Preliminary Design Study for an Integrated Coal Gasification Combined Cycle Power Plant

EPRI

MASTER

EPRI AF-880
Project 986-4
Final Report
August 1978

Keywords:
Coal Gasification
Demonstration Plant Design
Combined Cycle Power Generation
Texaco Coal Gasification

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ELECTRIC POWER RESEARCH INSTITUTE

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ABSTRACT

This report presents the preliminary design, implementation schedules, and cost data for a fully integrated coal gasification/combined cycle power plant using the oxygen-blown Texaco Coal Gasification Process. The plant will have a net electrical output of 92 MW, and will be located at Southern California Edison Company's Coolwater Generating Station near Barstow, California.

Three approaches for implementation of the plant were investigated: (1) Proceed initially with construction of the fully integrated plant; (2) proceed initially with construction of the coal gasification facility coupled to a new combustion turbine-generator only; and (3) proceed initially with construction of the coal gasification facility only, with the product gas fired in an existing boiler. In the latter two cases, the additional power-generation equipment required to complete the combined cycle would be added after a one-year testing program in the initial configuration. Cost estimates and schedules are presented for each of these three approaches to implementation.

The report includes general arrangement drawings and complete performance and emissions data for the plant. Process flow diagrams, equipment lists, and system descriptions are presented for major systems in the plant.

EPRI PERSPECTIVE

PROJECT DESCRIPTION

This final report, Preliminary Design Study for an Integrated Coal Gasification Combined Cycle Power Plant, presents preliminary design configurations, cost estimates and project schedules for the construction of an integrated coal gasification combined cycle power plant to be located at Southern California Edison Company's Coolwater Generating Station near Barstow, California. The plant would have a net electrical output of 92 MW based on use of the oxygen blown Texaco Coal Gasification Process to produce clean intermediate Btu fuel gas for firing in a commercially available frame size combustion turbine.

This study is an extension of an earlier study performed by the Ralph M. Parsons Company for Southern California Edison as part of SCE's coal gasification development program.* The objective of the earlier study was to develop preliminary design, engineering and construction schedules, and a cost estimate for a free standing coal gasification plant and associated raw gas cleanup systems. The product gas was to be used to fire an existing boiler and an existing combustion turbine at SCE's Coolwater Generating Station during a three-year test program for the purpose of providing a technical basis for design of future integrated coal gasification/power plants.

PROJECT OBJECTIVES

The objective of the present study was to develop preliminary designs, engineering and construction schedules, and cost estimates for three different approaches to integrating the coal gasification plant developed in the previous study with a new combined cycle power plant at SCE's Coolwater Generating Station. These three approaches have been designated Cases I, II, and III and are defined as follows: Case I, proceed initially with construction of the fully integrated plant; Case II, proceed initially with construction of the coal gasification facility coupled to a new combustion turbine-generator only; and Case III, proceed initially with construction of the coal gasification facility only, with the product gas fired in an existing boiler. In the latter two cases, the additional power-generation equipment required to complete the combined cycle would be added after a one-year testing program in the initial configuration.

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*"Coal Gasification to Replace Oil - Feasibility Study - A Demonstration Project Using the Texaco Gasification Process at Coolwater Generating Station," Final Report, November 1977. This report contains data proprietary to Texaco, Inc., the Southern California Edison Company and the Ralph M. Parsons Company. Therefore availability of the report is restricted.

CONCLUSIONS AND RECOMMENDATIONS

The final integrated gasification combined cycle power plant representative of all three cases above would feed approximately 1000 tons/day of coal to the Texaco gasifier and would generate a net power output of 92.4 MW at a net plant heat rate of 11,060 Btu/kWh.

Costs for the three cases, in April 1978 dollars escalated in accordance with the project schedules, are:

- Case I $233,980,000
- Case II $258,710,000
- Case III $266,680,000

The overall coal to busbar heat rate determined from this study of 11,060 Btu/kWh is considerably higher than the heat rates predicted in other EPRI conceptual design studies for similar plants, e.g., EPRI Report AF-753, Economics of Texaco Gasification Combined Cycle Systems. The major reasons for these differences are:

- The previous design studies were based on advanced combustion turbine machinery having combustor outlet temperatures of 2400°F. This present study was based on state-of-the-art temperatures of approximately 2000°F.
- The other EPRI studies were based on large plants having capacities of approximately 1000 MW. Such large plants can accommodate large and efficient reheat steam turbines as well as fuel gas expansion turbines for additional power recovery. The relatively small plant (92 MW) designed for this study utilizes smaller, less efficient non-reheat steam turbines and does not warrant the use of fuel gas expansion equipment.

It is recommended by Parsons that the following items be investigated further prior to establishing the final design configuration for the plant:

- Superheating of steam in the gasification plant syngas coolers.
- A comparative evaluation of the Rectisol and Benfield sulfur removal processes with the SELEXOL process.
- The use of cooling tower blowdown and/or gasification process effluent for coal slurrying.

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SUMMARY

This study was performed to develop a preliminary design, implementation schedules, and cost data for a fully integrated coal gasification/combined cycle power plant using the Texaco Coal Gasification Process. The plant will be operated over a three-year testing program to demonstrate the feasibility of using coal gasification for power generation on a commercial scale. Table S-1 lists the preliminary performance data for the proposed plant based upon the results of the study.

The plant will be located at Southern California Edison Company's Coolwater Generating Station near Barstow, California. The Coolwater site offers a number of unique advantages for locating such a plant. Among these are the availability of conventional boilers that can be fired with the product gas during the demonstration program, adequate space for the plant, available coal transportation facilities, and adequate water supplies within the site area.

The plant design is based on low-sulfur western coal feed; however, the effect of high-sulfur coal feed was also investigated.

Three approaches - designated Cases I, II, and III - for implementation of the fully integrated plant were evaluated in the study:

Case I - Proceed initially with construction of a fully integrated coal gasification/combined cycle power plant.

Case II - Proceed initially with a coal gasification plant coupled to a new, simple cycle gas turbine only. After a one-year program of testing the coal gasification/gas turbine plant, the heat recovery steam generator, the steam turbine-generator, and other equipment required for a fully integrated plant would be released for manufacturing if the results of the initial test program and other circumstances at the time justified further development of the plant. The new equipment would be integrated with the existing plant, with the end result being a plant nearly identical to the Case I plant.

Table S-1

OVERALL PLANT PERFORMANCE
(based on Kaiparowits coal)

Coal In	83,500 lb/hr (dry basis)
Coal Heating Value	12,241 Btu/lb (HHV - dry basis)
Water In (Makeup)	1393 gpm
Heat In Coal	1022.1 x 10^6 Btu/hr
Clean Fuel Gas Produced	145,000 lb/hr (dry basis)
Heat in Clean Fuel Gas	757 x 10^6 Btu/hr (HHV - dry basis)
Total High-Pressure Steam Produced	385,940 lb/hr at 1175 psig and 952°F
Total Medium-Pressure Steam Produced	36,750 lb/hr at 150 psig saturated
Total Low-Pressure Steam Produced	22,360 lb/hr at 50 psig saturated
Gross Power Generated	100,700 kW
Electrical Auxiliary Power Consumed	8,295 kW
Net Power Generated	92,405 kW
Net Plant Heat Rate	11,060 Btu/kWh
Overall Net Plant Efficiency (Coal-to-Busbar)	30.9%

Plant performance is based on the following:

- Coolwater site elevation of 2,000 ft
- 80°F ambient air
- Effect of water injection for NO_x control on gas turbine performance was not taken into account
- No cooling of gas turbine intake air
- No supplementary firing in the heat recovery steam generator

Case III - Proceed initially with installation of a coal-gasification plant only. After one year of testing the gasification plant by firing the product gas in the existing Unit 1 boiler, the power-generation equipment and other equipment required for a fully integrated coal gasification/combined cycle power plant would be released for manufacturing (again assuming that the results of the initial testing program and other circumstances at the time justified further development of the plant). As in Case II, the additional equipment would be fully integrated into the plant, with the end result being a plant nearly identical to the Case I plant.

System descriptions, process flow diagrams, and equipment lists for the major systems are included in Section 3. The plant consists of the following major systems:

- Coal storage and transfer facilities for receipt and transfer of coal delivered to the site by rail.
- A coal grinding and slurrying system for preparing and transferring coal slurry to the gasifier.
- An air-separation plant for production of oxygen for the gasification process.
- A Texaco Coal Gasification Process unit consisting of an entrained bed gasifier and gas-cooling and particulate-cleaning stages.
- A sulfur-removal system for removing H_2S and COS from the raw gas product.
- A sulfur-recovery system for converting the H_2S and COS to elemental sulfur.
- A combined cycle power generation plant consisting of a combustion turbine-generator fired with the clean product gas, a heat recovery steam generator for generating steam from the turbine exhaust gas, and a steam turbine-generator.
- Water treatment systems for providing condensate and cooling water makeup and for treating effluents from the gasification process.
- A flare system to dispose of excess clean gas generation during startup or abrupt demand changes.
- A plant cooling water system that rejects heat to a mechanical-draft cooling tower.

The plant will use the oxygen-blown Texaco Coal Gasification Process to produce a medium Btu gas having a higher heating value of approximately 283 Btu per standard cubic foot. (This compares with a heating value of approximately 1,000 Btu per standard cubic foot for natural gas.) The plant will be designed to produce clean gas at a rate of about 145,000 lb per hour, which is the rate required to fire the combustion turbine at its base-load rating and for fired heaters in the sulfur plant. This rate of gas production will require coal feed at a rate of approximately 1,000 tons per day.

The oxygen-blown Texaco Coal Gasification Process consists of reacting a coal-water slurry with oxygen in a refractory-lined chamber to produce a gas consisting mainly of CO, H_2, and CO_2. The ash in the coal is melted into a slag during the gasification process. This slag is water-quenched and withdrawn through a lock hopper as gravel-like particles for disposal. The gas stream is initially cooled by recycling cooled gas into the hot gas stream. The gas is cooled further in shell-and-tube-type gas coolers (syngas coolers) by producing 1,200 psig saturated steam, which, after superheating to 950°F, is used to drive the turbine-driven oxygen plant compressors and for other process-steam uses in the plant. In this manner, most of the full heating value of the coal feed is recovered and used. After cooling, the gas passes through further particulate-removal stages. Sulfur is removed and recovered in a SELEXOL-type sulfur-removal system, which removes H_2S and COS from the raw gas stream; and a Claus-type sulfur-recovery system, with a Beavon-type tail gas treating unit, which converts the bulk of the H_2S removed by the SELEXOL system to elemental sulfur.

The steam, condensate, and feedwater systems for the plant in its final Case I configuration are fully integrated to maximize plant efficiency and minimize capital cost. The syngas coolers produce saturated steam, which is superheated in the heat recovery steam generator (HRSG). A portion of the steam produced in the gas-cooling process and the HRSG is used for driving the oxygen plant compressors and for process requirements within the plant. All of the remaining steam is used to generate power through the steam turbine-generator.

An auxiliary steam supply system - consisting of an auxiliary boiler and a fired superheater - will be required for the initial phases of the Case II and Case III approaches to implementation of the plant. The auxiliary boiler is required to supplement the steam produced by the gasification process and the superheater is required for superheating the saturated steam produced by the gasification process for use in driving the oxygen plant compressor turbine drivers.

A listing of emissions and waste products is given in Section 5. The plant is expected to meet or exceed all present environmental regulations. The design incorporates a very high level of sulfur removal and recovery from the raw product gas. Of the sulfur in low-sulfur coal feed containing 0.7% sulfur by weight, 97% is recovered as elemental sulfur, leaving only 3% emitted to the atmosphere from all sources in the plant. This 3% consists of approximately 34 lb/hr of SO_x and 1.5 lb/hr of H_2S and COS. This sulfur emission level is equivalent to that which would result from firing the combustion turbine with fuel oil containing approximately 0.05% by weight sulfur to produce an equivalent generator output.

Sulfur emissions resulting from coal feed containing 3.5% by weight of sulfur, using basically the same sulfur-removal and -recovery units designed for the 0.7% coal feed, were also investigated. This was done for the purpose of determining the effect of using the plant for short periods of demonstration with high-sulfur coal. In this case, approximately 97% of the sulfur is also removed from the raw gas stream. However, sulfur emissions from all sources in the plant are about 380 lb/hr of SO_x which corresponds to approximately 7% of the sulfur contained in the coal feed. Much of the increase over that for the 0.7% coal results from bypassing the Beavon tail gas treating unit, which is not designed for continuous operation with coals containing more than 0.7% sulfur in accordance with the design criteria established for the study. In this case, total sulfur emissions are equivalent to that which would result from firing the combustion turbine with fuel oil containing about 0.5% sulfur by weight. No technological barrier exists to designing the tail gas treating unit for recovery of sulfur in the tail gas to a level equivalent to that for the 0.7% sulfur coal case. This would reduce total emissions from 3.5% sulfur coal to approximately 150 lb/hr of SO_x - less than 3% of the sulfur in the coal feed.

The results of this study indicate that high levels of sulfur removal and recovery for power plants utilizing coal gasification can be accomplished, at reasonable costs, with technology that has been proven in commercial service. This is significant when compared to the technological progress achieved in flue-gas desulfurization associated with direct-coal firing, and provides a primary incentive for proceeding with the development of coal gasification for power generation.

Figure S-1 shows the summary schedules for the three approaches to implementation of the plant that were evaluated in the study. As can be seen, the Case II and Case III approaches result in implementation of the fully integrated plant approximately 3-1/2 years later than the Case I approach. Detailed schedules for each of the cases are included in Section 6.

Table S-2 is a summary of the estimated total plant costs for each of the cases evaluated. These cost figures include all costs associated with design, construction, and startup of a grassroots plant, with the exception of land acquisition and transmission facilities. The plant will be constructed on land presently owned by the Southern California Edison Company, and transmission facilities from the site are already in place. All costs are April 1, 1978 costs escalated in accordance with the schedules shown in Figure S-1 and include appropriate contingency factors. Detailed cost summaries for each case and the basis for these estimates are given in Section 7.

Table S-2

PLANT COST SUMMARY
(All costs in $000's)

Case I	233,980
Case II	
Initial Phase	205,600
Add-on Phase	53,110
Total Case II Cost	258,710
Case III	
Initial Phase	173,190
Add-on Phase	93,680
Total Case III Cost	266,680

As can be seen from Table S-2, the total cost for Cases II and III is somewhat higher than for Case I. This is primarily because of additional escalation and the additional equipment required forthe initial phases of Cases II and III. However, the initial financial commitment required for the Case II and III approaches is significantly less than that for the Case I approach.

The overall coal-to-busbar efficiency (30.9%) is somewhat lower than that which was expected on the basis of several other recent conceptual design studies for similar plants. Several reasons for this can be identified:

- Most previous studies have assumed combustion turbine first-stage inlet temperatures of 2,400 to 3,000°F, as compared with the present state-of-the art firing temperature of approximately 2,000°F assumed herein.
- Other studies have not gone as far into identification of auxiliary electrical loads and steam requirements as this study.
- Most previous studies were based on considerably larger plants than the one contemplated herein.

