessary, plant supervisors, assisted by safety and health staff, should conduct scheduled meetings with workers to provide supplemental or follow-up training. Meetings of this type also provide opportunities for suggestions and discussion to seek solutions to current safety and health problems.

Training Records

It is a good idea to keep a record of all safety and health training. Records can provide evidence of an organization's good faith and compliance with OSHA standards and can serve as a record for plant personnel to determine follow-up and supplemental training needs.

9.4.2.2 Safety and Health Inspections

Safety and health inspections are a principal means of locating accident causes and health hazards and help determine what mitigating measures are necessary to safeguard workers and property. These inspections should involve employees at all levels and should include daily inspection by workers of the workplace, procedures and provisions.

Periodic Inspection

Inspections by plant safety and health officials should be conducted periodically on a scheduled basis. These inspections should serve to evaluate the safety and health performance of supervisors and hourly employees as well as to ensure safe and healthful conditions in the plant. These inspections are typically done systematically, using a checklist, and are conducted by the safety and health supervisor, operations and maintenance supervisor and an hourly representative, often a chief operator. The inspection should address unsafe conditions and unsafe actions. A periodic inspection checklist might include the following subjects:

- Fire protection
- Housekeeping
- Tools
- Protective equipment
- Material handling equipment
- Access/egress
- First aid provisions
- Pressure equipment
- Machinery
- Material storage
- Walking - working surfaces

- Unsafe practices
- Sanitation

Any unsafe or unhealthful conditions or acts, OSHA violations, substandard preventative maintenance, etc. should be recorded. Corrective actions from these inspections generally result in maintenance work requests or additional training and orientation.

General Inspections

Periodically, perhaps quarterly, the plant manager should conduct a safety and health inspection with staff level managers. The purpose of this inspection is to assure that staff and executive level personnel are aware of conditions within the plant and to evaluate the performance of the overall program.

Industrial Hygiene Field Surveys and Monitoring

Industrial hygiene field surveys should be conducted to determine if any health hazards exist in the plant as a result of plant conditions or worker activities. Surveys typically involve quantitative measurement of chemical or physical elements in the work environment and relate the concentration or magnitude of the element to worker exposure. Industrial hygiene surveys and monitoring practices are discussed in greater detail in Section 9.4.8.

Fire Protection Inspections

Fire is a hazard associated with coal conversion facilities due to the nature of the process. Consequently, fire protection features, either fixed equipment such as sprinkler systems or mobile and portable equipment including fire extinguishers would be necessary and subject to inspection.

Periodic systematic inspection of fire protection equipment should be made and any deficiencies given priority status when activities scheduling maintenance.

The following table itemizes some of the fire protection systems and components typically addressed in process plant fire protection and prevention inspections:

Fire Protection Inspections

Item	Inspection Frequency
Fire Hydrant and Hose Station	Monthly
Fire Hydrant Maintenance and Flow	Annually
Fire Hose Hydro-Test	Annually
Water Supply Pressure Checked	Weekly
Water Supply Flow Tested	Annually
Fire Extinguishers	Monthly
Fire Doors	Bi-Weekly
Housekeeping	Bi-Weekly
Electrical Equipment	Bi-Weekly
Special Extinguishing or Monitoring Systems	Bi-Weekly
Pressure Relief, Inventory Dump and Blowdown Systems	Bi-Annually

It is highly advisable that insurance underwriters conduct independent inspections periodically. These inspections should be comprehensive and include systems performance evaluations, emergency preparedness and response, and plant disaster plans. A description of the fire protection features is found in Section 9.4.5 of this report.

9.4.3 Accident Prevention

An accident is an unintentional occurrence that may or may not result in an injury or loss. Accidents are the result of hazardous acts, hazardous conditions, both, or acts of God. The five basic principles of accident prevention are:

- Knowing the hazard
- Finding the hazard
- Eliminating unnecessary hazards
- Dealing with hazards that cannot be removed
- Avoiding the creation of hazards

Accident prevention plans should concentrate on training and motivating individuals to avoid hazardous acts and to recognize and eliminate hazardous conditions through positive engineering control measures and safe operating procedures.

Hazardous conditions may become apparent through the inspections detailed in Section 9.4.2 Safety and Health Training and Inspection. These conditions should be mitigated by repairing the condition, establishing or modifying a procedure, installing personal protection equipment or a similar conventional remedy. These are traditional industrial safety methods which have been used successfully over the years and for which there is no substitute.

9.4.3.1 System Safety

Other methods of accident prevention exist which are also effective, though less often used. System safety is a method of accident prevention which uses various analysis techniques in an attempt to "act out" situations associated with accidents in advance and determine what accidents might occur, how they occur, the consequences of their occurrence and their degree of frequency. Preventative measures can then be taken before accidents occur.

System safety takes into account the various elements required to complete a task and assesses the impacts on the system by inducing variables into the elements, or by assuming an effect (an accident) has occurred and deducing how the effect may have occurred through the elements of the system. System safety is particularly valuable when the plant or some portion is undergoing change as with a start-up, shut down, or plant modification, since accidents often occur when systems are changed. Many times accidents from change can be seen in advance by asking "What if...????" and introducing a variable, or assuming an accident and asking, "How did...????". Methods such as those described are often of great value when developing operating procedures because they require the analyst to systematically think through the task sequence. System safety methods are discussed in Section 9.4.8 of this report.

9.4.3.2 Job Safety Analysis

A proven effective method of accident prevention which involves analyzing workplace/worker hazards is job safety analysis (JSA). Job safety analysis may be highly applicable to the Wellman-Galusha Gas Producer System which uses a closely supervised small operating crew.

Job safety analysis is the technique of breaking down any given work assignment into its basic steps or operations, studying each step for inherent or potential hazards, and developing specific work procedures that will eliminate or control each individual exposure. Job safety anaylses are most properly developed by individual supervisors and those employees most closely associated with specific jobs.

9.4.3.3 Operating Procedures and Permits

Standard Operating Procedure

A fundamental component of an accident prevention plan is the implementation of standard operating procedures (SOP's) for performing duties (tasks). SOP's can be derived from system safety analysis, job safety analysis or from experience. Some elements that should be considered when preparing SOP's are:

- A description of the equipment or system and a statement of the purpose of the operation.
- A statement relative to the qualifications of personnel.
- Operating instructions for the proper operation of the equipment or system including, where applicable, tables, charts of operating data, adjustments, warnings, and precautions.
- A list of all facilities, communication equipment, tools, instruments, and power requirements.
- Warnings and precautions required to prevent injury to personnel or damage to equipment.
- Requirements for a visual inspection if equipment is to be tested.
- Preparatory procedures necessary for the required operation, including environmental requirements, assembly or test equipment setup, and preliminary checks or tests.
- Step-by-step instructions for performing the operation.
- Instructions for stopping the operation and disassembling or disconnecting equipment.
- Emergency shutdown and backout instructions.
- Provisions for originator and approval signatures.

Hazardous operations should have soundly conceived SOP's and permit requirements. Examples of hazardous operations which might occur during the operating of the Wellman-Galusha Gas Producer System are:

Maintenance	Operational
. Some line breakings	. Start-up
. Vessel and tank entry; other confined-space activity	. Shut down

- Hot work (burning and welding) and some cold work
- Some excavations
- Electrical work on process equipment
- Turn down
- Emergency shutdown

Safe Work Permits

Operations such as the maintenance procedures noted above should require a safety permit as an assurance check. In general, the safety permit system is initiated by the Production Supervisor in the area. It should bear the signatures of the Production Supervisor, Maintenance of Mechanical Supervisor (usually the job supervisor) and the Safety Representative monitoring the job. The permit is valid only for the time period stated and should never exceed one full shift. The permit must be displayed at the job site and returned to the Production Supervisor when the job is completed. Regardless of the types used, safety permits serve the same objectives -- to provide a record showing that a particular job has been checked by the proper responsible parties.

9.4.3.4 Accident Prevention Evaluation Plan

The same objective evaluation criteria discussed under Section 9.4.1 of this report should be used for evaluation of accident prevention performance. Based upon previous performance records, objectives for improved performance in deficient areas should be established. A course of action outlining the major steps planned to achieve the objectives should be established and a timetable set. The accident prevention evaluation plan is designed as a management objective to improve accident prevention performance.

A typical application of this method is provided below. Assume the plant had 4 OSHA lost workday cases in one year, the Lost Workday Case Incidence Rate is given by:

$$\text{L.W.D.C.I.R.} = \frac{\text{No Lost Workday Cases} \times 200{,}000}{\text{Hours Worked}}$$

$$\text{L.W.D.C.I.R.} = \frac{4 \text{ Cases} \times 200{,}000}{104{,}000^{*}} = 7.7$$

As the example L.W.D.C.I.R of 7.7 is somewhat high, a reasonable goal would be to set an objective of reducing the rate by 10%/year, or to 6.9 the following year - attainment of the objective, followed by another 10% reduction objective the following year and so on. In this manner, a continual progressive improvement in performance can by outlined. The percentage reduction should correspond to previous performance levels and the desired future performance.

The concept can be applied to any performance variable which can fit a rate equation. Some examples include:

- OSHA Total Case Incidence Rate
- No. of Operators Trained in Hazard Recognition
- No. of Supervisors Completing Standard First Aid

This progressive objective approach has been successfully applied in related process industries and should be useful in this application.

9.4.3.5 Reporting Unsafe Conditions and Near Misses

Unsafe conditions can result from poor design, modifications, equipment deterioration or failure, human error or poor housekeeping to name just a few. A formal, though not necessarily burdensome method of reporting and correcting unsafe conditions should be established. One method used in the process industries with good success is the safety maintenance work request. Safety maintenance work requests usually take the form of carbon-copied forms for describing the nature, location and other pertinent information concerning an unsafe condition. The criticality of the condition is ranked and a suitable time table established for rectification. Copies of the request are generally distributed to the maintenance and safety departments, the originator maintaining his own copy.

* 50 workers X 2080 hours worked/year

Near misses typically occur more frequently than accidents, but reports on their occurrences are less frequently submitted, chiefly because formalized reporting procedures are generally lacking. Near misses should be formally reported and compiled. Safety analysis of near misses should be applied depending upon criticality of the effects should an accident have occurred and the probability of a repeat occurrence. Several of the analytical techniques using reliability data as described in Section 9.4.8 of this report are applicable for near miss analysis and evaluation.

9.4.4 Compliance With the Occupational Safety and Health Act

9.4.4.1 General

The Occupational Safety and Health Act of 1970 essentially requires employers to provide employment conditions free from recognized safety and health hazards that could result in injury, illness, or death. All establishments employing one or more persons are subject to the Act. The administration of the Act falls under several agencies:

- OSHA (The Occupational Safety and Health Administration), in the U.S. Department of Labor (DOL), establishes and enforces occupational safety and health standards through inspections, citations, and fines.

- NIOSH (National Institute for Occupational Safety and Health), in the U.S. Department of Health and Human Services recommends safety and health standards and conducts research, investigations, demonstrations, and programs of education and training relating to occupational safety and health.

- OSHRC (The Occupational Safety and Health Review Commission), an independent government body, holds hearings on appeals from DOL or the employer and renders decisions, which may be appealed.

- State OSHA Programs (State Occupational Safety and Health Administration Programs). Some states, including Kentucky, have chosen to assume responsibility for administration of the Act. Under special plans negotiated with DOL, states agree to establish programs of inspection, citation, and training that meet or exceed the minimum standards promulgated under the Act.

The occupational safety and health criteria for statutory compliance will be the U.S. Department of Labor Occupational Safety and Health Administration Standards for General Industry (29 CFR 1910). As previously noted some states have adopted their own OSHA programs which must be at least as stringent as the federal regulations. All state plans must be approved by the U.S. Department of Labor. Kentucky is one such state with its own plan.

Currently there are no occupational health standards which specifically address coal gasification facilities. However, extensive research has been directed at developing such a standard. NIOSH published performance-oriented criteria for a recommended standard for occupational exposures in coal gasification plants in 1978. Many of the concepts from that document have been incorporated into this plan.

9.4.4.2 OSHA Reporting and Recordkeeping Requirements

Operators of the Wellman-Galusha Gas Producer System would be required to maintain certain records concerning occupationally related injuries and illness. Briefly, the recordkeeping includes:

- OSHA Form 200, Log and Summary of Occupational Injuries and Illnesses.

- OSHA Form 101, Supplementary Record of Occupational Injuries and Illnesses.

Additionally, the Bureau of Labor Statistics may require the completion and submittal of the following form to assist in its annual survey of occupational injuries and illnesses:

- Form 200S, Occupational Injuries and Illnesses Annual Survey.

A portion of the OSHA Form 200 must be posted in the workplace from February 1 to March 1 each year summarizing the previous year's injuries and illnesses. Recordkeeping forms must be retained for 5-years after the end of the calender year to which they relate. The OSHA Form 200 must be maintained over the 5 year period; i.e., changes in the extent of and outcome of cases must be made to the original case entries. Recordkeeping forms must be made available for inspection and copying by representatives of the Departments of Labor; Health and Human Services; or the State accorded jurisdiction under the act.

In the event of a fatality or an incident involving hospitalization of 5 or more employees, the OSHA office having jurisdiction must be notified within 48 hours of the occurrence.

Copies of OSHA Forms 101 and 200 are included as Exhibits 9-1 & 2.

9.4.4.3 Advisory Standards

Several organizations and one agency publish environmental health exposure and safety standards as a result of research investigations. These standards should be consulted for guidance in the event a health hazard may exist and no standard has yet been adopted by OSHA:

- NIOSH Criteria Documents.

- American Conference of Governmental Industrial Hygienists Threshold Limit Values.

- American Industrial Hygiene Association Hygienic Guides and Workplace Environmental Exposure Limits.

- American National Standards Institute Safety Standards.

9.4.5 Control Systems

The system safety design controls are intended to provide in-place positive mitigation against the three primary process hazards: fire, explosion and toxic release. All three primary hazards can potentially occur with the Wellman-Galusha Gas Producer System.

9.4.5.1 Fire

Fire protection is necessary due to the combustible nature of coal tar and liquid sulfur, both being Class III B Combustible Liquids (flash points above 200°F). Coal, the feedstock of the operation, is a combustible solid.

Fire Protection

Layout

A block layout system whereby the process units are connected by a main service rack would be used to separate the coal storage, gasification, tar removal, sulfur handling, utility and waste treatment and product storage areas. This arrangement provides spacing between the units to limit property damage, allows access for fire fighting equipment and egress for personnel and permits battery limit isolation of process units in the event of a fire.

Water Supply

Water for fire fighting would be obtained from the board plant by extending an 8" main into the plant and providing two standard fire hydrants at central locations. Hose stations with 2-1/2 inch fire hose lines should be provided along with nozzles or play pipes and spanner wrenches. Within the Gasification Building, Sulfur Recovery and Utility Buildings, standard utility water supply would be available.

Plant Construction Features

Process containment is central not only to the production of LBG, but to fire protection as well. The gasifiers and feed hoppers are closed units which operate slightly above atmospheric pressure. The two units are separated by a feed control instrument and further by 12-1/2 feet of vertical feed pipe. This configuration makes the opportunity for ignition of the coal in the feed hoppers and storage silo minimal. Should this occur, a fire in the coal feed hopper or storage silo would be contained easily and extinguished with water supplied from utility lines.

Process containment throughout the tar removal area is essentially hermetic, consisting of open chemical-plant-style construction with piping vessels and rotating equipment exposed to the atmosphere. This construction permits maximum natural ventilation to dissipate any flammable vapors and gases from leaks, spills, fugative emissions or controlled emissions.

The sulfur recovery area consists of a combination closed and open process unit, part of which is enclosed in a building. The closed portion of the process, handles the LBG which is, of course, flammable and explosive. The process piping and vessels are of closed-fixed design and located outside. The opportunity for a fire caused by the release of LBG is slight. If a fire were to occur it would be a flare or torch-type gas fire which could be extinguished by cutting off the fuel (gas) supply to the fire.

A portion of the sulfur recovery area is indoors, open to the atmosphere, and involves handling elemental sulfur in its liquid state. Liquid sulfur is combustible with a relatively low ignition point (auto ignition - 450°F). Consequently, process conditions are maintained well below this range (process temperature is 280°F). The use of open flames and sparking equipment should

be allowed by permit only, and then only with an adequate fire watch. Smoking in the sulfur recovery building and vicinity should be prohibited. Standard utility hose lines and nozzles would be provided for fire fighting.

Coal tar and liquid sulfur would be stored in fixed roof atmospheric tanks near the east end of the plant. Both tanks would be diked for containment, reasonably spaced apart and from the adjacent occupancies to minimize jeopardy, and readily accessible for fire fighting. Storage temperatures for both materials are below their respective flash points and heating coils would be located beneath the liquid level making ignition unlikely.

There are no distinctive fire hazards associated with the utilities or waste treatment areas other than those which might be attributable to careless smoking around combustible materials. Reasonable caution and good housekeeping should minimize this possibility. Standard utility hand lines with nozzles and type ABC extinguishers should be adequate for fire fighting.

Electrical Classification

The basis for the control of electrical equipment to prevent its acting as a source of ignition is the classification of the process areas according to degree of hazard using the criteria specified in Article 500 of the National Electrical Code. Once the various areas are classified, electrical equipment with the proper electrical safeguards can be specified. The details of the electrical classification can be found in Specification C-10, Hazard Specification in Section 6.6.

Emergency Egress

The process areas - gasification, gas quench and tar recovery, sulfur recovery and waste treatment as well as the coal storage, product storage and utility areas, fall into the category of a Special Purpose Industrial Occupancies Section 14-1.3.2 of the Life Safety Code, NFPA. This includes ordinary and low hazard manufacturing operations in buildings designed for and suitable only for particular types of operations, characterized by a relatively low density of employee population, with much of the area occupied by machinery or equipment.

Special purpose industrial occupancies must provide for a minimum of two means of egress for each level where routine occupancy is expected and that the maximum travel to either exit not exceed 100 ft. These criteria have been integrated into the design of the plant.

9.4.5.2 Explosion

Explosion hazards may exist from the process materials and the nature of the process conditions. The explosive nature of coal dust is well known as are dust explosion mitigating measures. The coal transfer tunnel, bucket elevator and coal distribution system -- drop points into gasifier storage bins - would be provided with an exhaust ventilation and a dust collection system to prevent the

generation of explosive mixture. The gasifier building itself is provided with general ventilation and make-up air. The sulfur recovery building would also be provided with a general ventilation system for atmospheric control.

Accumulation of a gaseous explosive atmosphere in the gasifier building would be continuously monitored on the operating level and in the penthouse with fixed monitoring equipment which would detect process emissions and alarm locally and in the control room.

Explosive conditions can arise in the gasifiers in the event that oxygen should enter a gasifier in sufficient quantities to create an explosive mixture with the process materials. The gasifiers are provided with relief from the pressure of an explosion by a rupture disc located off of a nozzle from the ash collection chamber. A similar arrangement -- rupture disc -- is provided in the coal feed bin atop the gasifier where the possibility of a coal dust explosion exists.

The tar separation and recovery, sulfur removal and recovery and waste treatment areas of the plant would be designed for containment and suitably relieved to a safe place by relief devices. These areas would be essentially open air, thereby maximizing natural ventilation. Portions of the sulfur recovery area would be located indoors and the process would not be contained in a fixed closed system. The risk of explosion hazards in this area is slight because sulfur is wet and dust generation should not occur. Product storage-tar and liquid sulfur storage should not pose a significant explosion hazard due to liquid phase storage which eliminates dust explosion hazards. Explosion hazards associated with vapors in the liquid sulfur storage tank would be offset by the inclusion of a steam vent atop the tank to permit vapor dispersion.

9.4.5.3 Release of Toxic Substances

A release of toxic material usually involves the rapid release of a large quantity of toxic substances from a process into an area which under normal circumstances poses no significant hazard. The effects -- irritation or asphyxiaton -- may be lethal, cause irreversible injury, or may be reversible depending upon the materials involved, nature of exposure and individual susceptibility. Generation of a flammable mixture may also occur.

Control Configurations

The greatest potential for a release of toxic substances with serious consequences would be in the gasification building where carbon monoxide and other toxic materials, due to a loss of containment in the gasifier/cyclone equipment, could under the proper adverse conditions result in a situation immediately dangerous to life or health conditions (IDLH). IDLH conditions would occur when carbon monoxide concentrations exceed 1500 ppm. Process containment offered by the vessels and fixed piping of the system and several additional control systems would be included in the design of the gasifiers and are the primary means of control of toxic releases.

Backflow of process materials from the gasifier during coal feeding is prevented by design of the control instrument. The interlocked valve configuration is designed so that it is impossible to have an open feed valve to the gasifier and an open feed valve from the feed bin simultaneously.

Another design control system to prevent a toxic release from the gasifier is the steam injection system on the poke holes atop the gasifier. When a poke hole is opened for insertion of a poke rod, an interlock activates a steam injection feed through an annulus at the throat of the poke hole creating a constant steam flow into the gasifier and preventing the escape of process materials through the poke hole.

The entire gasification building would be provided with a ventilation system to assist in the removal of any fugitive emissions from the process. Additionally an auxiliary forced air system would be provided in the penthouse portion of the gasifier building. The forced air system, in conjunction with the location of the intakes for the combustion air blowers in the penthouse, would create a sweeping effect across the tops of the coal feed bins. Any process materials present, such as from fugitive emissions as well as any aerosol coal dust, would be vented through the combustion air blower to the process.

A system of continuous gas monitoring instruments would also be included. The system is capable of detecting carbon monoxide at very low levels and issuing an alarm to operators. The system is described in greater detail in Section 9.4.6 of this report.

The majority of the remainder of the process would be of typical chemical-plant process design. This includes: open air construction to maximize natural ventilation; fixed piping and vessels; appropriate seals on rotating equipment; and proper routing of bleed and blowdowns, all of which are integral components of the containment system.

9.4.6 Personnel Environmental Exposure Monitoring

9.4.6.1 Criteria for Evaluating Chemical Health Hazards

The Wellman-Galusha Gas Producer System is typical of many coal conversion processes in that its operation results in the utilization and generation of hazardous substances with potential emissions into the environment and the workplace. These substances may range from simple substances such as hydrogen sulfide and carbon monoxide to complex organic compounds, such as benzo (a) pyrene. The potential health effects resulting from exposure to these compounds may range from nuisance and mild irritation to carcinogenesis and death. Some of the compounds exhibit acute effects while others are chronic in nature, consequently the response interval may range from immediate to 25 and 30 years. The situation is further complicated because many of these compounds enhance or accelerate the action of other compounds when present together.

Several physical elements would be present in the work area including noise and heat. Although most coals do contain small amounts of radioactive compounds as trace elements (uranium and thorium: less than 400-500 ppm by weight), it is not foreseen that ionizing radiation would be a significant factor in gas producer operations. Non-ionizing radiation would be significant only in the case where solar UV light may exert co-carcinogenic properties with polycyclic aromatic hydrocarbon exposures.

The extent of personnel environmental exposure monitoring will vary from installation to installation and will depend on factors such as compliance attainment in the past. In general, two consecutive subhazard monitoring periods can justify a relaxation on monitoring from quarterly to bi-annual. The correlation of exposure levels with medical determinations can increase or decrease the extent of monitoring required. Process factors such as stablity, maintenance practices, equipment reliability and process or work practice modifications can affect monitoring needs. Section 9.4.5 of this report describes some of the control systems used for minimizing personnel exposures. Effective control systems would also reduce monitoring needs.

Detailed below is a scheme for categorizing personnel exposures as well as a description of suitable monitoring methods.

Category I

Immediately Dangerous to Life and Health (IDLH)

An IDLH exposure involves an acutely hazardous compound and is one in which the maximum concentration attained exceeds the limit from which one could escape within 30 minutes without any escape-impairing symptoms or irreversible health effects.

Category II

High Risk, But Not Immediately Hazardous

Exposures of this nature involve either chronic low level exposure, and single or repeat high level exposures, which may result in irreversible damage, occupationally acquired disease or shortened life span.

Category III

Moderate Risk and Not Immediately Hazardous

Moderate risk and not immediately hazardous exposures do not pose an immediate life-threatening or life-shortening hazard, they can be readily diagnosed and respond to medical attention and therapy.

Category IV

Short Term Nonroutine High Hazards

Compounds in this category may be escalated to Category I, IDLH, due to unusual circumstances. An O_2 deficiency due to inert purging or a confined space incident would fit into this category.

9.4.6.2 Monitoring Methods

Continuous gas monitring is well suited for Category I, Immediately Dangerous to Life and Health. Category I exposures may occur around the gasifiers, feed bins, quench and tar separation units primarily as a result of carbon monoxide leakage from the process.

Category II, high risk, but not immediately hazardous exposure, may cause irreversible effects such as carcinogenesis, mutagenic and teratogenic effects and includes compounds such as polycyclic aromatic hydrocarbons, trace metals and free silica in coal dust.

Routine monitoring of individual compounds would be difficult and expensive. Consequently, industrial hygiene surveys and data collection coupled with the indicator monitoring concept should be used. Initially, emphasis should be placed on establishing a representative data base consisting of qualitative and quantitative industrial hygiene measurements using personal exposure and survey techniques. Wipe sampling may be useful for this task. At the same time, records of emissions indicated by the real-time indicator monitoring systems should be compiled so that statistical relationships between process emissions as seen by the real-time monitors and worker exposure levels to different compounds within the process emission can be established.

Category III compounds, those that pose a moderate risk and are not immediately hazardous, may include hydrocarbons, trace elements, phenolic and cresols as well as other compounds. Exposures to these compounds should be determined by industrial hygiene methods qualitatively and quantitatively. This may entail the use of personal monitors and survey equipment.

It is anticipated that direct reading, real-time survey equipment would be the most appropriate monitoring method for Category IV, short-term, nonroutine high hazard exposure situations. In situations such as upsets involving large releases or confined space applications, the portability and fast response of a direct reading instrument is highly desirable.

Real-Time Continuous Monitoring and the Indicator Concept

Whenever the possibility exists that process materials of a highly hazardous nature may be quickly released from the process equipment, or where the same materials may accumulate and pose serious high risk conditions to personnel, continuous monitoring equipment should be employed to give immediate (real-time) warning of concentrations likely to become hazardous to life. Details of the continuous monitoring can be found in Sections 9.4.5, 9.4.6.2 and 9.4.6.3.

A monitoring system to achieve this capability would consist of a series of detector heads located at strategic locations in the process area. Upon detection of some pre-set minimal concentration of the indicator compound, a signal is sent to a dedicated annunciator at an occupied location in the plant such as a control room. Another signal is sent to an alarm station in the process area which activates an audible and visual alarm. Interlocks to activate ventilation systems or deactivate process equipment can be easily accommodated by most available instrumentation.

The initial detection is of a safe, but significant concentration. A second alarm, indicating that an acutely hazardous concentration in the area exists is sent to the dedicated annunciator if that concentration is attained.

Indicator Monitoring

The underlying concept of indicator monitoring is that concentrations of different chemical compounds from a process emission may be estimated if the concentration of the indicator substance is known. If the ratio of concentrations of hazardous substances in the process emission is known (from a process flow diagram) and the actual concentration of the indicator in the workplace is known (from the continuous monitor) then an accurate estimate of the concentration of the other hazardous compound can be made.

Application of the indicator monitoring concept involves some fairly complex mathematics correlating factors such as the leak rate of each substance, workroom volume, ventilation, depositions/sedimentation of particulates and vapor condensation.

The indicator compound should meet the following criteria:

- Easily monitored in real-time by commercially available equipment.
- Suitable for analysis where resources and technical skills are limited.
- Not present in ambient air at high or widely fluctuating concentrations.
- Measurable without interference from other substances in the process stream or ambient air.
- Regulated substance.

In this way the monitoring system fulfulls the two purposes:

(1) it is an acutely hazardous condition monitoring system with alarm capabilities, and

(2) allows the use of the indicator monitoring concept.

Carbon monoxide meets the above criteria and should be utilized as the indicator compound. Concentrations of 17-20% carbon monoxide can be found in the piping and vessels through the gasification and tar recovery process areas and can be monitored in the external (ambient) environment at concentrations below 1 PPM. Additional concerns for off-site effects from process emission could also be relieved by continuously monitoring ambient carbon monoxide levels. Further detail on the indicator monitoring concept can be found in Cohen and Hermanns' paper*.

9.4.6.3 Monitoring Physical Health Hazards

As mentioned previously, physical health hazards may exist during operation of the Gas Producer System. Heat and noise exposures may be significant and should be monitored periodically.

Heat

The gasifiers, coal feed bins, cyclones and blowers would be housed indoors in a multi-level building. Operations in the warm season may produce elevated workroom temperatures. Operator and maintenance activities on the operating level, around the ash removal section and to a lesser extent, in the remainder of the building, may pose heat stress hazards.

Prolonged exposure to excessive heat may cause increased irritability, lassitude, decrease in morale, increased anxiety, and inability to concentrate. The results are mirrored by a general decrease in the efficiency of production. The physical disabilities caused by excessive heat exposure are, in order of increasing severity, heat rash, heat cramps, heat exhaustion, and heat stroke. The ACGIH** threshold limits should be consulted regarding potential heat stress exposures.

Noise

Significant noise levels would be produced by the operation of the Gas Producer System. Principal noise sources would be mainly mechanical equipment. The Table below lists the principle noise sources.