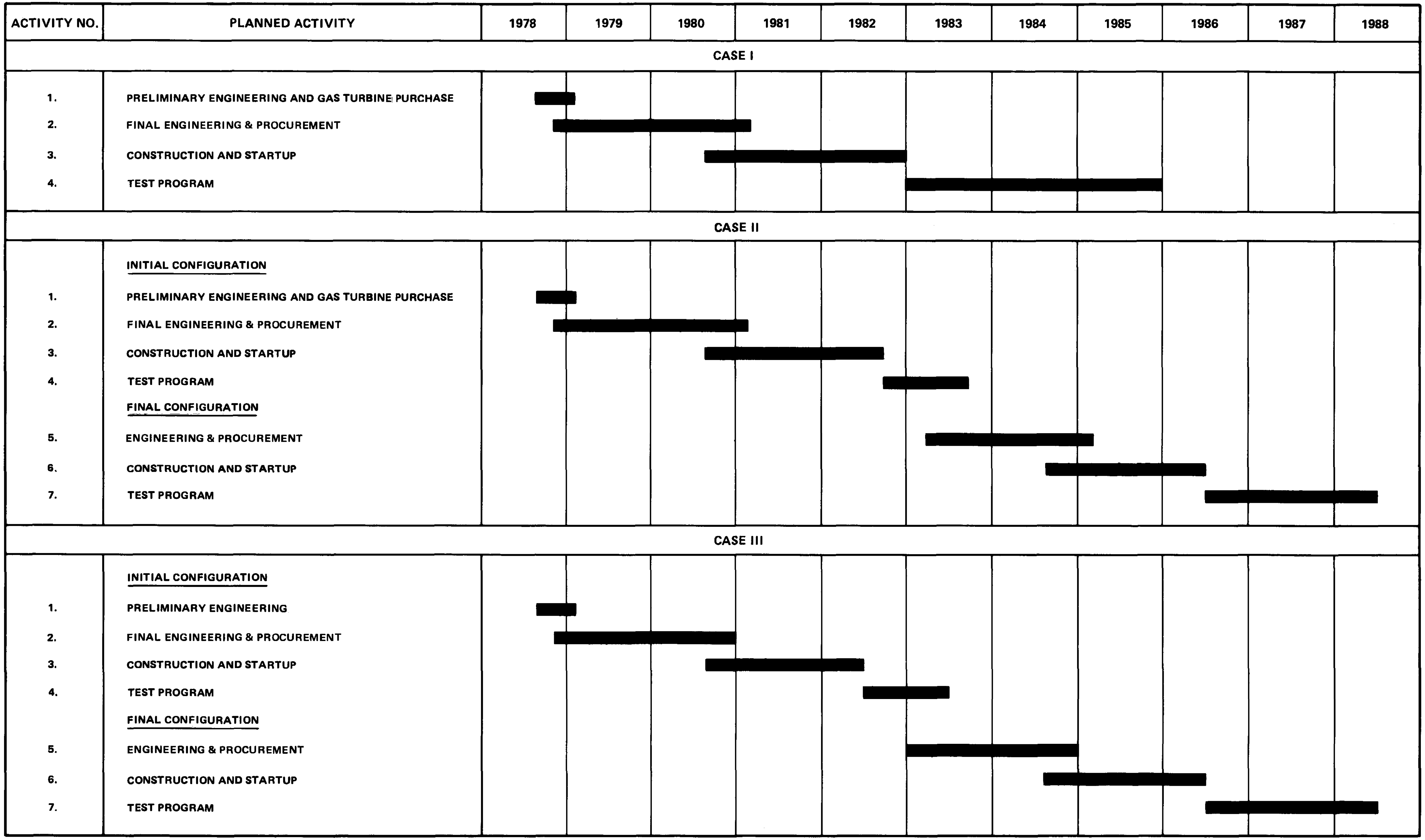

Figure S-1 - Summary Schedule - Cases I, II and III

- This study is based on site conditions (2,000 ft. elevation and 80°F ambient temperature) that penalize the plant performance due to derating of the combustion turbine.

With regard to the first item, it is well known that increases in combustion turbine first-stage firing temperatures can result in rather dramatic increases in combined cycle plant efficiencies. Much work is presently being done toward development of commerical gas turbines using higher inlet temperatures and such turbines are expected to be commercially available within the next 5 years. Turbine-firing temperatures, however, are not directly related to demonstrating the technical feasibility of an integrated coal gasification combined cycle power plant. If such a plant can be successfully demonstrated using present-day turbine technology, later addition of advanced combustion turbine technology to such plants will be a relatively simple matter. Therefore, presently available firing temperatures were assumed for the purposes of this study in order to minimize the impact of the combustion turbine as a limiting factor on the successful implementation and operation of the demonstration plant.

With regard to auxiliary electrical loads and steam requirements, the sulfur removal efficiency of 97% used for this study is of particular significance. The electrical and steam requirements for the sulfur removal and recovery systems are equivalent to approximately 4,000 kW or nearly 5% of 92 MW net power generation output. This power and steam consumption is more than twice that required for a 90% sulfur removal efficiency.

The relatively small size of the plant (92 MW) as compared with 1,000 MW plus plants which have been assumed in most previous studies penalizes overall efficiency in several ways. First, the individual equipment components -- the steam turbines in particular -- are less efficient due to their smaller size. In addition, there are several features which can be included in larger plants for improvement of thermal efficiency that are not practical for a small demonstration plant. These features include a reheat steam cycle for improving the thermal efficiency of the steam bottoming cycle and a gas expander-generator for using the energy available from reducing the gas pressure between the outlet of the gasifier and the inlet to the combustion turbine.

Although, due to its relatively small size, the plant described herein does not represent an optimum design from the standpoint of overall thermal efficiency, it does include all of the essential features required for assessment of the technical feasibility of integrated coal gasification/combined cycle power plants and for predicting the performance of future fully optimized large scale commercial plants.

There are several areas which should be investigated further prior to establishing the final design configuration of the plant. One important area is the steam-generation temperature in the gasifier syngas coolers. This study assumes generation of saturated steam in the syngas coolers in accordance with the state of development of the Texaco Coal Gasification Process at the time the study was conducted. At the time of completion of the study, Texaco was working on the development of incorporating superheated steam generation into the syngas coolers. This should be pursued and incorporated into the plant, as it will simplify the steam cycle and result in an increase in overall plant efficiency.

Another important area that should be investigated further is the selection of the sulfur-removal process. The SELEXOL process was selected for this study on the basis that it was used in a prior study in which the sulfur-removal requirements were considerably less severe. Witn the higher sulfur-removal criteria used in the present study, there may be more economical processes that could be used. These include the Rectisol Process and the Benfield Hi Pure System. Parametric studies should be conducted to determine the best process to be used in the final design of the plant.

Still another area that deserves attention is investigation of the possibility of using cooling tower blowdown and/or gasification process effluent for coal slurrying. This could result in a savings in makeup water requirements as well as a reduction in evaporative pond area required for effluent disposal.

Section 1

INTRODUCTION

The Electric Power Research Institute (EPRI) and the Southern California Edison Company (SCE) have long recognized the need for developing new technologies to provide future generating resources to meet public demand for electric power. Much of the work sponsored by EPRI in recent years has been directed toward this end.

Over the past several years, SCE has also conducted independent investigations of several alternative methods for generating electric power using advanced technologies. In view of the extremely large reserve of low sulfur coal in the Western United States, an important part of SCE's investigative effort has been directed toward utilizing coal in California. Coal gasification has been given special attention because of its potential for meeting very stringent air quality requirements.

The study reported here is an extension of an earlier study (Phase I) performed by the Ralph M. Parsons Company for SCE as part of SCE's coal gasification development program.* It was the objective of the earlier study to develop preliminary design, engineering and construction schedules, and a cost estimate for a free standing coal gasification plant and associated raw gas cleanup systems. The product gas was to be used to fire an existing boiler and an existing combustion turbine at SCE's Coolwater Generating Station during a three-year test program for the purpose of providing a technical basis for design of future integrated coal gasification/power plants.

It was the objective of the present EPRI-sponsored study (Phase II) to develop preliminary designs, engineering and construction schedules, and cost estimates for three different approaches to integrating the coal gasification plant developed in the previous study with a new combined cycle power plant at SCE's Coolwater Generating Station. These three approaches have been designated Cases I, II and III and are defined as follows:

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*"Coal Gasification to Replace Oil - Feasibility Study - A Demonstration Project Using the Texaco Gasification Process at Coolwater Generating Station" Final Report, November 1977. This report contains data proprietary to Texaco, Inc., the Southern California Edison Company and the Ralph M. Parsons Company. Therefore availability of the report is restricted.

Case I - Proceed initially with construction of a fully integrated coal gasification/combined cycle power plant.

Case II - Proceed initially with a coal gasifiation plant coupled to a new simple cycle gas turbine only. After a one-year testing program on the coal gasification/gas turbine plant, the heat recovery steam generator, steam turbine generator and other equipment required for a fully integrated plant would be released for manufacturing if the results of the initial test program and other circumstances at the time justify further development of the plant. The new equipment would be integrated with the existing plant with the end result being a plant nearly identical to the Case I plant.

Case III - Proceed initially with only installation of a coal gasification plant. After one-year of testing the gasification plant by firing the product gas in the existing Unit 1 boiler, the power generation equipment and other equipment required for a fully integrated coal gasification/combined cycle power plant would be released for manufacturing - again assuming that the results of the initial testing program and other circumstances at the time justify further development of the plant. As in Case II the additional equipment would be fully integrated into the plant with the end result being a plant nearly identical to the Case I plant.

It was a further objective of this study to provide a basis for a decision among the participants in the Coolwater Coal Gasification Demonstration Plant regarding which of these approaches should be taken in implementation of the plant.

Whatever the final approach to implementation of the plant it is intended that the plant be used for a demonstration and testing program covering approximately three years, including the one-year initial testing program in Cases II and III. It will be the primary objective of the test program to demonstrate the feasibility of using coal gasification for power generation on a commercial scale. The test program will include evaluation of process designs, operation and control of the plant, hardware designs, thermal efficiency, and emissions and effluent levels, as well as an assessment of operating and maintenance costs.

Section 2

DESIGN CRITERIA

The plant design described herein is based on the following criteria provided by the Southern California Edison Company and the Electric Power Research Institute.

PLANT SITE

The Plant will be located at the Southern California Edison Company Coolwater Generating Station which is about 12 miles east of Barstow, California. Site conditions are as follows:

- Elevation: 2,000 ft. above sea level
- Ambient temperature conditions: 10 to 120°F

PLANT SIZE

The plant size shall be based on full load operation of one General Electric Frame 7 combustion turbine unit, in a combined cycle mode, without supplementary firing during full load operation.

COAL FEED

The coal feed to be used for basic process design and performance calculations shall be low-sulfur western coal from the Kaiparowits field in the State of Utah having the following properties:

Proximate Analysis, Wt.% - as received	
Moisture	8.80
Ash	7.48*
Volatile Matter	39.21
Fixed Carbon	44.51
	100.00

* To account for variations in coal feed, the plant is designed to handle coal with up to 14 percent ash

Ultimate Analysis, Wt.% - dry basis

Carbon	71.24
Hydrogen	4.97
Nitrogen	0.95
Chlorine	0.02
Sulfur	0.46**
Ash	8.20*
Oxygen (by difference)	14.16
	100.00

Heating Values

As received: 11,163 Btu/lb.
Dry basis: 12,241 Btu/lb.

Other Properties

2-inch top size
1.37 sp. gr.
46.5 Hardgrove index

* To account for variations in coal feed, the plant is designed to handle coal with up to 14 percent ash.
**The plant is designed to handle coal with higher sulfur contents, as described under the criteria for the sulfur removal and recovery systems.

GASIFICATION PROCESS

The oxygen-blown Texaco Coal Gasification Process as developed by the Texaco Development Corporation is to be used. The gasifier effluent water treatment process developed by Texaco for their gasification process is also to be used. All systems interfacing with the gasification process shall be compatible with the gasification process design provided by Texaco. A coal-water slurry concentration of 61% is to be assumed for purposes of the study.

SULFUR REMOVAL AND RECOVERY

A SELEXOL sulfur removal system shall be used for sulfur removal. SELEXOL is a proprietary process of the Allied Chemical Corporation for selective gas purification.

The sulfur removal and recovery systems shall be designed to recover 97% of the sulfur contained in coal feed containing 0.7 percent by weight sulfur. (Three percent or less of the sulfur contained in the coal to be emitted to the atmosphere from all sources in the plant.)

The sulfur removal and recovery systems shall also be designed to process the raw gas product from coal containing up to 3.5 percent sulfur by weight. However, no specific criteria for total sulfur removal shall apply to coals containing greater than 0.7 percent sulfur by weight. Total sulfur removal for coals containing greater than 0.7 percent sulfur shall be that which results from the basic design of the system for 97 percent removal for coals containing 0.7 percent sulfur. It is expected that western low-sulfur coal, containing 0.7 percent sulfur or less, will be used most of the time during the demonstration program and exclusively during any subsequent commercial operation of the plant. It is assumed that somewhat higher sulfur emission levels than the level resulting from the basic criteria for 0.7 percent sulfur coal can be tolerated, during short periods of operation, with high-sulfur coals during the demonstration program. However, there is no technological barrier to designing systems for recovering an equivalent percentage of sulfur from high-sulfur coals.

MAKEUP WATER SUPPLY

All makeup water shall be supplied from water wells at the plant site. Water analysis is as follows:

Substance	ppm
Calcium (as $CaCO_3$)	310
Magnesium	80
Sodium	180
Bicarbonate alkalinity	250
Sulfate	193
Chloride	127
Total TDS (Sum of ions)	837
Silica (as SiO_2)	35

EQUIPMENT

State-of-the-art equipment is to be used throughout the plant. Equipment and system designs which have been demonstrated in similar commercial applications shall be used whenever possible.

Section 3

PLANT DESCRIPTION

This section presents a description of the plant. A general description of the plant is followed by detailed system descriptions, process flow diagrams and equipment lists for each major system in the plant. A description of the startup and operation of the plant is also included.

3.1 GENERAL DESCRIPTION

The Coolwater Coal Gasification Demonstration Plant will be located at the Southern California Edison Company Coolwater Generating Station which is located at Daggett, California, approximately 12 miles east of Barstow in the Mojave Desert. The overall site consists of about 2,700 acres owned by SCE.

The Coolwater Generating Station presently contains four generating units. Units 1 and 2 are oil-fired steam units, which were started up in 1961 and 1964, respectively. Unit 1 is rated at 65 MW and Unit 2 is rated at 81 MW. Units 3 and 4 are combined cycle generating units, with a total rating of 472 MW net. These units are now in the final stages of construction, and are scheduled for startup in 1978. Each of these identical units consists of two oil-fired gas turbine-generators, each of which exhausts into a supplementary fired, heat recovery steam generator, which supplies steam to a single steam turbine-generator. Units 1 and 2 share common balance-of-plant facilities, as do Units 3 and 4.

All makeup water is furnished from wells located on SCE's property. All waste water is discharged into evaporation ponds on the site. These ponds have impervious linings to prevent contamination of groundwater supplies.

The site has a number of unique features that lend it to a coal gasification demonstration plant:

- It is a remote location on the edge of desert, so that construction and demonstration activities will have a minimum impact on heavily populated areas.
- It is located in California but outside the South Coast Air Basin.
- It is close enough to Los Angeles (a 2-hr drive) to allow access for construction and test crews, as well as visitors.

- It is well served by transportation facilities. Two railroads near the site can provide transportation for potential coal supplies from several areas of the country, and also facilitate delivery of new equipment by rail.

- Fired boilers of recent vintage are available for test firing with the product gas.

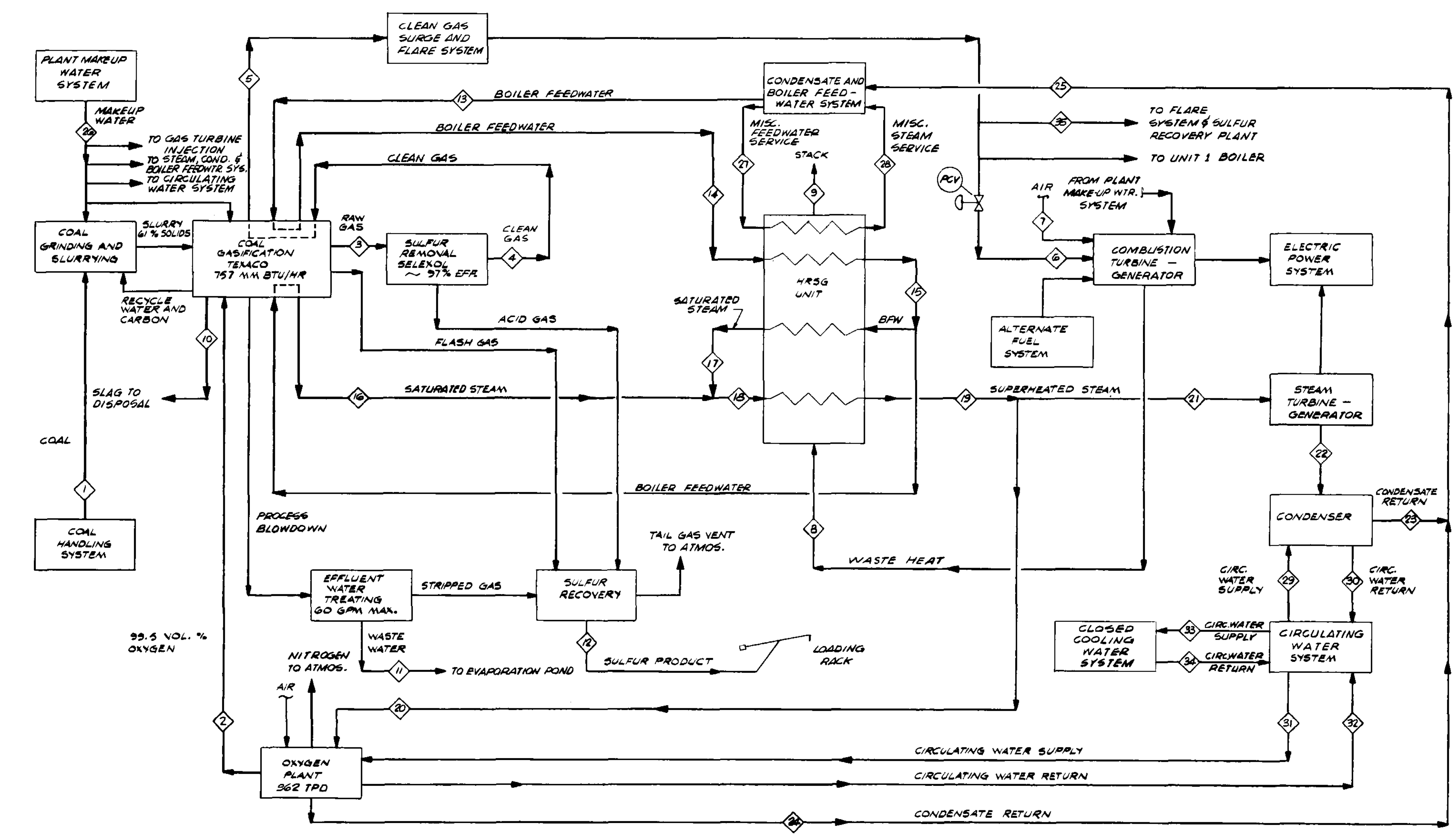
- The site contains ample open area for installation of the required new equipment for the gasification plant.