Noise Sources

Noise Source	Location
Bucket Elevator	Outside of the Gasification Building
Air Blowers	Gasification Building
Gasifier Grate Drives	Gasification Building
ESP Compressors	Tar Removal (Outside)
Producer Gas Compressors	Tar Removal (Outside)

Portions of the gasification building would be in the medium to high density noise level; notably the penthouse area where the combustion air blowers are located. Noise levels in the penthouse may be in the 85-90 dBA range. This area would not normally be occupied so compliance with OSHA exposure limits should not be a problem. Personal hearing protectors should be available for workers needing access to the penthouse.

* M. L. Cohen, E. R. Hermann., A Methodology for Testing the Reliability of Carbon Monoxide As An "Indicator" for Monitoring Toxic Chemical Exposures in Coal Gasification Plants, University of Illinois School of Public Health, NIOSH Educational Resource Center.

** American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1980.

Noise levels in the tar recovery area would be somewhat less than the gasification penthouse area, this being a medium noise density area due primarily to the compressors. Speech interference levels would exist near the compressors, however, it is not anticipated that this area be routinely occupied and it would outdoors. Again, OSHA compliance should not be a problem.

The coal unloading and sulfur recovery areas would be medium to low noise density areas. Noise sources in the coal handling would due mainly to truck and end loader traffic, the vibrating feeder and the conveyor. These operations are very common in industry and are not noted for being particularly troublesome with regard to noise exposure. Noise levels in the sulfur recovery area would be attributable mainly to the motors on various pumping equipment. Although motor horsepowers range from 1/2 to 200 hp, most are below to 20 hp. This type of equipment, coupled with the open-air configuration of the area, would correspond to a medium-low noise level area. Product storage areas would be low density noise level areas.

Noise Level Monitoring

The basics of a hearing conservation monitoring program should be applied to the gas producer operations. Included should be provisions for the following:

- Baseline audiometric examination and annual follow-up
- Initial noise level survey and periodic follow-up surveys
- Rectification of any acutely hazardous noise exposures
- Posting of all areas where continuous noise levels exceed 85 dBA
- Personal hearing protection including training and fitting

Currently OSHA is proposing a comprehensive hearing conservation noise standard which if promulgated will greatly expand the basic program described above.

9.4.7 Evaluation of Operations

9.4.7.1 Occupational Health Evaluations

Safety and health considerations, particularly relating to toxic substances, have been considered in the design stage and are described in Section 9.4.5 of this report. To assure the effectiveness of these controls throughout the life of the facility and to monitor the adequacy of work practices employed for hazard control, safety and health evaluations should be conducted periodically, and when modifications of the existing controls are made.

Health evaluations usually take the form of industrial hygiene field surveys in which air or process samples, representative of worker exposures and conditions, are taken and evaluated by reliable methods. Typical industrial hygiene field surveys include the following:

- Recognition of potential hazards
- Selection of equipment and methods
- Conducting the survey
- Data analysis and interpretation

Several gas producer operations which may be considered for evaluation include:

Operation	Possible Hazards
Combustion Zone Determination	Asphyxiation, Heat, and Noise
Ash Removal	Skin and Respiratory Exposure to Coal Tar Products Asphyxiation, Ash Fines and Trace Elements
Burning & Welding	Welding Fumes and Volatilization of Coal Tar Hydrocarbons From Welding Substrate
Coal Bunker Inspection	Asphyxiation
General Maintenance on Gasifier and Tar Removal Area Tar Products	Skin and Somewhat Less Respiratory Exposure to Coal
Vessel Entries	Asphyxiation, Heat

Material Flow Assistance (Steaming, Rodding, Bleeding, Draining)	Skin and Respiratory Exposure to Coal Tar Products, Asphyxiation, Heat
General Maintenance and Housekeeping Around Coal Handling Equipment	Respiratory Exposure to Coal Dust
Drum Handling of Process Reagents (Sulfur Recovery)	Skin and Respiratory Exposure to Irritant Materials

9.4.7.2 Operating Safety Evaluations

Safety evaluations, aside from routine safety and housekeeping inspections, usually take the form of a protection system evaluation or reliability assessment. The criteria for evaluation should be the performance of the system against design. Some systems which may be suject to safety performance evaluation include:

- Fire prevention and protection systems
- Pressure relieving devices
- Explosion vents
- Continuous monitoring systems

Safety evaluations should also be performed when any significant modification to the process unit is to be made. Plant modifications which are not thoroughly analyzed, particularly a temporary maintenance modification such as temporary piping, can introduce significant change in the process which can result in unanticipated hazards.

9.4.7.3 Safety Evaluation Methods

Checklists

One of the most useful tools of hazard identification is the checklist. Checklists must be appropriate to the subject activity and stage of the project. Checklists are applicable to all stages of activity starting with basic materials and process features, continuing through detailed design and throughout operations. An example of an operating checklist is a burning and welding permit. A checklist's primary purpose is that of a final check that nothing has been neglected.

Other Safety Evaluation Methods

Several safety evaluation or "analysis" methods which can be employed are listed below. These methods are often couched under the term in System Safety and in-volve considerable time and expertise to be effectively used. They are listed in increasing order of complexity:

- Hazard and Operability Studies (Hazop) - a systematic evaluation of the process and equipment parameters using an interdisciplinary team approach.

- Failure Mode and Effects Analysis (FMEA) - concerned with the equipment, ways in which its components could fail, the effects that could be generated and estimation of the failure rates.

- Fault Tree Analysis (FTA) - uses a deductive tree approach to ferret out faults inherent in complex systems.

9.4.8 Clinical Occupational Medicine

Operators of the Wellman-Galusha® Gas Producer system should establish a Clinical Occupational Medicine Function. The medical function should be under the direction of a certified physician whose responsibilities in addition to overall administration should include recognizing, diagnosing, and treating occupational injuries and illnesses. In view of the limited manpower requirements for operation of the gas producer it may be practical to obtain a physician on a contract part-time basis. Nursing services which include assisting the physician, first aid, health maintenance training, maintenance of medical records and follow-up treatment of injuries can also be obtained on a part-time basis. Facilities employing 100 or more employees should obtain the services of a full-time nurse.

9.4.8.1 Medical Monitoring Program

The Medical Monitoring Program is a fundamental component of the occupational safety and health program. It is designed to identify physical conditions that would be aggravated by exposure to hazards in the workplace; to ensure that the employee's health is adequate to withstand job requirements; and to detect any adverse physiological effects in workers from the workplace environment before the actual onset of disease or injury so that corrective actions can be taken.

The Medical Monitoring Program will include preemployment physical examinations and periodic examinations for all employees. The physicals should include the following elements:

- Comprehensive medical and work histories, with special emphasis on the identification of pre-existing disorders of the skin, respiratory tract, liver, kidneys and blood.

- Physical examination giving particular attention to the oral cavity, skin and respiratory system. This includes a posteroanterior x-ray (14 inches x 17 inches).

- Pulmonary function tests, including forced vital capacity (FVC) and forced expiratory volume at one second (FEV 1.0).

- Other tests (e.g. sputum cytology, urinalysis, urine cytology, electrocardiogram and multiple serum chemistry tests) as deemed necessary by the Clinical Occupational Medicine Physician.

- Audiometric examination to determine baseline audiograms and detect any change in hearing ability.

- Evaluation of the employee's ability to use respiratory protection equipment.

- Employees or prospective employees with medical conditions that may be directly or indirectly aggravated by work in the plant should be so

counseled. Acceptance of employment shall be contingent upon successful completion of the pre-employment physical examination, as determined by the Clinical Occupational Medicine Physician.

Recent developments in coal conversion medical monitoring include skin charting, in which detailed documentation of dermal observation are made and recorded or "charted" on body drawings to show size, location, color etc. of skin features. Another development is detailed photography using 35 mm equipment to record skin lesions and their activity. Either of these methods may prove to be beneficial for documenting skin abnormalities and should be incorporated if successful in other coal conversion facilities.

Periodic follow-up examinations using the same protocols should be conducted at least annually for all employees and bi-annually for workers with routine high coal tar product exposures or with skin abnormalities which need to be closely monitored. X-rays at follow-up examinations should be at physician's discretion.

9.4.8.2 First Aid

Like many industrial operations, gas producer operations can be expected to produce minor non-reportable occupational injuries such as cuts, scratches, bruises and minor burns which require first aid. Additionally, although not expected, serious injuries can occur in the industrial environment and provisions should be in place to deal with them should they occur.

One method of approach to providing first aid capabilities in industrial operations without around-the-clock medical staffs is to train and certify key personnel in first aid and maintain at least one certified first-aider on the premises at all times. First aid supplies can be prescribed by the physician and stored in a central location. Often supervisory personnel are designated as first aiders as they typically have ready access to all plant facilities including medical supplies. It is common practice in industry to have ongoing first aid training available for all employees. In an operation such as the gas producer where the census is small, it is conceivable that a majority of the work force could be trained in some aspect of first aid in a short time. Several levels of first aid training are available through national organizations. Briefly, first aid training includes:

- Multi-media first aid - basic first aid and life saving requiring 8 hours of training.

- Cardiopulmonary resuscitation - life saving techniques for heart and respiratory failure victims requiring 8 hours of training.

- Standard first aid - a comprehensive course in life saving and emergency care for acute care situations requiring 16 hours of training.

Training programs can generally be coordinated with local chapters of national organizations such as the Red Cross and American Heart Association or local hospitals.

9.4.8.3 Recordkeeping

A central duty of the Clinical Occupational Medicine function would be the systematic keeping of medical records. This includes individual medical files on all employees, first aid and treatment logs and records of any medications which might be dispensed. The medical records of employees should be retained for thirty years after employment has terminated.

9.4.8.4 Training and Other Programs

Health Education from the Clinical Occupational Medicine function should be an on going program. Skin care and training in the recognition of abnormal changes should be provided. Periodic medical update training and occupational health maintenance information services should also be provided.

9.4.8.5 Work Recertification and Termination Examination

If a worker is absent from work for longer than 5 days due to illness or longer as in the case of an injury, the worker should present a certification from his physician or obtain one from the Clinical Occupational Medicine Physician before returning to work.

On termination of employment, a physical examination (following the same protocols as the periodic examination) should be performed, provided no such examination has been performed in the preceding calendar year.

9.5 Carcinogenic Safety

9.5.1 General

Recent concern for environmentally related cancer has had several prime focal points, one of which is the occupational environment. This is evidenced by extensive research into the nature and occurrence of occupationally related carcinogenesis and legislative action, particularly by OSHA.

The coal conversion industry is one in which occupationally related carcinogenesis has received much attention and concern. An excess incidence of cancer has been seen in coke oven workers, gas producer workers and at one coal hydrogenation facility operated in the 1950's. Most research indicates that the volatile constituents of coal (particularly bituminous) which are generated as a result of processing such as might occur during pyrolysis or gasification contain certain species of chemical compounds which have carcinogenic activity potential.

In view of the serious nature of cancer and the worker exposure potential associated with coal conversion operation, it is expected that Wellman-Galusha Gas Producer operators using bituminous coal feedstocks will have to take special precautions to reduce the risk of occupationally related cancer. Section 9.2.1 describes a battery of precautions which are generally used in coal conversion facilities.

9.5.2 Specialized Precautions - Industrial Hygiene

9.5.2.1 Industrial Hygiene Program for Carcinogen Control

The industrial hygiene program objective regarding worker exposures to carcinogenesis is to control exposures to as low a level as is reasonably attainable, and to assist the medical department in monitoring the work force for exposure to and the incidence of cancer and other related maladies. Basic industrial hygiene practice based on the following principles shall be employed:

- Recognize the materials of concern with carcinogenesis, and the interaction(s) of the materials with workers and job activities associated with exposures.

- Evaluate the materials of exposure, the routes of exposure, the exposure dose, the nature of the exposure and the effect of exposures.

- Control to as low as is reasonably attainable the levels of exposure through engineering, work practice and administrative measures.

Some specific industrial hygiene considerations which should be used in controlling carcinogenic hazards include the following:

9.5.2.2 Regulated Areas

- Establishment of regulated areas to limit access to only those employees whose duties necessitate their entry into such areas. This effectively limits potential carcinogenic exposures to known individuals and permits approximation of duration of exposure.

- The establishment of regulated areas also demarks boundaries for the implementation and enforcement of specific rules and restrictions designed to reduce carcinogenic exposure risk. This includes tobacco use; food storage, perparation and consumption; personal hygiene practice; personal protective equipment and clothing provisions; and workplace exposure monitoring.

- The regulated area concept will also establish a framework for categorizing workplace conditions and worker exposure levels for future uses such as epidemiologic studies.

For small gas producer plants, a reasonable approach would be to restrict the entire process area from outside personnel such as office personnel and gas user personnel.

9.5.2.3 Labeling and Posting

- Entry ways to any regulated area should be so posted. Signs should be kept clean and readily visible. The signs should clearly name any restricted activities, the nature of the hazard, and other pertinent information.

9.5.2.4 Personnel Protective Equipment

- The objective of the personnel protective clothing program should be to limit worker's skin contact with carcinogenic materials. An effective personnel protective clothing program is a key element in reducing carcinogenic related skin problems.

- All process area workers should wear ANSI-approved, steel-toed safety shoes. Neoprene rubber overshoes or boots should be provided in the event that significant contamination may occur.

- ANSI-approved safety glasses with side shields should be worn by all process areas workers and laboratory personnel. Chemical-type safety goggles should be worn when specific tasks dictate their use.

- All process area workers should wear protective clothing consisting of underclothing (undershirts, underwear and cotton socks) and outerclothing (shirts and trousers or coveralls). Also provided should be heavy weather gear, jackets and gloves.

- A respiratory protection program, meeting the requirements of OSHA 1910 134, Respiratory Protection, should be implemented as necessary. The respiratory protection program should address the potential immediately dangerous to life and health (IDLH) hazards associated with LBG operations. This should include provisions for self-contained breathing apparatus for emergency escape and rescue and supplied air such as a cascade-airline system for maintenance procedures.

9.5.2.5 Personal Hygiene Practice

- A personal hygiene practice program should be implemented with the following objectives: (1) providing workers the means for decontamination; (2) limiting, to the extent feasible, the transporting of carcinogenic material to other locations, particularly off-site, and avoiding food contamination.

9.5.2.6 Shower Facility

A two-sided pass-through shower facility should be located near the main entrance between the plant entrance and the process area. An arrangement of this nature should assist in the implementation of a mandatory clothes change and mandatory shower program.

9.5.2.7 Mandatory Clothes Change and Shower Program

- Process area workers should change their underclothing daily and outerclothing as necessary. In the event of considerable contamination, process area workers should change their clothing as soon as practically possible.

- At the start of the shift, process area workers arriving at work should pass through the main entrance, enter the shower facility through the "clean door", and proceed to a dispensing area where they will receive clean work clothes. They will proceed to their assigned personal locker, remove all street clothes, and change into the clean work clothes provided. They will then proceed in stocking feet through a one way door to the dirty clothes removal room, where storage facilities for personnel protection equipment (e.g. shoes, protective helmet, heavy weather gear, etc.) are provided. After donning personal protection equipment, they will proceed through the "dirty door" to the process area.

- Process area workers should shower at the end of each workshift. At the end of the shift, process area workers should enter the dirty-clothes removal room through the process side door, or "dirty door", and remove all clothing, storing personal equipment and outer garments in the facilities provided. Dirty clothes (undergarments, and outer garments when necessary) will be deposited in receptacles, and workers will proceed into the shower room to take a shower. After showering, workers will change into street clothes, exit through the "clean door" and out of the plant.

9.5.2.8 Laundering of Work Clothes

Outer clothing should be dry-cleaned followed by wet washing. Inner clothes should be wet washed only. Outer clothing, which serves as the outer protective shell, should be laundered when necessary, perhaps every second or third work day; tops should be laundered daily. Consequently, a fairly large inventory of clothing should be provided. Several large industrial laundry concerns have programs tailored specifically to this type of program.

9.5.2.9 Washroom and Eating Facilities

- Washroom and toilet facilities may be provided in the process area. Process area workers should be encouraged to wash all exposed areas, such as their hands, arms, face and neck, when using the toilet facilities and prior to eating.

- Eating facilities should be located outside of the regulated area with washing facilities provided for process workers to thoroughly wash prior to eating. Food storage preparation and consumption should not be allowed in the regulated area.

9.5.2.10 Industrial Hygiene Sampling Program

Industrial hygiene survey methods have been detailed elsewhere in this report, section 9.1.6. Regarding carcinogenic materials, the major objectives of the surveys would be the following:

- Definition of the components comprising the carcinogenic hazard, and quantification and documentation of workers' exposure.
- Evaluation of the air sampling and process data to determine the adequacy of engineering and workpractice controls.

Research and development are underway to develop alternate survey methods and analysis. One method currently used in the pesticide industry which may be applicable to coal conversion facilities is a surface contamination switch for wipe sampling.

The OSHA Field Operations Manual, Instruction CPL 2-2.20, April 30, 1979 should be consulted for wipe sampling procedures.

Research into the use of ultra-violet radiation sources, the fluorescent properties of polycyclic arematic hydrocarbons (PAH), is also under development. UV scanning to detect PAH skin and surface contamination may soon be available.

9.5.2.11 Medical Monitoring

The medical monitoring program detailed in section 9.4.6 was designed to monitor carcinogen exposures as well as other occupational maladies.

9.5.2.12 Health Education

An education program to inform employees of the nature of the hazard should include:

- Possible effects of exposure
- Hazard recognition and preventive measures
- Personal hygiene practices
- Workpractices for minimizing exposure
- Necessity for and interpretation of exposure monitoring data
- Recognizing and reporting physiological changes that may indicate a response to the carcinogenic hazard.

A basic training program outlining these topics should be developed for new employees, visitors, and for periodic retraining, perhaps annually. As additional information and developments arise, they should be incorporated into the training program detailed in section 9.1.2.

9.5.3 Product Toxicological Testing and TSCA

The objective of the Toxic Substances Control Act, TSCA, is to identify and control toxic chemicals in all phases of commerce. The act applies to chemicals produced for commercial purposes; intermediates may also be regulated. The priorities for regulation are set according to risk to human health or the environment. The final impact of TSCA can range from prohibition or restriction of a product from commerce to labelling the product as a hazardous material.

One of the major requirements before the manufacturing of chemical products is the submission of information concerning the health and environmental effects of the new product. Sufficient test data would have to be submitted to the EPA for assessment. Other factors in the risk assessment equation include the quantity of material expected to be produced, the human exposure potential or degree of risk to the population or the environment, and finally what is know or can be predicted about the toxicity of the chemical.

9.5.3.1 Section 4 Testing Requirements

Testing requirements for TSCA are outlined in Section 4 of the Act which establishes the authority of the Administrator of the USEPA to require testing. Before requiring testing, the Administrator must set forth the need for such testing. Specifically, the Adminstrator must find that (1) the chemical may present an unreasonable risk to health or the environment, or there may be substantial human or environmental exposure to the chemical; (2) there are insufficient data and experience for determining or predicting the health and environmental effects of the chemical; and (3) testing of the chemical is necessary to develop such data. The manufacturers or processors of a chemical must bear the costs of testing that chemical.

Additional information about the Toxic Substances Control Act can be obtained from the Federal Register, EPA's Office of Industry Assistance or from numerous publications in general circulation.

OSHA No. 101
Case or File No. _____

Form approved
OMB No. 44R 1453

Supplementary Record of Occupational Injuries and Illnesses

EMPLOYER

1. Name _____
2. Mail address _____
   (No. and street) (City or town) (State)
3. Location, if different from mail address _____

INJURED OR ILL EMPLOYEE

4. Name _____ Social Security No. _____
   (First name) (Middle name) (Last name)
5. Home address _____
   (No. and street) (City or town) (State)
6. Age _____ 7. Sex: Male_____ Female_____ (Check one)
8. Occupation _____
   (Enter regular job title, *not* the specific activity he was performing at time of injury.)
9. Department _____
   (Enter name of department or division in which the injured person is regularly employed, even though he may have been temporarily working in another department at the time of injury.)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS

10. Place of accident or exposure _____
    (No. and street) (City or town) (State)
    If accident or exposure occurred on employer's premises, give address of plant or establishment in which it occurred. Do not indicate department or division within the plant or establishment. If accident occurred outside employer's premises at an identifiable address, give that address. If it occurred on a public highway or at any other place which cannot be identified by number and street, please provide place references locating the place of injury as accurately as possible.
11. Was place of accident or exposure on employer's premises? _____ (Yes or No)
12. What was the employee doing when injured? _____
    (Be specific. If he was using tools or equipment or handling material,
    _____
    name them and tell what he was doing with them.)
    _____
13. How did the accident occur? _____
    (Describe fully the events which resulted in the injury or occupational illness. Tell what
    _____
    happened and how it happened. Name any objects or substances involved and tell how they were involved. Give
    _____
    full details on all factors which led or contributed to the accident. Use separate sheet for additional space.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS

14. Describe the injury or illness in detail and indicate the part of body affected. _____
    (e.g.: amputation of right index finger
    _____
    at second joint; fracture of ribs; lead poisoning; dermatitis of left hand, etc.)
15. Name the object or substance which directly injured the employee. (For example, the machine or thing he struck against or which struck him; the vapor or poison he inhaled or swallowed; the chemical or radiation which irritated his skin; or in cases of strains, hernias, etc., the thing he was lifting, pulling, etc.)
    _____
    _____
16. Date of injury or initial diagnosis of occupational illness _____
    (Date)
17. Did employee die? _____ (Yes or No)

OTHER

18. Name and address of physician _____
19. If hospitalized, name and address of hospital _____
    _____

Date of report _____ Prepared by _____
Official position _____

EXHIBIT 9-1

OSHA No. 101
Case or File No. _____

Form approved
OMB No. 44R 1453

Supplementary Record of Occupational Injuries and Illnesses

EMPLOYER

1. Name _____
2. Mail address _____
   (No. and street) (City or town) (State)
3. Location, if different from mail address _____

INJURED OR ILL EMPLOYEE

4. Name _____ Social Security No. _____
   (First name) (Middle name) (Last name)
5. Home address _____
   (No. and street) (City or town) (State)
6. Age _____ 7. Sex: Male_____ Female_____ (Check one)
8. Occupation _____
   (Enter regular job title, *not* the specific activity he was performing at time of injury.)
9. Department _____
   (Enter name of department or division in which the injured person is regularly employed, even though he may have been temporarily working in another department at the time of injury.)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS

10. Place of accident or exposure _____
    (No. and street) (City or town) (State)
    If accident or exposure occurred on employer's premises, give address of plant or establishment in which it occurred. Do not indicate department or division within the plant or establishment. If accident occurred outside employer's premises at an identifiable address, give that address. If it occurred on a public highway or at any other place which cannot be identified by number and street, please provide place references locating the place of injury as accurately as possible.
11. Was place of accident or exposure on employer's premises? _____ (Yes or No)
12. What was the employee doing when injured? _____
    (Be specific. If he was using tools or equipment or handling material,
    _____
    name them and tell what he was doing with them.)
    _____
13. How did the accident occur? _____
    (Describe fully the events which resulted in the injury or occupational illness. Tell what
    _____
    happened and how it happened. Name any objects or substances involved and tell how they were involved. Give
    _____
    full details on all factors which led or contributed to the accident. Use separate sheet for additional space.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS

14. Describe the injury or illness in detail and indicate the part of body affected. _____
    (e.g.: amputation of right index finger
    _____
    at second joint; fracture of ribs; lead poisoning; dermatitis of left hand, etc.)
15. Name the object or substance which directly injured the employee. (For example, the machine or thing he struck against or which struck him; the vapor or poison he inhaled or swallowed; the chemical or radiation which irritated his skin; or in cases of strains, hernias, etc., the thing he was lifting, pulling, etc.)
    _____
    _____
16. Date of injury or initial diagnosis of occupational illness _____
    (Date)
17. Did employee die? _____ (Yes or No)

OTHER

18. Name and address of physician _____
19. If hospitalized, name and address of hospital _____

_____

Date of report _____ Prepared by _____
Official position _____

EXHIBIT 9-1

OSHA No. 101
Case or File No. _____

Form approved
OMB No. 44R 1453

Supplementary Record of Occupational Injuries and Illnesses

EMPLOYER

1. Name _____
2. Mail address _____
   (No. and street) (City or town) (State)
3. Location, if different from mail address _____

INJURED OR ILL EMPLOYEE

4. Name _____ Social Security No. _____
   (First name) (Middle name) (Last name)
5. Home address _____
   (No. and street) (City or town) (State)
6. Age _____ 7. Sex: Male_____ Female_____ (Check one)
8. Occupation _____
   (Enter regular job title, *not* the specific activity he was performing at time of injury.)
9. Department _____
   (Enter name of department or division in which the injured person is regularly employed, even though he may have been temporarily working in another department at the time of injury.)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS

10. Place of accident or exposure _____
    (No. and street) (City or town) (State)
    If accident or exposure occurred on employer's premises, give address of plant or establishment in which it occurred. Do not indicate department or division within the plant or establishment. If accident occurred outside employer's premises at an identifiable address, give that address. If it occurred on a public highway or at any other place which cannot be identified by number and street, please provide place references locating the place of injury as accurately as possible.
11. Was place of accident or exposure on employer's premises? _____ (Yes or No)
12. What was the employee doing when injured? _____
    (Be specific. If he was using tools or equipment or handling material,
    _____
    name them and tell what he was doing with them.)
    _____
13. How did the accident occur? _____
    (Describe fully the events which resulted in the injury or occupational illness. Tell what
    _____
    happened and how it happened. Name any objects or substances involved and tell how they were involved. Give
    _____
    full details on all factors which led or contributed to the accident. Use separate sheet for additional space.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS

14. Describe the injury or illness in detail and indicate the part of body affected. _____
    (e.g.: amputation of right index finger
    _____
    at second joint; fracture of ribs; lead poisoning; dermatitis of left hand, etc.)
15. Name the object or substance which directly injured the employee. (For example, the machine or thing he struck against or which struck him; the vapor or poison he inhaled or swallowed; the chemical or radiation which irritated his skin; or in cases of strains, hernias, etc., the thing he was lifting, pulling, etc.)
    _____
    _____
16. Date of injury or initial diagnosis of occupational illness _____
    (Date)
17. Did employee die? _____ (Yes or No)

OTHER

18. Name and address of physician _____
19. If hospitalized, name and address of hospital _____

_____

Date of report _____ Prepared by _____
Official position _____

EXHIBIT 9-1

Bureau of Labor Statistics
Log and Summary of Occupational
Injuries and Illnesses

U.S. Department of Labor

For Calendar Year 19 ____ Page ____ of ____

Form Approved
O.M.B. No. 44R 1453

NOTE: This form is required by Public Law 91-596 and must be kept in the establishment for 5 years. Failure to maintain and post can result in the issuance of citations and assessment of penalties. *(See posting requirements on the other side of form.)*

RECORDABLE CASES: You are required to record information about every occupational death, every nonfatal occupational illness, and those nonfatal occupational injuries which involve one or more of the following: loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment (other than first aid). *(See definitions on the other side of form.)*

Company Name
Establishment Name
Establishment Address

Case or File Number	Date of Injury or Onset of Illness	Employee's Name	Occupation	Department	Description of Injury or Illness	Extent of and Outcome of INJURY: Fatalities — Injury Related	Nonfatal Injuries — Injuries With Lost Workdays				Injuries Without Lost Workdays	Type, Extent of, and Outcome of ILLNESS: Type of Illness — CHECK Only One Column for Each Illness (See other side of form for terminations or permanent transfers)							Fatalities — Illness Related	Nonfatal Illnesses — Illnesses With Lost Workdays				Illnesses Without Lost Workdays
Enter a nondupicating number which will facilitate comparisons with supplementary records	Enter Mo./day/yr.	Enter first name or initial, middle initial, last name	Enter regular job title, not activity employee was performing when injured or at onset of illness. In the absence of a formal title, enter a brief description of the employee's duties	Enter department in which the employee is regularly employed or a description of normal workplace to which employee is assigned, even though temporarily working in another department at the time of injury or illness	Enter a brief description of the injury or illness and indicate the part or parts of body affected. Typical entries for this column might be: Amputation of 1st joint right forefinger. Strain of lower back. Contact dermatitis on both hands. Electrocution - body	Enter DATE of death. Mo./day/yr.	Enter a CHECK if injury involves days away from work, or days of restricted work activity, or both	Enter a CHECK if injury involves days away from work	Enter number of DAYS away from work	Enter number of DAYS of restricted work activity	Enter a CHECK if no entry was made in columns 1 or 2 but the injury is recordable as defined above	Occupational skin diseases or disorders	Dust diseases of the lungs	Respiratory conditions due to toxic agents	Poisoning (systemic effects of toxic materials)	Disorders due to physical agents	Disorders associated with repeated trauma	All other occupational illnesses	Enter DATE of death. Mo./day/yr.	Enter a CHECK if illness involves days away from work, or days of restricted work activity, or both	Enter a CHECK if illness involves days away from work	Enter number of DAYS away from work	Enter number of DAYS of restricted work activity	Enter a CHECK if no entry was made in columns 8 or 9
(A)	(B)	(C)	(D)	(E)	(F)	(1)	(2)	(3)	(4)	(5)	(6)	(7) (a)	(b)	(c)	(d)	(e)	(f)	(g)	(8)	(9)	(10)	(11)	(12)	(13)
					PREVIOUS PAGE TOTALS																			
					TOTALS (transfer to other side of form)																			

INJURIES

ILLNESSES

Certification of Annual Summary Totals By _____ Title _____ Date _____

OSHA No. 200

POSTED

OSHA No. 200

POST ONLY THIS PORTION OF THE LAST PAGE NO LATER THAN FEBRUARY 1.