- Water supplies and waste disposal facilities are available within the site boundaries.

Drawing D-01-FS-1 shows an overall block flow diagram and material balance for the Case I totally integrated coal gasification/combined cycle power plant. Drawing D-01-FS-2 is the overall block flow diagram and material balance for the initial configurations of the Case II and Case III approaches to implementation of the plant. The material balance shown on Drawing D-01-FS-2 is based on the initial Case II configuration.

Cases II and III are alternatives to the Case I approach to implementation of the plant in which a portion of the power-generation equipment is not committed to manufacturing until after a one-year testing program of the plant in the initial configuration. In Case II, the steam-bottoming cycle, consisting of the heat recovery steam generator (HRSG) and the steam turbine-generator, is not included in the initial configuration. In Case III, none of the power generation equipment is included in the initial configuration; all product gas will be fired in the existing Unit 1 boiler during the initial one-year testing program. Since the HRSG is not available in the initial Case II and Case III configurations for supplementing and superheating the steam produced by the syngas coolers, an auxiliary boiler and a fired superheater must be provided as part of the initial plant configuration for these cases.

Detailed descriptions of each of the major systems required for the integrated plant are included in the subsections that follow this general description. Each of these includes a description of the Case I plant followed by a description of the initial configurations of the Case II and Case III plants, where these differ from the ultimate Case I configuration. System designs for Cases II and III are based upon ultimate integration into a plant nearly identical to the Case I configuration. This approach resulted in some differences in system design for the initial Case II and Case III configurations, as compared with the design that would have resulted if it were assumed that these initial configurations represented the final plant configuration. For example, the pressures and temperatures selected for the condensate, feedwater, and steam system were selected on the basis of ultimate integration with the combined cycle HRSG.



NOTES:

1. THIS FLOWSHEET IS BASED ON JUNE 25, 1977 TEXACO INC. DATA FOR LOW SULFUR WESTERN COAL.
2. SLAG HANDLING CAPACITY IS PROVIDED TO PROCESS COALS WITH UP TO 14 WT. PERCENT ASH.
3. SULFUR REMOVAL AND RECOVERY UNITS ARE DESIGNED TO LIMIT TOTAL PLANT SULFUR EMISSIONS TO 3% BASED ON A HYPOTHETICAL 0.7% SULFUR COAL
4. EXACT STEAM BALANCE IS SHOWN ON DWG. Nº. D-01-FS-3.

COAL ANALYSIS, WT. PERCENT (LOW SULFUR WESTERN COAL)

	AS RECEIVED	DRY BASIS
CARBON	64.99	71.26
HYDROGEN	4.53	4.97
NITROGEN	0.87	0.95
SULFUR	0.42	0.46
OXYGEN	12.91	14.16
ASH	7.48	8.20
WATER	8.80	—
	100.00	100.00
HHV BTU/LB. (HHV)	11,163	12,241

VOL. % COMP.	③ RAW GAS	④ CLEAN GAS
H_2	33.61	35.94
CO	48.22	51.51
CO_2	17.38	11.86
CH_4	0.09	0.10
N_2+A	0.54	0.58
H_2S	0.15	13 ppm V
COS	0.01	40 ppm V
TOTAL (DRY)	100.00	100.00
HHV BTU/SCF (HHV)	264.6	283.5

STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
FLUID OR COMMODITY	COAL	OXYGEN	FUEL GAS	FUEL GAS	FUEL GAS	FUEL GAS	AIR	EXHAUST GAS	EXHAUST GAS	SLAG	WASTE WATER	SULFUR	BFW	BFW	BFW	SATURATED STEAM	→
FLOW, LB/HR	*83,500	80,200	*166,500	*145,000	* →	*143,800	1,883,440	2,027,240	→	*12,600	30,000	376	393,660	→	→	221,660	164,280
PRESSURE, PSIG	ATM.	800	533	510	500	300	ATM	0.65	ATM	→	→	→	1300	1275	1250	1200	→
TEMPERATURE, °F	ATM	300	100	95	900	300	80	1,000	270	180	180	270	250	310.5	550	569	→

STREAM NO.	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
FLUID OR COMMODITY	→	SUPERHEATED STEAM	→	→	EXHAUST STEAM	CONDENSATE	→	→	MAKE-UP WATER	CONDENSATE	STEAM & COND.	CIRC. WATER	→	→	→	→	→	FUEL GAS
FLOW, LB/HR	385,940	→	144,060	241,880	→	→	144,060	385,940	686,500	59,710	53,710	16,150,000	→	7,200,000	→	11,250,000	→	1,200
PRESSURE, PSIG	→	1175	1150	→	-13.5	20	20	50	100.	100-200	50-150	50	40	50	40	50	40	500
TEMPERATURE, °F	→	952	950	→	108.7	→	→	→	60	250	298-366	80	95	80	100	80	90	300

* DRY BASIS
BFW = BOILER FEEDWATER

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE: OVERALL PROCESS BLOCK FLOW DIAGRAM CASE I

SCALE: NONE

ACCOUNT NUMBER

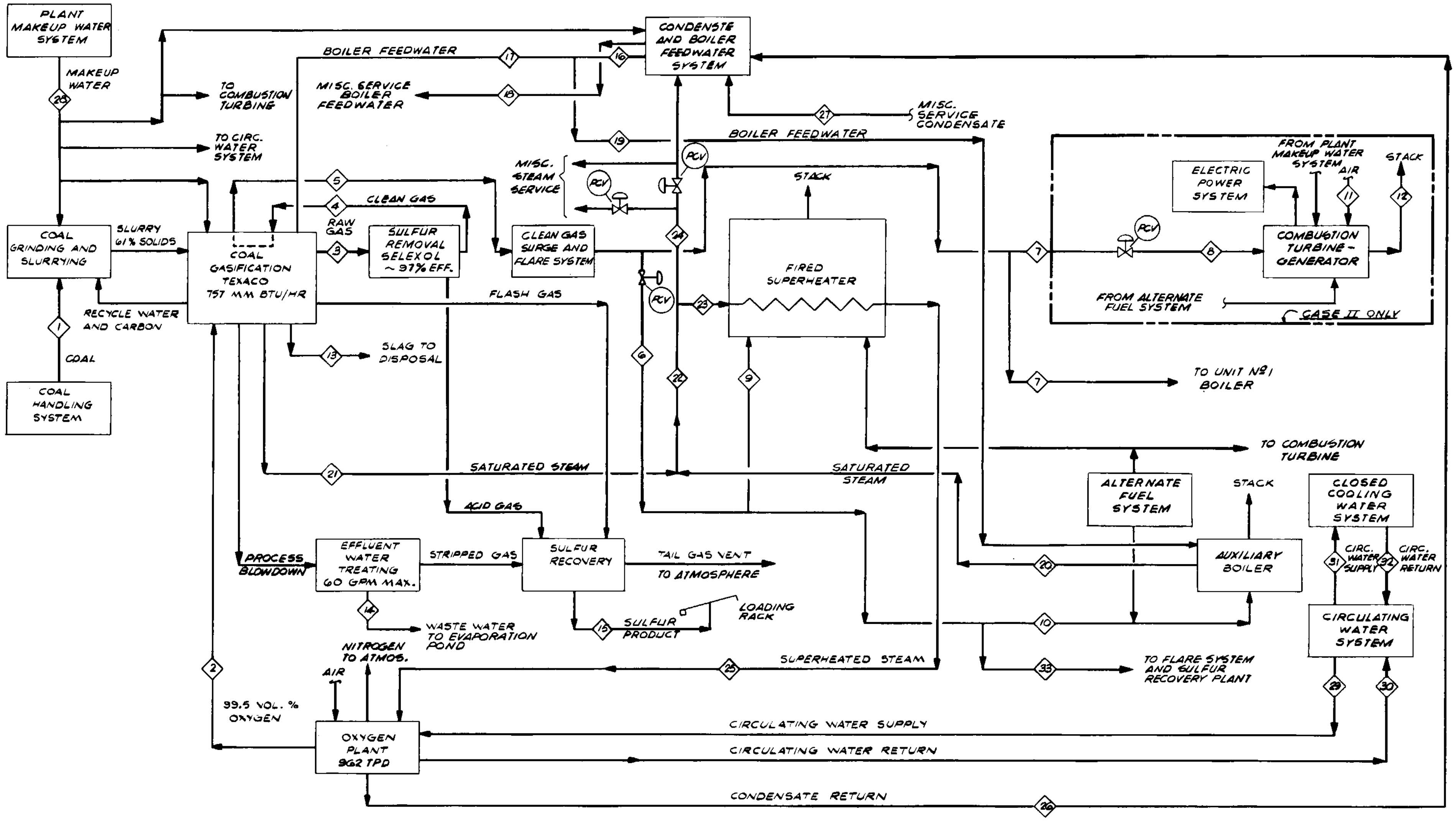
JOB NUMBER 5815 | DRAWING NUMBER D-01-FS-1 | REV. 1

RMP THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA

BY RCL DATE 1-23-78
CHECKED DATE 2-16-78
SECTION DATE 2-23-78
PROJECT DATE 2-28-78
CLIENT

NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
1	7-13-78	LNK					REVISED GAS FLOWS
0	4/21/78	RCL					ISSUED FOR FINAL REPORT
A	3/24/78	RCL					ISSUED TO SCE FOR REVIEW & COMMENT

REFERENCES DRAWING NO.	DESCRIPTION



NOTES:

1. THIS FLOWSHEET IS BASED ON JUNE 25, 1977 TEXACO INC. DATA FOR LOW SULFUR WESTERN COAL.
2. SLAG HANDLING CAPACITY IS PROVIDED TO PROCESS COALS WITH UP TO 14 WT. PERCENT ASH.
3. SYSTEM COMPONENTS SHOWN FOR CASE III EXCEPT AS NOTED.
4. FLOW PARAMETERS ARE BASED ON CASE II.
5. SULFUR REMOVAL AND RECOVERY UNITS ARE DESIGNED TO LIMIT TOTAL PLANT SULFUR EMISSIONS TO 3% BASED ON A HYPOTHETICAL 0.7% SULFUR COAL.
6. EXACT STEAM BALANCE IS SHOWN ON DWG. Nº. D-01-FS-4.
7. FUEL GAS RATE (STREAM ③) IS BASED ON A COAL GASIFICATION PLANT DESIGNED FOR THE FINAL CASE I CONFIGURATION.

COAL ANALYSIS, WT. PERCENT (LOW SULFUR WESTERN COAL)	AS REC'D.	DRY BASIS
CARBON	64.99	71.26
HYDROGEN	4.53	4.97
NITROGEN	0.87	0.95
SULFUR	0.42	0.46
OXYGEN	12.91	14.16
ASH	7.48	8.20
WATER	8.80	—
	100.00	100.00
HHV BTU/LB. (HHV)	11,163	12,241
VOL. %	③	④
COMP.	RAW GAS	CLEAN GAS
H_2	33.61	35.94
CO	48.22	51.51
CO_2	17.38	11.86
CH_4	0.09	0.10
N_2+A	0.54	0.58
H_2S	0.15	18 ppmV
COS	0.01	40 ppmV
TOTAL (DRY)	100.00	100.00
HHV BTU/SCF (HHV)	264.6	283.5

STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FLUID OR COMMODITY	COAL	OXYGEN	FUEL GAS	→	→	→	→	→	→	→	AIR	EXHAUST GAS	SLAG	WASTE WATER	SULFUR	BFW
FLOW, LB/HR	*83,500	80,200	166,500	145,000	→	16,800	128,200	→	9,060	6,540	1883,440	2011,640	*12,600	30,000	376	199,550
PRESSURE, PSIG	ATM.	800	533	510	500	50	500	300	50	→	ATM.	→	→	→	→	1300
TEMPERATURE, °F	ATM.	300	100	95	300	→	→	→	→	→	80	900	180	→	270	250

STREAM NO.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
FLUID OR COMMODITY	→	→	→	SATURATED STEAM	→	→	→	→	SUPERHEATED STEAM	CONDENSATE	→	MAKE-UP	CIRC. WATER	→	→	→	FUEL GAS
FLOW, LB/HR	173,090	4,040	31,680	31,060	169,700	200,760	144,060	56,700	144,060	144,060	36,750	415,000	7,200,000	→	10,600,000	→	1,200
PRESSURE, PSIG	1300	200	1300	1200	→	→	→	1200	1150	20	150	100	50	40	50	40	50
TEMPERATURE, °F	→	→	→	569	→	→	→	569	950	108.7	366	60	80	100	80	90	300

* DRY BASIS

BFW = BOILER FEEDWATER

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

REVISIONS NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
1	7-18-78	LN	CK				REVISED GAS FLOWS
0	4/21/78	RL					ISSUED FOR FINAL REPORT
A	3/7/78	RL					ISSUED TO SCE FOR REVIEW & COMMENT

BY RL — DATE 3/2/78
CHECKED — 3/2/78
SECTION — 3/1/78
PROJECT — 5-3-78
CLIENT

RMP — THE RALPH M. PARSONS COMPANY, PASADENA, CALIFORNIA

TITLE: OVERALL PROCESS BLOCK FLOW DIAGRAM CASES II AND III

SCALE: NONE

ACCOUNT NUMBER

JOB NUMBER 5815 — DRAWING NUMBER D-01-FS-2 — REV. 1

REFERENCES: DRAWING NO. | DESCRIPTION

The coal handling system, the coal grinding and slurrying system, the oxygen plant, the coal gasification process, and the sulfur removal and recovery systems are identical for Cases I, II, and III. These systems produce a medium Btu, clean fuel gas through partial oxidation of coal. In the process, coal is ground and slurried in water, and gasified at high temperature and pressure by partial combustion with oxygen in the Texaco Coal Gasification Process. The hot raw gas is cooled to recover heat as high-pressure saturated steam, scrubbed for particulate removal, and further cooled. Most of the sulfur in the gas is removed in a SELEXOL unit. The clean gas is delivered for use in the existing boiler or new combustion turbine. A part of the gas is used as fuel for the gasification plant in the steam superheater (Cases II and III) and in fired heaters in the process units.

Oxygen for the process is produced in an air-separation plant, whose output is dedicated solely to the gasification plant.

Sulfur removed from the fuel gas product is recovered in a Claus sulfur recovery plant and a Beavon tail gas treating unit.

The power generation portion of the plant consists of a single combined cycle plant of conventional design. The clean product gas is burned in a combustion turbine equipped with a special combustor designed for medium Btu gas. The turbine exhaust gases generate steam in the HRSG and also superheat the steam produced by the syngas coolers in the gasification plant. The superheated steam is used to drive the oxygen plant compressors and for generation of power through a steam turbine-generator.

The steam, condensate, and feedwater systems are fully integrated to maximize plant efficiency and minimize capital cost. All support systems, such as the cooling water system and plant electrical systems, are also fully integrated.

Plant water requirements are supplied from wells on the plant site. An overall plant water balance is shown in Drawing D-01-FS-5. For NO_x control, 100 gpm demineralized water demand for combustion turbine injection is assumed for purposes of conservatism in the cost estimate. The actual requirement for control of NO_x to permissible levels may be considerably less, pending final design of the combustion turbine. The combustion turbine performance used in the study is based on no water injection for NO_x control.

All waste water will be discharged to a new 70-acre lined evaporation pond to be constructed on the site.

Table 3.1-1 lists the overall energy balance for the fully integrated Case I plant. A tabulation of the plant auxiliary electrical power consumption is given in Table 3.1-2. Steam production and uses of this steam are shown in Drawings D-01-FS-3 and D-01-FS-4 (Cases I, II, and III), included with subsection 3.9.

Drawing D-01-GA-1 shows the site plan for the plant. Drawing D-01-GA-2 shows an overall plot plan for the integrated plant. Drawings D-01-GA-3, D-01-GA-7, and C-01-GA-8 show general arrangements of various individual units of the plant.

Certain data regarding the Texaco Coal Gasification Process, the Texaco effluent water treatment system, the SELEXOL unit, the Claus sulfur-recovery unit, and the Beavon tail gas treating unit are proprietary, and cannot be included herein. These data include sizes and duties of the equipment in these process and, in certain cases, process flow diagrams and equipment lists. Although these data are not shown in this report, such data was developed for the systems in question to the same level of detail as shown for the other systems described herein and was used for the development of the cost estimate.

Table 3.1-1

OVERALL ENERGY BALANCE

Basis: 80°F Ambient, Water as Liquid at 80°F, 3413 Btu/kWh

	10^6 Btu/hr
ENERGY IN	
Coal (HHV)	1022.1
Water	(13.9)
Air	0
TOTAL ENERGY IN	1008.2
ENERGY OUT	
Flue Gas	
Combustion Turbine (based on 270°F stack temperature)	116.2
Process Heaters	0.6
Electric Power Generation	
Combustion Turbine-Generator (gross output)	234.5
Steam Turbine-Generator (gross output)	109.2
Auxiliary Power Consumption (8,295 kW per Table 3.1-2)	(28.3)
Sulfur Recovery Plant Vent Gas (based on 93°F)	0.1
Circulating Water System	
Power Plant Steam Turbine Condenser	242.3
Oxygen Plant Steam Turbine Condensers	144.0
Closed Cooling Water System	112.5
Slag (based on 180°F)	0.8
Waste Water	
Gasification Process Waste Water (Based on 180°F)	3.0
Cooling Tower Blowdown (Based on 95°F)	1.1
Retention Basin Waste Water (Based on 60°F)	(0.4)

Table 3.1-1 (Cont)

	10^6 Btu/hr
Nitrogen (based on $70^{o}F$)	(0.9)
Sulfur (based on $270^{o}F$)	1.1
Air Coolers	
Gasification Plant Air Coolers	64.3
Gasification Effluent Water Treatment Plant	4.7
Beavon Sulfur Recovery Plant	2.7
TOTAL ENERGY OUT	1007.5
Energy Unaccounted For	0.7

$$\text{Overall Plant Efficiency} = \frac{234.5 + 109.2 - 28.3}{1022.1} = 30.86\%$$

$$\text{Net Plant Heat Rate} = \frac{3413 \text{ Btu/kWh}}{0.3086} = 11{,}060 \text{ Btu/kWh}$$

(   ) Indicates negative number.

Table 3.1-2

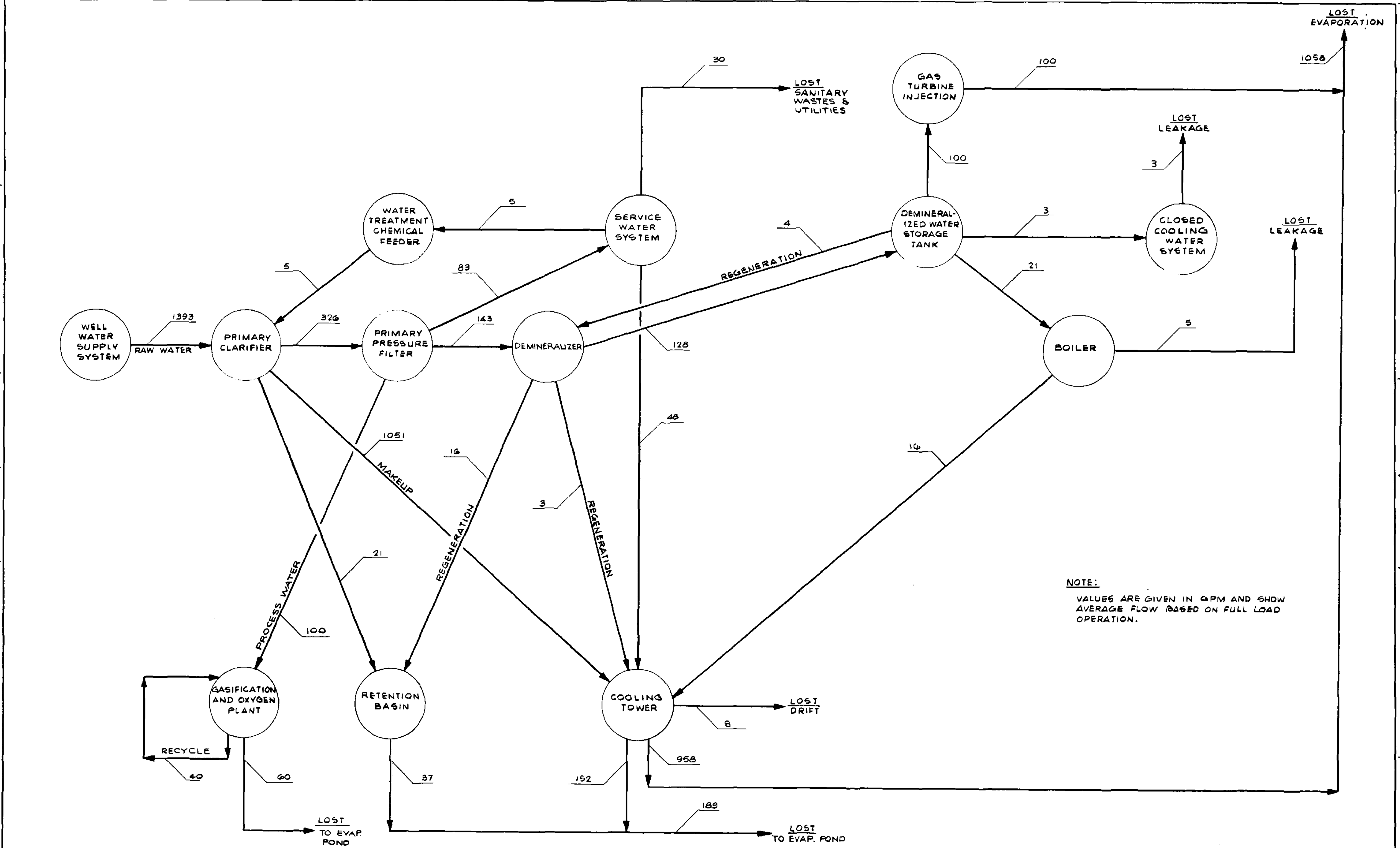
PLANT AUXILIARY ELECTRICAL POWER CONSUMPTION

SYSTEM	TOTAL OPERATING LOAD (hp)
Coal Handling System	800
Coal Grinding and Slurrying System	1,151
Oxygen Plant	170
Gasification Plant	2,536
Gasifier Effluent Water Treatment Plant	107
Sulfur Removal Plant	1,678
Sulfur Recovery	206
Steam Condensate and Boiler Feedwater System	1,162
Integrated Plant Cooling Water System	3,100
Plant Makeup Water System	412
Power Generation	150
Other Plant Supporting Systems and Facilities	302
TOTAL	11,774

Normal Electrical Power Consumption at Full Load:

$$\frac{(11{,}774 \text{ hp})\ (0.85)^{*}\ (0.746 \text{ kW/hp})}{0.90 \text{ (average motor efficiency)}} = 8{,}295 \text{ kW}$$

*Average load demand as a fraction of nameplate horsepower.



SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

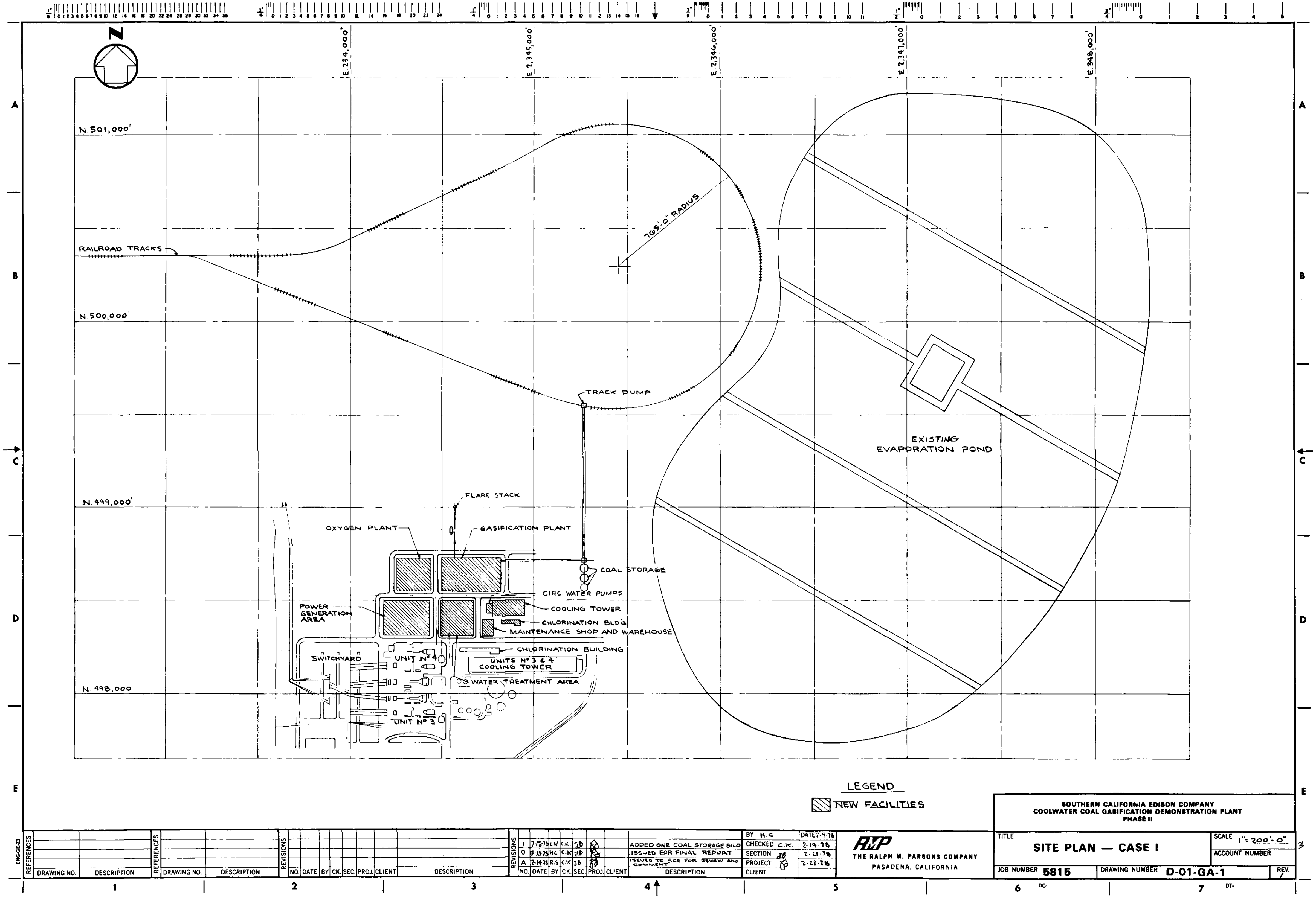
TITLE	OVERALL PLANT WATER BALANCE CASE I
SCALE	NONE
JOB NUMBER	5815
DRAWING NUMBER	D-01-FS-5
REV.	0

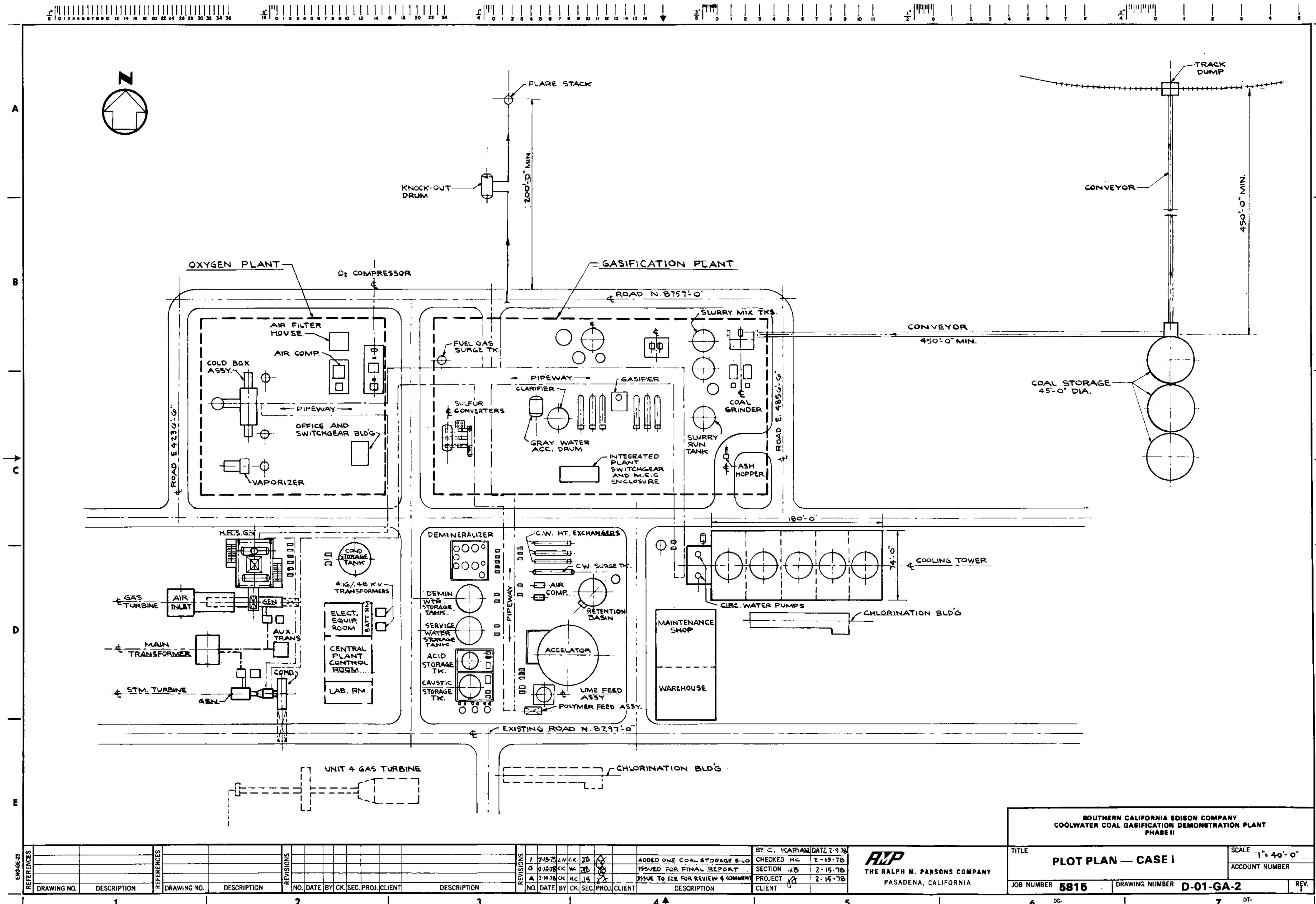
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

BY	P.L.	DATE 2-8-78
CHECKED		3-1-78
SECTION		3-2-78
PROJECT		3-3-78
CLIENT		

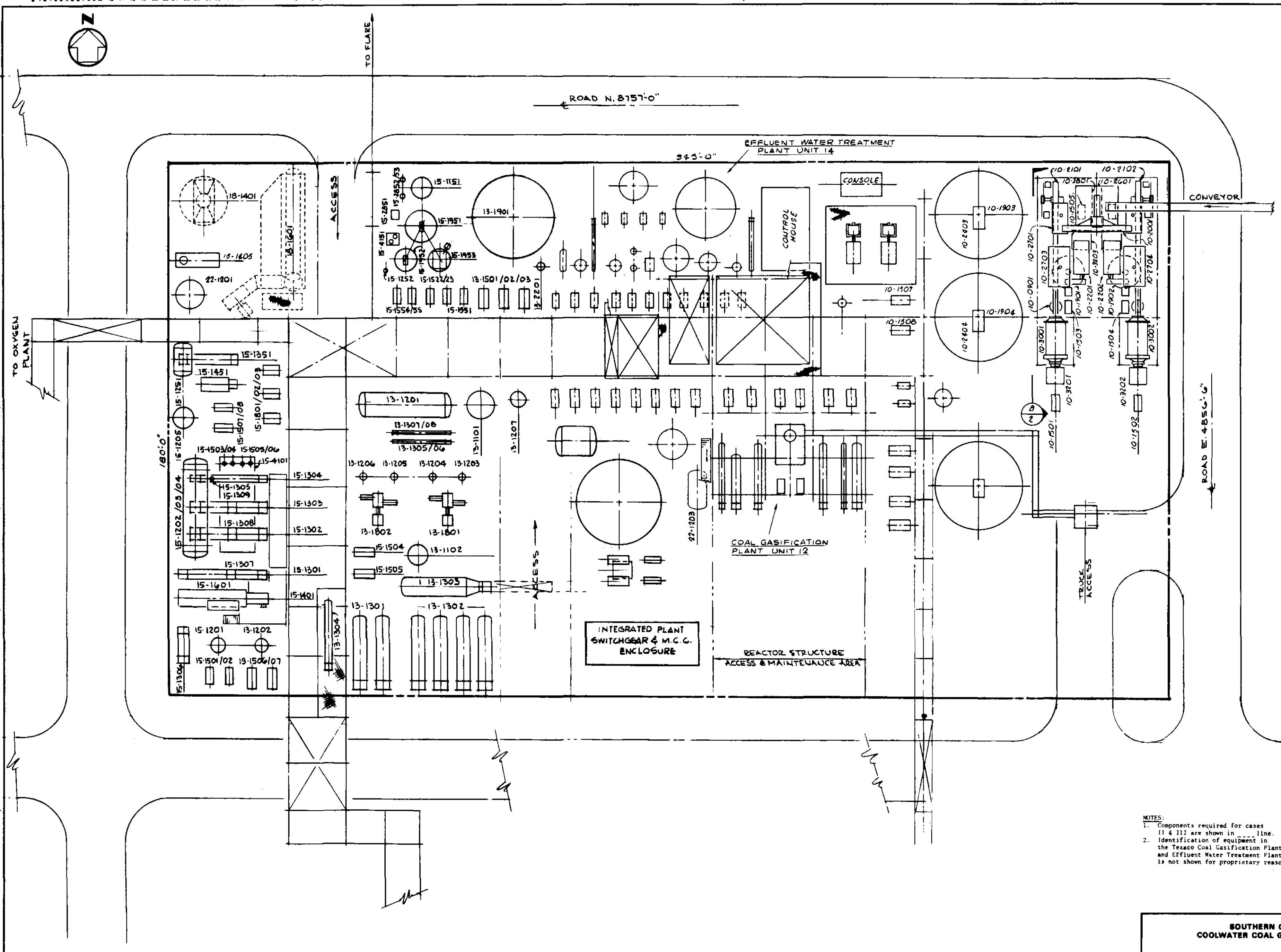
Revisions:

NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
0	3-10-78						ISSUED FOR FINAL REPORT
A	2-8-78						ISSUED TO SCE FOR REVIEW & COMMENT


E 2,344,000'
E 2,345,000'
E 2,346,000'
E 2,347,000'
E 2,348,000'
N 501,000'
N 500,000'
N 499,000'
N 498,000'
RAILROAD TRACKS
703'-0" RADIUS
TRACK DUMP
EXISTING EVAPORATION POND
FLARE STACK
OXYGEN PLANT
GASIFICATION PLANT
COAL STORAGE
CIRC WATER PUMPS
POWER GENERATION AREA
COOLING TOWER
CHLORINATION BLD'G
MAINTENANCE SHOP AND WAREHOUSE
CHLORINATION BUILDING
SWITCHYARD
UNIT Nº 4
UNITS Nº 3 & 4 COOLING TOWER
WATER TREATMENT AREA
UNIT Nº 3
LEGEND
NEW FACILITIES
SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II
TITLE
SITE PLAN — CASE I
SCALE 1" = 200'-0"
ACCOUNT NUMBER
JOB NUMBER 5815
DRAWING NUMBER D-01-GA-1
REV. 1
RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA
BY H.C. DATE 2-9-78
CHECKED C.K. 2-19-78
SECTION 2-21-78
PROJECT 2-23-78
CLIENT
REVISIONS
1 7-18-78 LN C.K. ADDED ONE COAL STORAGE SILO
0 4-13-78 HC C.K. ISSUED EPR FINAL REPORT
A 2-14-78 R.S. C.K. JB ISSUED TO SCE FOR REVIEW AND COMMENT
NO. DATE BY CK. SEC. PROJ. CLIENT DESCRIPTION
REFERENCES
DRAWING NO. DESCRIPTION



FLARE STACK
KNOCK-OUT DRUM
200'-0" MIN.
TRACK DUMP
CONVEYOR
450'-0" MIN.
OXYGEN PLANT
O_2 COMPRESSOR
GASIFICATION PLANT
ROAD N. 8757'-0"
AIR FILTER HOUSE
AIR COMP.
COLD BOX ASSY.
PIPEWAY
OFFICE AND SWITCHGEAR BLD'G
VAPORIZER
ROAD E. 4236'-6"
FUEL GAS SURGE TK.
SLURRY MIX TKS.
CONVEYOR
450'-0" MIN.
GASIFIER
CLARIFIER
SULFUR CONVERTERS
GRAY WATER ACC. DRUM
INTEGRATED PLANT SWITCHGEAR AND M.C.C. ENCLOSURE
COAL GRINDER
SLURRY RUN TANK
ASH HOPPER
ROAD E. 4856'-6"
COAL STORAGE 45'-0" DIA.
180'-0"
74'-0"
COOLING TOWER
CIRC. WATER PUMPS
CHLORINATION BLD'G
H.R.S.G.
GAS TURBINE
AIR INLET
GEN
COND. STORAGE TANK
4.16/.48 KV TRANSFORMERS
ELECT. EQUIP. ROOM
BATT. RM.
AUX. TRANS
MAIN TRANSFORMER
CENTRAL PLANT CONTROL ROOM
LAB. RM.
STM. TURBINE
GEN.
COND.
DEMINERALIZER
C.W. HT. EXCHANGERS
C.W. SURGE TK.
AIR COMP.
RETENTION BASIN
DEMIN. WTR. STORAGE TANK
SERVICE WATER STORAGE TANK
ACID STORAGE TK.
CAUSTIC STORAGE TK.
ACCELATOR
LIME FEED ASSY.
POLYMER FEED ASSY.
MAINTENANCE SHOP
WAREHOUSE
EXISTING ROAD N. 8297'-0"
UNIT 4 GAS TURBINE
CHLORINATION BLD'G
SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II
TITLE
PLOT PLAN — CASE I
SCALE 1" = 40'-0"
ACCOUNT NUMBER
JOB NUMBER 5815
DRAWING NUMBER D-01-GA-2
REV. 1
RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA
BY C. KARIAN DATE 2-9-78
CHECKED HC 2-15-78
SECTION JB 2-15-78
PROJECT 2-15-78
CLIENT
1 7-13-78 LN C.K. JB ADDED ONE COAL STORAGE SILO
0 4-18-78 CK HC JB ISSUED FOR FINAL REPORT
A 2-14-78 CK HC JB ISSUE TO SCE FOR REVIEW & COMMENT
NO. DATE BY CK. SEC. PROJ. CLIENT DESCRIPTION
REFERENCES DRAWING NO. DESCRIPTION
REVISIONS



EQUIPMENT LIST *

UNIT 10 - COAL GRINDING & SLURRYING

Pumps	
10-1501/02	Screen Feed Pumps
10-1503/04	Make-up Tank Pumps
10-1505/06	Centrifuge Effluent Pumps
10-1507/08	Slurry Transfer Pumps
Storage Tanks	
10-1901/02	Slurry Make-up Tanks
10-1903/04	Slurry Mix Tanks
Reduction Equipment	
10-2101/02	Cage Mills
Separation Equipment	
10-2201/02	Centrifuges
Environmental and Process Ventilation	
10-[redacted]	Dust Filter
Rod & Ball Mills	
10-3001/02	Rod Mills

UNIT 12 - COAL GASIFICATION (TEXACO)

UNIT 13 - SULFUR REMOVAL (SELEXOL)

Columns	
13-1101	Absorber
13-1102	Stripper
Vessels	
13-1201	Flash Drum
13-1202	Reflux Drum
Heat Exchangers	
13-1301	Cooler
13-1302	Exchanger
13-1303	Reboiler
13-1304	Condenser
Pumps	
13-1501/02/03	Circulating Pumps
13-1504/05	Stripper Pumps
13-1506/07	Reflux Pumps
Compressor	
13-1801/02	Recycle Compressors
Tank	
13-1901	Storage Tank

UNIT 14 - EFFLUENT WATER TREATING

UNIT 15 - SULFUR RECOVERY

Columns	
15-1151	Absorber Reaction Tank
Vessels	
15-1201	Acid Gas Knockout Drum
15-1202/03/04	Converters
15-1205	Therminol Surge Tank
15-1251	Hydrogenation Reactor
15-1252	Sulfur Decanter
Heat Exchangers	
15-1301/02/03 /04	Sulfur Condensers
15-1306	Acid Gas Preheater
15-1307/08/09	Reheaters
15-1351	Reactor Effluent Cooler
Furnaces and Burners	
15-1401	Reaction Furnace
15-1405	Therminol Heater
15-1451	Reducing Gas Generator
Pumps	
15-1501/02	Sour Water Pumps
15-1505/06	Sulfur Pumps
15-1507/08	Therminol Pumps
15-1554/55	Sulfur Slurry Pumps
15-1552/53	Solution Circulating Pumps
Boilers	
15-1601	Reaction Boiler
Blower	
15-1801/02/03	Air Blowers
Tanks	
15-1951	Oxidizer Tank
15-1952	Slurry Tank
15-1953	Balance Tank
Miscellaneous Equipment	
15-2852/52	Venturi Scrubbers
Pit	
15-4101	Sulfur Pit

UNIT 22 - MISCELLANEOUS SYSTEMS

Vessels	
22-1201	Clean Gas Surge Tank
22-1203	Start-up Fuel Tank

Cases II & III Only

UNIT 18 - STEAM, COND. & BFW SYSTEM

18-1401	Fired Superheater
18-1601	Auxiliary Boiler

NOTES:
1. Components required for cases II & III are shown in ____ line.
2. Identification of equipment in the Texaco Coal Gasification Plant and Effluent Water Treatment Plant is not shown for proprietary reasons.

REFERENCES	
DRAWING NO.	DESCRIPTION
D-01-GA-2	PLOT PLAN

REVISIONS NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
1	7-27-78	LN	CK				DELETED PROPRIETARY INFO.
0	5-1-78						ISSUED FOR FINAL REPORT
A	3/14/78						ISSUED TO SCE FOR REVIEW & COMMENT

BY EWS DATE 3/14/78
CHECKED DATE 3/10/78
SECTION DATE 3/10/78
PROJECT DATE 3/10/78
CLIENT

RMP THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA

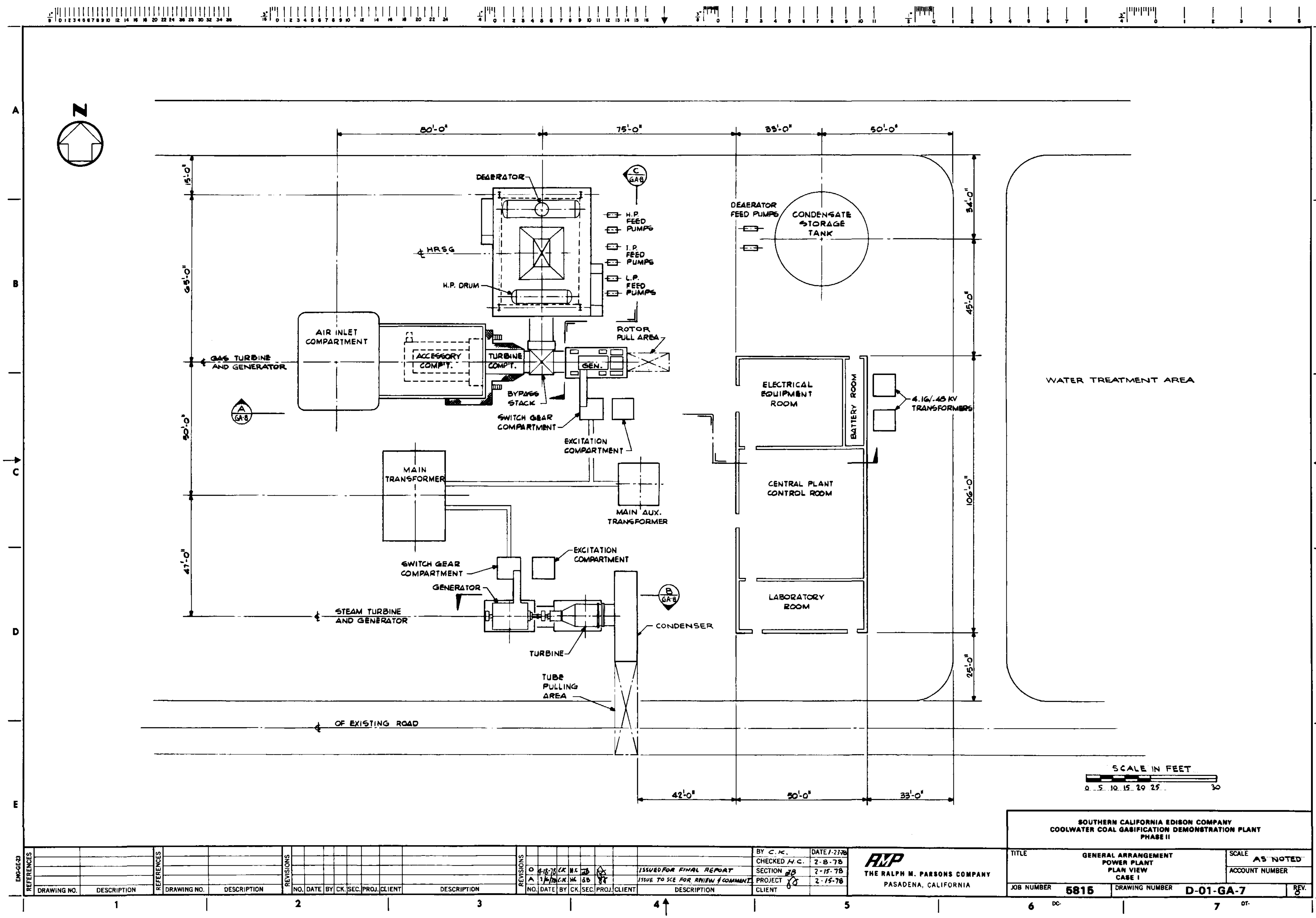
SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE GENERAL ARRANGEMENT COAL GASIFICATION PLANT PLAN VIEW CASES I II AND III

SCALE 1" = 15'-0"