U.S. GOVERNMENT PRINTING OFFICE 1980 611-598/1016 2-1

EXHIBIT 9-2

Instructions for OSHA No. 200

I. Log and Summary of Occupational Injuries and Illnesses

Each employer who is subject to the recordkeeping requirements of the Occupational Safety and Health Act of 1970 must maintain for each establishment a log of all recordable occupational injuries and illnesses. This form (OSHA No. 200) may be used for that purpose. A substitute for the OSHA No. 200 is acceptable if it is detailed, easily readable, and convertible to the OSHA No. 200.

Enter each recordable case on the log within six (6) workdays after learning of its occurrence. Although other records must be maintained at the establishment to which they refer, it is possible to prepare and maintain the log at another location using data processing equipment if desired. If the log is prepared elsewhere, a copy updated to within 45 calendar days must be present at all times in the establishment.

Logs must be maintained and retained for five (5) years following the end of the calendar year to which they relate. Logs must be available (normally at the establishment) for inspection and copying by representatives of the Department of Labor, or the Department of Health, Education and Welfare or States accepted jurisdiction under the Act.

II. Changes in Extent of or Outcome of Injury or Illness

If, during the 5-year period the log must be retained, there is a change in the extent and outcome of an injury or illness which affects entries in columns 1, 2, 6, 8, 9, or 13, the first entry should be lined out and a new entry made. For example, if an injured employee at first required only medical treatment but later lost workdays away from work, the check in column 6 should be lined out and checks entered in columns 2 and 3 and the number of lost workdays entered in column 4.

In another example, if an employee with an occupational illness lost workdays, returned to work, and then died of the illness, any entries in columns 9 through 12 should be lined out and the date of death entered in column 8.

The entire entry for an injury or illness should be lined out if later found to be incorrect or invalid. For example, an injury which is later determined not to be work related, or which was initially thought to involve medical treatment but later was determined to have involved only first aid.

III. Posting Requirements

A copy of the totals and information following the fold line of the last page for the year must be posted at each establishment in the place or places where notices to employees are customarily posted. This copy must be posted no later than *February 1 and must remain in place until March 1.*

Even though there were no injuries or illnesses during the year, zeros must be entered on the totals line, and the form posted.

The person responsible for the *annual summary totals* shall certify that the totals are true and complete by signing at the bottom of the form.

IV. Instructions for Completing Log and Summary of Occupational Injuries and Illnesses

Column A — CASE OR FILE NUMBER. Self explanatory.

Column B — DATE OF INJURY OR ONSET OF ILLNESS

For occupational injuries, enter the date of the work accident which resulted in injury. For occupational illnesses, enter the date of initial diagnosis of illness, or, if absence from work occurred before diagnosis, enter the first day of the absence attributable to the illness which was later diagnosed or recognized.

Columns C through F — Self explanatory.

Columns 1 and 8 — INJURY OR ILLNESS RELATED DEATHS

Self explanatory.

Columns 2 and 9 — INJURIES OR ILLNESSES WITH LOST WORKDAYS

Self explanatory.

Any injury which involves days away from work, or days of restricted work activity, or both must be recorded since it always involves one or more of the criteria for recordability.

Columns 3 and 10 — INJURIES OR ILLNESSES INVOLVING DAYS AWAY FROM WORK. Self explanatory.

Columns 4 and 11 — LOST WORKDAYS — DAYS AWAY FROM WORK.

Enter the number of workdays (consecutive or not) on which the employee would have worked but could not because of occupational injury or illness. The number of lost workdays should not include the day of injury or onset of illness or any days on which the employee would not have worked even though able to work.

NOTE: For employees not having a regularly scheduled shift, such as certain truck drivers, construction workers, farm labor, casual labor, part-time employees, etc., it may be necessary to estimate the number of lost workdays. Estimates of lost workdays shall be based on prior work history of the employee AND days worked by employees, not ill or injured, working in the department and/or occupation of the ill or injured employee.

Columns 5 and 12 — LOST WORKDAYS — DAYS OF RESTRICTED WORK ACTIVITY.

Enter the number of workdays (consecutive or not) on which because of injury or illness:

(1) the employee was assigned to another job on a temporary basis, or
(2) the employee worked at a permanent job less than full time, or
(3) the employee worked at a permanently assigned job but could not perform all duties normally connected with it.

The number of lost workdays should not include the day of injury or onset of illness or any days on which the employee would not have worked even though able to work.

Columns 6 and 13 — INJURIES OR ILLNESSES WITHOUT LOST WORKDAYS. Self explanatory.

Columns 7a through 7g — TYPE OF ILLNESS.

Enter a check in only *one* column for each illness.

TERMINATION OR PERMANENT TRANSFER. Place an asterisk to the right of the entry in columns 7a through 7g (type of illness) which represented a termination of employment or permanent transfer.

V. Totals

Add number of entries in columns 1 and 8.
Add number of checks in columns 2, 3, 6, 7, 9, 10, and 13.
Add number of days in columns 4, 5, 11, and 12.
Yearly totals for each column (1-13) are required for posting. Running or page totals may be generated at the discretion of the employer.

If an employee's loss of workdays is continuing at the time the totals are summarized, estimate the number of future workdays the employee will lose and add that estimate to the workdays already lost and include this figure in the annual totals. No further entries are to be made with respect to such cases in the next year's log.

VI. Definitions

OCCUPATIONAL INJURY is any injury such as a cut, fracture, sprain, amputation, etc., which results from a work accident or from an exposure involving a single incident in the work environment.

NOTE: Conditions resulting from animal bites, such as insect or snake bites or from one time exposure to chemicals, are considered to be injuries.

OCCUPATIONAL ILLNESS of an employee is any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to environmental factors associated with employment. It includes acute and chronic illnesses or diseases which may be caused by inhalation, absorption, ingestion, or direct contact.

The following listing gives the categories of occupational illnesses and disorders that will be utilized for the purpose of classifying recordable illnesses. For purposes of information, examples of each category are given. These are typical examples, however, and are not to be considered the complete listing of the types of illnesses and disorders that are to be counted under each category.

7a **Occupational Skin Diseases or Disorders**
Examples: Contact dermatitis, eczema, or rash caused by primary irritants and sensitizers or poisonous plants, oil acne, chrome ulcers, chemical burns or inflammations, etc.

7b **Dust Diseases of the Lungs (Pneumoconioses)**
Examples: Silicosis, asbestosis, coal worker's pneumoconiosis, byssinosis, siderosis, and other pneumoconioses.

7c **Respiratory Conditions Due to Toxic Agents**
Examples: Pneumonitis, pharyngitis, rhinitis or acute congestion due to chemicals, dusts, gases, or fumes; farmer's lung, etc.

7d. **Poisoning (Systemic Effect of Toxic Materials)**
Examples: Poisoning by lead, mercury, cadmium, arsenic, or other metals, poisoning by carbon monoxide, hydrogen sulfide, or other gases, poisoning by benzol, carbon tetrachloride, or other organic solvents, poisoning by insecticide sprays such as parathion, lead arsenate, poisoning by other chemicals such as formaldehyde, plastics, and resins, etc.

7e **Disorders Due to Physical Agents (Other than Toxic Materials)**
Examples: Heatstroke, sunstroke, heat exhaustion, and other effects of environmental heat, freezing, frostbite, and effects of exposure to low temperatures, caisson disease, effects of ionizing radiation (isotopes, X rays, radium), effects of nonionizing radiation (welding flash, ultraviolet rays, microwaves, sunburn), etc.

7f **Disorders Associated With Repeated Trauma**
Examples: Noise induced hearing loss, synovitis, tenosynovitis, and bursitis, Raynaud's phenomena, and other conditions due to repeated motion, vibration, or pressure.

7g **All Other Occupational Illnesses**
Examples: Anthrax, brucellosis, infectious hepatitis, malignant and benign tumors, food poisoning, histoplasmosis, coccidioidomycosis, etc.

MEDICAL TREATMENT includes treatment (other than first aid) administered by a physician or by registered professional personnel under the standing orders of a physician. Medical treatment does NOT include first aid treatment (one-time treatment and subsequent observation of minor scratches, cuts, burns, splinters, and so forth, which do not ordinarily require medical care) even though provided by a physician or registered professional personnel.

ESTABLISHMENT: A single physical location where business is conducted or where services or industrial operations are performed (for example: a factory, mill, store, hotel, restaurant, movie theater, farm, ranch, bank, sales office, warehouse, or central administrative office). Where distinctly separate activities are performed at a single physical location, such as construction activities operated from the same physical location as a lumber yard, each activity shall be treated as a separate establishment.

For firms engaged in activities which may be physically dispersed, such as agriculture, construction; transportation, communications, and electric, gas, and sanitary services, records may be maintained at a place to which employees report each day.

Records for personnel who do not primarily report or work at a single establishment, such as traveling salesmen, technicians, engineers, etc., shall be maintained at the location from which they are paid or the base from which personnel operate to carry out their activities.

WORK ENVIRONMENT is comprised of the physical location, equipment, materials processed or used, and the kinds of operations performed in the course of an employee's work, whether on or off the employer's premises.

10.0 CAPITAL COST ESTIMATES

10.1 Basis of Cost Development

This basis is for the development of all capital costs for a gasification facility which will produce 6.0 billion Btu's per day of low Btu gas to fire GREFCO's existing expander furnaces, drying ovens, and any anticipated future plant expansion. These costs will include those for the battery limits gasification plant, the gas distribution lines from the gasification plant to the intended GREFCO gas users and all retrofit/conversion costs.

As explained in Section 3.0 the design and engineering basis considered plant sequencing whereby first a two-gasifier train with complete clean-up facilities would be installed; followed, if appropriate, by a three-gasifier module. This sequencing would permit an initial reduction in capital cost outlay and an opportunity to establish operational confidence and long-term reliability including evaluation of product gas quality. The complete capital costs were developed for the initial installation of just two gasifiers as they were for the five-gasifier case, which again includes the distribution main and retrofit cost to accommodate the final five-gasifier installation. The following proposed commercial project will be studied from two ownership options: 1) GREFCO owns and operates the gasification facility, and 2) the gasification facility is owned and operated by Dravo, and GREFCO purchases the gas "over-the-fence" on a long-term take or pay type contract.

Even though the expected utilization rate for the gasification plant is five days per week for about six months and then six days per week for the remainder of the year, both gasification plant schemes were designed with the ability to operate 24 hours per day and seven days per week with each gasifier scheduled for a two to four week shutdown each year for repairs and maintenance. The capital costs were estimated accordingly.

10.2 Capital Cost Estimate Methodology

All capital costs are 1981 dollars. The gasification system, based on Wellman-Galusha technology, is provided as a packaged unit by Dravo. The costs used in this report are for an installed gasification system including the gasifiers, blowers, cyclone (with refractory), coal bins, elevators, lock hoppers, flare with flame front generator, controls, instrument panel and supporting structure.

The remaining capital costs were estimated by obtaining prices for major pieces of equipment from vendors. The installed cost for the major process equipment (e.g. towers and columns and field fabricated tanks) were then estimated using prevailing union wages for construction labor and pricing for any subcontract work. The installed costs for the various process equipment categories are given in Tables 1 and 3. The remainder of the estimate included bulk take-offs of major materials and generally accepted administrative fees and factors based on experience to obtain the total installed cost. The total installed cost includes all labor and materials necessary to erect a complete gasification plant with all clean-up facilities. This includes items such as painting,

electrical work, insulation, foundations, supporting structure, piping, instrumentation, etc. A complete breakdown of all sub-craft areas is listed in the capital cost summary in Tables 2 and 4. Also listed in these tables are the sales tax and payroll taxes and insurance and the indirect construction costs. Dravo's experience and in-house data were used to estimate the indirect construction costs, such as construction equipment (purchases and rentals) and supervision, to arrive at a total miscellaneous field expense. Finally, these same tables list the estimates for Engineering, Procurement Service, General and Administrative Expenses, which includes project administrative costs, contingencies and the contractor's fee. The summation of all these costs on Tables 2 and 4 equals the total capital cost figures for the five-gasifier case and the two-gasifier case (Dravo-owned and -operated). These costs are $33,007,000 and $24,316,000 respectively.

The original accuracy of the estimate was to be ±10 to 15 percent. However, certain technical problems arose requiring time-consuming study and investigation to determine the proper direction thereby extending the project schedule. To meet the major objectives of the feasibility study and to perform additional work found necessary as a result of information obtained during this period General Refractories revised Dravo's scope of work. The major impact on the accuracy of the estimate for capital costs was as follows: Originally, equipment pricing was to be obtained from vendors through formal quotation requests requiring construction specifications. In place of this pricing procedure, informal telephone quotations were received from the same vendors thereby saving considerable engineering work by eliminating the need for additional equipment layouts. Also preliminary engineering was deferred on foundations, structures, one-line electrical and H & V. The process flow diagrams, preliminary engineering flow diagrams and plot plans coupled with specifications were combined to arrive at the new estimate accuracy of ±20 percent by using factoring of equipment costs along with these telephone quotations. It is believed that since much of the equipment had been priced prior to this job scope change, the resulting overall plant estimate accuracy would be ±15 percent, which is sufficiently accurate for budget or appropriations purposes.

10.3 Exclusions and Options

The total capital costs for the Dravo owned and operated case are given in Tables 2 and 4. The only capital cost difference between "over-the-fence sale" of gas and a GREFCO owned and operated gasification plant is a deletion in both cases (five-gasifier and two-gasifier installation) of the office and change house. With GREFCO owning the gasification plant, its existing facilities for office, lavatory, shower and lockers could be modified with minimal expense to accommodate the additional personnel required for the gasification plant. Therefore, it is estimated that with GREFCO owning the complex, a deduction of $400,000 from the total capital costs listed in Tables 2 and 4 can be made.

It should be noted that no costs were included in the capital cost estimate for the land required by the gasification plant, nor were any costs included for raw water treatment facilities since the water used in the gasification plant confines would be untreated city water. Also, when estimating the cost of this project, certain items were omitted from the total estimate since they were not part of the original proposal. These items have since been integrated in the design engineering of the plant so as to allow for any possible future plant expansion. The items not included in the capital estimate are as follows: 1) the new 20-foot-wide concrete roadway, 2) repaving with black top the existing truck turning area and existing employee parking lot, 3) the new fence and gate surrounding the area for the new employee parking lot and the future plant expansion, 4) all grading, reseeding of grass and lighting except for that required to install the new employee parking lot, 5) the cost of the new electrical substation work--over and above that which is necessary to outfit the proposed gasification plant and retrofit area with electric power, and finally 6) the new 175-foot-long 6-foot-wide concrete pad for trailor parking. The six items designated above amount to $610,000.

10.4 Capital Cost Depreciation Factors

In allowing for depreciation the new tax laws in effect were followed. The accelerated cost recovery system (ACRS) method for depreciation purposes was used. The total capital cost was broken down into four major categories. They are listed below with the accepted depreciation life permitted by ACRS.

Office and Change House	15-Year Life	$ 400,000
Other Buildings	5-Year Life	2,850,000
All Fixed Equipment & Structures	5-Year Life	29,667,000
Front End Loader	3-Year Life	90,000

The above categories and their dollar figures are based on a Dravo owned and operated five-gasifier installation.

10.5 Plant Start-Up Costs

The plant start up costs are outlined in Tables 5 and 5A. They have been incorporated in the operating expenses in the first year of operation - 1984.

TABLE 1

MAJOR PROCESS EQUIPMENT

5-GASIFIER CASE

Description	Sub-Contract	Purchased Mat'l. & Freight	Direct Labor	Total
Heat Exchanger		$ 424,000	$ 4,700	$ 428,700
Towers & Columns		493,000	22,000	515,000
Principal and Proprietary	115,000	1,327,300	81,800	1,524,100
Field Fabricated Tanks	468,500			468,500
Other Vessels		476,100	9,000	485,100
Agitated Vessels	104,000	265,900	4,400	374,300
Agitators		101,900	4,600	106,500
Pumps		505,800	37,500	543,300
Compressors, Blowers & Vacuum Pumps		1,475,000	34,900	1,509,900
Mechanical Conveying Equipment		117,600	21,000	138,600
Heaters, Boilers & Coolers	156,300	8,800	3,400	168,500
Blending and Separation Equipment	42,000	2,009,400	21,500	2,072,900
Formation and Reduction Equipment				
Package Systems		903,800	214,000	1,117,800
Miscellaneous Installed Equipment		58,900	7,500	66,400
Miscellaneous Un-Installed Equipment		90,000	100	90,100
HVAC - Process Gas Treating Systems	52,800	21,000	1,600	75,400
Total	$938,600	$8,278,500	$468,000	$9,685,100

TABLE 2

CAPITAL COST SUMMARY

5-GASIFIER CASE

DRAVO OWN & OPERATE

Description	Sub-Cont.	Purchased Mat'l. & Freight	Direct Labor	Total
Major Process Equipment	$ 938,600	$ 8,278,500	$ 468,000	$ 9,685,100
HVAC - Building Systems	116,000	50,400	11,200	177,600
Instrumentation		926,800	378,800	1,305,600
Piping		1,868,800	968,100	2,836,900
Insulation	770,000			770,000
Painting		40,000	97,500	137,500
Site Work & Preparation	50,200	270,200	593,600	914,000
Concrete		525,400	852,900	1,378,300
Structural Steel		636,400	208,900	845,300
Buildings - Architectural	246,500	64,400	44,600	355,500
Fire Protection & Safety Equipment		10,000	1,000	11,000
Grouting		2,300	16,100	18,400
Electrical	1,634,200	557,200		2,191,400
Dryer - Expander Retrofit		480,300	166,500	646,800
Sub-Total Direct Costs	$3,755,500	$13,710,700	$3,807,200	$21,273,400

TABLE 2 (Continued)

Sales Taxes & P/R Taxes and Insurance	1,404,400
Indirect Construction Costs*	3,826,000
Engineering & Procurement	2,990,700
G & AE Fees and Contingencies	3,512,500
Total Capital Cost	$33,007,000

* These costs include the following accounts:

21.000 Title: TEMPORARY CONSTRUCTION

This classification covers the material, erection and maintenance of temporary buildings, utilities, roads, fences and weather protection required to facilitate the installation of the permanent work.

22.000 Title: CONSTRUCTION EQUIPMENT

This classification covers costs incurred in the use of Major Equipment (over $300 value per item) required for handling and/or erecting materials and equipment for the project. Also includes assemblies or lots such as scaffolding.

23.000 Title: SMALL TOOLS AND CONSTRUCTION SUPPLIES

This classification covers minor items of tools and supplies purchased for the project.

25.000 Title: OTHER CRAFT LABOR

This classification covers craft labor which is required for job cleanup and other construction requirements that cannot be properly allocated to other accounts.

26.000 Title: SUPERVISORY AND NON-MANUAL PAYROLL

This classification covers the costs of all field personnel other than local craft hired, or those included in A/C 21.700 (nurse and safety), 28.300 (surveyors), or 28.400 (guards). Also included is time charged by home office construction department employees or supervisors attributed to the project in Pittsburgh or at the jobsite.

TABLE 2 (Continued)

28.000 Title: MISCELLANEOUS

This classification covers other costs associated with operating the field construction office, survey and guard service, and travel, subsistence and relocation expense of employees assigned to or visiting the jobsite representing the Construction Department.

29.000-D/A Title: CONSTRUCTION SALARY OVERHEAD

This classification is the overhead costs of the personnel salaries charged to the Pittsburgh office Construction Department and expressed as a percentage of salaries or payroll costs.

TABLE 3

MAJOR PROCESS EQUIPMENT

2-GASIFIER CASE

Description	Sub-Cont.	Purchased Mat'l. & Freight	Direct Labor	Total
Heat Exchangers		$ 180,800	$ 2,000	$ 182,800
Towers & Columns		192,000	10,000	202,000
Principal and Proprietary		534,800	32,900	567,700
Field Fabricated Tanks	235,500			235,500
Other Vessels		257,100	5,700	262,800
Agitated Vessels	104,000	128,100	2,400	234,500
Agitators		64,700	3,800	68,500
Pumps		390,000	30,300	420,300
Compressors, Blowers & Vacuum Pumps		810,700	19,700	830,400
Mechanical Conveying Equipment		94,600	19,000	113,600
Heaters, Boilers & Coolers	83,800	3,800	1,700	89,300
Blending and Separation Equipment	42,000	1,143,100	18,100	1,203,200
Formation and Reduction Equipment				
Package Systems		903,800	214,000	1,117,800
Miscellaneous Installed Equipment		49,600	6,000	55,600
Miscellaneous Un-Installed Equipment		90,000	100	90,100
HVAC - Process Gas Treating Systems	46,000	21,000	1,600	68,600
Total	$511,300	$4,864,100	$367,300	$5,742,700

TABLE 4

CAPITAL COST SUMMARY

2-GASIFIER CASE

DRAVO OWN AND OPERATE

Description	Sub-Cont.	Purchased Mat'l. & Freight	Direct Labor	Total
Major Process Equipment	$ 511,300	$4,864,100	$ 367,300	$ 5,742,700
HVAC - Building Systems	116,000	50,400	11,200	177,600
Instrumentation		582,800	183,300	766,100
Piping		1,179,300	724,500	1,903,800
Insulation	529,100			529,100
Painting		29,100	69,500	98,600
Site Work & Preparation	50,200	264,100	520,800	835,100
Concrete		462,900	739,800	1,202,700
Structural Steel		414,600	112,600	527,200
Buildings - Architectural	220,900	61,200	43,400	325,500
Fire Protection		10,000	1,000	11,000
Grouting		2,000	14,000	16,000
Electrical	1,197,300	547,400		1,744,700
Dryer - Expander Retrofit		400,300	166,500	646,800
Sub-Total Direct Costs	$2,624,800	$8,948,200	$2,953,900	$14,526,900
Sales Taxes & P/R Taxes and Insurance				1,005,700
Indirect Construction Costs				3,363,700
Engineering & Procurement				2,698,000
G & AE Fees and Contingencies				2,721,700
TOTAL				$24,316,000

TABLE 5

START UP COSTS - 5 GASIFIERS DRAVO OWN

Start up period will occur over first 3 months of 1984

COAL	$4,066,070/yr. x 3 mos/yr. x 50% =	$508,259

The following assumptions will be made:

The gasifiers will be "on stream" approximately 50% of the time. Only 50% of the IFG and by-products will be of saleable grade.

CHEMICALS	$224,208/yr. x 3 mos/yr. x 50% =	$28,026

The operating work force and administration work force will begin at about the 50% and build up to 100% at the end of the startup period averaging about a 75% level overall.

UTILITY POWER	$1,024,500/yr. x 3 mos/yr. x 50% x 1.2 (inrush load factor) =	$153,690

The cost of IFG is estimated at $6.00/MM Btu

LABOR

OPERATING

2 coal HDLG	$30,000		
2 foremen	40,000		
18 operators	280,800		
	$350,800/yr. x 3 mos/yr.	=	$87,700

MAINTENANCE			
Internal 10 men	$250,000/yr. x 3 mos/yr.	=	$62,500
OPERATING SUPPLIES	$60,000/yr. x 3 mos/yr.	=	$7,500
ADMIN. & GEN O.H.	$119,300/yr. x 3 mos/yr. x 75%	=	$22,369
REAL ESTATE TAXES	$72,200		
INSURANCE	700,000		
	$772,200/yr. x 3 mos/yr.	=	$193,050
DRAVO CONSUL. (See Table 5A)		=	89,000
			$1,164,094

LESS:

Revenues from -

IFG	90 days x 50% x 50% cap. x 6.0 x 10^9 Btu/Day x $6.00	= $810,000
TAR	$1,875,000/yr. x 3 mos/yr. x 50% x 50%	= 117,188
SULFUR	$440,000/yr. x 3 mos/yr. x 50% x 50%	= 27,500
		= $209,406

TABLE 5A

DRAVO CONSULTANTS

2 Dravo Field Consultants @ $40,000/yr. for 3 mos. x 2.0 Multiplier	$40,000
Living Expenses @ $120/day for 100 days	12,000
Travel Expense @ $220/trip 2 men Pitts-Cinn 6 trips each	2,640
2 Dravo Home Office @ $30,000 for 3 mos. each Operating Manuals, etc. x 2.0 Multiplier	30,000
Reports & Other Materials	4,360
	$89,000

11.0 OPERATING COSTS, WORKING CAPITAL, BY-PRODUCTS

11.1 Operating and Maintenance Cost

The following describes the basis upon which the operating and maintenance costs were developed for the Dravo-owned and -operated facility (Tables 11-1 through 11-4).

11.1.1 Coal

Available locally at $33.20/ton to be purchased from the Sands Hill Coal Company, Inc.

11.1.2 Electric Power

Available locally from the Union Light, Heat and Power Company on a sliding scale which averages $0.034/Kw-hr.

11.1.3 Water

All water is considered to be supplied by the Kenton County Water District No. 1 on a sliding scale which averages $0.00059/gal.

11.1.4 Sewage

To be treated by the Kenton County Sanitation Authority on a sliding scale which averages $0.00107/gal.

11.1.5 Ash Disposal

Two cinder/concrete block companies and the Ohio State Highway Department have indicated that they would be willing to purchase or at least remove the ash for free. Even if a $2.00/ton charge was allowed, the net benefit would be negligible; therefore a break-even position was taken.

11.1.6 Operating Labor

This was set at $7.50/hr for gasifier and process operators, $7.20/hr for coal handling operators and $20,000/yr for supervision. These wages were adjusted to include fringe benefits of between 25-27 percent. Twenty-five men are required for operating the five gasifiers, retrieving coal, feeding and controlling the gasifiers, operating and controlling the gas cooling, compression and sulfur removal systems plus attending to the steam generator, cooling tower and water treatment facilities.

The distribution of the work force is as follows:

Plant Work Force

Job Description	No. of Men
Gasification Operator	11
Process Operator	10
Coal Handling Operator	2
Supervisor (foreman)	2
	25

11.1.7 Maintenance Labor

Labor costs were included in the estimated annual maintenance expenses. An estimated maintenance charge of 3.2 percent of the total plant investment has been allocated. This would cover both outside contract maintenance materials and labor required and routine internal maintenance labor and materials at 2.05 percent and 1.15 percent of total plant investment respectively. The internal maintenance labor consisted of two maintenance foreman and eight maintenance workers whose average annual salary including fringe benefits was estimated at $25,000 each. This internal maintenance would be expensed. The contract maintenance would be capitilized.

11.1.8 Operating Supplies

This includes coveralls, grease, diesel fuel, office supplies, small hand tools and instrument charts. These were estimated at $1000 per month per gasifier.

11.1.9 Catalyst and Chemicals

Tables 11-1 and 11-3 provide a complete list of materials required with prices and annual replacement quantities. Included here is the addition of a de-icer to the coal pile for four months of the year although it is assumed to be applied to coal by the supplier.

11.1.10 Administration and General Overhead

Charges in this category have been estimated at 60 percent of direct labor and supervision.

11.1.11 Taxes

Real estate taxes were estimated as the sum of 0.756 percent of that portion fair percent market value of the total plant investment attributed to buildings, and 0.16 percent of the remainder of the total plant investment.

11.1.12 Insurance

Insurance was estimated at 2 percent of the total plant investment.

11.1.13 GREFCO-Owned and -Operated Facility

In the development of the Grefco-owned and -operated facility's operating and maintenance costs, all of the above are applicable with the following

exceptions. A 20-percent reduction in labor and maintenance costs could be realized by using existing personnel in the board plant for some of these tasks. In addition, the administration and general overhead costs could be lowered to 30 percent of the total plant investment.

11.2 Working Capital

The following describes the basis upon which the working capital is developed.

11.2.1 Short Term Assets

The short term assets include accounts receivable, raw material inventory and cash on hand. The accounts receivable is based on 15 days' sales of low Btu gas at $7.00 per million Btu's, liquid sulfur at $100 per ton and tar at $0.70 per gallon. The raw material inventory is 14 days of coal while the cash on hand is set at one month's payroll for direct labor and supervision, general administration and overhead, operating supplies, and maintenance.

11.2.2 Short Term Liabilities

The short term liabilities for this study are just the accounts payable, which is comprised of 30 days' cost for coal, chemicals and catalysts, electric power, water and sewage.

11.2.3 Working Capital

By definition the working capital is the difference between the short term assets and the short term liabilities. The development of the actual figures for working capital can be found in Tables 11-2 and 11-4.

11.3 By-Product Disposal Credits

Since all by-product credits are treated as negative costs in the Financial Analysis, this section was considered applicable to Section 11.0, Operating Costs, Working Capital, By-Products.

By-products, as distinguished from wastes, are considered those additional materials generated in sufficient quantity over and above the fuel gas which have a reasonable expectation for either sales to others or use within General Refractories' manufacturing operations. There are only three by-products of any consequence and they are listed in order of importance for possible revenue generation. They are coal tars, high purity liquid sulfur and ash. The estimated quantities produced are 2,452,000 gallons per year of coal tar, 4,000 tons per year of sulfur and 11,400 tons per year of ash. The successful sale of these three by-products can have a very beneficial effect upon the viability of the proposed gasification plant. A short discussion on how the by-products are generated including a description of their characteristics are given in a separate section for each by-product. The potential markets for these

by-products, the approach that was taken and the results of a fairly thorough marketing investigation are also included. The final section on conclusions and recommendations is based upon the results of the marketing survey. An appendix follows with back-up data and reference material for the marketing survey.