ACCOUNT NUMBER

JOB NUMBER 5815 DRAWING NUMBER D-01-GA-3 REV. 1


N
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75'-0"
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65'-0"
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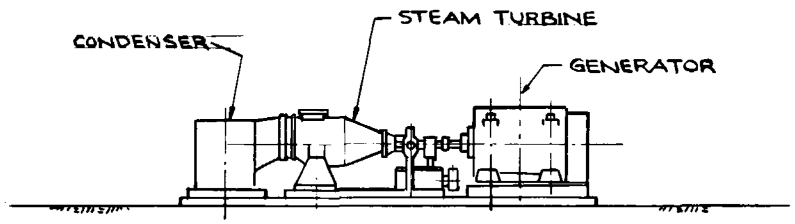
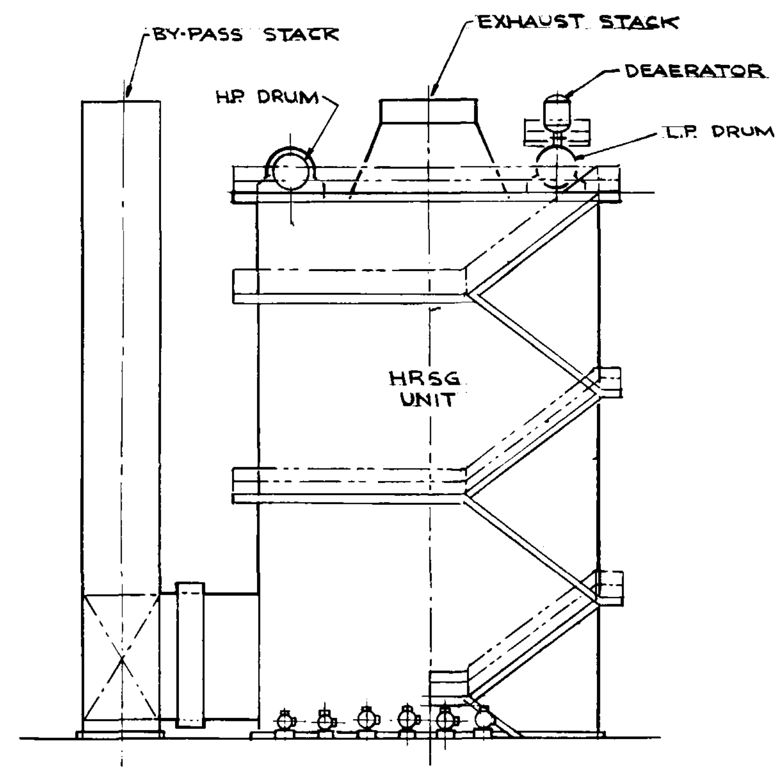
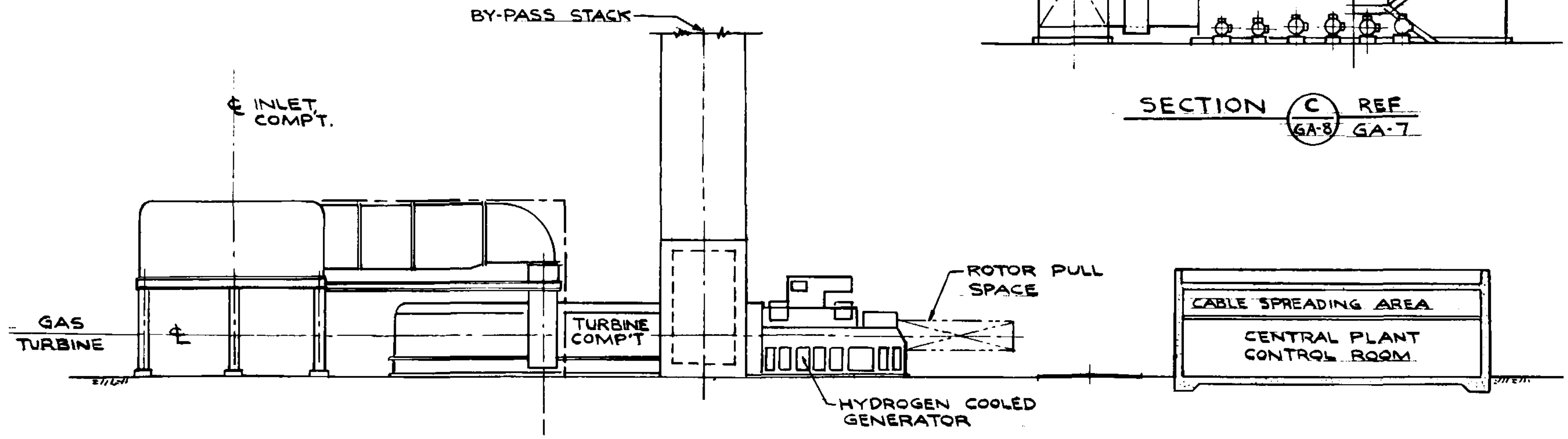
106'-0"
25'-0"
42'-0"
50'-0"
33'-0"
DEAERATOR
HRSG
H.P. DRUM
H.P. FEED PUMPS
I.P. FEED PUMPS
L.P. FEED PUMPS
C GA-8
DEAERATOR FEED PUMPS
CONDENSATE STORAGE TANK
AIR INLET COMPARTMENT
ACCESSORY COMP'T.
TURBINE COMP'T.
GEN.
ROTOR PULL AREA
GAS TURBINE AND GENERATOR
BYPASS STACK
SWITCH GEAR COMPARTMENT
EXCITATION COMPARTMENT
A GA-8
ELECTRICAL EQUIPMENT ROOM
BATTERY ROOM
4.16/.48 KV TRANSFORMERS
WATER TREATMENT AREA
MAIN TRANSFORMER
MAIN AUX. TRANSFORMER
CENTRAL PLANT CONTROL ROOM
LABORATORY ROOM
SWITCH GEAR COMPARTMENT
EXCITATION COMPARTMENT
GENERATOR
B GA-8
STEAM TURBINE AND GENERATOR
CONDENSER
TURBINE
TUBE PULLING AREA
OF EXISTING ROAD
SCALE IN FEET
0 5 10 15 20 25 30
SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II
TITLE GENERAL ARRANGEMENT POWER PLANT PLAN VIEW CASE I
SCALE AS NOTED
ACCOUNT NUMBER
JOB NUMBER 5815
DRAWING NUMBER D-01-GA-7
REV. 0
RMP THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA
BY C.K. DATE 1-27-78
CHECKED H.C. 2-8-78
SECTION 2-15-78
PROJECT 2-15-78
CLIENT
0 ISSUED FOR FINAL REPORT
A ISSUE TO SCE FOR REVIEW & COMMENT
NO. DATE BY CK. SEC. PROJ. CLIENT DESCRIPTION
REFERENCES DRAWING NO. DESCRIPTION
REVISIONS



SECTION (B / GA-8) REF GA-7



SECTION (C / GA-8) REF GA-7



SECTION (A / GA-8) REF GA-7

SCALE IN FEET

0 5 10 15 20 25 50

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE: GENERAL ARRANGEMENT POWER PLANT SECTIONS A B AND C CASE I

SCALE: AS NOTED

ACCOUNT NUMBER

JOB NUMBER: 5815

DRAWING NUMBER: C-01-GA-8

REV.: 0

BY: C.K. 2-6-78

CHECKED: H.C. 2-10-78

SECTION: JB 2-22-78

PROJECT: 2-23-78

CLIENT

RMP THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA

NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
0	4-18-78	C.K.	H.C.	JB			ISSUED FOR FINAL REPORT
A	2-6-78	C.K.	H.C.	JB			ISSUE TO SCE FOR REVIEW AND COMMENT

REVISIONS

REFERENCES

DRAWING NO.	DESCRIPTION

ENG-GE-22

DC-

DT-

3.2 COAL RECEIVING STORAGE AND TRANSFER FACILITIES

Complete coal handling facilities will be provided for receiving and storing coal delivered by rail and transferring the coal to the plant.

Coal Receiving

The coal will be delivered to the plant by unit trains consisting of eighty 100-ton bottom dump cars. The coal will have a nominal size of 2-inches by 0-inches, weight 50 pounds per cubic foot, and have an angle of repose of 38 degrees.

Coal will be received at the track unloading hopper. An enclosure will be provided over the hopper, incorporating a manually operated car shaker to assist in unloading wet or frozen coal. Dust suppression and collection systems will be provided to control the fugitive dust generated by the unloading operation.

The unloading hopper will be bifurcated and a manually operated shutoff gate and a vibrating feeder with a capacity of 1,100 TPH will be provided at the outlet of each leg. The vibrating feeders will discharge to the unloading conveyor. The tunnel housing the unloading hopper will be provided with a French drain at the low point for disposal of accumulated rainfall runoff and washdown water.

Conveying to Live Storage, Weighing and Sampling

The unloading conveyor will be 54 inches wide and have a capacity of 2,200 TPH. It will convey coal from the track unloading hopper to the coal storage silos fill system, and will be enclosed in a walk-through gallery.

As the conveyor leaves the unloading hopper tunnel, at a point just above grade elevation, a self-contained weight scale will be provided for billing purposes. The weight scale will be capable of printing out instantaneous flow rate and total integrated accumulated flow, and will have provisions for periodic calibration.

The unloading conveyor head pulley will be located in the sampling system enclosure. A magnetic separator will be provided to remove tramp iron from the coal stream. These rejects will be chuted outside of the sampling enclosure to a tote box at grade. Periodic truck removal of the tote box accumulations will be made.

The sampling system installation will be in accordance with ASTM standards, and the primary cutter will sample the stream as the coal is transferred from the unloading conveyor to the silo fill system. The gross primary sample will be crushed and again sampled with a secondary cutter. This process will be repeated and the gross tertiary sample will be split into four equal parts for: 1) laboratory analysis, 2) coal supplier's use, and 3) referee sample. Gross primary, secondary and tertiary sample rejects will be returned to the silo fill system via a bucket elevator.

The sampling system enclosure will be ventilated, and dust suppression and collection systems will be installed. These systems will serve the dual purpose of controlling fugitive dust generated by the coal transferring and sampling operations, and to prevent coal from being contaminated by salting with fugitive dust during the sampling operations. In addition, the portion of the sampling enclosure in which the final sample will be collected and prepared will be temperature controlled to prevent loss or gain of moisture in the sample.

Live Coal Storage

The system will include three coal storage silos. The silos will be filled by a cascading conveyor system that is fed from the unloading conveyor discharge. Each of the cascading conveyors will be 54 inches wide and have a capacity of 2,200 TPH. The entire silo fill system will be enclosed and dust suppression and collection systems will be provided to control the fugitive dust generated by the filling operation.

Each storage silo will be 45 feet diameter and have a live capacity of 3,000 tons. The top of the silos will be at an elevation of approximately 116 ft. above grade. The bottom of each silo will be bifurcated, and a power operated shutoff gate and a vibrating feeder with a variable capacity up to 100 TPH will be provided at the outlet of each leg. The vibrating feeders will discharge to the silo outlet conveyor.

A dust collection system will be provided for the silos to minimize internal combustible atmospheres.

Conveying to the Gasification Plant

The silo outlet conveyor will be 30 inches wide and have a capacity of 600 TPH. The portion of the conveyor under the storage silos will be horizontal. Once out from under the silos, the conveyor will curve vertically upwards and terminate in a transfer tower. The coal discharged from the silo outlet conveyor will then be transferred to the gasification plant feed conveyor.

The gasification plant feed conveyor will be 18 inches wide and have a capacity of 100 TPH.

The inclined portion of the silo outlet conveyor and the feed conveyor will be enclosed in walk-through galleries. Dust suppression systems will be installed at transfer points.

Control House

A coal handling system control house will be provided for performing all system operating and control functions. A graphic panel installation will be included. Local control functions will also be provided for each piece of equipment.

3.3 COAL GRINDING AND SLURRYING

The coal grinding and slurrying system is shown on Process Flow Diagram D-10-FS-1. Two full-size trains of equipment are provided to ensure continuity of operation. Each train is designed to process 50 tph (1,200 tpd) of coal feed (dry basis) and to produce a slurry with a total solids concentration of 61 wt%. The selection of grinding system equipment is expected to provide a high degree of control on particle size and water balance in the product. These are important features in producing a pumpable slurry of the desired concentration.

Raw coal 2-in and under is conveyed from live storage silos under a self-cleaning tramp iron magnet into a 50-ton coal feed bin equipped with a bag-type dust filter and an exhaust fan. This filter will handle all dust abatement requirements of the unit. From the bin, a weight flow controlled belt feeder supplies coal to either of the two grinding trains via a reversible belt conveyor.

The coal is first fed to a scalping screen from which the larger material, 2-in x 1/4-in, is fed to a four-row cage mill. The cage mill is sized and powered to reduce the feed so that 80% will pass through 14 mesh. The mill is equipped with variable speed drive which provides for adjustment of size reduction. The cage mill has little tolerance for tramp metal, so metal detectors are provided on the reversible belt to stop the conveyor and protect against metals entering the mill.

Fines from the scalping screen join the crushed coal from the cage mill and the mixture is conveyed to a sampler, from which it flows to the rod mill for grinding. The rod mill operation is a wet process, and the volume of water used to maintain pulp density for grinding is set manually.

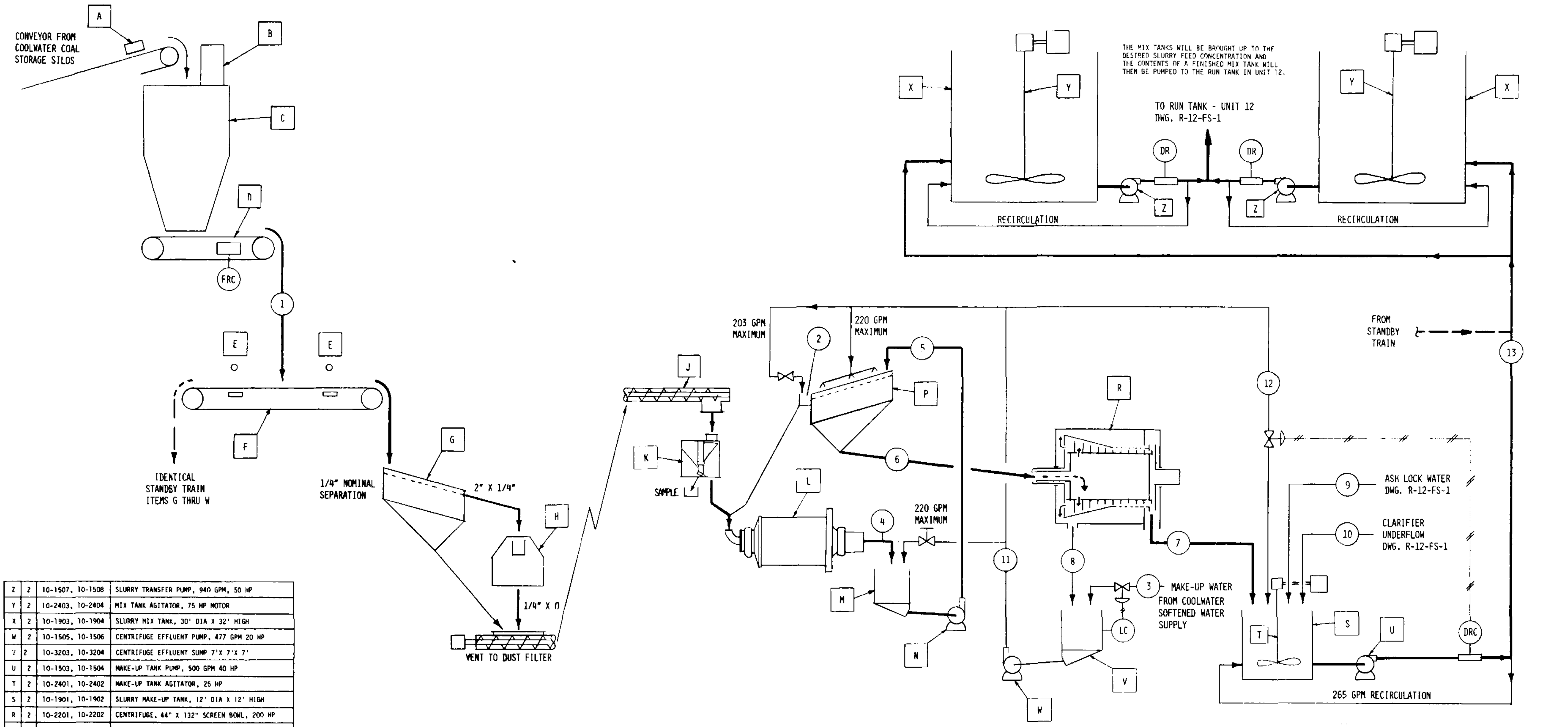
The rod mill product, containing about 50% solids, discharges to a sump, where it is diluted with water and then pumped to the wet screen. This screen provides one of the prime elements of control over particle size in the process.

The rod mill discharge is further diluted by sprays % on the wet screen up to an effective screen feed dilution of 35 percent. The screen makes a nominal separation at 14, mesh which may be varied either up or down as desired by changing one or all of the 16 screen sections. The oversize is recycled to the rod mill. The system has the capability of adjusting the slurry consistency while maintaining the required size distribution for good operation.

The wet screen fines flow to the screen bowl centrifuge. The centrifuge filtrate, containing up to 3% solids, is augmented with make-up water and returned to the grinding process. The flow of make-up water is controlled by the level in the centrifuge filtrate sump. A late-model screen bowl centrifuge was selected to dewater the slurry as the last step in preparing the coal for the final mixing operation. This machine is critical since it must adequately dewater the slurry without returning excessive amounts of material to the grinding equipment in the concentrate.

The centrifuged product discharges directly into an agitated slurry makeup tank. Process return water is added, as required, to produce a slurry with a total solids content of 61 wt% which is used as the design basis slurry concentration for this study. The water flow is controlled by a density controller in the makeup tank pump circulating loop. For some coals, it is necessary to add a basic material to the slurry to prevent corrosion because of low pH. Provision will be made to add ammonia for these cases.

The slurry product is pumped to either of two agitated mix tanks. These tanks also have circulating pumps and density meters. The tanks are brought up to desired slurry feed concentration and the contents of a finished tank will then be pumped to the run tank in the gasification unit.