11.3.1 Coal Tar

Considerable amounts of coal tar are produced by the de-volatilization of the coal during the early stages of coal gasification. These tars are carried over with the high temperature fuel gas leaving the gasifier. Almost all the tars are collected through gas quenching and electrostatic precipitator operations which were described to a much greater extent earlier in this report. The tars are collected in one large tank and separated from the quench water. The tars collected are in many ways similar to coke oven coal tars in that they are a conglomeration of many chemicals. Some of the main chemicals found in these tars are light oils, naphtha and naphthalenes, creosols (tar acids), heavy oils and pitch. Each of these products have different characteristics and therefore are useful in different applications. For instance, creosols are used mainly as a wood preservative, naphtha and naphthalenes as either fuels or chemical feed-stocks, and pitches, to a great extent, in the manufacture of aluminum electrodes. To try to market the coal tars to any one of these industries (wood preservative, electrode manufacturing, etc.) would prove futile in that few if any have their own coal tar processing facilities. Even if they were to try to separate the components that they are interested in they would have a sizeable marketing job for the remainder of the coal tar. Unfortunately no one industry (of any size) uses coke oven or coal tar directly without processing.

The most likely candidates for the sale of coal tars are a handful of coal tar processors. These coal tar processors are well situated to take the coal tars from the Florence gasification plant and regenerate them into other useful and valuable chemicals. Another reason for concentrating marketing efforts on sold the coal tar processors is that most of their feedstock (coal tars) comes from the coke oven industry. Due to the cutback in coke making specifically and the overall depressed nature of the U.S. steel industry in general, this feedstock is very hard to obtain. Consequently, even though the coal tars that would emanate from the gasifiers are somewhat different than coal tars derived from coke oven operations, all coal tar processors are quite interested in the coal tars for use as a supplement feedstock in their operations. Many have said that even if the characteristics are too different for their current processing operations, the tars could be used as a blending agent to increase the amount of feedstock.

Because the coal tars originating from the gasification plant are somewhat different than coke oven coal tars, it was necessary to establish as best as possible the precise physical and chemical characteristics of the gasifier coal tar. This would enable the prospective coal tar processors to easily evaluate the tars and the degree of their interest in them. The gasifier coal tars are considered a low temperature carbonization product whereas the coke oven coal tars are considered a high temperature carbonization product. Since an analysis of coal tar derived from the type of coal to be used at the proposed plant does not exist, it was necessary to compose an analysis by culling all available literature. Considerable research was made into what to expect from the

gasifier coal tars and their differences (and similarities) when compared with coke oven coal tars. The results of this research is a quasi-specification entitled "Description of -- Low Btu Coal Gasification Coal Tar Characteristics" (found in Appendix A).

Four major coal tar processors reasonably close to Florence, Kentucky, were contacted. All expressed keen interest in the subject project and a preliminary specification was sent to them for evaluation. These processors and pertinent information concerning these potential users are as follows.

COAL TAR PROCESSOR	PLANT LOCATION	INTEREST, REPLY OR RESULTS
Allied Chemical Corp.	Ironton, OH	$0.73/gal. Fuel value or higher
Koppers Company, Inc.	Follansbee, WV	No estimate value
Reilly Tar & Chemical Corporation	Indianapolis, IN	#6 Fuel oil value or higher
Witco Chemical Corp.	Port Comfort, TX	$0.65-0.75/gal. For coke tar @ Neville Island.

Other uses for the coal tar were considered such as burning it as a fuel in the gasification plant boiler. This would only consume about 60 percent of the total coal tar produced even if the coal tar were to be burned exclusive of other fuels. Special considerations for this application would have to be made such as heat tracing for the fuel line, operation of a specially adapted boiler for coal tar, over-firing of the burner to insure complete combustion of all polycyclic organics (which could violate air pollution regulations), and adoption of certain measures to insure that the SO_2 EPA limitations are not exceeded. One measure might be to mix a low sulfur fuel oil with the coal tar to meet the EPA Standards on SO_2 emissions. However combining a high priced low sulfur fuel oil with the coal tar valued at 70 cents per gallon, which is consistent with the marketing research results, will provide a mixed fuel having a value approximately equal to the LBG. It could be that instead of a boiler an incinerator may be necessary to insure compliance in meeting all local, state and federal EPA regulations. This could possibly result in a much lower overall thermal efficiency. Furthermore under the EPA Toxic Substance Control Act, any new chemicals being used in the manufacture of a product or any significant use of a chemical for a new application must be cleared first through EPA using a premanufacturing notification. A full analyses of the proposed new use would have to be analyzed and approved by EPA. This could take extensive time and effort to get the coal tar approved for use as fuel or in some other application.

If the coal tar was burned in a boiler or incinerator with a low sulfur fuel oil

(at about 75-25 ratio, which is necessary to meet EPA SO^2 emissions standards), about 55 percent of the tar would still have to be sold or used by General Refractories. Potential uses for the tar within GREFCO have been presented.

Because of the excellent market potential for coal tar and considering the extensive testing required by the EPA, equipment suppliers and General Refractories before internal usage can be approved, selling the coal tar is recommended. If the proposed project advances and the market for coal tar does not materialize as expected, then the required additional testing and design/engineering for other use of the tar can be accomplished at that time.

11.3.2 High Purity Liquid Sulfur

Large quantities of H_2S are removed from the gas by the Stretford sulfur removal system. The Stretford system absorbs the H_2S and through a series of chemical reactions converts it to elemental sulfur. It is then separated from the Stretford solution in the form of first a froth, and then cake, and then is melted to produce a 99.5 percent or better liquid sulfur. There are many Stretford designs and licensors, all basically the same. However, depending on certain design configurations and the operation of the plant, even higher purity can be obtained. Peabody-Holmes advertises a sulfur purity of 99.8 percent. At least four existing Stretford plant operators[1] have claimed that they produce a liquid sulfur with a purity of 99.7 percent or better. These same Stretford operators have also stated that they have or are selling their sulfur to sulfuric acid producers. The sulfur has a grayish-white tint to it in solid form, which is probably the result of any contaminant carry-over. Although the exact contaminants and their amounts are not known yet, they are listed and the sulfur described as best as possible in a "Description of -- Liquid High Purity Sulfur Characteristics", is found in the appendix section.

An evaluation of sulfur uses in industry revealed that in 1968 approximately 87 percent of the sulfur consumed in the United States was used to make sulfuric acid.[2] This relationship must still hold true since a comparison of the annual capacities in the United States for elemental sulfur vs. the capacity for sulfuric acid (using the molecular weight ratios for the respective commodities) indicates this ratio of capacities in 1979 to be 87.5 percent.

The fertilizer industry accounts for a large portion of sulfur consumption. Fertilizers account for about half of the world demand for sulfur. However, in the fertilizer industry the use of sulfur is employed primarily in the form of sulfuric acid. The main sulfur compound found in fertilizers is ammonium sulfate, most of which is made by recovering ammonia from coke oven gas by scrubbing with sulfuric acid.[4] This is the case for any ammonium sulfate produced anywhere close to Florence, Kentucky. There are other processes used for ammonium sulfate production but normally they begin with either a sulfate or sulfuric acid. Therefore, in the production of ammonium sulfate the market for liquid sulfur is practically non-existent.

Other principal industries using sulfur include wood pulp, carbon disulfide, insecticides and fungicides, rubber, sulfur dioxide, and dye manufacturers. The main use of sulfur in insecticides and in fungicides is in the form of copper sulfate and carbon disulfide. Because there is no copper sulfate production nor SO_2 or sulfur dye manufacturers even reasonably close to Florence these potential sulfur markets are being discounted. The wood pulp industry uses little elemental sulfur; in the sulfite pulp process, sulfur is burned to form sulfur dioxide. However, in the predominant sulfate pulp process used, the sulfur chemicals consumed are sulfuric acid, sodium sulfate and sodium sulfide. Aside from sulfuric acid these other compounds are formed primarily as by-products from many other industries which are distributed widely throughout the country. Therefore, a minimal effort was made to find a market for sulfur in the wood pulping area.

In the rubber (elastomer) industry the elemental sulfur is used directly or in compound form. It was established that only the tire manufacturers use elemental sulfur. The other elastomer manufacturers use sulfur in much smaller quantities and in complex compound forms. The tire manufacturers buy sulfur in a powdered form with certain additives from a handful of special suppliers. In the elastomer industry it is these suppliers who seem to be the only viable prospective purchasers of sulfur. One final major use of sulfur is in manufacturing aluminum sulfate; however, once again, sulfur is used indirectly in its manufacture through the reaction of sulfuric acid with bauxite. This possibility was therefore dropped from consideration.

This covers the major users of sulfur in the Florence, Kentucky area (radius of 400 miles) and further investigation of other markets for elemental sulfur is not considered worthwhile since, as with many other commodities, successful marketing, is highly sensitive to transportation costs and thereby geographically constrained.

In general, the current market outlook for the sale of elemental sulfur is considered quite good. This is due to a sulfur shortage (at least in the Ohio valley and perhaps nationwide). As a matter of fact, some of the potential buyers contacted said they are now purchasing from western Canada, where there is a large surplus of sulfur which results in an abnormally low sulfur price. However, this low price is more than offset by the transportation charges to deliver the sulfur to the Ohio valley. One potential sulfur user contacted stated that he is paying transportations costs of $68 per ton, which approximates the selling price for the sulfur in Canada. The future outlook for marketing sulfur is expected to remain relatively bright. A shortage is expected to remain for quite some time due to the constantly increasing demand worldwide as well as domestically. This worldwide increase in demand will largely be caused by the developing countries becoming more industrialized and capable of producing more of their own food requirements through increased use of fertilizers.

The market search was initiated by contacting 12 possible sulfur users. Of the

12, four used sulfur but not in elemental form; they were pulp manufacturers and elastomer (non-tire) producers. The other eight elemental sulfur users were all interested in developing new sources for this chemical. They are presented below in tabular form with their locations, the products they manufacture, and a price that either they would be willing to pay for GREFCO's sulfur or what they are now paying for sulfur.

Company	Product	Location	Price
International Chemicals Company	Processed granular sulfur to tire industry.	Middlepoint, OH	$110/ton
Maclair Asphalt Company	Sulfur/asphalt mixture for paving industry.	Collinville, IL	$100/ton
PPG Industries	Carbon Disulfide	Natrium, WV	$143/ton
3M Company	H_2SO_4 (Sulfuric acid)	Copley, OH	None Given
Allied Chemical Company	H_2SO_4	Nitro, WV Claymont, DE	$115/ton
Coulton Chemical Corporation	H_2SO_4	Oregon, OH Cairo, OH	None Given
National Distillers & Chemical Corporation	H_2SO_4	Tuscola, IL	None Given
E. I. du Pont de Nemours & Company, Inc.	H_2SO_4	North Bend, OH	None Given

Based upon the initial findings of the market research on elemental sulfur, it was decided that the strongest prospects for selling sulfur would be to sulfuric acid manufacturers because of the large amount of sulfur used in the sulfuric acid and fertilizer industries. However, of the five sulfuric acid manufacturers contacted, we received mixed results ranging from "Yes, we are definitely interested in the possibility of buying your sulfur" to "We need new sulfur suppliers, but we don't think that your Stretford sulfur can be used at our plant". The reason for this dichotomy of opinions is that Stretford sulfur generally contains more contaminants than the sulfur from Klaus units or the Frasch process. This situation can be further complicated depending on Stretford plant design and operation. These higher levels of contaminants, mainly carbon and ash, poison the catalysts used in the manufacture of sulfuric acid. This situation can be alleviated, however, either at the sulfuric producer's end or at the user's end. For instance, Getty Oil produces Stretford sulfur but mixes this sulfur with sulfur from a Klaus unit which accounts for about 95 percent of total sulfur, thereby diluting considerably the contaminants from the Stretford unit. Another measure the producer can take is to design the plant for maximum removal of contaminants and to follow good operating

procedures. At the other end the buyer can combat the problem by blending the Stretford sulfur with other sources of sulfur and keeping the sulfurs well mixed. Some sulfuric acid manufacturers have and will use this capability while others do not or will not. Even though some acid producers may have this capability they may not want to commit themselves until the actual and precise nature of contaminants is known. Allied Chemical and duPont probably fall into this classification. One other possibility is if an acid plant has a "decomposition chamber" it can process the Stretford sulfur through this chamber along with spent sulfuric acid. This chamber regenerates the acid by decomposing any impurities. Allied Chemical has stated that it would purchase the Stretford sulfur for use in its Claymont, Delaware, plant which has a decomposition chamber. It should be noted that in this case GREFCO would receive a lower net price due to transportation costs involved in shipping the sulfur to Delaware.

Overall it is felt that the Stretford sulfur can be sold to a sulfuric acid manufacturer. However, a price penalty may have to be conceded or diligence in design and operation of the sulfur removal system taken, which could increase the cost of operating the unit.

It appears that carbon disulfide manufacturers have even more stringent specifications for sulfur than the manufacturers of sulfuric acid. PPG, a carbon disulfide producer, has used off spec sulfur in the past which did not cause significant trouble since it was mixed with other sulfur sources in PPG's large 5,000-long-ton storage tank. PPG would definitely be interested in purchasing the Stretford sulfur depending on the final contaminant levels.

The tire manufacturing industry uses elemental sulfur in granular form, which is produced by blending solid sulfur classified to the right size with minute amounts of oils and other chemicals. The solid sulfur is then bagged and shipped to the tire manufacturers. The purpose of the oils is to reduce any sulfur dusting problems while handling.

Ohio is the center of the tire manufacturing industry and one producer of granular sulfur is located close to Florence, Kentucky. The producer, International Chemicals Company, has indicated that it would be very interested in purchasing the entire production of sulfur at a delivered price of $124 per ton. Even though they normally purchase sulfur in solid form, International Chemicals would be willing to receive it in a liquid or solid form--with no variation in price. The contaminant situation with Stretford systems was not considered a problem.

One final prospect for marketing sulfur might be with the paving industry. Some states and Canada have had ongoing experimental programs using "sulfur extended asphalt" (SEA). SEA is a mixture of sulfur and asphalt for use in place of 100 percent asphalt. The advocates for SEA feel that, depending upon the price for sulfur and asphalt, it can be cheaper than regular asphalt, it wears better, and is more flexible than regular asphalt paving. Some investigation into its use revealed that the state of Illinois has had less than desirable results. The SEA has cracked and caused discoloration similar to that caused by dry salt. Canada, Pennsylvania and Texas have not experienced these problems. The advocates of SEA explained the problem by saying that Illinois, which has mostly

concrete highways, used SEA over more rigid concrete; the constant freeze-thaw cycles during the winters caused the concrete to crack and in turn deteriorate the SEA. Canada has many more asphalt roads and did not experience the same freeze-thaw situation, since its roads freeze once and thaw once throughout the entire winter. Although Pennsylvania has a climate similar to Illinois, it has many more asphalt roads than concrete and apparently its experimental programs have been conducted on asphalt-paved roads. Texas, of course, has essentially no freeze-thaw cycles. The use of sulfur in this way is still experimental, and it may be a while before it is proved successful and large quantities are needed. Even if proved successful, SEA may have limited application due to location.

11.3.3 Gasifier Bottom Ash

After the coal is gasified the ash inherent in the coal forms a residue at the bottom of the gasifier. It is dumped through a revolving grate to a conical container at the bottom of the gasifier, then sluiced using water from the bottom of the cone through a valve into a dumpster. The ash takes the form of 2" x 1/2" lumps. Through handling, these particles can be broken up into smaller pieces. An analysis of the ash is similar to the bottom ash coming from many coal-fired boilers. Below is an ultimate analysis of the ash from an Ohio high sulfur bituminous coal which was gasified:

Component	Wt. & (Dry Basis)
Carbon	5.7
Hydrogen	0.3
Nitrogen	-
Chlorine	-
Sulfur	1.2
Ash	92.8
Oxygen	0.1
Btu/Lb.	870

This analysis can be considered typical of the ash expected from the gasifiers at Florence, Kentucky. Proper crushing and sizing of the ash results in cinders which approximate those produced in a coal-fired boiler. As such, the ash or cinders from the gasifier could be used in much the same way as ash or cinders from the coal-fired boilers. These uses would essentially be in the manufacture of cinder or concrete block or in the use of cinder abrasives for snow and ice control on highways. If neither of these two uses are possible, then the ash can always be used as land fill since it is classified by the EPA as nonhazardous.[5]

Two examples prove that these uses are viable. Glen Gary, Inc., which has a Wellman-Galusha installation, has sold its ash/cinders to the New Jersey

Highway Department for road control at the price of $5 to $10 per ton F.O.B. their plant. Hazelton Brick Company, located in Hazelton, Pennsylvania, also operates a Wellman-Galusha gasifier, and uses its ash in the manufacture of cinder block.

To establish the possibility of disposing the ash in this manner, we contacted two concrete/cinder block manufacturing companies in the Cincinnati area and phoned the Ohio Highway Department, District No. 8 to learn of any interest in using the cinders for road control. The cinder block companies contacted were C-Block, Inc. and Reading Concrete Products Corporation. Both stated that the supply of cinders has been diminishing for some time and new sources of cinders are hard to find; therefore they both would definitely be interested in using the cinders when they become available. The size requirements are 3/8" and below with a limitation on fines not exceeding 100 mesh. C-Block does not have crushing and screening capability. Therefore this would have to be done at the Florence site before shipping. Reading Concrete Products does have crushing and screening capabilities, and therefore, the ash could be shipped to them as is. Both companies talked in terms of $2 to $3 per ton of cinders F.O.B. Florence.

The District No. 8 office of the Ohio Highway Department also indicated a keen interest in the purchase of Florence's potential cinders for use in the counties surrounding Cincinnati. In an average year it may spread roughly 50,000 tons of salt and abrasive. Traditionally the mixture has been 30 percent abrasive (cinders, sand and gravel) and 70 percent salt. However, over the last few years and primarily due to cost, the trend has been to use more abrasive than salt. The Highway Department stated that it is currently paying between $1.75 to $2.75 per ton of cinders.

Due to the foregone statements it is concluded that a fairly good market for the ash will exist when the gasifier plant comes on stream.

11.3.4 Results and Conclusions of Market Survey

Coal tar is in very short supply due to the depressed nature of the domestic iron and steel industry. A turn around in this situation is not forecasted, certainly not in the near future and probably not until the intermediate term or later (possibly the next 10 to 15 years). Because of this the coal tar processors have and will have a very large and real need for further supplies of coal tar from whatever source. This was revealed explicitly in the recent market survey with the coal tar purchasers. A recent telephone conversation with Shenango Furnance revealed a first-hand example of what is today a seller's market for coal tar. Some of the coal tar processors are actually competing through personal visits to Shenango's plant for its supply of coal tar.

The coal tar processors contacted have not been able to accurately estimate the value of the coal tar to be expected from the proposed gasification plant due to the unavailability of the complete characteristics of the coal tar. They have stated, however, that for now we could figure on a "fuel value", basically that of fuel oil No. 6, as a starting point and depending on the coal tar's actual ingredients and how it fits into their operation, the price may be elevated from there. The price in the Cincinnati area for high sulfur No. 6 fuel oil is between $.65 and $.75 per gallon. It is believed that a figure of $.70 per

gallon is a valid and conservative estimate of the present value of the coal tar to be expected from the proposed gasification plant. It is quite conceivable that the coal tar will have a higher value to the coal tar processor once its actual ingredients are known.

Because of the current and projected shortage of sulfur, which was evident in the generally overall interest in developing new sources of elemental sulfur by those companies contacted who use it, it is believed that there is a very good chance of marketing all sulfur produced from the Stretford system at a reasonably good market price. From the very beginning it was recognized that some difficulties can exist in selling liquid sulfur to the sulfuric acid manufacturing industry. This is unfortunate in that this industry represents the biggest single market for liquid sulfur in the immediate vicinity of Florence, Kentucky, as well as throughout the United States. However, it is felt that General Refractories can still hold a better chance of selling the sulfur to this market provided they take the necessary measures to overcome some of the obstacles. These measures include special care in designing for maximum purity and diligence in maintaining high quality operation of the system. Alternately a more exhaustive marketing search may be necessary to find a sulfuric acid manufacturer that can use a liquid sulfur having higher contaminant levels. This may result in a discounting of the price due to the sulfur's lower quality or to perhaps higher transportation costs due to the buyer's location.

Regardless of the above, two companies seemed to offer the best prospects for marketing the elemental sulfur. They are PPG Industries and International Chemical Company. Both are reasonably close to Florence and apparently can accept the sulfur from the Stretford without taking on any special programs or precautions. Also both should be able to offer a price close to the prevailing market price for sulfur coming from other sources.

As far as the sulfur market in the paving industry, it may hold a fairly sizeable market for sulfur in the future, but this should not be counted on. Based on market conditions it is felt that a price as high as $120 per ton for the sulfur from the proposed gasification plant can be realized. On the other hand a more pessimistic view could force a discounted price of $70 per ton. For the study it is suggested that the price of $100 per ton be used.

The prospects seem good for selling the ash at between $2 to $3 per ton. However, to do so, a small crushing and screening operation may have to be installed and operated at the plant site. The cost to install and operate this crushing and screening plant should be absorbed by the revenues generated in selling the ash. Even if the crushing and screening plant is unnecessary, the total revenues from selling the ash would only be in the order of $20,000 to $30,000 per year. Because this amount is negligible in comparison to the total revenues and/or costs, it was decided to treat the disposal of the ash as a wash or revenues equaling cost.

11.4 Waste Disposal Costs

As the system is designed, there will be two separate sludges generated. These

are the primary sludge from the tube settler after dewatering by a centrifuge, and the secondary waste-activated sludge dewatered by a filter press.

The primary sludge will have a solids concentration of about 40 percent and will be generated at the rate of 139 lbs/hr on a wet basis. This sludge will contain phenols, benzene, analine and naphthalene which will classify it as hazardous from the standpoint of the Resource Conservation and Recovery Act (RCRA).

The secondary waste-activated sludge will have a solids concentration of approximately 20 percent and will be generated at the rate of 137 lbs/hr on a wet basis. Unless shown otherwise by an extraction test, this sludge will probably be considered non-hazardous.

Disposal alternatives include on-site incineration or pyrolysis, or off-site incineration or landfill.

Responsible off-site disposal contractors are available in the Cincinnati area. The Metropolitan Sewer District of Greater Cincinnati operates a fully-permitted, industrial hazardous waste incineration system and currently charges approximately $.06/lb (not including transport) for disposal. CECOS International operates a first-grade secure landfill facility in Williamsburg, Ohio (40 miles east of Cincinnati) and currently charges about $80/ton for disposal and about $500/20 tons for pick-up and transportation.

It appears, however, that in view of the relatively small quantities of sludge involved, on-site disposal can be considered without significantly, affecting the gasification system design or cost.

An incinerator will be provided as part of the system, but it will be of the liquid combustor type. Even though the sludges will probably be pumpable, they could not be burned efficiently in this type of unit.

We therefore recommend, on a preliminary basis, pyrolyzing the sludges in the gasifier by blending them in the coal charge to this unit. The ratio of sludge-to-coal would be relatively insignificant, about 0.8 percent, and this would not affect the gasifier performance or have any significant impact on the quality of the ash or exhaust gases.

References

Natural Gas Pipeline Co. of America, Oil and Gas Journal, Jan. 12, 1981 p. 80 - 99.95% purity.

Getty Oil Company, E. R. Bailey - 99.5 to 99.8% + purity.

Britsh Steel Corp. paper presented by W. A. P. Carter, P. Rodgers, L. Morris at "McMaster's " May 1977 - 99.7% purity.

1. DOFASCO paper presented by James Plenderleith at "McMaster's Symposium on Treatment of Coke Oven Gas" May 1977 - 99.7% purity.

2. Encyclopedia of Chemical Technology, Kirk-Othmer, Vol. 19, p.363, 1969.

3. 1979 Directory of Chemical Producers - United States, p. 910.

4. Chemical Process Industries, R. Norris Shreve, 1956 pp. 370 & 410.

5. "Environmental Assessment Report: Wellman-Galusha Low Btu Gasification Systems" EPA-600/7-80-093 p. 257.

TABLE NO. 11-1

OPERATING AND MAINTENANCE COST
FOR 5 GASIFIER FACILITY-DRAVO OWN AND OPERATE

RAW MATERIALS	UNIT COST	ESTIMATED ANNUAL USE	ESTIMATED ANNUAL COST
Coal	$ 33.20/ton	122,472 tons	$4,066,070
Catalyst and Chemicals			
Coal Pile Dust Spray	2.65/gal	250 gals	663
Phosphoric Acid	0.275/lb	20,100 lbs	5,528
Sulfuric Acid	62.52/ton	57 tons	3,564
Salt (NaCl)	0.04/lbs	162,790 lbs	6,512
Activated Carbon Type I	25.50/cu-ft	385 cu-ft	9,818
Ion Exchange Resin	92.10/cu-ft	32.5 cu-ft	2,994
Sludge Conditioner	1.19/lb	2,850 lbs	3,391
Coagulant Aid	1.66/lb	300 lbs	3,818
Filter Aid	1.65/lb	450 lbs	743
Stretford Chemicals			116,257
Cooling Tower Chemicals	0.90/lb	5,225 lbs	4,703
Chelant	1.20/lb	3,696 lbs	4,435
Sodium Sulfite	0.33/lb	3,927 lbs	1,296
Caustic Soda	0.165/lb	350 lbs	58
Chlorine	0.115/lb	127,800 lbs	14,670
Activated Carbon Type II	46.50/cu-ft	55 cu-ft	2,558
Coal Pile De-Icer	4.00/gal	10,800 gals	43,200
Utilities			
Electric Power Kw-Hr	0.034	30,127,496 Kwhr	1,024,500
Water Cu-Ft	0.004	11,489,988 cu-ft	51,000
Sewage Cu-Ft	0.008	3,548,964 cu-ft	28,500
Labor (Operating)			
Process Operators	$ 7.50/hr @ 2080 hr/yr	21 Men	$ 327,600
Coal Handling Operators	$ 7.25/hr @ 2080 hr/yr	2 Men	30,000
Labor (Supervision)			
Foreman	$20,000/yr	2 Men	40,000

TABLE NO. 11-1 (CONT'D)

RAW MATERIALS	UNIT COST	ESTIMATED ANNUAL USE	ESTIMATED ANNUAL COST	
Maintenance	3.2% x (Total Plant Investment)			
	Internal	10 Men & Materials	377,000	
	External Materials and Contract Labor	($673,000 Capitalized & not included in these costs)		
Operating Supplies	$1000/Month-Gasifier	60 Gasifier-Months	60,000	
Administration and General Overhead	60% of Direct Labor and Supervision		238,560	
Taxes			72,200	
Insurance	2% x (Total Plant Investment)		660,000	
Gross Operating Cost				$7,199,638
By Product Credits				
Tar	$ 0.70/gal	2.45×10^6 gal	1,715,000	
Sulfur (Liquid)	$100.00/ton	4000 ton	400,000	
Total Credits				$2,115,000
Net Operating Cost				$5,084,638

TABLE 11-2

WORKING CAPITAL
FOR 5 GASIFIER FACILITY - DRAVO OWN AND OPERATE

Short Term Assets			
Accounts Receivable			
Gas	$ 7.00/MM Btu x 15d x 6 x 10^3 MM Btu/d	$630,000	
Sulfur	$100.00/ton x 25d/279d/yr x 4000 tons/yr	35,842	
Tar	$ 0.70/gal x 25d/279d/yr x 2.5 x 10^6 gals/yr	156,810	
Ash	$ 0.00		
Raw Material Inventory			
Coal	$33.20.ton x 6100 tons	202,520	
Catalyst and Chemicals	1/12 x $224,208	18,684	
Cash on Hand			
1 Month Payroll (Direct Labor & Supervision)	1/12 x $397,600/yr	33,133	
Administration, Overhead	1/12 x $238,560/yr	19,880	
Operating Supplies	1/12 x $ 60,000/yr	5,000	
Maintenance	1/12 x $1,050,000/yr	87,500	
Total Short Term Assets			$1,189,369
Short Term Liabilities			
Accounts Payable (30 Days)			
Coal	$33.20/ton x 10,800 tons	358,560	
Catalyst and Chemicals	1/12 x $ 224,208/yr	18,684	
Electric Power	1/12 x $1,024,500/yr	85,375	
Water	1/12 x $ 51,000/yr	4,250	
Sewage	1/12 x $ 28,500/yr	2,375	
Total Short Term Liabilities			$ 469,244
Working Capital			
Short Term Assets - Short Term Liabilities			$ 720,125

TABLE 11-3

OPERATING AND MAINTENANCE COST
FOR 2 GASIFIER FACILITY-DRAVO OWN AND OPERATE

RAW MATERIALS	UNIT COST	ESTIMATED ANNUAL USE	ESTIMATED ANNUAL COST
Coal	$ 33.20/ton	51,665 tons	$1,715,278
Catalyst and Chemicals			
Coal Pile Dust Spray	2.65/gal	63 gal	167
Phosphoric Acid	0.275/lb	8,100 lbs	2,228
Sulfuric Acid	62.52/ton	23 tons	1,438
Salt (NaCl)	0.04/lb	65,116 lbs	2,605
Activated Carbon Type I	25.50/cu-ft	193 cu-ft	4,922
Ion Exchange Resin	92.10/cu-ft	15 cu-ft	1,382
Sludge Conditioner	1.19/lb	475 lbs	1,755
Coagulant Aid	1.66/lb	1,000 lbs	1,660
Filter Aid	1.65/lb	450 lbs	743
Stretford Chemicals			54,259
Cooling Tower Chemicals	0.90/lb	2,090 lbs	1,881
Chelant	1.20/lb	1,584 lbs	1,901
Sodium Sulfite	0.33/lb	1,683 lbs	555
Caustic Soda	0.165/lb	350 lbs	56
Chlorine	0.115/lb	51,100 lbs	5,877
Activated Carbon Type II	46.50/cu-ft	28 cu-ft	1,302
Coal Pile De-Icer	4.00/gal	4,317 gals	17,268
Utilities			
Electric Power Kw-hr	0.	17,288,291 Kw-hr	567,000
Water Cu-Ft	0.	4,606,100 cu-ft	25,806
Sewage Cu-Ft	0.	2,129,308 cu-ft	17,210
Labor (Operating)			
Process Operators	$ 7.50/hr @ 2080 hr/yr	10 Men	$ 156,000
Coal Handling Operators	$ 7.25/hr @ 2080 hr/yr	2 Men	30,000
Labor (Supervision)			
Foreman	$20,000/yr	2 Men	40,000

TABLE 11-3 (CONT'D)

RAW MATERIALS	UNIT COST	ESTIMATED ANNUAL USE	ESTIMATED ANNUAL COST	
Maintenance	3% x (Total Plant Investment)			
	Internal	5 Men & Materials	184,200	
	External Materials and Contract Labor	($545,300 Capitalized and not included in these costs)		
Operating Supplies	$1000/Month-Gasifier	24 Gasifier-Months	24,000	
Administration and General Overhead	60% of Direct Labor and Supervision		135,600	
Taxes			54,609	
Insurance	2% x (Total Plant Investment)		486,320	
Gross Operating Cost				$3,536,022
By Product Credits				
Tar	$ 0.70/gal x 10^6 gals		700,000	
Sulfur (Liquid)	$100.00/ton x 1,600 tons		160,000	
Total Credits				$ 860,000
Net Operating Cost				$2,676,022

TABLE NO. 11-4

WORKING CAPITAL
FOR 5 GASIFIER FACILITY - DRAVO OWN AND OPERATE

Short Term Assets			
Accounts Receivable			
Gas	$ 7.00/MM Btu x 15d x 2.4 x 10^3 MM Btu/d	$252,000	
Sulfur	$100.00/ton x 25d/279d/yr x 1,600 tons/yr	14,337	
Tar	$ 0.70/gal x 25d/279d/yr x 1 x 10^6 gals/yr	62,725	
Ash	$ 0.00		
Raw Material Inventory			
Coal	$33.20/ton x 3,700 tons	122,840	
Catalyst and Chemicals	1/12 x $99,999/yr	8,333	
Cash on Hand			
1 Month payroll (Direct Labor & Supervision)	1/12 x $226,000/yr	18,833	
Administration Overhead	1/12 x $135,600/yr	11,300	
Operating Supplies	1/12 x $ 24,000/yr	2,000	
Maintenance	1/12 x $729,500/yr	60,792	
Total Short Term Assets			$552,160
Short Term Liabilities			
Accounts Payable (30 Days)			
Coal	$33.20/ton x 4,320 ton	143,424	
Catalyst and Chemicals	1/12 x $ 99,999/yr	8,333	
Electric Power	1/12 x $567,000/yr	47,250	
Water	1/12 x $ 25,805/yr	2,151	
Sewage	1/12 x $ 17,210/yr	1,427	
Total Short Term Liabilities			$202,585
Working Capital			
Short Term Assets - Short Term Liabilities			$349,575

APPENDIX A

DESCRIPTION OF-
LOW BTU COAL GASIFICATION COAL TAR CHARACTERISTICS

The following is to be used as a guide in establishing the characteristics or specifications of the coal tar derived from coal gasification systems. From an extensive literature search of sources comparing coal tars derived from coal gasification and those derived from coke ovens, some general statements concerning these tars can be made: 1) Coal liquids derived from low temperature processes are different from those produced from high temperature processes (coke ovens). 2) Although coal gasification liquids are generally regarded as low temperature tars and oils, they might more properly be considered as hybrids because their characteristics fall between those of high and low temperature carbonization products. 3) Typically, low temperature tars exhibit only small concentrations of any individual compound and, in this respect, resemble petroleum and shale oil. 4) The chemical composition of low temperature tars and liquids is related to the coal source, which characteristically is not nearly as true for coke oven liquids because of the severe cracking and cyclization caused by high process temperatures. 5) Given the same feedstock (coal source), different gasification systems will result in coal tars with differing characteristics. High temperature and pressure gasification systems will result in coal tars more closely approximating those derived from coke ovens. 6) Gasification coal tars exhibit more side chain alkylation, unsaturation, oxygenation (tar acids), lower aromatics content, and inferior pitching properties when compared to coke oven liquids. 7) A number of atmospheric fixed-bed low Btu coal gasification systems are presumed to produce a "super light tar" in comparison to coke oven tar. These super light tars, when processed, produce a relatively higher percentage of distillables and a much lower percentage of residuals or residue pitch than their coke oven tar counterparts.

The following is a list of examples of the analyses of low Btu gasifier coal tars. A comparison of the various example analyses is quite difficult in that each example utilizes either a different coal feedstock or a different gasification system or both. Also, in most cases the parameters measured are not the same for each analyses thereby further complicating comparison. All examples are for fixed-bed atmospheric gasifiers.

The first example is for a coal tar derived from a high volatile bituminous Ohio coal. The information was taken from a technical article presented at the University of Kentucky in January of 1976 by Riley Stoker personnel associated with its Worchester, Massachusetts, pilot facility. This facility, as do all other examples, uses an air steam blast to produce a low Btu fuel gas from coal. The analysis is given in Table A-1.

The next example of a coal tar analysis is taken from a report entitled "Preparation of a Coal Conversion System's Technical Data Book" and prepared by the Institute of Gas Technology. These analyses were taken from a section marked pyrolysis. Table A-2 indicates how the differences in coal types affect the carbonization products in the coal tars using a low temperature carbonization process. Figures III.1-8 through Figure III.1-11 (taken directly from the report) reveal how the carbonization temperature produces different products and characteristics of the coal tars. Note that many of the general statements previously mentioned are proven by these Figures and Table.

The third example is from an EPA Report entitled "Environmental Assessment Report: Wellman-Galusha Low-Btu Gasification Systems", dated May 1980. The coal tar samples were taken from the Holston Army Ammunition Plant in Kingsport, Tennessee, which operates Wilputt low Btu coal gasifiers. The facility was using a low sulfure eastern Kentucky coal and the ultimate analysis of the by-product tar given in the report is presented in Table A-3. In the report the Holston gasification plant is referred to as the Chapman facility and a more detailed analysis of the organics in the tar produced at that facility is given in Table 3.4-6. The major organic categories identified were polycyclic aromatic hydrocarbons and heterocyclic organics. A wide distribution of trace elements was found, with sulfur and potassium being the predominant ones. These trace elements are given in EPA's Table No. 3.4-7 also attached.

The fourth example is taken from "The Coal Tar Data Book", published by The Coal Tar Research Association, Oxford Road, Gomersal, Leeds, Great Britain. The book lists coal tar assay of 32 selected coal tars from coke oven and gas work origin. Three coke oven tars and three fixed-bed atmospheric gasifier coal tars were excerpted from this publication for comparison. They are listed in Tables 5 and 6 respectively. The gasifiers are Woodall-Duckham. The assay results are expressed as weight percent on the dry tar unless otherwise indicated. Table 4 is a complete listing of the coal tar ultimate analyses for these tars.

TABLE A-1

DISTILLATION FRACTION, WEIGHT % OVER

1.3%	75 - 100° C
2.8%	110 - 170° C
14.7%	170 - 235° C
20.3%	235 - 270° C
29.2%	270 - 300° C
31.7%	Residue
1.090	SPECIFIC GRAVITY

MW (#/MOLE)

800 = 73.3 wt. % = unsoluble in Benzol

320 = 25.7 wt. % = soluble in Benzol, unsoluble in Petroleum Ether

210 = 1.0 wt. % = soluble in Petroleum Ether

TABLE A-2

AVERAGE YIELDS AND RANGE OF YIELDS OF 500°C (932°F) FISCHER ASSAY CARBONIZATION PRODUCTS FROM COALS OF VARIOUS RANKS, AS-RECEIVED COAL BASIS[1]

	Coke, Per Cent		Tar, Gallons Per Ton		Light Oil, Gallons Per Ton		Gas, Cubic Feet Per Ton		Water Per Cent	
	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Lvb	89.7	85.8-93.3	8.6	6.3-12.7	1.02	0.73-1.61	1,760	1,600-1,960	3.2	1.1-6.
Mvb	83.3	77.4-90.4	18.9	9.7-25.6	1.67	1.07-2.30	1,940	1,390-2,240	4.1	2.8-7.
Hvcb	67.1	65.4-68.6	27.0	18.5-38.8	1.88	1.29-2.71	1,800	1,560-2,070	15.9	12.0-19

Lvb, low-volatile bituminous; Mvb, medium-volatile bituminous; Hvcb, high-volatile C bituminous.

[1] Selvig, W. A. and Ode, W. H., "Low Temperature Carbonization Assays of North American Coals," Bulletin No. 571, Washington, D. C. Bureau of Mines (1957).

TABLE A-3

ULTIMATE ANALYSIS OF BY-PRODUCT TAR

LOW-SULFUR BITUMINOUS COAL

Ultimate Analysis Components	Wt. % (Dry Basis)[a]
C	85.2
H	7.9
O	5.1
N	1.2
S	0.5
Ash	0.1

[a] Moisture contents are about 0.10 kg/kg tar.

TABLE 3.4-6. ORGANIC COMPOUNDS IDENTIFIED IN THE TAR PRODUCED FROM A CHAPMAN FACILITY USING BITUMINOUS COAL

MEG Category No.	Organic Category / Organic Compound	Estimated Stream Concentration (μg/g)
1	Aliphatic Hydrocarbons	
	$>C_6$ Alkanes	4.0×10^2
	$\geq C_{10}$ Alkanes	9.0×10^2
5	Alcohols	
	$>C_6$ Alkylalcohols	3.4×10^3
8	Carboxylic Acids and Their Derivitives	
	Phthalic acid	1.0×10^2
	Phthalate esters	3.0×10^2
	Adipate esters	2.2×10^2
	$>C_8$ Aliphatic esters	4.8×10^2
10	Amines	
	Aminotetratin	9.0×10^2
	C_2-Alkylaniline	1.0×10^2
	C_3-Alkylaniline	2.0×10^2
	Benzofluoreneamine	6.0×10^2
	Methylbenzofluoreneamine	2.0×10^2
	Aminonaphthalene	1.0×10^2
	Methyl-aminoacenaphthylene	2.0×10^2
15	Benzene, Substituted Benzene Hydrocarbons	
	Indene	3.0×10^2
	C_2-Alkylindene	3.0×10^2
18	Phenols	
	Phenol	1.8×10^3
	Anisoles	8.4×10^3
	C_2-Alkylphenol	5.8×10^3
	C_3-Alkylphenol	1.0×10^3
	Indanol	3.0×10^3
	Naphthol	1.8×10^3
	Methylnaphthol	2.0×10^3
	C_2-Alkylnaphthol	3.0×10^3
	Acenaphthol	3.0×10^3
	Methylacenaphthol	9.0×10^3
	C_2-Alkylacenaphthol	1.6×10^3
	C_3-Alkylacenaphthol	7.0×10^3
	Hydroxyanthracene	1.5×10^3
	C_2-Alkylhydroxyanthracene	2.0×10^3
	C_2-Alkylhydroxypyrene	2.1×10^3
	Hydroxybenzofluorene	3.5×10^3
21	Fused Aromatic Hydrocarbons and Their Derivitives	
	Naphthalene	2.1×10^3
	Methylnaphthalene	4.2×10^3
	C_2-Alkylnaphthalene	4.4×10^3
	Acenaphthene	1.4×10^3
	Methylacenaphthene	6.0×10^3
	C_2-Alkylacenaphthene	1.2×10^3
	C_3-Alkylacenaphthene	5.0×10^3
	Acenaphthylene	4.3×10^3
	Methylacenaphthylene	2.8×10^3
	C_2-Alkylacenaphthylene	1.4×10^3
	Anthracene	6.3×10^3
	Methylanthracene	2.1×10^3
	C_2-Alkylanthracene	8.0×10^3
	Methylphenanthracene	2.1×10^3
	Chrysene	2.9×10^3
	Methylchrysene	1.2×10^3
	Perylene	8.0×10^3
	Pyrene	2.4×10^3
	Methylpyrene	3.8×10^3
	Benzoperylene	5.0×10^3
	Benzopyrene	8.0×10^3
	Triphenylene	2.9×10^3
	Methyltrophenylene	1.2×10^3
22	Fused Non-Alternant Polycyclic Hydrocarbons	
	Fluorene	2.4×10^3
	Methylfluorene	2.1×10^3
	Fluoranthene	1.4×10^3
	Benzofluorene	3.8×10^3
23	Heterocyclic Nitrogen Compounds	
	Carbozole	4.0×10^3
	Methylcarbozole	2.0×10^3
	C_3-Alkylpyridine	1.0×10^3
	C_4-Alkylpyridine	2.0×10^3
	Acridine	9.0×10^3
	Methylacridine	4.0×10^2
	C_2-Alkylacridine	4.0×10^2
	C_3-Alkylacridine	6.0×10^2
	Quinoline	1.9×10^2
	Methylquinoline	6.0×10^2
	C_2-Alkylquinoline	2.3×10^2
	C_3-Alkylquinoline	1.1×10^2
	Benzoquinoline	7.0×10^2
	Methylbenzoquinoline	1.1×10^2
	C_2-Alkylbenzoquinoline	3.0×10^2
	C_3-Alkylbenzoquinoline	6.0×10^2

MEG: Multimedia Environmental Goals
Source: Ref. 43

TABLE 3.4-7. TRACE ELEMENTS (BY SSMS) IN THE BY-PRODUCT TAR PRODUCED FROM LOW-SULFUR BITUMINOUS COAL

MEG Category Number	Element	Concentration (μg/g) Sample 1	Concentration (μg/g) Sample 2	MEG Category Number	Element	Concentration (μg/g) Sample 1	Concentration (μg/g) Sample 2
27	Lithium	ND	4	57	Chlorine	ND	6
28	Sodium	ND	71	58	Bromine	ND	2
29	Potassium	3000	100	59	Iodine	5	1
30	Rubidium	0.5	0.2	60	Scandium	<1	0.7
31	Cesium	ND	0.1	61	Yttrium	1	0.2
32	Beryllium	ND	0.1	62	Titanium	ND	29
33	Magnesium	200	23	63	Zirconium	ND	0.7
34	Calcium	ND	630	65	Vanadium	1	0.8
35	Strontium	20	10	66	Niobium	<5	ND
36	Barium	50	27	68	Chromium	50	3
37	Boron	1	19	69	Molybdenum	ND	1
38	Aluminum	ND	25	71	Manganese	ND	0.9
39	Galbium	<9	8	72	Iron	ND	120
43	Silicon	ND	170	74	Cobalt	ND	5
44	Germanium	ND	1	76	Nickel	ND	5
45	Tin	ND	0.9	78	Copper	300	3
46	Lead	50	10	81	Zinc	ND	7
48	Phosphorus	ND	17	82	Cadmium	<6	ND
49	Arsenic	<0.2	4	83	Mercury	0.06*	0.12
50	Antimony	80	0.8	84	Lanthanum	5	0.6
51	Bismuth	5	ND	84	Cerium	5	0.5
53	Sulfur	2000	520	84	Praseodymium	ND	0.3
54	Selenium	0.003*	3	84	Neodymium	ND	0.6
56	Fluorine	20	22				

Sample 1: Ref. 13
Sample 2: Ref. 36
*Determined by Atomic Adsorption Spectrometry

TABLE A-4

PROPERTIES OF ASSAY TARS

Number and Type of Tar	4 Coke Oven	5 Coke Oven	6 Coke Oven	16 Continuous Vertical Retort	17 Continuous Vertical Retort	18 Continuous Vertical Retort
Specific gravity at 15.5° C	1.175	1.185	1.172	1.086	1.072	1.077
Viscosity Redwood No. 1, seconds at 60° C	185	425	185	95	89	78
Water (Dean & Stark) per cent	5.2	4.5	6.2	2.1	3.4	3.5
Carbon (on dry tar) per cent	89.80	91.68	91.02	87.15	85.98	85.24
Hydrogen (on dry tar) per cent	5.41	5.37	5.55	7.67	7.61	7.69
Sulfur (on dry tar) per cent	0.78	0.81	0.98	0.87	0.81	0.94
Nitrogen (on dry tar) per cent	0.91	1.05	1.07	0.84	1.23	1.65
Ash per cent	0.07	0.39	0.47	0.04	0.06	0.05
Toluene-insoluble content (on dry tar) per cent	5.4	7.5	6.0	3.7	4.6	0.9

A1

NUMBER AND TYPE OF TAR	4 COKE OVEN	5 COKE OVEN	6 COKE OVEN
Liquor (weight per cent, on crude tar)	4·00	3·93	5·84
Benzole (50°C–100°C)	0·21	0·12	0·29
Toluole (100°C–125°C)	0·19	0·10	0·38
Xylole (125°C–150°C)	0·22	0·14	0·50
benzene	0·202	0·124	0·252
toluene	0·176	0·090	0·353
o-xylene	0·031	0·020	0·071
m-xylene	0·096	0·056	0·175
p-xylene	0·039	0·020	0·072
ethylbenzene	0·005	0·05	0·03
styrene	0·03	0·02	0·067
Total Tar Acids	2·81	2·91	3·91
phenol	0·56	0·48	0·56
cresols (100°C–120°C/40 mm)	1·04	0·96	1·59
o-cresol	0·30	0·25	0·34
m-cresol	0·42	0·39	0·56
p-cresol	0·23	0·23	0·37
xylenols (120°C–140°C/40 mm)	0·44	0·48	0·64
high-boiling tar acids (>140°C/40 mm)	0·77	0·99	1·12
Total Tar Bases	1·50	1·94	1·92
Naphtha (150°C/760 mm–137°C/100 mm)	0·44	0·52	2·04
paraffins in naphtha (weight per cent)	0·3	2·0	1·0
bromine number of naphtha	24	55	42
hemimellitene	0·019	0·008	0·109
pseudocumene	0·042	0·016	0·141
mesitylene	0·017	0·005	0·085
indene	0·028	0·172	0·252
hydrindene	0·132	0·076	0·328
coumarone	0·036	0·032	0·204
Crude Naphthalene (137°C–145°C/100 mm)	8·81	7·75	8·18
sulphur in crude naphthalene (weight per cent)	0·80	0·56	1·00
naphthalene	7·93	7·29	7·43
Methylnaphthalene Oil (145°C/100 mm–155°C/50 mm)	2·76	2·38	2·92
1-methylnaphthalene	0·75	0·60	0·80
2-methylnaphthalene	1·23	1·22	1·41
Biphenyl Oil (155°C–168°C/50 mm)	1·34	1·51	1·36
biphenyl	0·58	0·80	0·34
Acenaphthene Oil (168°C–184°C/50 mm)	2·31	2·82	1·75
acenaphthene	1·15	1·34	0·92
Fluorene Oil (184°C/50 mm–180°C/20 mm)	2·23	3·00	2·11
fluorene	0·86	1·24	1·20
diphenylene oxide	1·21	1·37	0·95
Anthracene Oil (180°C/20 mm–200°C/5 mm) } Heavy Oil (200°C/5 mm–pitch)	11·68	11·18	6·60 3·09
anthracene	0·95	0·71	0·57
phenanthrene	7·1	7·4	2·31
carbazole	1·19	1·35	0·58
Pitch	62·81	62·73	64·02
softening point °C (K. & S.)	72·0	70·5	68·8
toluene-insolubles in pitch (weight per cent)	21·0	21·5	19·7
Water/Light Oils formed during distillation	0·07/0·10	0·08/0·05	0·01/0·31
Total Loss during assay	2·52	2·78	0·93

TAR NUMBER 4

(i) West Cumberland coals, Index Nos. 500–502 (61·8%), Durham coals, Index Nos. 301, 501 (28·2%) and South Wales coal (10%)
(ii) 64 W.D. Becker combination ovens
(iii) 40′ 8″ × 13′ × 16″
(iv) flue: 1295
(v) 14·5 tons/16 hrs.
(vi) g. 12,000 cu. ft. (c.v. 540)
b. 3·8 gallons
l. 9 gallons (0·6% NH_3)
TAR 8·75 gallons
4·7% by weight

TAR NUMBER 5*

(i) Durham coals, Index Nos. 401, 501 (at plants A and B), 301, 401A (at plant C), 401B, 501B (at plant D)
(ii) A: S.C. underjet ovens
B: S.C. regenerative ovens
C: S.C. twin-flue underjet ovens
D: Koppers regenerative ovens
(iii) A: 45′ 1½″ × 14′ 11″ × 17¼″
B: 35′ × 8′ 6″ × 21″
C: 40′ 0½″ × 12′ 6″ × 17¾″
D: 35′ × 8′ 7″ × 19¼″
(iv) flue: A, 1270 B, 1050 C, 1360 D, 1200
(v) A. 19–19·5 tons/20 hrs.
B. 9·5 tons/30 hrs.
C. 15·8 tons/16 hrs.
D. 10·5 tons/30 hrs.

(vi)	A	B	C	D	
g.	11,324	11,200	11,400	10,500	cu.ft.
(c.v.)	(520)	(486)	(429)	(550)	
b.	2·84	2·5	2·0	2·3	gal.
l.	not measured				
TAR	4·15	3·6	3·7	4·4% by weight	

* This tar is a mixed tar derived from the four plants in the proportion 40·6% from A, 17·8% from B, 29·9% from C and 11·7% from D.

TAR NUMBER 6

(i) Durham coal, Index No. 401
(ii) W.D. underjet combination ovens
(iii) 43′ 2½″ × 12′ 6″ × 17″, taper 2″
(iv) flue: 1230
(v) 15 tons/24 hrs.
(vi) g. 10,800 cu.ft. (c.v. 540)
b. 2·8 gallons
TAR 9·4 gallons
4·9% by weight

A1

NUMBER AND TYPE OF TAR	16 CONTINUOUS VERTICAL RETORT	17 CONTINUOUS VERTICAL RETORT	18 CONTINUOUS VERTICAL RETORT
Liquor (weight per cent, on crude tar)	1·78	3·60	3·42
Benzole (50°C–100°C)	0·29	0·19	0·37
Toluole (100°C–125°C)	0·24	0·22	0·47
Xylole (125°C–150°C)	0·46	0·45	0·74
benzene	0·221	0·137	0·258
toluene	0·166	0·147	0·292
o-xylene	0·053	0·050	0·083
m-xylene	0·117	0·112	0·162
p-xylene	0·045	0·037	0·072
ethylbenzene	0·03	0·02	0·04
styrene	0·03	0·02	0·06
Total Tar Acids	15·59	16·20	20·80
phenol	1·22	0·49	1·36
cresols (100°C–120°C/40 mm)	4·20	4·42	4·76
o-cresol	1·27	1·32	1·12
m-cresol	1·06	1·04	1·33
p-cresol	0·91	0·91	1·03
xylenols (120°C–140°C/40 mm)	3·10	3·43	3·58
high-boiling tar acids (>140°C/40 mm)	7·07	7·86	11·10
Total Tar Bases	2·05	2·05	1·94
Naphtha (150°C/760 mm–137°C/100 mm)	2·98	3·84	3·24
paraffins in naphtha (weight per cent)	9·5	24·0	10·3
bromine number of naphtha	39	41	31
hemimellitene	0·281	0·164	0·094
pseudocumene	0·138	0·289	0·201
mesitylene	0·050	0·106	0·075
indene	0·286	0·427	0·062
hydrindene	0·112	0·227	0·272
coumarone	0·060	0·060	0·120
Crude Naphthalene (137°C–145°C/100 mm)	4·12	4·38	3·86
sulphur in crude naphthalene (weight per cent)	0·67	0·92	0·95
naphthalene	2·82	3·16	2·60
Methylnaphthalene Oil (145°C/100 mm–155°C/50 mm)	3·51	3·41	3·17
1-methylnaphthalene	0·50	0·46	0·64
2-methylnaphthalene	0·66	0·62	0·63
Biphenyl Oil (155°C–168°C/50 mm)	2·48	2·56	2·16
biphenyl	0·46	0·49	0·3
Acenaphthene Oil (168°C–184°C/50 mm)	3·02	2·78	2·21
acenaphthene	0·75	0·80	0·54
Fluorene Oil (184°C/50 mm–180°C/20 mm)	3·39	4·13	5·07
fluorene	1·23	0·37	0·33
diphenylene oxide	0·72	0·65	0·68
Anthracene Oil (180°C/20 mm–200°C/5 mm)	11·10	8·84	6·66
Heavy Oil (200°C/5 mm–pitch)	3·16	6·85	6·71
anthracene	0·29	0·30	0·18
phenanthrene	2·9	2·0	0·4
carbazole	1·43	1·14	0·14
Pitch	44·57	41·68	41·01
softening point °C (K. & S.)	70·0	73·0	69·9
toluene-insolubles in pitch (weight per cent)	14·5	15·4	11·5
Water/Light Oils formed during distillation	0·59/0·32	0·38/0·45	0·51/0·53
Total Loss during assay	2·15	1·61	1·10

TAR NUMBER 16

(i) East Midlands and Yorkshire coals, Index Nos. 501B (28%), 601A, 601B (37%), 701
(ii) 58 W.D. continuous v.r.
(iii) 58 of 25′ long, 29 tapering 10″–20″ on minor axis, 78″–82″ on major axis over 5′, thence parallel and 29 tapering 10″–18″ on minor axis over 17′, thence parallel and 78″–82″ on major axis over 5′, thence parallel
(iv) Combustion chamber: Passes No. 1, 1289: No. 2, 1315 No. 3, 1334: No. 6, 1091 (mean of maximum readings)
(v) 8·5 tons/24 hrs. (steaming to average 10% by weight on coal charge)
(vi) g. 14,000 cu. ft. (c.v. 514)
b. 1·88 gallons
I. 46 gallons (1·49% NH_3)
TAR 14 gallons
6·8% by weight

TAR NUMBER 17

(i) Yorkshire coals, Index Nos. 502 (33%) and 602 (67%).
(ii) W.D. continuous v.r. new battery, 16 retorts upward heating old battery, 16 retorts downward heating
(iii) 25″ × 18″ at base, tapering to 10″ at top, main axis rectangular cross section: of new retorts, 62″ of old retorts, 57½″
(iv) Combustion chamber: new 1120 (top), 1330 (bottom) old 1350 (top), 1130 (bottom)
(v) new: 6 tons/24 hrs. old: 5 tons/24 hrs. (steaming to average 20% by weight on coal charge)
(vi) g. 18,200 cu. ft. (c.v. 450)
b. no recovery
I. 40 gallons
TAR 16–17 gallons
7·9% by weight

TAR NUMBER 18

(i) East Midlands coal, Index No. 802
(ii) 16 W.D. continuous v.r.
(iii) 23′ × 4′ 5″, tapering 10″–16″
(iv) Combustion chamber: 1270 (average)
(v) 7·2 tons/24 hrs.
(vi) g. 11,466 cu. ft. (c.v. 523)
b. no recovery
I. 35 gallons
TAR 16·3 gallons
7·88% by weight

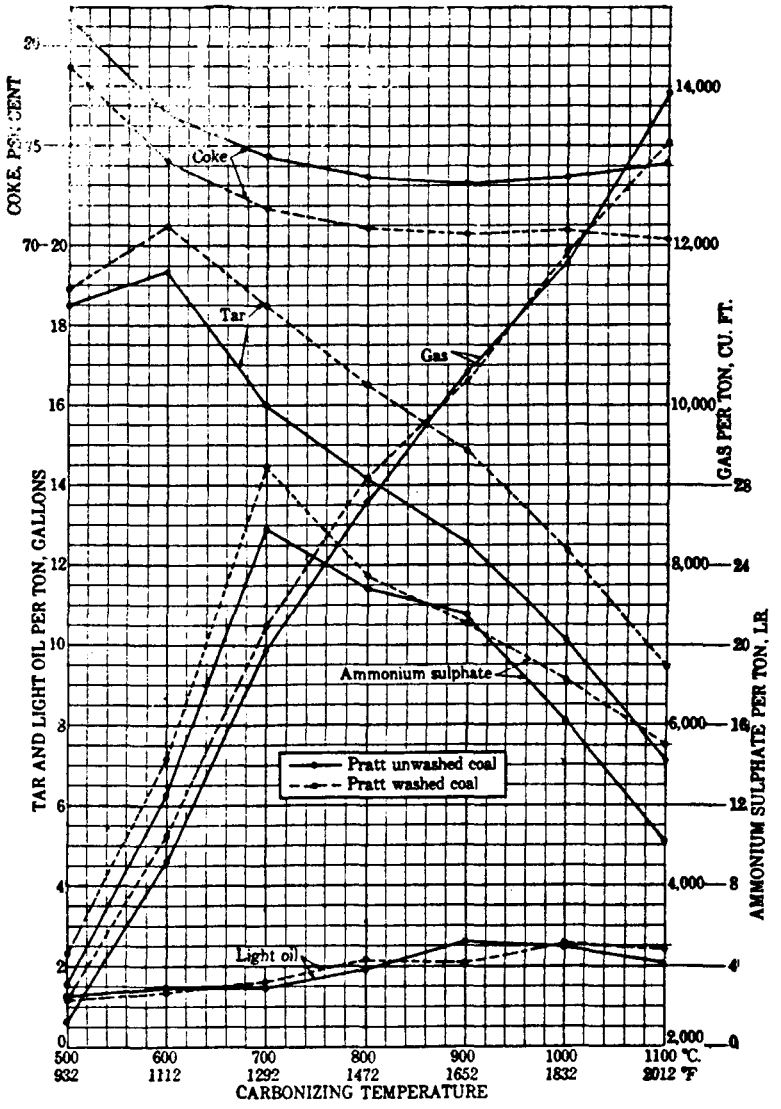


Figure III.1-8. YIELDS FROM PRATT COAL[1] BY A.G.A. - BM ASSAY

1. Fieldner, A.C. and Davis, J.D., "Gas-, Coke-, By-Product-Making Properties of American Coals and Their Determination," U.S. Bureau of Mines Monograph No. 5. Printed by A.G.A., New York, 1934.