	QTY	ITEM NO.	DESCRIPTION
Z	2	10-1507, 10-1508	SLURRY TRANSFER PUMP, 940 GPM, 50 HP
Y	2	10-2403, 10-2404	MIX TANK AGITATOR, 75 HP MOTOR
X	2	10-1903, 10-1904	SLURRY MIX TANK, 30' DIA X 32' HIGH
W	2	10-1505, 10-1506	CENTRIFUGE EFFLUENT PUMP, 477 GPM 20 HP
V	2	10-3203, 10-3204	CENTRIFUGE EFFLUENT SUMP 7'X 7'X 7'
U	2	10-1503, 10-1504	MAKE-UP TANK PUMP, 500 GPM 40 HP
T	2	10-2401, 10-2402	MAKE-UP TANK AGITATOR, 25 HP
S	2	10-1901, 10-1902	SLURRY MAKE-UP TANK, 12' DIA X 12' HIGH
R	2	10-2201, 10-2202	CENTRIFUGE, 44" X 132" SCREEN BOWL, 200 HP
P	2	10-2703, 10-2704	WET SCREEN, 8' X 16', 20 HP
N	2	10-1501, 10-1502	SCREEN FEED PUMP, 796 GPM 40 HP
M	2	10-3201, 10-3203	ROD MILL SUMP, 6'X 6'X 6'
L	2	10-3001, 10-3002	ROD MILL, 7' DIA X 12' LONG, 350 HP
K	2	10-0901, 10-0902	VEZIN SAMPLER, 1 HP MOTOR & TIMER
J	2	10-2002, 10-2003	FINE COAL CONVEYOR, 20" SCREW TYPE, 10 HP
H	2	10-2101, 10-2102	CAGE MILL, 40" CAGE 4 ROW, 125 HP & 75 HP
G	2	10-2701, 10-2702	SCALPING SCREEN, 5' X 10', 7-1/2 HP
F	1	10-2001	REVERSIBLE BELT CONVEYOR, 24" WIDE X 25', 5 HP
E	1	10-2802, 10-2803	TRAMP METAL DETECTOR
D	1	10-3801	COAL FEEDER, MERRICK 36" MODEL 450, 2 HP DC
C	1	10-2601	COAL FEED BIN, 50 TON CAPACITY
B	1	10-2901	DUST FILTER WITH 5 HP EXHAUSTER
A	1	10-2801	TRAMP IRON MAGNET, WITH SELF-CLEANING BELT

	COAL FEED (1)	ROD MILL RECYCLE (2)	WATER MAKE-UP (3)	ROD MILL DISCHARGE (4)	SCREEN FEED (5)	CENTRIFUGE FEED (6)	CENTRIFUGE CAKE (7)	CENTRIFUGE EFFLUENT (8)	ASH LOCK WATER (9)	CLARIFIER UNDERFLOW (10)	RETURN WATER (11)	CONTROL WATER (12)	FEED SLURRY (13)
COAL LB/HR.	83,500												83,500
CARBON LB/HR.													2,460
ASH LB/HR.													3,670
WATER LB/HR.	8,000		33,129										57,310
TOTAL LB/HR.	91,500		33,129										146,940
GPM			67										235
SLURRY % SOLIDS													61
SPECIFIC GRAVITY	1.37												1.24
TEMP °F	60		80										100
COMMENT													

NOTE:
SOME FLOWS ARE NOT SHOWN FOR PROPRIETARY REASONS.

NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
0	4-20-78						ISSUED FOR FINAL REPORT
1	7-27-78	LH	K.K.				DELETED PROPRIETARY INFORMATION

REFERENCES: DRAWING NO. | DESCRIPTION

ENG-GE-23

BY / CHECKED / SECTION / PROJECT / CLIENT / DATE

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE
PROCESS FLOW DIAGRAM
COAL GRINDING AND SLURRYING

SCALE
ACCOUNT NUMBER
JOB NUMBER 5815 | DRAWING NUMBER D-10-FS-1 | REV. 1

EQUIPMENT LIST

COAL GRINDING & SLURRYING

SAMPLERS & ANALYZERS

Item No.	Description	Size/Capacity/Remarks	Driver	Driver hp
10-0901	Ground Coal Sampler	24" W/Timer	Motor	1
10-0902	Ground Coal Sampler	24" W/Timer	Motor	1

PUMPS

Item No.	Description	Capacity gpm	Diff. Press. psi	Type	Driver hp	Driver	Material
10-1501	Screen Feed Pump	796	48	Centrifugal	40	Motor	CI, Rubber Lined
10-1502	(Spare 10-1501)						
10-1503	Makeup Tank Pump	500	50	Centrifugal	40	Motor	CI, Rubber Lined
10-1504	(Spare 10-1503)						
10-1505	Centrifuge Effluent Pump	477	30	Centrifugal	20	Motor	CI, Rubber Lined
10-1506	(Spare 10-1505)						
10-1507	Slurry Transfer Pump	940	50	Centrifugal	50	Motor	CI, Rubber Lined
10-1508	(Spare 10-1507)						
10-1509	Sump Pump	50	30	Vertical	10	Motor	Ni Iron

EQUIPMENT LIST

COAL GRINDING & SLURRYING (Contd)

TANKS

Item No.	Description	Size	Design	Material
10-1901	Slurry Makeup Tank	12'-0" Dia. x 12'-0", Open Top W/Agitator 10-2401	ATM	CS
10-1902	Slurry Makeup Tank	12'-0" Dia. x 12'-0", Open Top W/Agitator 10-2402	ATM	CS
10-1903	Slurry Mix Tank	30'-0" Dia. x 32'-0", Open Top W/Agitator 10-2403	ATM	CS
10-1904	Slurry Mix Tank	30'-0" Dia. x 321-0", Open Top W/Agitator 10-2404	ATM	CS

MATERIAL HANDLING

Item No.	Description	Size/Capacity/Remarks	Driver	Driver hp	Material
10-2001	Reversible Belt Conveyor	24" x 25'-0" Long	Motor	5	Rubber Belt
10-2002	Fine Coal Conveyor	20" Screw Type	Motor	10	CS
10-2003	Fine Coal Conveyor	20" Screw Type	Motor	10	CS

EQUIPMENT LIST

COAL GRINDING & SLURRYING (Contd)

REDUCTION EQUIPMENT

Item No.	Description	Size/Capacity/Remarks	Driver	Driver hp	Material
10-2101	Cage Mill	40" 4 Row Variable Speed belt drive, 50 T/hr.	2 Variable Speed Motors	125 75	Ni hard striking plates, CS wear plates
10-2102	Cage Mill	40" 4 Row Variable Speed belt drive, 50 T/hr.	2 Variable Speed Motors	125 75	Ni hard striking plates, CS wear plates

SEPARATION EQUIPMENT

Item No.	Description	Size/Capacity/Remarks	Driver	Driver hp	Material
10-2201	Centrifuge	44" x 132" Screen Bowl	Motor	200	SS Bowl and Screen
10-2202	Centrifuge	44" x 132" Screen Bowl	Motor	200	SS Bowl and Screen

EQUIPMENT LIST

COAL GRINDING & SLURRYING (Contd)

AGITATORS

Item No.	Description	Model Type	Driver	Driver HP	Material
10-2401	Makeup Tank Agitator	48" Propeller type with V belt drive and worm gear reducer	Motor	25	CS rubber covered
10-2402	Makeup Tank Agitator	48" Propeller type with V belt drive and worm gear reducer	Motor	25	CS rubber covered
10-2403	Mix Tank Agitator	108" Propeller type with V belt drive and worm gear reducer	Motor	75	CS rubber covered
10-2404	Mix Tank Agitator	108" Propeller type with V belt drive and worm gear reducer	Motor	75	CS rubber covered

HOPPERS, BINS & CHUTES

Item No.	Description	Size	Material
10-2601	Coal Feed Bin	15' Dia. x 11'-10", W/13'-2" Deep Cone	CS
10-2602	Belt Feed Bin Chute	Chutes are various sizes and configurations to suit the applications.	Chutes will have CS frame work and SS lining to prevent rust build-up when not in service.

EQUIPMENT LIST

COAL GRINDING & SLURRYING (Contd)

HOPPERS, BINS & CHUTES (Contd)

Item No.	Description	Size	Material
10-2603	Belt Discharge Chute	Chutes are various sizes and configurations to suit the applications.	Chutes will have CS framework and SS lining to prevent rust build-up when not in service.
10-2604	Belt Discharge Chute		
10-2605	Scalping Screen Undersize Chute		
10-2606	Scalping Screen Undersize Chute		
10-2607	Cage Mill Feed Chute		
10-2608	Cage Mill Feed Chute		
10-2609	Cage Mill Discharge Chute		
10-2610	Cage Mill Discharge Chute		
10-2611	Rod Mill Feed Chute		
10-2612	Rod Mill Feed Chute		
10-2613	Rod Mill Discharge Chute		
10-2614	Rod Mill Discharge Chute		

EQUIPMENT LIST

COAL GRINDING & SLURRYING (Contd)

HOPPERS, BINS & CHUTES (Contd)

Item No.	Description	Size	Material
10-2615	Wet Screen Oversize Chute	Chutes are various sizes and configurations to suit the applications.	Chutes will have CS framework and SS lining to prevent rust build-up when not in service.
10-2616	Wet Screen Oversize Chute		
10-2617	Wet Screen Undersize Chute		
10-2618	Wet Screen Undersize Chute		
10-2619	Centrifuge Discharge Chute		
10-2620	Centrifuge Discharge Chute		

SCREENS

Item No.	Description	Size/Capacity/Remarks	Driver	Driver hp	Material
10-2701	Scalping Screen	5' Wide x 10' Long, two surface w/1" and 1/4" screens	Motor	7-1/2	Screens SS
10-2702	Scalping Screen	5' Wide x 10' Long, two surface w/1" and 1/4" screens	Motor	7-1/2	Screens SS
10-2703	Wet Screen	8' Wide x 10' Long, one surface 1.25 mm iso rod	Motor	10	Screens SS

EQUIPMENT LIST

COAL GRINDING & SLURRYING (Contd)

SCREENS (Contd)

Item No.	Description	Size/Capacity/Remarks	Driver	Driver hp	Material
10-2704	Wet Screen	8' Wide x 16' Long, one surface 1.25 mm iso rod	Motor	10	Screens SS

OTHER MAJOR EQUIPMENT

Item No.	Description	Size/Capacity/Remarks	Driver	Driver hp	Material
10-2801	Tramp Iron Magnet	Permanent magnet w/self-cleaning belt	Motor	3/4	-
10-2802 /03	Metal Detectors	Induction coil type w/dual coils for reversible belt feeder. Alarm and trip features are included.	-	1.17 KW	-

ENVIRONMENTAL AND PROCESS VENTILATION

Item No.	Description	Size/Capacity/Remarks	Driver	Driver hp	Material
10-2901	Dust Filter	236 ft^2 self-cleaning bag type with exhauster	Motor	5	-

EQUIPMENT LIST

COAL GRINDING & SLURRYING (Contd)

ROD AND BALL MILLS

Item No.	Description	Model Type	Driver	Driver hp	Material
10-3001	Rod Mill	7' Dia x 12' Long, w/air clutch	Motor	350	
10-3002	Rod Mill	7' Dia x 12' Long, w/air clutch	Motor	350	

LAUNDERS & SUMPS

Item No.	Description	Size	Material
10-3201	Rod Mill Sump	6' W x 6' L x 6' D	CS
10-3202	Rod Mill Sump	6' W x 6' L x 6' D	CS
10-3203	Centrifuge Effluent Sump	7' W x 7' L x 7' D	CS
10-3204	Centrifuge Effluent Sump	7' W x 7' L x 7' D	CS
10-3205	Area Drain Sump	5' W x 5' L x 5' D	Concrete w/grating cover

WEIGHING EQUIPMENT

Item No.	Description	Model Type	Driver	Driver hp	Material
10-3801	Coal Feeder	36" weigh belt type with rate controller and test	D.C. Motor	2	Rubber belt chain

3.4 OXYGEN PLANT

A single-train plant with a capacity of 1,000 tpd provides oxygen for the Texaco gasifier.

The oxygen purity is 99.5 vol % with 0.5% nitrogen plus argon. The oxygen plant will be a turnkey facility. Engineering and design will be furnished by a contractor experienced in this field. The price for the estimate in this study was furnished by the Union Carbide Corporation, Linde Division. The plant will consist of factory-fabricated and -assembled cold box components which include reversing heat exchangers, distillation columns, superheaters and gel traps.

Air for the plant will be supplied by a condensing steam-turbine driven axial centrifugal compressor with interstage cooling. The oxygen product will be boosted to the gasifier operating pressure by a condensing steam-turbine driven centrifugal compressor, specially designed for oxygen service with intercoolers and recycle cooler.

Steam for the turbines is supplied by the plant steam supply system as described in Section 3.9.

The process for separating oxygen from air is a distillation operation that takes place at low temperatures under moderate pressure in which the air is reduced to the liquid state and the components are separated by fractionation. The cryogenic temperatures are achieved by special heat-exchange equipment and expansion turbines that efficiently transfer heat and energy between feed and products to make the operation economically practical.

Special features included with the oxygen plant are two expansion turbines that drive electric generators which will supply the full refrigeration requirements for the plant. The air handling system will include a filter house for the air-compressor intake with removable dry-type filter elements. A direct-contact aftercooler will be provided to cool the air-compressor discharge. This will allow a three-degree approach on the air-to-cooling-water temperature difference.

A 900-scfm compressor is provided to supply nitrogen at 125 psig. This nitrogen compressor will be used for utility, instrument, and purging requirements during startup and normal operation of the plant. A 6,000 gal liquid nitrogen storage reservoir, with a vaporizer, is provided for plant cooldown, purging and instrument air backup.

Thaw equipment is included which consists of shell-and-tube heat exchangers that are used to heat air. This equipment is used for a total plant thaw, as well as for operational thaws of gel traps. While the plant is operating, thaws are required approximately every 60 days, and take approximately 48 hrs. to complete. There is no reduction in capacity during this period. The thaws remove ice and CO_2 that accumulate as frozen crystals in the low temperature heat-exchange equipment. A total plant thaw is required approximately every 2 years and will take about 24 hours to complete.

The air and oxygen compressors will be furnished with lubricating oil systems and should be capable of continuous operation over extended periods of time. The service factor for the oxygen plant is expected to be 98 % or better.

An oxygen surge tank is provided to supply up to 15 min of oxygen capacity for a 20 % increase in demand. This tank stores oxygen at 800 psig and lets down to the oxygen compressor suction to be recompressed for gasifier feed. This arrangement provides a useful storage capacity from 800 psig down to near-atmospheric pressure without the need for additional compressors. The surge tank would be refilled gradually after the demand is met and the oxygen plant production level is adjusted to the higher load.

EQUIPMENT LIST

OXYGEN PLANT

Cold-Box Components

Factory-fabricated and assembled components will be shipped to the field for enclosure within field-erected, carbon-steel insulation casings. Included in the factory components are the reversing heat exchangers, distillation columns, superheaters, and gel traps.

Miscellaneous General Assembly Items

This material consists of control valves, safety valves, piping, expansion joints, and other similar material required for the field assembly of the cold-box packages. Included in this equipment are the switching valves for the reversing heat exchangers and the reversing heat-exchanger blowdown silencer.

Expansion Turbines

Two radial-flow, generator-loaded expansion turbines are provided; one is a fully installed spare. These units are complete with lube-oil system, local instrumentation, and automatic nozzle control. The generators will be 480-V, 3-phase, induction units. Either turbine will supply the full refrigeration requirements for the plant.

Air Compressor

This unit consists of an axial-centrifugal machine with intercooling between stages. Included with this machine will be an oil system, local instrumentation, vibration monitors, and control.

Air Compressor Driver

Mechanical drive steam turbine, complete with accessories, condenser, and condensate pumps.

Air Suction Filter House

Two-stage, dry-type filter with removable filter elements.

Direct-Contact Aftercooler

A Union Carbide-designed, direct air-water-contact aftercooler is provided to cool the air compressor discharge. This unit provides a very close air-to-water approach ($3^{o}F$).

Oxygen Compressor

This unit is a centrifugal-type compressor suitable for oxygen service, and includes intercoolers and a recycle cooler. Also included are the oil system, seal system, and local instrumentation.

Oxygen Compressor Driver

Mechanical-drive steam turbine, complete with accessories, condenser, and condensate pump.

480-V MCC

This assembly consists of starters for compressor auxiliaries, condensate pumps, lighting, and other plant utility feeders.

Silencers

All silencers are to meet OSHA and local code requirements.

Thaw Equipment

This equipment consists mainly of shell-and-tube heat exchangers to be used for heating air during total plant thaw, as well as operational thaw of the traps.

Building

A 30- x 60-ft, prefabricated, sheet-metal building is provided to house the MCC and storage and service areas.

Surge Tank

Oxygen surge tank 5'-0" dia x 40'-0" CS tank. Design pressure 880 psig @ 650°F.

Nitrogen Compressor

This unit is designed to deliver 900 scfm of dry nitrogen at 125 psig, and is provided with all auxiliaries, including nitrogen receivers.

3.5 COAL GASIFICATION

The Texaco Coal Gasification Process unit is shown in Process Flow Diagram B-12-FS-1. The coal slurry feed, consisting of fresh ground coal together with recycled fine slag and carbon has a total solids content 50 to 65% by weight. For the purposes of this study, a design concentration of 61 wt % was selected. The slurry is pumped from mix tanks in the grinding and slurry section to the gasifier slurry tank. A circulating pump circulates the slurry through this tank and supplies slurry to the suction of the high pressure charge pump.

The coal-water slurry is fed through a specially developed burner into a refractory-lined gasifier reactor. Partial combustion with oxygen takes place at a pressure of 600 psig and a temperature in the range of 2300 to 2800°F to produce a gas consisting mainly of CO, H_2, CO_2 and steam. Most of the sulfur in the coal is converted to H_2S and the balance converts to COS. Nitrogen and argon from the oxygen feed appear in the gas together with most of the nitrogen from the coal. The gas contains a small amount of methane, some unconverted carbon and all of the ash in the form of slag. The gas is essentially free of uncombined oxygen.