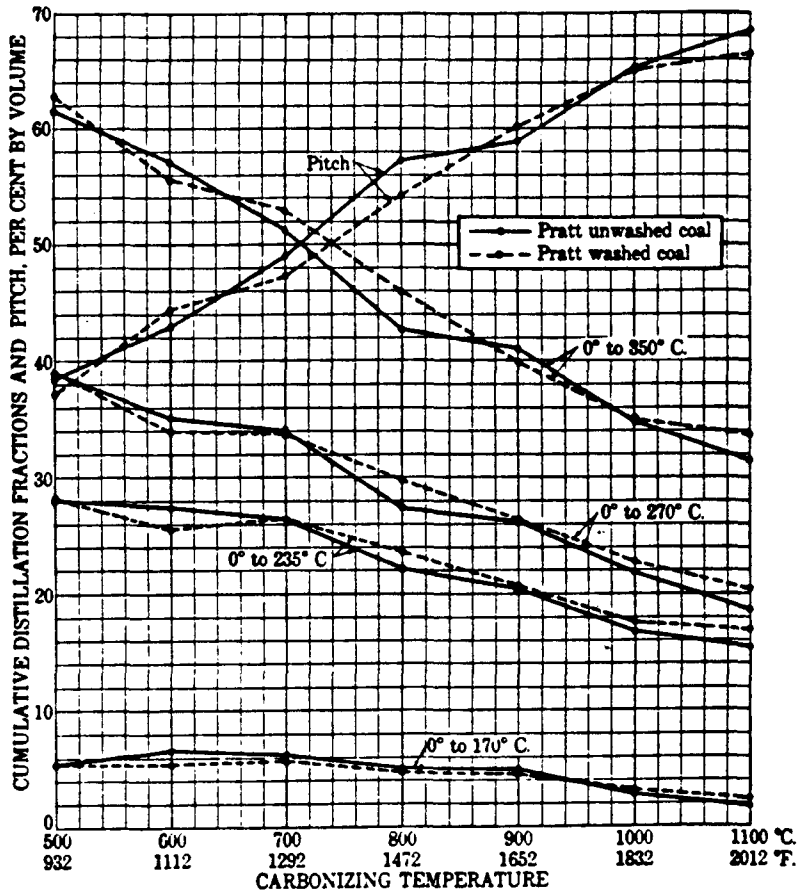


Figure III.1-9. DISTILLATION OF PRATT COAL TAR[1]

1. Fieldner, A.C. and Davis, J.D., "Gas-, Coke-, By-Product-Making Properties of American Coals and Their Determination," U.S. Bureau of Mines Monograph No. 5. Printed by A.G.A., New York, 1934.

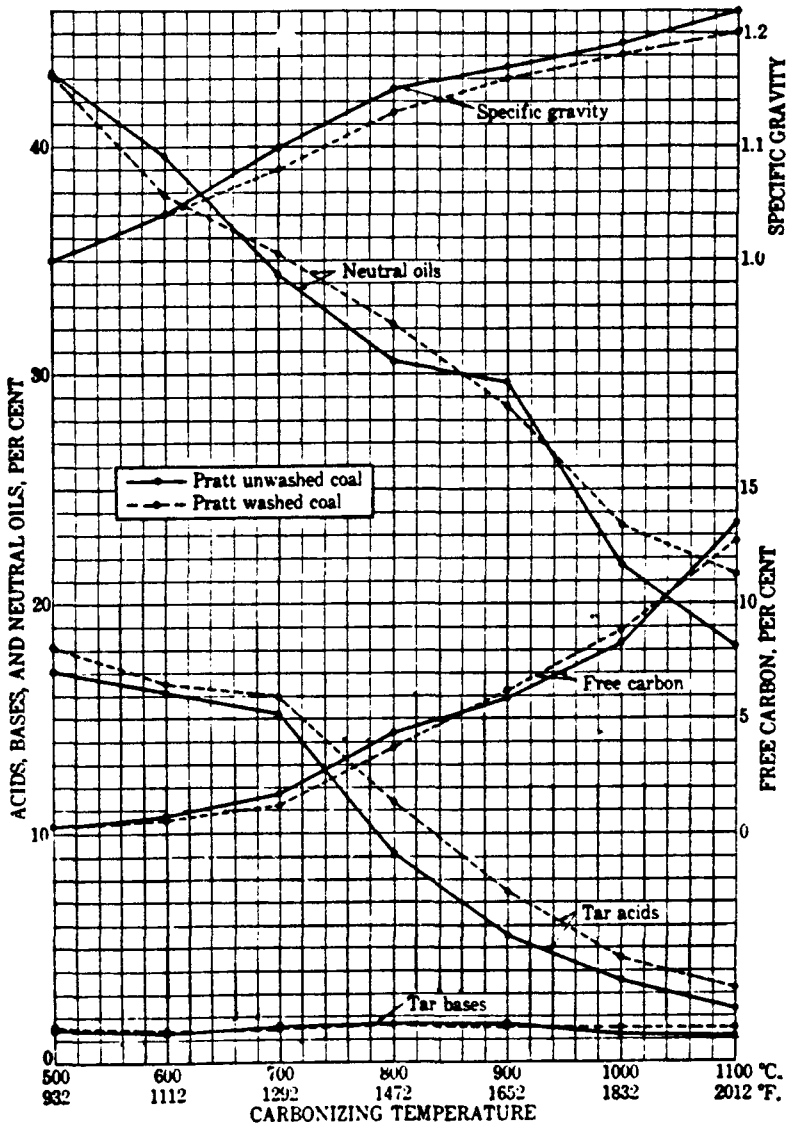


Figure III.1-10. COMPOSITION OF TAR, PRATT COAL[1]

1. Fieldner, A.C. and Davis, J.D., "Gas-, Coke-, By-Product-Making Properties of American Coals and Their Determination," U.S. Bureau of Mines Monograph No. 5. Printed by A.G.A., New York, 1934.

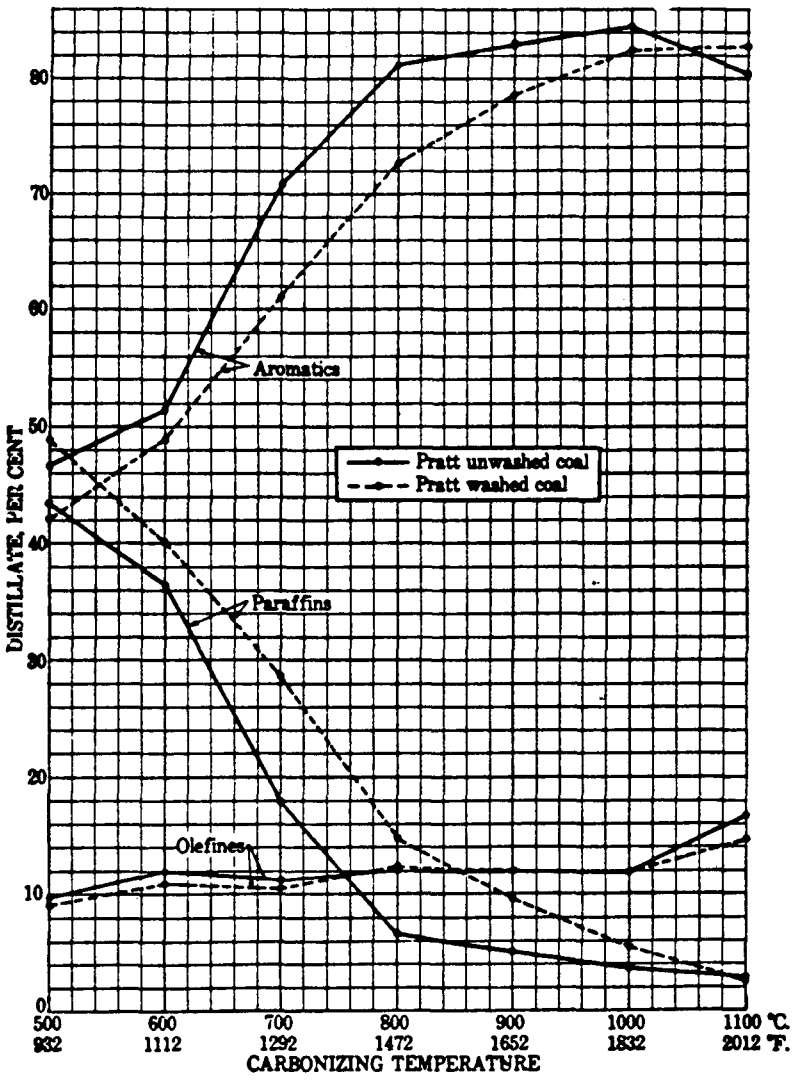


Figure III.1-11. COMPOSITION OF NEUTRAL TAR OILS TO 350°C, PRATT COAL[1]

1. Fieldner, A.C. and Davis, J.D., "Gas-, Coke-, By-Product-Making Properties of American Coals and Their Determination," U.S. Bureau of Mines Monograph No. 5. Printed by A.G.A., New York, 1934.

APPENDIX B

DESCRIPTION OF -- LIQUID HIGH PURITY SULFUR CHARACTERISTICS

The sulfur from this gasification plant, primarily in the form of H_2S is extracted using a Stretford sulfur removal system resulting in a liquid high purity elemental sulfur of approximately 99.5+%.

The Stretford people say that the sulfur product from many of their plants has been found to be of salable grade and suitable for use in sulfuric acid plants. Molten sulfur produced in Stretford units is of bright color and essentially free of contaminants, if proper techniques and design are used for contaminant-removal from the feed gas prior to the Stretford unit. Dravo's Stretford licensor has stated that the maximum expected amounts of hydrocarbons and ash are 0.4% and 0.05% by weight respectively. Of any trace amounts of other contaminants carried over into the sulfur it is estimated that they might be composed of sodium carbonates and vanadium salts. Below are listed the sulfur properties for pure sulfur taken from the "Sulfur Data Book" put out by the Freeport Sulfur Company and authored by William N. Teller. These properties should closely approximate the sulfur from our Stretford system.

SULFUR PROPERTIES:

Solid Bulk Density (Lb./Cu. Ft.):	85
Melting Temperature ^{o}F:	246°
Specific Heat Liquid (Btu/Lb. ^{o}F):	.242
Specific Heat Solid (Btu/Lb. ^{o}F):	.177
Heat of Fusion (Btu/Lb.):	1.24
Viscosity (Lb./Sec. Ft.):	.0074
Thermal Conductivity (L) (Btu/Hr. Ft. ^{o}F):	.076
Thermal Conductivity (S) (Btu/Hr. Ft. ^{o}F):	.093
Liquid Density (Lbs./Cu. Ft.):	112.45

12.0 FINANCIAL ANALYSIS

12.1 Summary

A financial analysis of the proposed coal gasification plant indicates that ownership by General Refractories (GREFCO) of a 5 gasifier facility will permit the most competitive low BTU gas (LBG) price. A $7.68/MMBTU price in 1984 will generate a 20% project discounted cash flow return on investment.

All cash flows and LBG prices are expressed in inflated dollars and should be evaluated on a $/MMBTU basis to concensus projections for average natural gas prices in 1984 and beyond.

12.2 Estimates and Methodology

Financial Analysis has calculated the LBG price (in 1984 dollars/MMBTU) necessary to generate the required discounted cash flow return on investment for the proposed project. Estimates used in the analysis have been obtained from the Market Analysis, Coal Supply and Engineering and Estimating groups. Two ownership scenarios have been studied.

- Gasification facility owned and operated by GREFCO.

- Gasification facility owned and operated by Dravo with Dravo selling the LBG "over-the-fence" under a long-term take or pay contract with GREFCO.

Estimates for the following have been included in the analysis (underlying assumptions are listed in Exhibit I):

12.3 Capital Requirements (Sec. 10.0)

Plant Investment
Costs Construction Plans and Drawings
Site Preparation
Plant Construction
Construction Engineering
Contingency
Initial Charge Catalyst and Chemicals
Paid-Up Royalties
Administrative Overhead
Start-Up Costs
Working Capital (Sec. 11.2)
Capitalized Maintenance

12.4 Operating Costs and Credits (Sec. 11.1, 11.4)

By-Product Credits (Sec. 11.3)
Coal (Sec. 3.5)

Labor Supervision and Related Costs
Maintenance Material and Equipment Costs
Catalysts and Chemicals
Operating Supplies
Utilities
Water
Plant Overhead
Insurance and Local Taxes
General Administrative Expense

12.5 Results of Analysis

Base Case:

GREFCO ownership of the plant could result in lower direct labor costs and general overhead expenses. In addition, the $400,000 office/change house would no longer be required. These capital and operating savings are reflected in the 3% lower LBG price in the GREFCO owned and operated scenario:

GREFCO OWNED/OPERATED	$7.68/MMBTU
DRAVO OWNED/OPERATED	$7.94 MMBTU

Tax and book income and cash flow statements for the above were prepared by Dravo in computer runs.

Sensitivities:

Sensitivity analyses of the 1984 LBG price have been performed with respect to the following variables: (Tables 1-2).

- Plant Capacity
- Capital Requirement
- Operating Costs
- Discounted Cash Flow Return On Investment
- Discounted Cash Flow Return on Equity at various Debt/Equity ratios
- Plant On-Stream Time

As the LBG prices reflect the actual price that will be charged to the Industrial user in 1984, they must be compared with estimates for the market price of LBG in 1984 (Appendix A).

Plant Capacity

The installation of a 2 gasifier facility reduces the total plant capacity by 60%. Although the investment is 25% lower, gross revenues drop by 43%. The GREFCO Owned/Operated LBG price at a 20% ROI discount rate increases 56% from $7.68 to $11.98.

Capital Costs ± 15% and Operating Costs ± 15%

A variance in the operating costs estimate has a greater impact upon the required gas price than does a similar percentage variance in the capital cost estimate. Were the final investment to be 15% below exceptions, the gas price would fall from 4-6% (depending upon the discount rate). A similarly conservative estimate for operating costs, however, would serve to reduce the gas price by 9-12%.

The higher the discount rate, the more the relative impacts converge: At a 15% ROI, the effect of a 15% underestimate of operating costs for the GREFCO Owned/Operated Case is 3 times greater than a 15% capital cost overrun. At a 25% discount rate, the difference narrows to a factor of approximately 1.5.

Discounted Cash Flow Return On Investment

Target ranges of 15%, 20% and 25% ROI have been provided. A higher applicable discount rate will necessitate a higher LBG price.

Discounted Cash Flow Return On Equity at Various Debt/Equity Ratios

Two debt cases were analyzed. One capitalizes the project at the General Refractories debt/total capital ratio of approximately 33%. The other assumes debt financing of all the pollution equipment and incorporates a debt/total capital ratio of 66%. As Congress has yet to determine the future of the Industrial Development Bond program, both cases were analyzed at a long-term conventional financing interest rate of 16%. As expected, at the same ROI targets, the ROE rises with increased leverage. LBG prices are unchanged.

Plant On-Stream Time

The Dravo Owned/Operated case was analyzed to determine what effect a 345 day plant utilization would have upon the required gas price. Although the initial investment remains the same, all the costs components have been increased to reflect the higher production rate. Reducing slack capacity increases the attractiveness of the project. At a 20% ROI discount rate, the required gas price decreases from $7.94 to $6.87.

Exhibit I

Assumptions

- All costs and revenues found in the proposal have been stated in average 1981 dollars. However, in accordance with General Refractories' request, all cash flows used in the discounted cash flow analysis have been expressed in current dollars. Inflation rate adjustments are:

  10% inflation rate for 1981-1982
  7% inflation rate for 1983-1998 for all cash flows with the following exceptions:

LBG*	10%/year price rise
Utilities (electric)	10%/year price rise
Coal	10%/year price rise

  *It is assumed that the seller will price the gas to maintain a profit margin sufficient to generate the required discounted cash flow return on investment. A 10%/year price rise in LBG is needed to offset the combined effect of the 10%/year rise in coal and electricity and the lower 7%/year rise in the tar and sulfur by-product revenues.

- 5 gasifier installation. Construction period of 1½ years (7/82 - 12/83).

- 3 month start-up period (1/84 - 3/84).

- On-stream project life of 15 years (1984-1998).

- Tax depreciation reflects the recently enacted Accelerated Cost Recovery System (ACRS). Allowing a far more rapid project write-off than was previously permitted, the entire project can be written off in 5 years with the exception of the front end loader ($90,000) which can be depreciated over 3 years and the office/change house ($400,000) which must be charged over a 15 year period. Annual capitalized repairs also qualify for the 5 year write-off.

- With the exception of the office/change house, the entire project is eligible for the 10% Energy Tax Credit. All the process equipment as well as the facilities in which they will be housed are eligible for the 10% Investment Tax Credit. The front end loader is eligible for a 6% ITC. The office/change house does not qualify. The combined credit is taken in the year in which the assets are expected to be placed in service (12/31/83). No carryforwards are assumed.

- The marginal tax rate of 49.2% incorporates both the Federal Corporate Tax of 46% and the 6% Kentucky state tax. Local energy taxes have been included in the operating costs.

- A one-time Royalty Payment of $119,000 to Sim Chem (the Stretford Sulfur Removal licensor) is incurred in 1984.

- Working capital estimates are approximately 7% of gross revenues (including by-product sales) and are recovered in the year of project termination, 1998.

- Residual value in 1998 of $20,000,000 (1998 dollars) has been developed by applying a 20% discount rate to the net operating cash flow stream expected at the time of sale in 1998.

- Gas prices obtained are expressed in 1984 dollars per million BTU. Cash flows have been discounted on an annual basis assuming a continuous inflow of revenue and outflow of expense during the year. The discount rate is 20%.

- Production is based upon a 279 day year @ 6,000 MM BTU/day.

TABLE 1

GREFCO OWNED AND OPERATED
5 GASIFIERS

All $ figures are in 1984 $/MMBTU
Percentages reflect deviation from base case

Discount Rate	Base Case	Plant Capacity 2 Gasifiers	Total Initial Capital Costs Underestimated By $5MM	Total Initial Capital Costs Overestimated By $5MM	Operating Costs Underestimated By 15%	Operating Costs Overestimated By 15%	ROE if 33% Debt Financed	ROE if 66% Debt Financed
15%	$6.55	$ 9.89/51%	$6.83/4%	$6.30/(4%)	$7.34/12%	$5.77/(12%)	19.0%	34.2%
20%	$7.68	$11.98/56%	$8.06/5%	$7.31/(5%)	$8.48/10%	$6.90/(10%)	26.0%	44.9%
25%	$9.03	$14.54/61%	$9.54/6%	$8.52/(6%)	$9.83/9%	$8.23/(9%)	33.0%	54.3%

TABLE 2

DRAVO OWNED AND OPERATED
5 GASIFIERS

All $ figures are in 1984 $/MMBTU
Percentages reflect deviation from base case

Discount Rate	Base Case	Plant Capacity 2 Gasifiers	Total Initial Capital Costs Underestimated By $5MM	Total Initial Capital Costs Overestimated By $5MM	Operating Costs Underestimated By 15%	Operating Costs Overestimated By 15%	345 Day Utilization	ROE if 33% Debt Financed	ROE if 66% Debt Financed
15%	$6.79	$10.22/51%	$7.04/4%	$6.51/(4%)	$ 7.59/12%	$5.96/(12%)	$5.93/(13%)	19.0%	33.1%
20%	$7.94	$12.37/56%	$8.31/5%	$7.57/(5%)	$ 8.76/10%	$7.12/(10%)	$6.87/(13%)	26.0%	43.7%
25%	$9.29	$14.96/61%	$9.79/5%	$8.83/(5%)	$10.12/9%	$8.48/(9%)	$7.98/(14%)	33.1%	53.9%

FIGURE 1 COMPOSITE FUEL COST PROJECTIONS

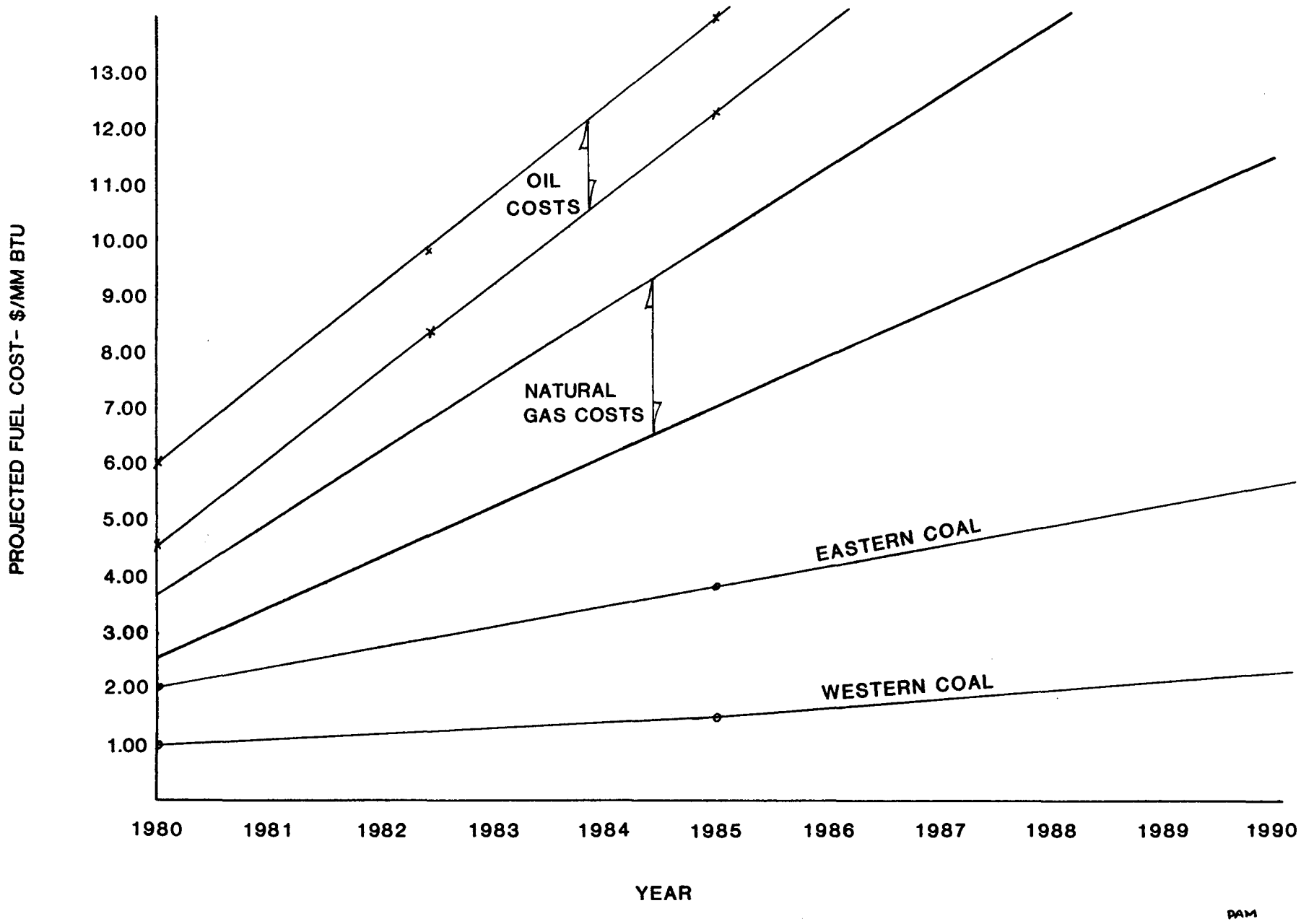


FIGURE 2 AVERAGE PROJECTED FUEL COSTS, INCLUDING LBG

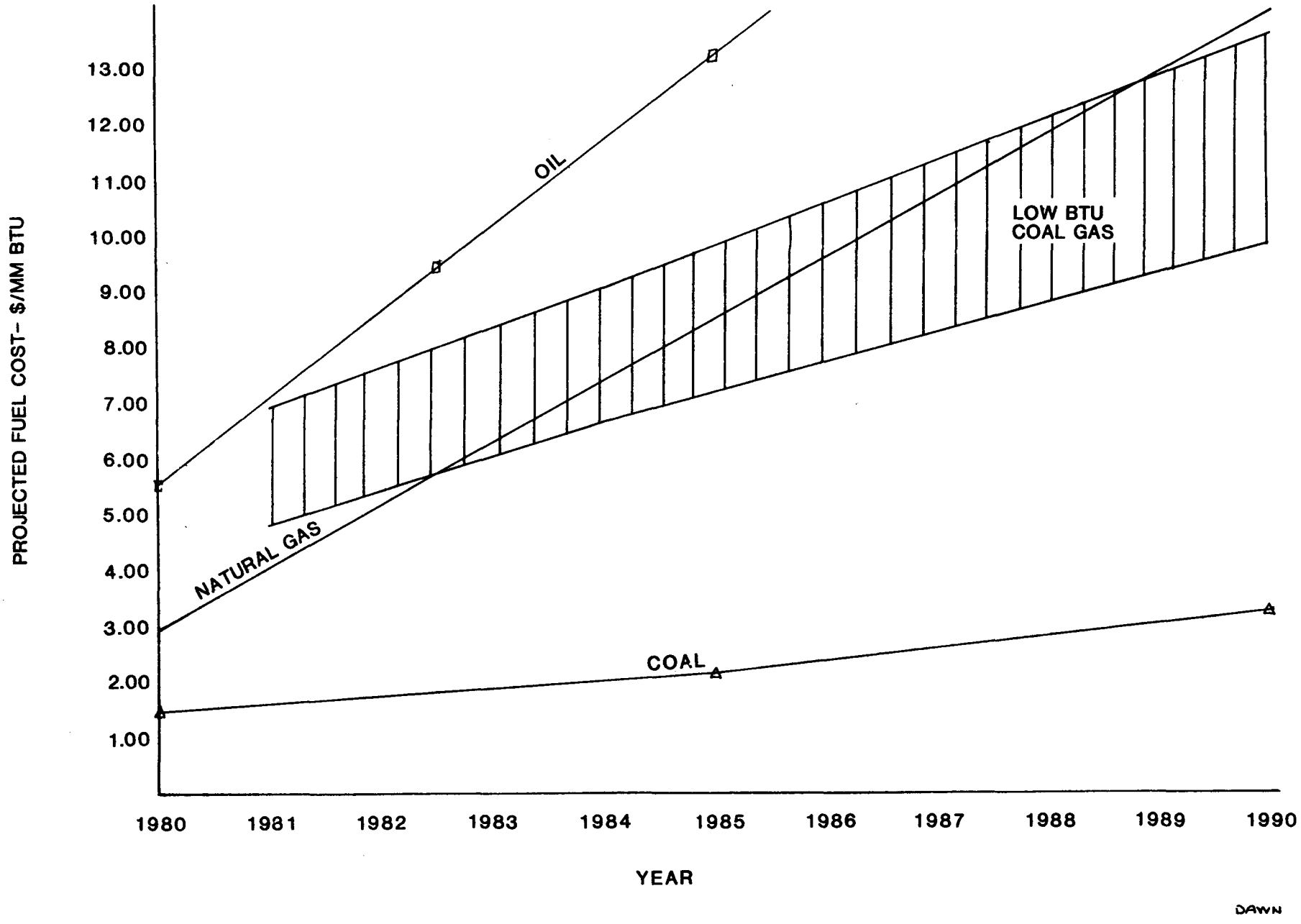
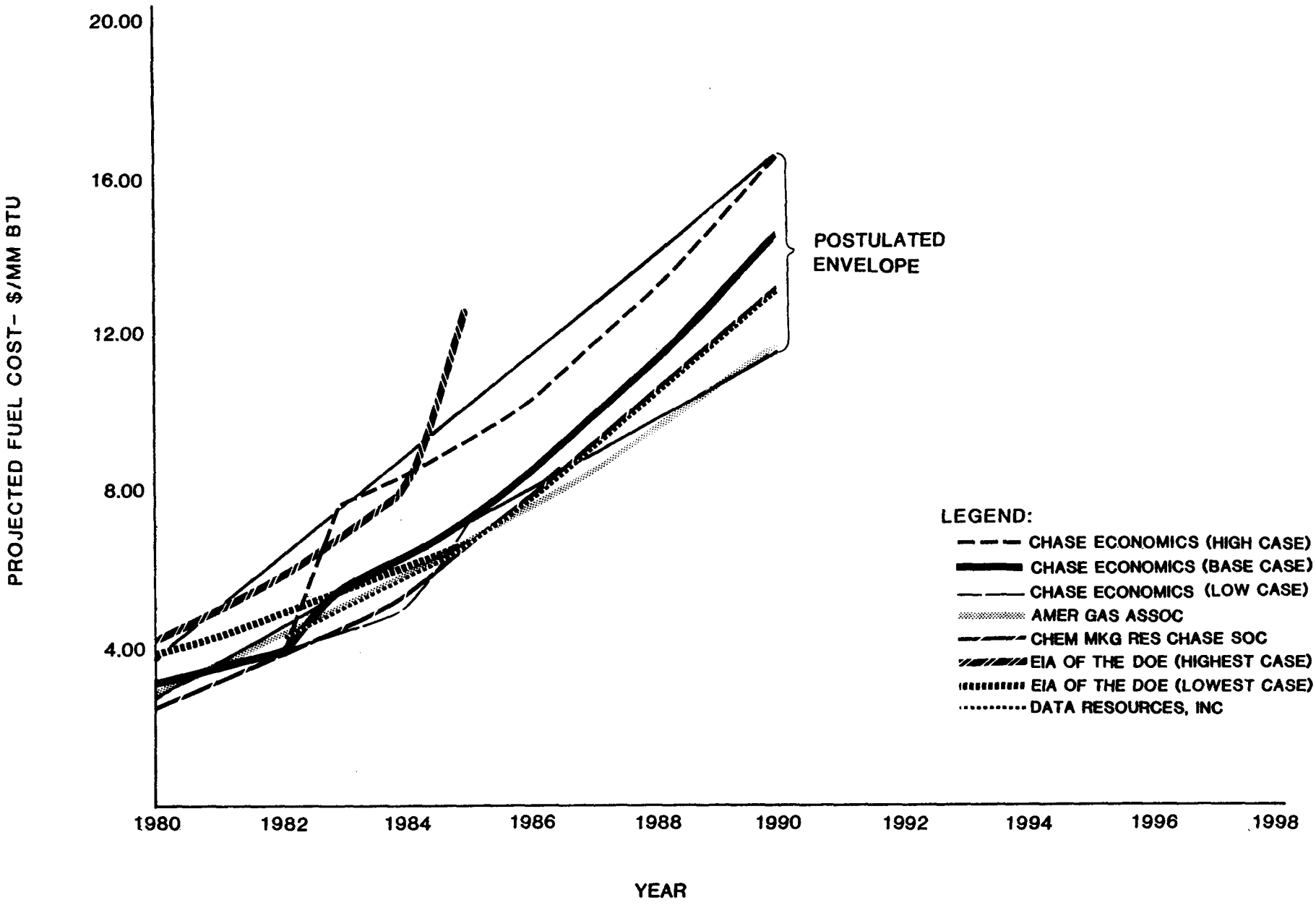
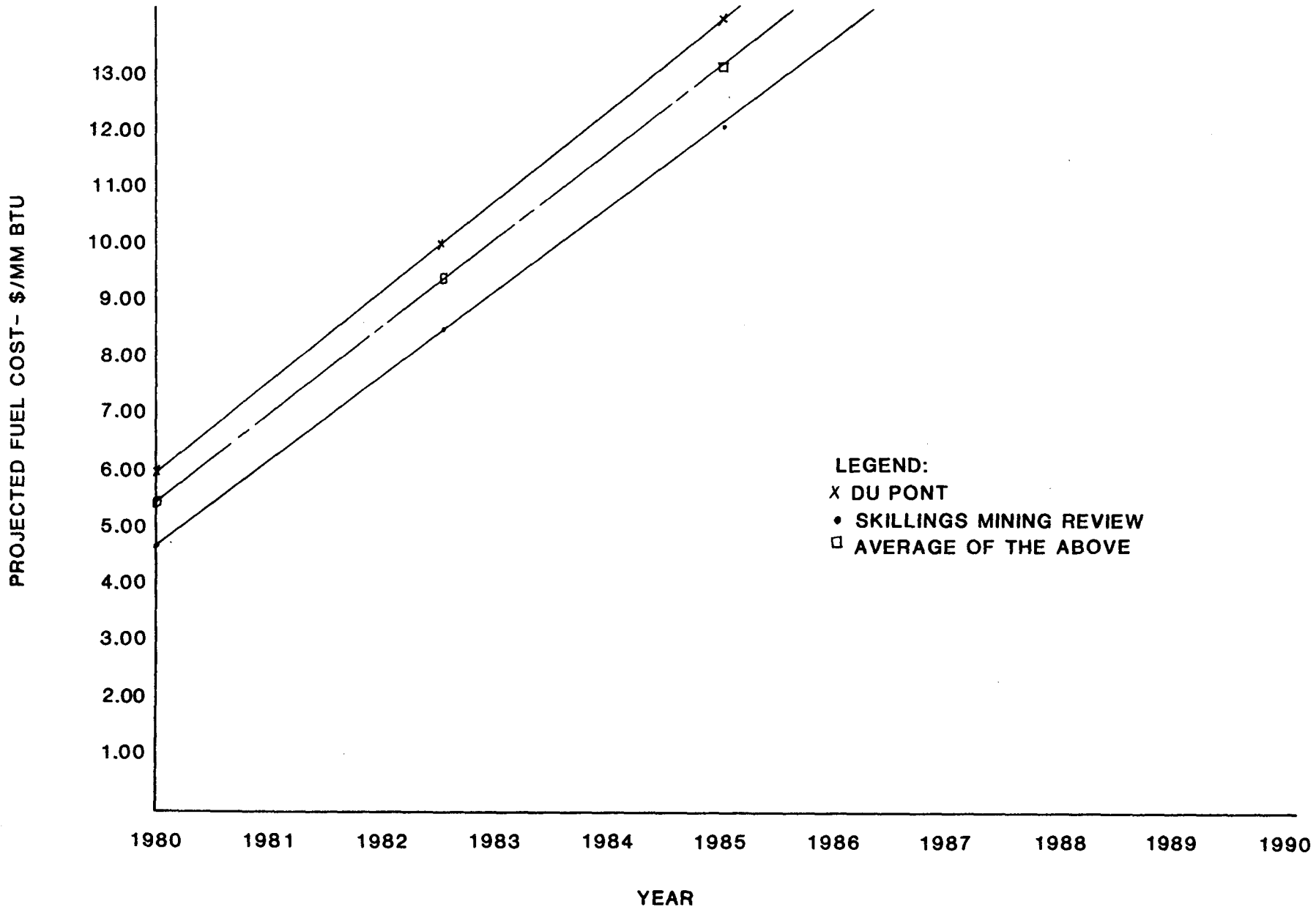


FIGURE 3 NATURAL GAS COST PROJECTIONS



PAM

FIGURE 4 FUEL OIL COST PROJECTIONS



DAWN

FIGURE 5 COAL COST PROJECTIONS

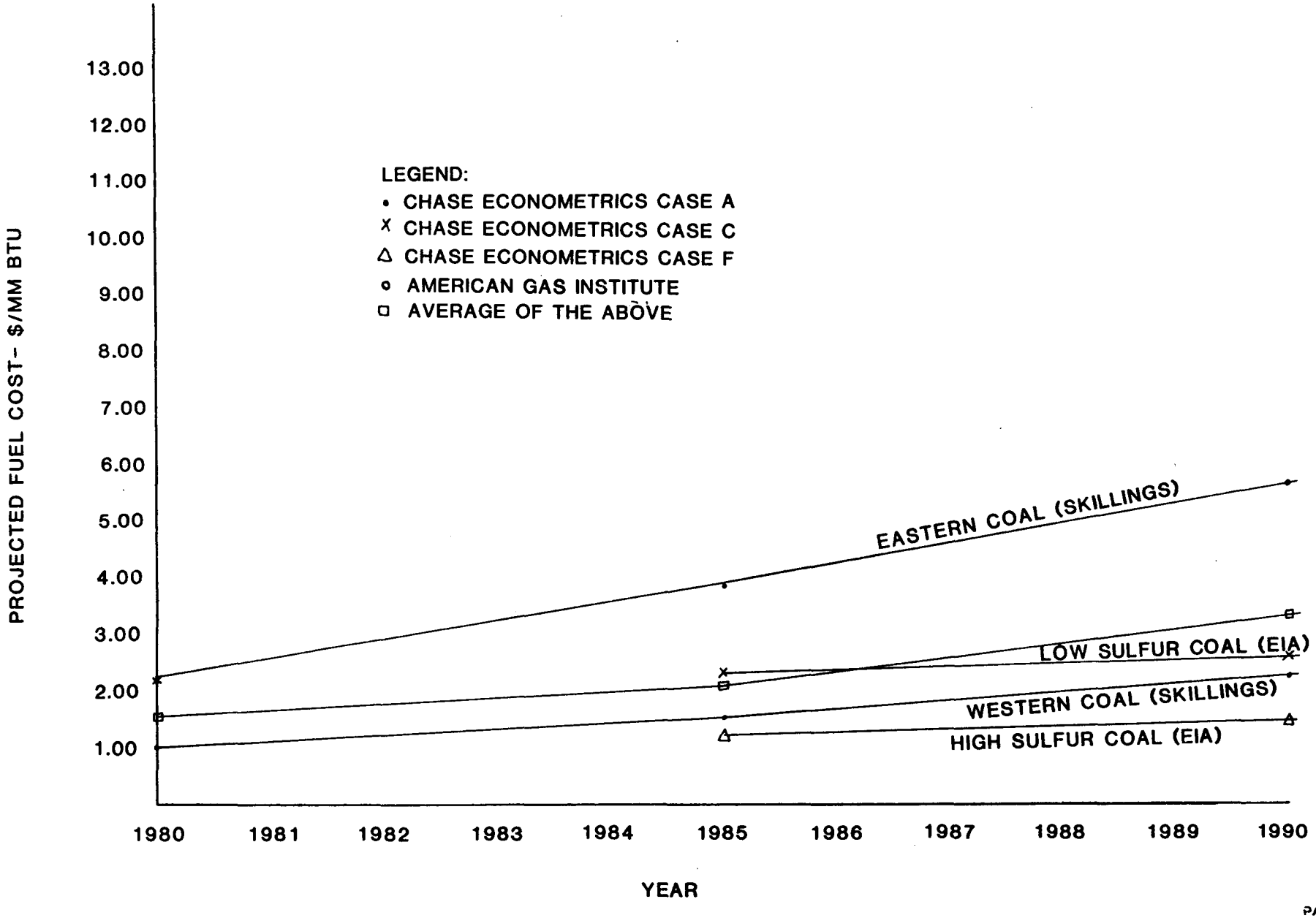


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FIGURE 6 LOW BT GAS COST PROTECTION

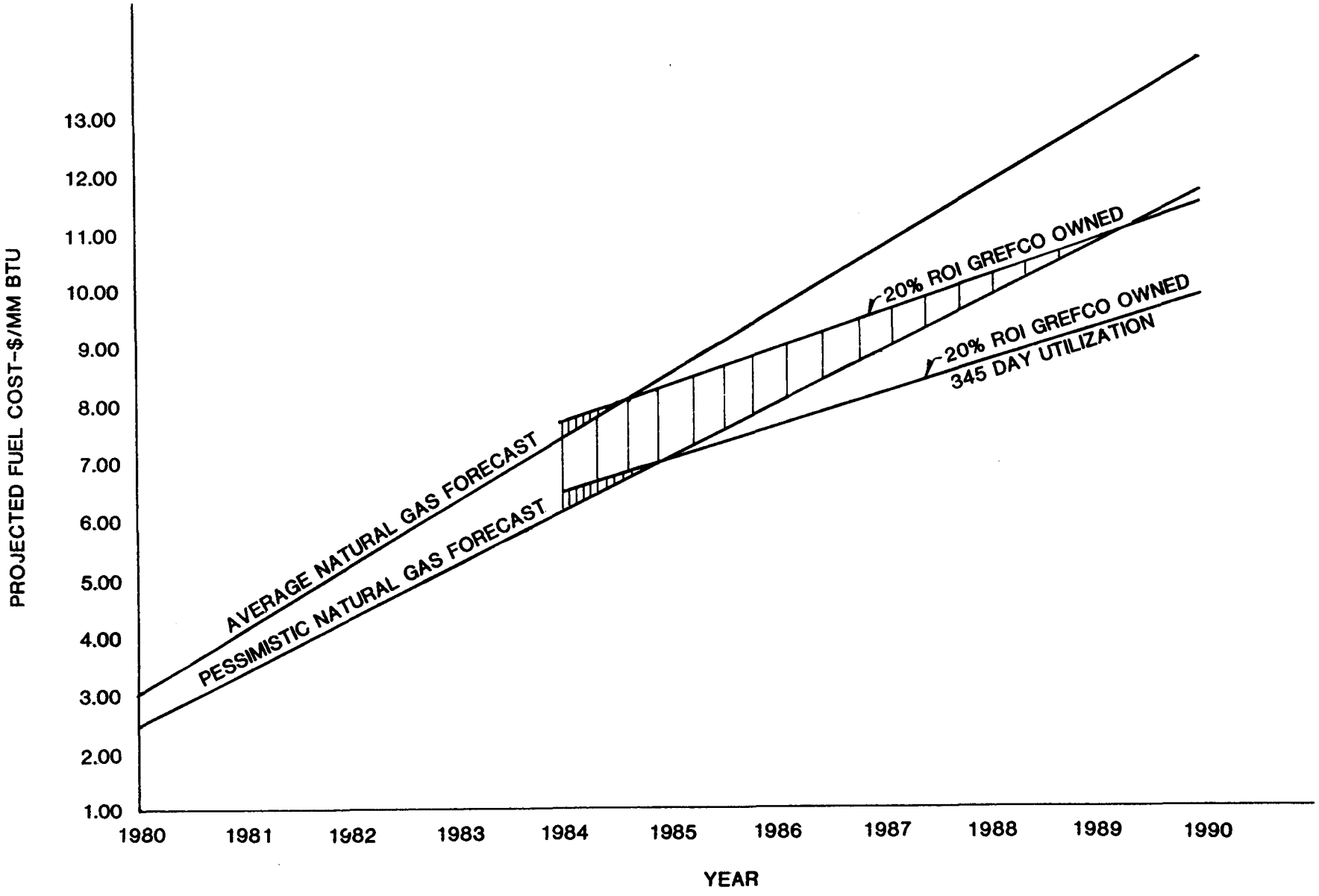
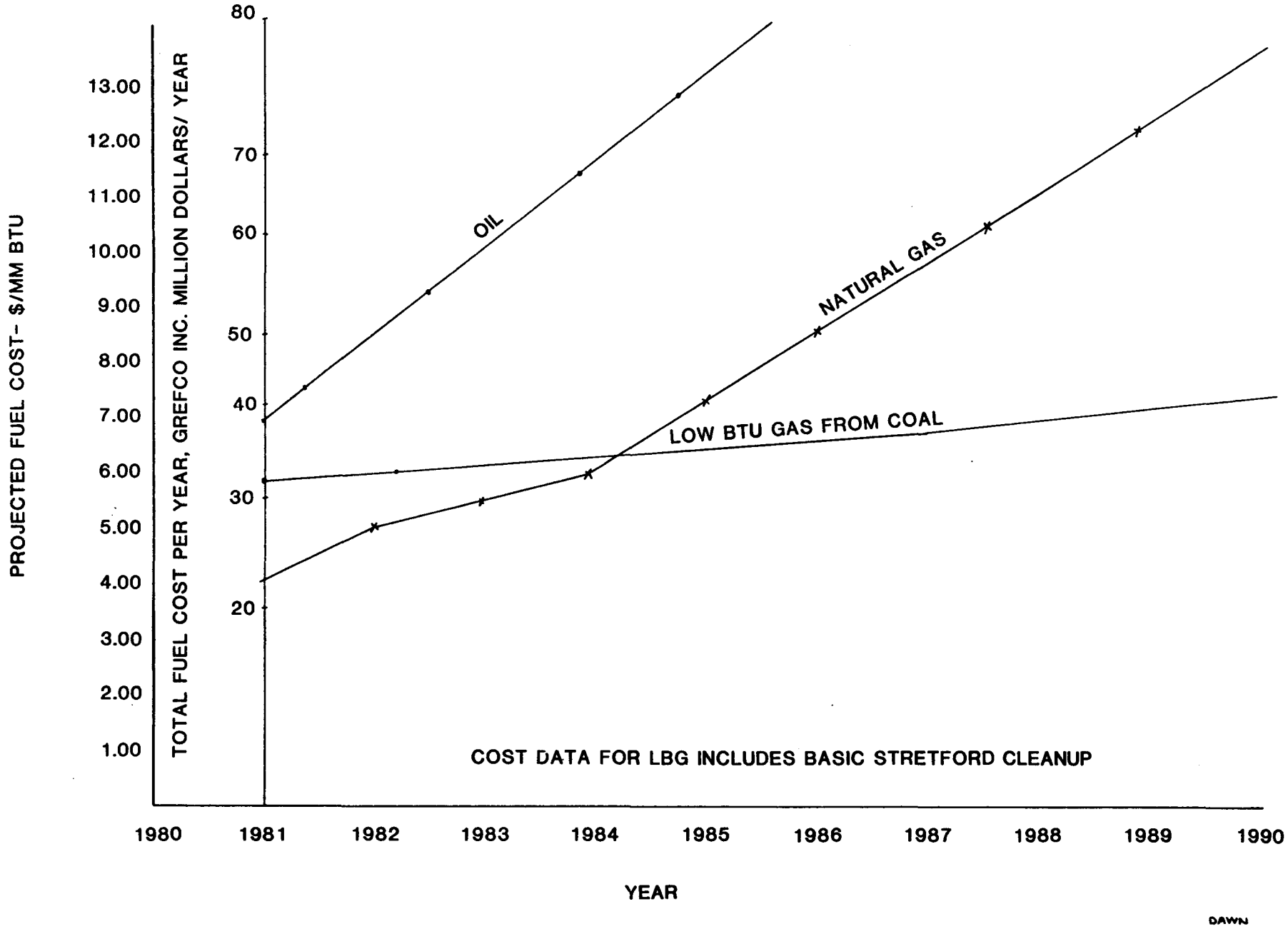


FIGURE 7. ANNUAL FUEL COST PROJECTION GREFCO FLORENCE PLANT



DAWN

13.0 RISK ANALYSIS

This section has been prepared with the object of identifying the costs and actions necessary to make a decision to place a processing facility into operation. The calculations and analyses have been based on assorted facts, laws, regulations and assumptions of varying degrees of certainty. If any of these bases change or turn out to be other than assumed, there is a possibility that the profitability of the project may be reduced or seriously jeopardized. In order to make the final decision, it is highly desirable to identify and, if possible, to quantify the areas of uncertainty and risk, where risk is defined as the possibility of occurrence of a specific deleterious consequence. This section identifies and discusses risks in various categories.

13.1 Technical Risks

Technical risks relate to the probability that the process reactions and equipment will perform as predicted for the range of operation specified. When a process system or piece of equipment has operated reliably over a period of time in essentially the same service, the risk is considered negligible.

Low risk may be said to exist when the technology has been proven in very similar service but may require minor modification.

Moderate risk may be said to exist when the technology is similar to proven technology but has not been proven under the operating conditions for the application considered.

13.1.1 Coal Handling

Technology for transporting, storing and reclaiming coals of all types is well proven. Risk is negligible.

13.1.2 Gasification

Wellman-Galusha technology is well proven for many coals including caking bituminous coals. Risk is negligible that the gasifier will not produce a satisfactory fuel gas. The gas composition may vary slightly from that predicted since there are no records of operation on the design coal.

13.1.3 Tar Removal

Quenching systems have been used on gas from fixed-bed pressurized gasifiers (Lurgi), coke ovens, fixed-bed atmospheric gasifiers and other gasifiers producing oils and tars. Since tars vary in composition and properties, some quench systems have had difficulties with fouling, plugging and emulsions. Such difficulties have not proved insurmountable. If they occur, it is expected that they will be overcome with minor modification. Therefore, this system must be considered a minor risk. The flexibility exists to operate the quench system at higher temperatures (subject to limitations on ESP compressors) to obtain a more fluid tar.

13.1.4 Sulfur Removal and Recovery

The Stretford sulfur removal system has been used successfully to remove sulfur from many coke oven gas streams. There is one installation in the U.S. and several in South Africa on producer gas streams. No problems have been reported and the risk in this application may be considered negligible.

13.1.5 Waste Treatment

Technical risks in waste treatment are discussed in part 13.3.

13.2 Operational Risks

Operational risks relate to the probability that, during plant operation, conditions will occur which were not allowed for or are outside the basis of design. Such risks are considered minor if the problem can be eliminated by change of specifications or source of supply (e.g. for coal), addition of labor, minor plant modifications or other moderate expenditures.

Moderate risk refers to the occurrence of conditions which would require replacement or addition of one or more major pieces of equipment or plant modification of a similar magnitude.

13.2.1 Coal Supply

While the plant as designed can operate on coals with a wide range of properties there is the possibility that a coal with less desirable characteristics will have to be used.

One of the important characteristics is size distribution. If a coal with excess fines is to be used, the plant would have to be modified to permit screening and sale or other disposal of fines. This must be considered a moderate risk.

A wide range of ash content in the coal can be tolerated, including a content of over 20 percent. Risk related to ash content is negligible. A change to a coal with a very low ash fusion temperature would require supplemental steam to the gasifier. This would result in some piping changes and can be considered a minor risk.

A change in sulfur content of coal would cause concern only if the sulfur content increased. The design coal already has an exceptionally high sulfur content and it is highly unlikely that a coal with the same or lower sulfur content could not be located. Brief (several hours) increases in sulfur content can be tolerated by the sulfur removal system. Lower sulfur content coals present no operational problem and the only risk is lower sulfur revenues.

A change in the content of volatiles in the coal would be reflected primarily in tar production. Since the volatile content of the design coal is fairly high, it is likely that a substitute coal would have less. This would result in lower tar production and a probable an increase in Btu value of the clean gas. The effects of this on operation are all beneficial, and the only risk is reduction in tar revenues.

13.2.2 Chemicals Availability

One of the chemicals used in the Stretford process is anthraquinone disulfonic acid (ADA). This is relatively uncommon and sources of supply are limited. The possibility of temporary or prolonged shortage of ADA must be considered a minor risk. Many Stretford plants around the world are dependent on ADA, and it is likely that if one source disappears another will be developed.

13.3 Environmental

Risks in the environmental area include technical, operational and regulatory. Since these risks are somewhat interrelated, they are all discussed in this section.

13.3.1 Aqueous Waste

The level of contaminants in aqueous quench streams contacting producer gas has been measured and published. This data has been used as a basis of design for this project. Although the data is for a bituminous coal, the actual concentration of contaminants for the design coal may differ. Minor differences can be tolerated by the treatment system in varying degrees for the different steps, from ±20 percent to perhaps ±50 percent. Significant increases in BOD or organics may require plant modification such as additional aeration capacity to achieve the desired discharge levels. This represents a moderate risk. Significant decreases in effluent may also require minor modification such as compartmentalization of the aerator.

Trace quantities of heavy metals in the untreated effluent (based on the above data source) are below limits prescribed by county and federal regulations. County regulations are being revised to "at least" the federal limits. It is conceivable that limits could be revised to the point where some contaminants exceed the limits. It is also possible that federal regulations will be made more stringent, although not likely in the near future. Therefore, it must be recognized that a risk of unknown magnitude exists in the regulatory area.

The basic treatment technology, biodegradation and carbon absorption, have been proven in industrial application to aqueous wastes from coke oven plants. These wastes are contaminated with similar materials. The risk of exceeding current regulated discharge levels is minor if any.

13.3.2 Solid Waste

The only solid waste of significant concern is sludge, which is generated in the Stretford solution. A reductive incineration system has been selected to convert the sludge to components which can be returned to the sulfur removal system. Two commercial versions of the process exist and have been used successfully. The technical risk can be considered negligible. The amount of sludge generated has been predicted by the Stretford licensor but could vary in practice. However, the system is designed for a one-shift operation, which gives considerable excess capacity. The only risk is the increased cost of those chemicals which are destroyed by incineration.

13.3.3 Gaseous Emissions

The product fuel gas must be capable of meeting SO_2 emission regulations when burned. Sulfur content of the fuel gas is essentially carbonyl sulfide (COS). Since all COS formed in the gasifier passes through into the product, the amount formed is critical. COS formed in producer gasifiers has been measured in the range of 4 to 10 percent of total sulfur in the gas phase when lower sulfur coals are used. It is predicted to be about 2 percent with high sulfur coals, and this data has been used in this design. Levels higher than 2 percent (up to about 5 percent) can be tolerated, but still higher levels would require a change in the coal specification. The risk is considered minor.

13.4 Financial Risk

13.4.1 Capital and Operating Costs

Assuming a decision to build the gasification facility is correct, it is felt that aside from any unforeseen project delay the financial risk from incorrect estimates of capital and operating costs will be minimal. The detail and extent with which these estimates were prepared, and Dravo's extensive experience in developing similiar estimates should preclude any large deviations from the original estimate. The risk is considered low that any estimated area will exceed 15 to 20 percent in actuality. As indicated in the financial analysis section, even if this accuracy level is exceeded by twice this amount, the project can still be considered profitable but suffer losses of return on investment in the order of only 3 to 6 percent.

13.4.2 Future IFG Price vs. Natural Gas

Other factors which more dramatically affect the IFG price than capital and operating costs are: (1) the ability to begin with a five-gasifier plant rather than a two-gasifier plant or at least an expansion to five gasifiers within a short time (1-3 years after the two gasifier start-up), (2) the ability to convert the Florence production plant and consequently the gasifier facility to a higher utilization rate than it now maintains and (3) the inclusion of debt financing for leveraging up the return on equity given a certain return on investment hurdle rate. The inclusion of any or all of these factors will serve to drastically lower the financial risk of the project.

The most important factor influencing the financial risk of the project is external -- the future market price of natural gas. The risk associated with this element is directly related to the ability to choose of a proper forecast of the prices for natural gas and how it conforms with the "real world" market place.

13.5 Project Schedule Timing

13.5.1 Equipment Deliveries

Equipment delivery is considered a high risk to the project schedule. Due to extended procurement cycles, long lead time material and equipment may represent a high degree of uncertainty. The procurement uncertainties can be minimized through effective purchasing policies and practices, including a monitoring system that would provide the lead time required to react to late or unavailable material and to identified events, which invariably occur during long projects but which can not be specifically anticipated when a project is scheduled.

Dravo's development of the MSS/DSS (Material Status System/Document Status System) controls, which is essentially a materials and equipment computer tracking device used during construction greatly minimizes problems due to long lead times or unanticipated delivery or "inventory practices".

The use of a critical path diagram system with other computer-assisted engineering-construction control documents will also help avoid and reduce bottlenecks or roadblocks to an orderly and timely project completion.

13.5.2 Effects of Labor Strikes and Walk-Offs on the Construction Schedule

This can be a high risk and is difficult to predict or avoid. A complete labor relations program will be developed and designed specifically to meet the condition of this project.

14.0 GOVERNMENT IMPACT

Government agencies and administrative bodies at the federal and lower levels can do a great deal to improve the economics and encourage the use of low Btu gas in industry. This can be accomplished by the introduction of new laws and regulations and more importantly by modification of existing laws and regulations, such as the Natural Gas Policy Act mentioned earlier.

At the federal level, some of the actions possible are as follows:

- Create a free market in competitive fuels. Artificially low prices for natural gas tend to discourage the use of low Btu gas. As a side effect, they also discourage domestic exploration. A very visible example of this is the magnitude of the increased number of exploratory drillings made after the recent decontrol of domestic oil. Under the current NGPA gas prices are rising by nowhere near what they would be had complete decontrol been implemented immediately. Consequently, although exploration for natural gas has increased with the passage of the NGPA its increase has been small when compared to that for oil.

- Restrict imports of oil and natural gas. This action is highly desirable in order to reduce our dependence on foreign, and possibly unstable, supply sources. A reduction in availability of these supplies will create a demand for alternate fuels.

- Create a mechanism to guard against precipitous price drops of foreign fuels. Potential investors in synthetic fuels plants are apprehensive about the fact that foreign oil and gas exporters can reduce their prices subtantially and still make a good profit. This could be used as a weapon to destroy competition.

- Pass legislation to ease the installation of coal slurry pipelines. This will tend to increase competition among coal transporters and keep shipping costs low.

- Restrict the use of natural gas and petroleum products. While there are already laws supporting this, many exceptions exist, and the federal government is even encouraging increased use of natural gas in some areas.

- Provide economic incentives and reduce financial risk. Many mechanisms are already in place to achieve these goals. These include tax writeoffs (mainly the new depreciation schedules instituted by the new tax laws), purchase agreements and price guarantees, grants, loan guarantees and others offered by the Synthetic Fuels Corporation. It remains for the government to implement them or make them more easily available.

At state and local levels, some of the helpful actions possible are as follows:

- Keep coal severance taxes at a reasonably low level. Some states have set severance taxes at levels high enough to make coal prices almost non-competitive with other fuels.

- Reduce restrictions on land fill or ash disposal sites. Some states and localities restrict siting and transportation to the extent that it is nearly impossible to dispose of coal ash or sludge from wastewater treatment plants.

- Amend regulations, in the case of utilities, to permit easier and quicker recovery of development and construction costs related to synthetic fuels.

Other actions which can be taken at either the federal level or lower levels may include the following:

- Revise environmental laws and regulations to eliminate unnecessary controls and restrictions. Many environmental regulations are based on reduction of pollutants to the maximum extent practicable, even if the pollutant is not definitely known to be harmful to humans, or if the lower harmful limits are not established. Also the definition of what is "practicable" often is not clear. A warning that health risks may exist should be adequate rather than the imposition of high-cost cleanup systems which may not be necessary. Also the owner of the facility should not be exposed to the possibility of retroactive laws or expensive changes to existing installations unless health hazards are clearly established.

- Streamline permitting and approval procedures. Existing procedures can result in delays of plant construction for years. Participation in hearings should be limited and possibilities of nuisance litigation should be eliminated. Time required for action by governing bodies on approvals or permits should be limited and the limitations adhered to.

- Eliminate unnecessary record keeping and reporting requirements. Several recent studies indicate that industry's costs for maintaining government-required records and producing reports are extremely high. Government agency costs for reviewing the reports and administration of the program are also high. The necessity for many of these should be evaluated and the requirements eliminated to help industry reduce its costs.

In summary, it is clear that government bodies can do much to reduce costs and eliminate risks for industries which could produce or utilize synthetic fuels such as low Btu gas.

15.0 CONCLUSIONS AND RECOMMENDATIONS

The primary purpose of this study is to determine if it is prudent for a company now using moderate quantities of natural gas to construct and operate a facility to make low BTU gas from coal. This gas would be used as a substitute fuel. There are three aspects of the study which must be completed in order to make that determination.

- It cannot be expected that a manufacturer such as General Refractories would have the time or capital necessary to develop a process for, or serve as the laboratory for the testing of, new and untried technology for coal gasification. Therefore, a prerequisite for a proposed gasification facility for such an industry must be that the design consider only well proven technology, and readily available equipment. The proposed gasification facility will be expected to be an integral part of the manufacturing process, and provide a fuel supply with the same reliability as is expected of natural gas or fuel oil. The first task of the study is to select the proper technology and equipment.

- Secondly, the fuel gas produced from coal must be compatible with the manufacturing process, and with the equipment used in that process. Many industries confronted with the rising cost of fuel have the option of converting to appliances fired directly with coal. For those industries the conversion cost from gas to coal, including the modifications necessary to meet environmental constraints, must be balanced against the costs of utilizing low BTU gas. In the case of General Refractories, and many other industries, conversion to coal firing is unlikely from a process standpoint, and gasification becomes the only practible way to convert from natural gas to domestic coal. It was necessary, therefore, to determine if the equipment now in use at the Florence plant of GREFCO can be converted from natural gas to coal gas. It was also necessary to identify retrofit procedures and costs.

- Finally, the sole reason for changing fuel from natural gas to "producer" gas is to reduce manufacturing cost. The third task of this study is, therefore, to perform sufficient engineering to identify all processes and the necessary equipment involved in these processes, and then to estimate the capital and operating costs involved in building and operating such a facility. From this cost estimate a projected gas cost is developed and this gas cost will be used to make the final determination of the feasibility of this project. The decision to proceed with the construction of a gasification facility rests with GREFCO, this study will provide the engineering design and cost information necessary to make that decision.

The proposed gasification facility for the Florence plant is based upon Wellman-Galusha technology. The Wellman-Galusha fixed bed, atmospheric gas producer has a highly respectable record of industrial performance using a wide variety of fuels. The first conclusion to be reached in deciding upon applicable technology, is that the Wellman-Galusha gas producer is the best available machine for this type of use, both from the standpoint of operation and installed cost.

The gas cleaning and compression design for this process is also based upon well proven technology, gas scrubbers followed by electrostatic precipitators are widely used to clean gas from coke oven plants, and the gas compressors specified in this preliminary engineering study are typical of those in current use in the same application. It is concluded, therefore, that this equipment is correct for the proposed gasification facility. It is also concluded that retrofit is possible at minimal expense.

Insofar as sulfur cleanup is concerned, the Stretford-Holmes system specified for this design is also in current use in existing plants, notably the LBG gasification system at the Caterpillar factory in York, PA, and operates satisfactorily. The configuration used in this study is not recommended, however. The design for this project was based upon a facility to be built in two stages, the first stage, or phase, using two gasifiers, and the subsequent phase adding three more. For the purposes of this study it was decided that each phase would have it's own sulfur cleanup system. It is the nature of a sulfur removal system of the size needed at Florence that the cost of a small plant is not significantly less than that of a plant having two or three times the throughput. After the cost analysis of the phased sulfur removal system was completed, it was concluded that the preferred approach to this facility would be to build a sulfur removal plant large enough to meet the requirements of the full five gasifier facility. There is little cost savings realized in building the smaller sulfur removal plant as part of the first phase, and it is decidely more expensive to add the additional sulfur cleaning equipment for the second phase than it would have been to construct a five gasifier clean-up system in the first place. Should GREFCO management decide to proceed to the next step in implementation of the proposed gasification facility, it is recommended that serious consideration be given to either constructing a full scale sulfur removal facility in the first place, or preferably, consider the use of low sulfur "compliance" coal for at least the initial installation, and possible for the proposed five gasifier plant. This recommendation is supported by the following cost information extracted from Section 10 of this report, and from back-up estimating documents.

- The sulfur removal equipment for the two gasifier design, including incineration required for the Stretford wastes, is $4.5 million.

- The same equipment required for the added three gasifiers is an additional $3.5 million.

- It is expected that a Stretford system installed for the full five gasifiers would cost less than $6.5 million.

- Based upon this comparison, it is clearly more economical to install a single full capacity Stretford system than it is to install two smaller systems.

The next question, then, is when to install the sulfur removal system. The difference in fuel cost between low sulfur "compliance" coal and high sulfur coal is the most significant determinant in the answer to that question.

The difference in cost between low sulfur compliance coal and high sulfur coal, is $6.00/ton. At an estimated annual usage of 122,472 tons, there is a total annual cost increase of $735,000. However, the interest on the $8 million dollar sulfur removal plant (assumed at 16%) is $1,280,000 almost twice the coal cost increase.

No fuel cost analysis was made on the impact of using low sulfur coal and eliminating the sulfur clean-up equipment, primarily because this consideration is outside the scope of work. However, should GREFCO decide to continue this project, it is recommended that the use of low sulfur coal be given primary attention.

The potential cost implication of constructing coal gasification facility at the Grefco Florence plant is a function of:

Fuel Requirements
Cost of Capital
Deregulation of Natural Gas
Potential for Expansion, and
Competition in the Insulation Board Industry

General Refractories has decided the high cost of capital, only partly, if at all, offset by tax credits and other governmental incentives; uncertainty over direction of long term gas availability and pricing, and market costs of production militate against the investment required at this time. However, the potential advantages of coal gasification for this plant location should and will be periodically reevaluated in light of economic conditions and improving technologies.

16.0 COMMERCIALIZATION PLAN

16.1 Approvals and Appropriations

If General Refractories decides to proceed with the further development of the proposed gasification plant, it ask its board of directors for final approval. If approval is issued and the necessary appropriations are made the succeeding steps in proceeding with a commercialization plan is as follows: 1) an engineering-construction firm will be hired to organize a management and control plan (see 16.2), 2) this firm would then develop a construction schedule (see 16.3), and 3) updated refinements are made to all portions of the commercialization plan including making allowances for any future expansions (see 16.4).

16.2 Management and Control

The success of the commercialization program for the substitution of a low Btu gas as fuel for the board drying operation at GREFCO's Florence, Kentucky, plant depends directly on the ability of the participating organizations to plan, direct and control the work, to monitor progress during all phases, to detect problems and to institute and follow through with corrective action. Only through the implementation of a project management plan designed to achieve these objectives can the completion of the project on schedule and within budgetary limitations be assured.

It is suggested that GREFCO use a management plan consisting of five steps:

Organizing	- Clearly defining project objectives to personnel responsible for the execution of the work.
Planning/Scheduling	- Developing a plan for achieving these objectives and establishing a time frame and budget for the completion of the effort.
Executing	- Implementing the work plan.
Reporting	- Providing information on progress and status of - Construction documents - Equipment and Material - Manpower - Expenditures - Schedule
Controlling	- Taking management action as indicated from reports to control changes and bring actual performance into line with the plan.

The more salient elements of the Project Management Plan are briefly described in the following sections.

16.2.1 Organization

The Program Manager has been vested by the management of General Refractories with the authority for all technical and administrative decisions for the program. He will report monthly to corporate management on progress, expenditures, commitments and other activities related to the project.

For the construction of a plant owned and operated by GREFCO, GREFCO will retain the services of an engineer-constructor with an organization similar to the one shown in Figure 16-1. This organization is structured so that the Project Manager is the single point of contact with the GREFCO Program Manager and has the overall responsibility for the execution of the engineering, procurement and construction effort. He also has the responsibility for the timely flow of information to and from GREFCO and for the establishment and implementation of all plans and procedures.

The Project Manager must provide a clear definition of the project requirements to the engineering, procurement and construction groups. To achieve this, he has the overall responsibility for the preparation of the Design Basis. This document provides:

- A description of the work to be performed as stipulated in the contract.

- A basis for the design, the preparation of engineering documents, cost estimates and reports.

- Basic standards, specifications and data governing the essential elements of the design concept and the quality of the work.

The Design Basis is a dynamic document insofar as it is continually revised throughout the project to reflect the development of updated information, the need for clearer definition or the incorporation of project changes.

At this stage, it is vital that the foundation be laid for the scheduling of the engineering, procurement and construction phases of the work. Accordingly, target devliery dates are developed through a joint effort of engineering, procurement and construction deparatment personnel. The dates are based on familiarity with current market conditions, availability of manufacturers' data and representative delivery times for key and long lead equipment and material. This information is entered into a computerized system dedicated to equipment tracking and serves as an important tool during preparation of the definitive engineering and milestone construction schedule.

16.2.2 Planning/Scheduling

As soon as the scope of work is sufficiently defined, the development of the initial project schedule begins. Initially, available information will permit the preparation of a definitive engineering schedule and only a milestone construction schedule. At this time the initial equipment and document lists are prepared. These are used to customize standard egineering discipline logic diagrams for the project. The integration of these diagrams, the incorporation of constraints unique to the project and the evaluation of impacts caused by critical equipment and material delivery times produce the definitive engineering schedule. From this the milestone construction schedule is prepared, which is the forerunner to the definitive construction schedule. As the engineering department proceeds with the preparation of the construction documents and a better definition of equipment and materal availability is received the progress is thoroughly reviewed by the Construction Management Department. When the information is deemed to be adequate, the relatively few activities in the milestone construction schedule are expanded to form the definitive construction schedule. This scheduling operation occurs prior to actual construction.

The integration of the two definitive schedules into one network produces the project schedule. Through the use of computerized programs, the scheduled activities are identified for each department participating in the project. Periodically, project progress is monitored and changes incorporated in the schedule to reflect the current status.

An important element of scheduling is the forecasting of manpower requirements to permit the timely completion of engineering and construction activities. This involves a two-step process: the initial forecast and the monthly forecast. The purpose of the initial forecast is to develop, as early as possible, the timing for assignment of personnel to the project. For engineering, the initial forecast should be the definitive estimate prepared for the project. In the event that this is unavailable, an estimate based on performances from previous projects of similar size and nature can be used. The initial forecast is subsequently refined as more accurate information is received from the engineering department and the Project Manager. Eventually, the forecast is computerized and becomes the basic control for manning the project and controlling engineering costs.

Initially the construction manpower requiremets are developed from the project cost estimate and the milestone construction schedule. As the definitive construction schedule is developed, labor units are assigned to each activity on a weight percent basis. A monthly field manpower forecast is, developed to reflect current manpower requirements and to reweight various activities to reflect that current status. The definitive construction schedule is then updated to show the progress.

16.2.3 Execution

With the organization of the project and the planning and scheduling completed, the preparation of the construction documents, the procurement of equipment and materials and the construction of the facility becomes the responsibility of the numerous groups comprising the three departments.

The Engineering Department in conjunction with the Project Manager has the responsibility to produce, according to the project plan, drawings, requisitions and specifications which are indispensable to the procurement of equipment and materials and the timely completion of construction.

The authority to purchase the equipment and materials and subcontract portions of the work resides with the Purchasing Department. Representatives of the Purchasing Department are organized so that the project management controls the "what" and "when" of procurement and the Purchasing Department controls the "how".

The Construction Department, through the Site Manager, is responsible for the detail planning and refinements which will be required to translate the basic elements of the construction plan and schedule into a successful construction program. The detailed planning spans engineering activities, procurement activities, vendor performance as well as the normal labor, construction equipment and material availability restraints associated with any project. The construction plan must be flexible and adjustable to capitalize on opportunities presented by favorable progress of the work and to minimize the impact of any adverse situations. The field organization proposed for this project is shown on Figure 16-2.

Whether it be engineering, procurement or construction the Project Manager and his staff monitor the progress of scheduled activities and control the implementation of the plan using the control systems which are an integral part of the Project Management Plan. Output from these project control systems establish when and if segments of any part of the plan must be modified to meet a changed situation. Further, the output provides basic information for the determination of the type and magnitude of the modifications needed.

The extensive experience of the Project Manager is used to identify problem areas in advance and to formulate alternate and contingency plans for corrective action.

A definitive cost estimate, which is fundamental to cost control, be developed from engineering and procurement data. It is important that both the estimated costs and the actual costs be identified by account numbers. For example, each item of major process equipment should be assigned a specific number so that the budgeted dollars can be compared with the expended dollars to determine variancies. Similarly, labor for installation should be identifiable to permit comparison and to facilitate trend detection.

16.2.4 Reporting and Control

Once the project is underway, it is essential that a feedback mechanism be initiated to provide the Project Manager with the information necessary for project control. This mechanism involves accurate and timely reports in key areas such as manning levels, expenditures, status of equipment, material procurement, progress of engineering or construction, and cost. The project control system will consist of a set of computer programs with techniques for utilizing them effectively.

An important element of the scheduling function is the development of the manpower forecast. In order to exercise control during the process of the work, it is essential that the reporting system permit analysis of manning levels to provide comparison, early trend detection and the initiation of remedial action. The system established for this project will provide such information weekly. Progress of work will be monitored and reported and the percentage completion determined through the use of a data management computerized system. Once a need is established, the status of drawings, specifications, and requisitions are pinpointed by means of a computerized document tracking system. The Material and Document Status System contains two subsystems - Material Status System (MSS) and Document Status System (DSS). The MSS tracks the status of requisitions for major equipment items and materials, the DSS follows the development of drawings and specifications. The major difference between the two subsystems is that items in the MSS are used for subsequent purchase while items, in the DSS are not. The procedure of tracking each item is the same and the system can provide both a detailed analysis of individual items or an overview of the project by discipline, class of item, etc. Both systems are status oriented. That is, each entry has a current STATUS which indicates what is happening to it: for example, a drawing will go through preparation, checking and approval. The system follows each document as it progresses from the identification of need to the point of its final issue. Not only is MSS/DSS used for reporting progress, but it also provides an internal expediting. Updated information appears in daily Action Reports, which list for each discipline all items which are overdue or which have been transferred from one discipline to another. The report describes:

What is being done to the item

Who is currently responsible

When the operation started

When the operation is to be completed

The contributions of this system toward project control are numerous, the most noteworthy being that the Project Manager is aware of any postponement of a planned activity within twenty-four hours of its occurrence, indicating at the earliest date the possible need for action.

In addition to providing specific data on the status of document preparation, the MSS/DSS system also computes the percentage of completion for engineering work. These and other features of the MSS/DSS system make it an invaluable project control tool.

Field data on construction activities and field material receipts are gathered at the site and forwarded to the office for a monthly update of the schedule and determination of the earned credit for the month. Construction progress is obtained from the labor units assigned to each activity on a weight percent basis and the percent complete for the activity.

Regardless of the reports generated and the parameters used to measure progress, the primary consideration is the current cost plus the estimated cost for completion. For this project computers will be used to provide the Project Manager with cost reports. Cost data are accumulated during the month and stored in the computer. At the end of the month, the computer produces the Cost Ledger Detail, which is a cumulative report of all costs incurred to date on the project. For internal cost control the Cost Ledger Detail is summarized on a Contract Status Report. Included on this report are the estimated costs for the various accounts and the final indicated cost (the current cost plus the cost estimated for completion). The final cost estimate is prepared by the Project Manager, the Site Manager and the Cost Engineer after a review of the status of the project and any unusual considerations.

Although the foregoing does not include all of the facets of the Project Management Plan, it does provide an insight into the numerous programs and procedures which comprise the overall approach. It is only through the intelligent application of such a plan that the "on time" and "within budget" completion of a quality facility can be assured.

16.3 Construction Schedule

General Refractories will obtain the services of an Engineer-Constructor for the engineering, procurement of equipment and materials and the construction of the coal gasification plant for the production of a low Btu gas at its Florence, Kentucky plant. The preliminary construction schedule, which is shown in Figure 16-3, indicates that a period of eighteen and a half months will be required for the construction. Allowing five and a half months lead time for engineering gives a twenty-four hour month overall time table.

The anticipated durations and sequencing of activities have been derived from considerations of the plant layout, which are shown on drawings in Volume II, and the estimated manhours of craft labor developed for the plant cost estimate. Durations are based on a normal forty hour work week with single shift operation.

It is expected that most of the construction work will be done by construction personnel who will be directly hired from the union hall by the Engineer-Constructor. Certain elements, however, will be subcontracted and these are indicated by a (SUB) which appears opposite the construction activity in the left hand column of Figure 16-3.

16.4 Future Expansion

The conceptual design of the plant is based on a phased approach to construction. In the event that General Refractories decides that the high gas cost from a two gasifier installation is acceptable, the initial facility will consist of the two-gasifiers with provisions for expansion. Subsequently, as the demand for low Btu gas grows, the production capability of the plant can be increased by the installation of three additional gasifiers. There are currently no plans to design the plant for any expansion beyond the five gasifier installation.

GREFCO, INC.
LOW BTU COAL GASIFICATION
FLORENCE, KY.
CPD-2994

PROJECT ORGANIZATION CHART

Dravo Engineers
and Constructors

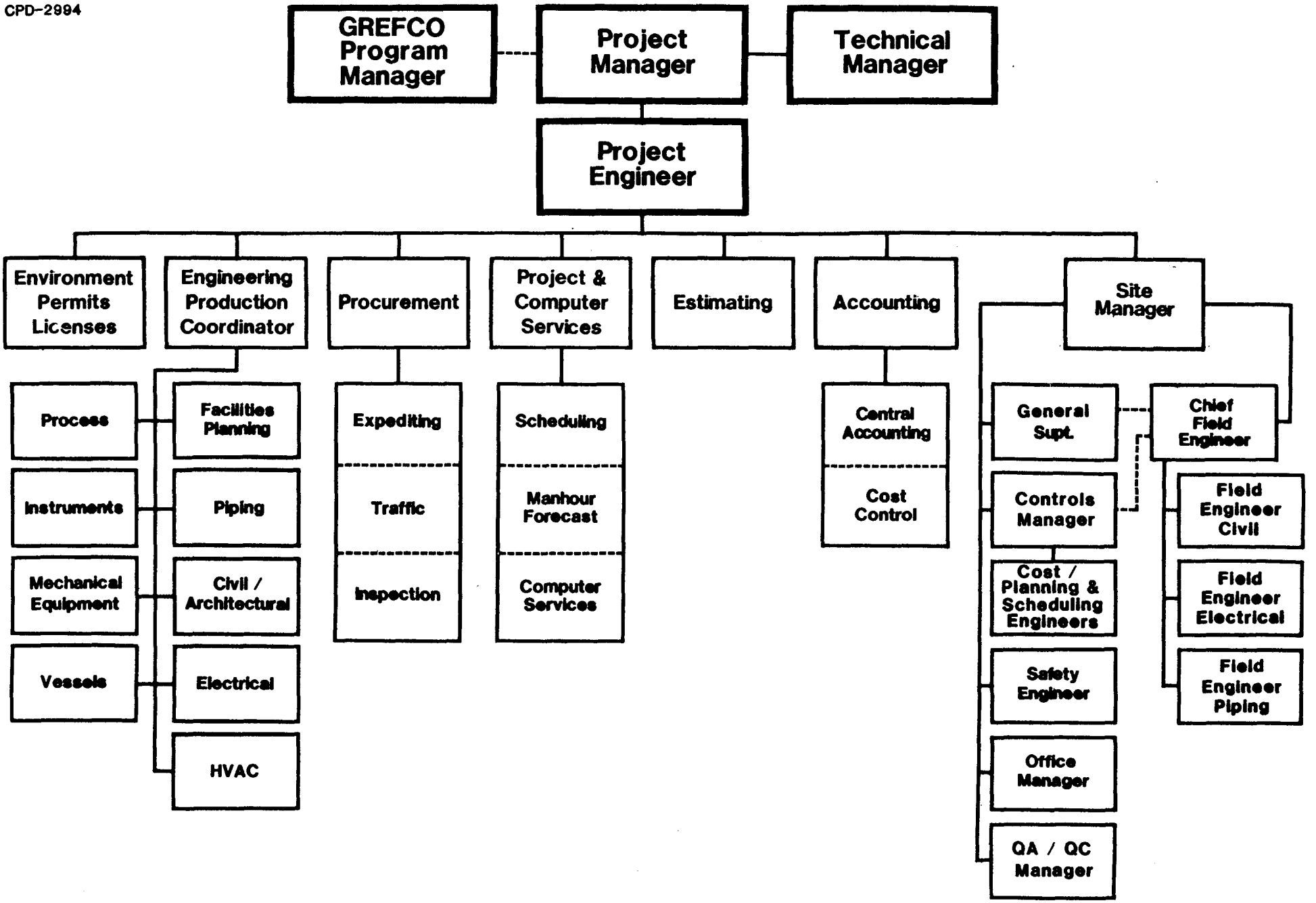


Figure 16-1

GREFCO, INC.
LOW BTU COAL GASIFICATION
FLORENCE, KY.
CPD-2994

FIELD ORGANIZATION CHART

Dravo Engineers
and Constructors

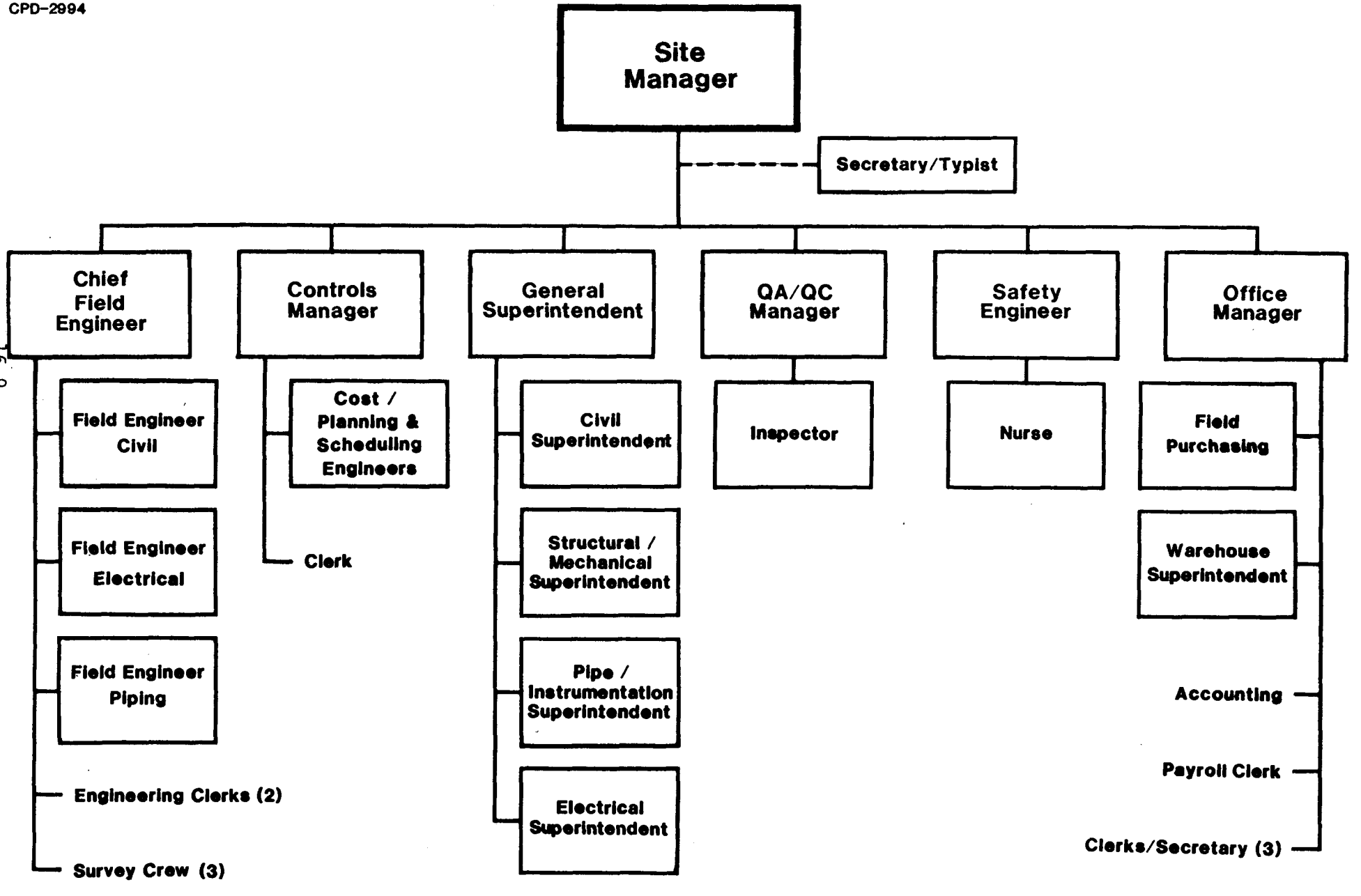


Figure 16-2

GREFCO, INC.
LOW BTU COAL GASIFICATION
FLORENCE, KENTUCKY
CPD-2994

ENGINEERING & CONSTRUCTION SCHEDULE

Dravo Engineers and Constructors

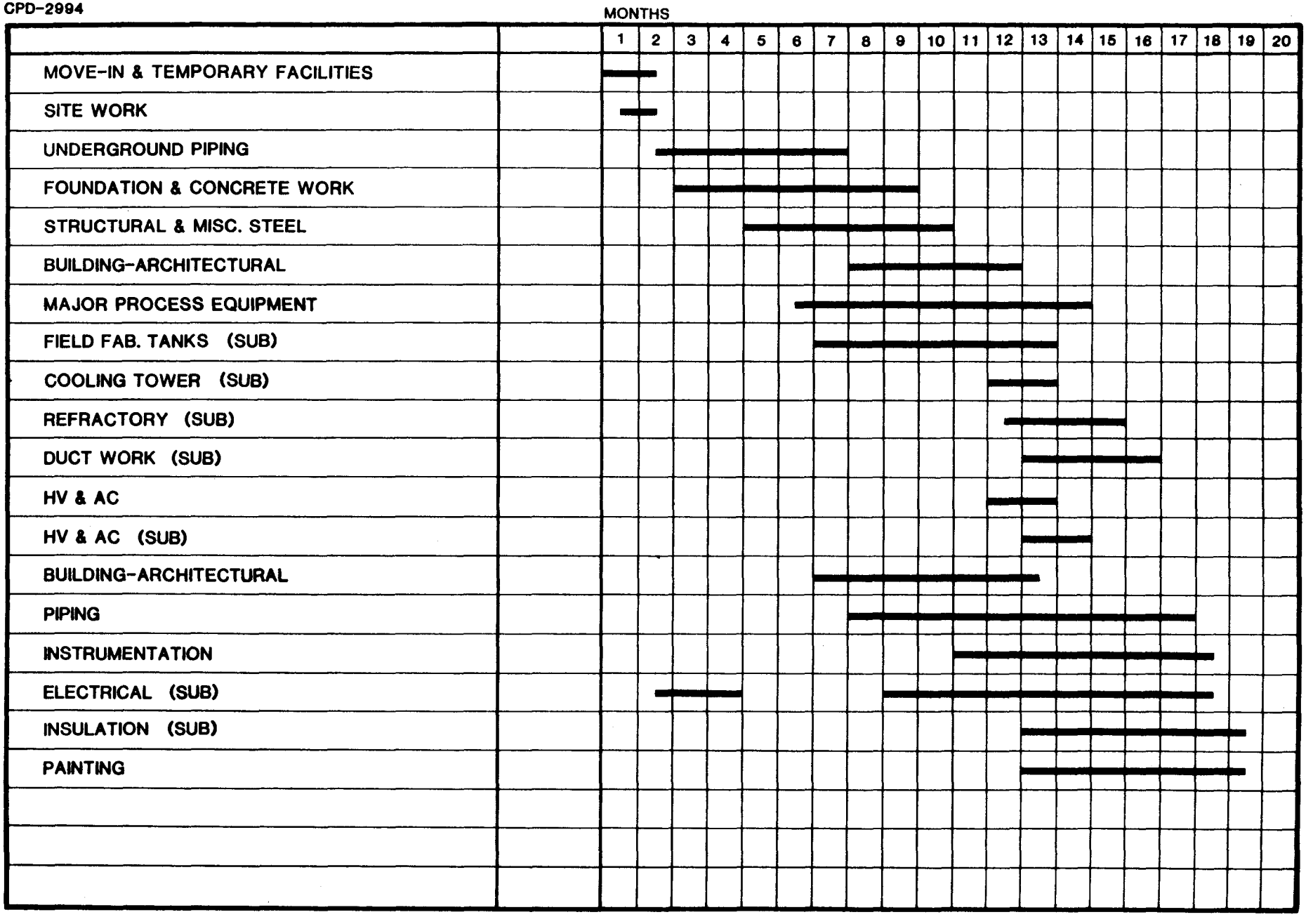


FIGURE 16-3