The raw gas produced from low-sulfur western coal has the following analysis:

	Mol.%
CO	35.57
H_2	24.80
CO_2	12.82
H_2O	26.22
CH_4	0.07
A_r	0.12
N_2	0.28
H2S	0.11
COS	0.01
	100.00

The upper section of the gasifier is the refractory-lined chamber in which the partial oxidation reaction takes place. At the bottom of the reaction chamber, the gas is withdrawn and quenched by mixing with cooler recycled gas. Entrained molten slag particles, solidified by the cooling action, are removed from the gas. The separated gas is cooled further by generating 1200 psig steam in the gas coolers. Water is circulated through the gas coolers by pumps.

The gas is cooled to 600°F in the gas coolers, then it exchanges additional heat with boiler feedwater and is cooled from 600 to 415°F. The gas then enters the lower section of the carbon scrubber where some of the fine particulate material is removed by water contact.

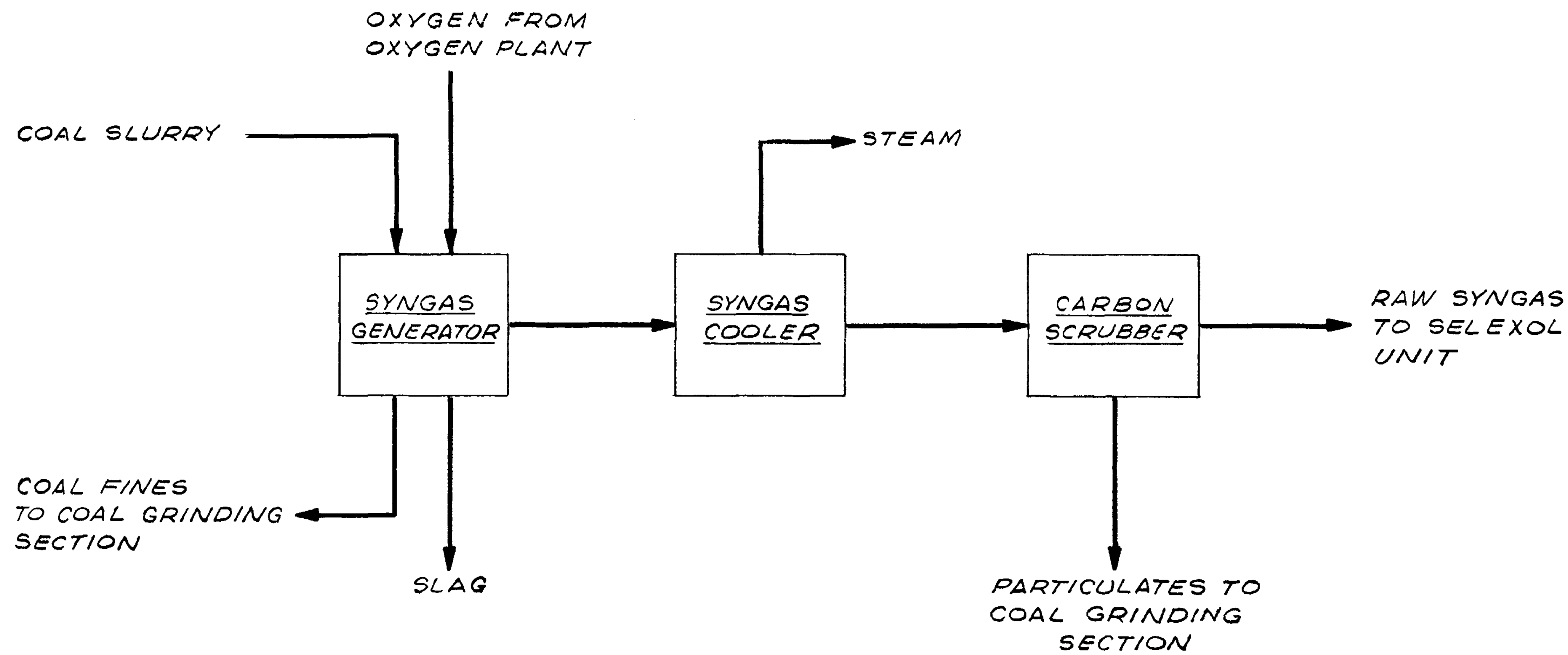
A portion of the gas from the gas generator reaction section passes straight down into the quench section of the gasifier. This stream carries the bulk of the larger particles of slag, and it is immediately quenched with water from the 2300 to 2800°F range to about 400°F. The gas from the generator quench chamber joins the main stream of gas from the lower section of the carbon scrubber.

The synthesis gas is contacted with a large quantity of circulating water to remove particulate material in the carbon scrubber. The last traces of particulate material in the gas are entrained in the water and the gas in completely saturated at this point.

The particulate-free gas flows on to further heat exchange. First, the gas is cooled to about 283°F in the clean gas heater by exchanging heat with the clean gas stream. The gas and condensate are separated in a drum and the gas stream is split. Recycle gas is picked up at this point by a compressor and recycled. The net product gas flows to an air cooler and a trim water cooler, where it is cooled to a final temperature of about 100°F. Water is removed from the gas in condensate separators following each cooler. The cooled, particulate-free gas flows from this point to the SELEXOL unit for sulfur removal. Condensate from the gas-cooling operations is pumped back to the carbon scrubber quench loop.

Water from the gasifier quench chamber is cooled and combined with water from the carbon-scrubber lower section. Both streams contain fine slag and unconverted coal. The water stream from the lock hopper and water from the final product cooler separator join this stream, and the total flows into the flash pot.

In the clarifier, the fine slag and unconverted coal settle out, leaving a clarified water overflow that is pumped back to the carbon scrubber via the grey water drum. Makeup water is added at this point.



SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

REFERENCES

DRAWING NO.	DESCRIPTION

REVISIONS

NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
0	9-27-78	LN	C.K.	[signature]	[signature]		ISSUED FOR FINAL REPORT

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

TITLE: SCHEMATIC PROCESS FLOW DIAGRAM TEXACO COAL GASIFICATION PROCESS

SCALE: NONE

ACCOUNT NUMBER

JOB NUMBER: 5815

DRAWING NUMBER: B-12-FS-2

REV.: 0

ENG-GE-21

DC-

DT-

A portion of the clarifier overflow is withdrawn as blowdown to control the dissolved solids content in the circulating water system. This water is pumped to the gasification process effluent water treatment unit.

The clarifier underflow is fed to a centrifuge for dewatering. The concentrated underflow is returned to the coal grinding and slurrying section and mixed with coal-feed slurry. The filtrate is returned to the clarifier.

Most of the ash in the coal feed agglomerates into essentially carbon-free molten slag droplets, which are quenched and solidified in the lower quench section of the reactor. This slag settles through the quench water into the lock hopper. The lock hopper is peridocially dumped onto a screen, from which the slag is conveyed to an open hopper where it is collected and disposed of by truck. Water from the screen is collected in a sump, and pumped to the coal-slurrying section for recycle.

A detailed process flow diagram and a detailed equipment list covering the Texaco Coal Gasification Process described in this section were developed specifically for this study. The cost data and physical layouts for the gasification process presented in this report are based on these detailed data. However, many of the details regarding the process are considered proprietary by Texaco; therefore, the detailed flow diagram and equipment list cannot be included herein.

3.6 GASIFICATION PROCESS EFFLUENT WATER TREATMENT SYSTEM

The effluent water treating unit is designed to process 60 gpm of blowdown water. Normal flow is expected to be significantly less than the design capacity of the treating unit.

The effluent water treatment system is intended to handle a water stream purged from the gasification section in order to limit buildup of dissolved minerals in the gasifier circulating water system. This effluent water treating process involves a combination of chemical treatments and physical separations. The discharged water contains 3,000 to 4,000 ppm dissolved solids.

Further details of the system are considered proprietary by Texaco. Therefore, no flow diagram or equipment list for the system is included herein. However, the system has been fully designed and the cost estimate included herein is based on a detailed equipment list.

3.7 SULFUR REMOVAL (SELEXOL*)

The SELEXOL sulfur removal system is shown on Process Flow Diagram R-13-FS-1.

SELEXOL is a proprietary process of the Allied Chemical Corporation for selective gas purification. In this application, it is designed to remove 97.1% of the combined H_2S plus COS from the fuel-gas product, derived from gasifying a hypothetical coal containing 0.7% by weight of sulfur, while removing only about 36% of the CO_2.

The gas is treated to reduce H_2S + COS from 2,470 ppm (2,270 ppm H_2S, 200 ppm COS) to 77 ppm (18 ppm H_2S, 59 ppm COS). The CO_2 content decreases from 17.4% to 11.9%.

Cooled gas at 520 asig enters the absorber which is a trayed column and contacts a countercurrent stream of lean SELEXOL solvent which is a physical solvent consisting of the dimethylether of polyethylene glycol. The purified gas passes from the unit as product gas.

The absorber bottom`s liquid is flashed and the flashed gas is recycled by a compressor back to the absorber feed. The rich solvent is heated by exchange with lean solvent and passes to the stripper where the acid gas is stripped from the solvent by steam generated in the reboiler. The stripper is a packed column.

The acid gases in the stripper overhead are cooled in a condenser and water is separated in the reflux drum from which it is pumped back to the stripper. The acid gases are released to the Claus sulfur recovery unit for further processing.

A steam heated reboiler is provided to generate stripping steam. From the bottom of the stripper, lean regenerated solvent is pumped through a lean-rich solution exchanger and then cooled by water in the solution cooler. The lean solvent balances in a storage tank, from which it is pumped to the absorber.

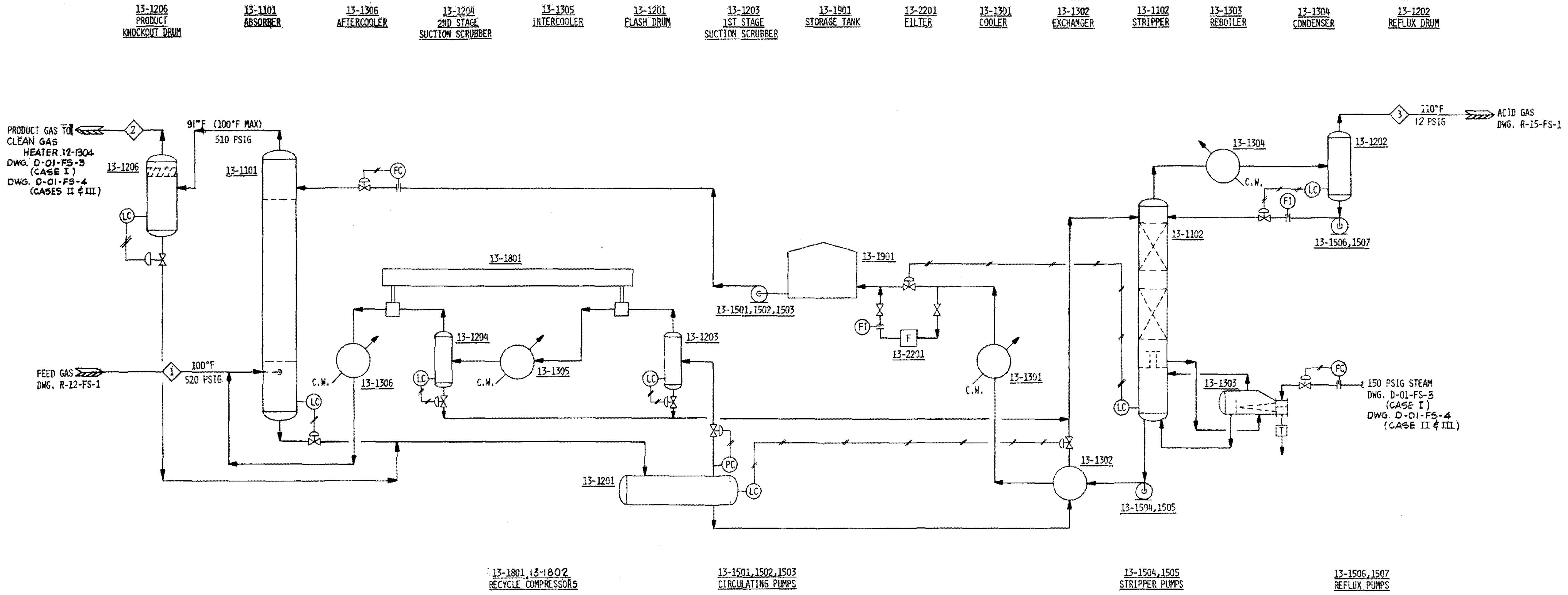
As an alternate case, coal containing 3.5% by weight of sulfur could be used as feed to the coal gasification unit. In this case, 97.4% of the combined H_2S plus COS is removed from the fuel gas product by the SELEXOL sulfur-removal system.

*SELEXOL is a registered trade mark of Allied Chemical Corporation.

The gas is treated to reduce H_2S and COS from 1.22% (1.12% H_2S, 0.10% COS) to 0.03% (34 ppm H_2S, 0.03% COS). The CO_2 content decreases from 17.2% to 11.8%.

The acid gases, containing 3.65% combined H_2S and COS are released to the Claus sulfur-recovery unit for further processing.

Because sizes and duties of equipment in the SELEXOL sulfur-removal system are proprietary, these data are not included in the attached equipment list. Although these are not shown in this report, they were developed and were used in the development of the cost estimate.



NOTE
THE SELEXOL PROCESS SHOWN ON THIS DRAWING IS A PROPRIETARY PROCESS OF THE ALLIED CHEMICAL CORPORATION.

	0.7 WT. % SULFUR COAL CASE			3.5 WT. % SULFUR COAL CASE		
STREAM	1	2	3	1	2	3
COMPONENT, VOL.%	FEED GAS	PRODUCT GAS	ACID GAS	FEED GAS	PRODUCT GAS	ACID GAS
H_2	33.59	35.94	0.13	33.26	35.96	0.12
CO	48.17	51.51	0.88	47.70	51.52	0.84
CO_2	17.36	11.86	95.33	17.19	11.81	83.20
CH_4	0.09	0.10	0.01	0.09	0.10	0.01
N_2+A	0.54	0.58	—	0.54	0.58	—
H_2S	(2270 ppm)	(18 ppm)	3.42	1.12	(34 ppm)	14.85
COS	(200 ppm)	(59 ppm)	0.23	0.10	0.03	0.98
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

PROCESS FLOW DIAGRAM
SELEXOL® SULFUR REMOVAL UNIT

REV. NO.	CUST. APPR.	DATE	REVISION	BY	PROC. ENGR.	CHECK	CHIEF PROC. ENGR.	CHIEF OPER. ENGR.	PROJ. DIR.
0		7/21/78	ISSUED FOR FINAL DISPOSAL	LN					
A		4/4/78	ISSUED TO SCE FOR REVIEW & COMMENT	LDS					

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

JOB NO. 5815 | DWG. NO. R-13-FS-1 | REV. 0

EQUIPMENT LIST
SULFUR REMOVAL (SELEXOL)

COLUMNS

Item No.	Description	Design psig @ F	Material
13-1101	Absorber	590 @ 550	Shell CS, Trays CS W/410 SS Valves
13-1102	Stripper	50 @ 650	Shell CS, Pall rings CS

VESSELS

Item No.	Description	Design psig @ F	Material
13-1201	Flash Drum	590 @ 550	CS
13-1202	Reflux Drum	50 @ 650	CS
13-1203	First Stage Suction Knockout Drum	590 @ 550	CS
13-1204	Second Stage Suction Knockout Drum	590 @ 550	CS
13-1205	Second Stage Suction Knockout Drum	590 @ 550	CS
13-1206	Product Knockout Drum	590 @ 550	CS
13-1207	Product Knockout Drum	590 @ 550	CS

HEAT EXCHANGERS

Item No.	Description	Design PSIG @ F	Material
13-1301	Cooler	Shell 75 @ 650 Tubes 75 @ 650	CS INH. ADM.
13-1302	Exchanger	Shell 75 @ 650 Tubes 605 @ 525	CS CS

EQUIPMENT LIST (Contd)
SULFUR REMOVAL (SELEXOL)

HEAT EXCHANGERS (Contd)

Item No.	Description	Design psig @ F	Material
13-13-3	Reboiler	Shell 75 @ 650 Tubes 175 @ 650	CS CS
13-1304	Condenser	Shell 75 @ 650 Tubes 75 @ 650	CS CS
13-1305	Interstage Cooler	Furnished with Compressor 13-1801	
13-1306	Aftercooler	Furnished with Compressor 13-1801	
13-1307	Interstage Cooler	Furnished with Compressor 13-1802	
13-1308	Aftercooler	Furnished with Compressor 13-1802	

PUMPS

Item No.	Description	Type	Driver	Material
13-1501	Circulating Pump	Centrifugal	Motor	S-1
13-1502	Circulating Pump	Centrifugal	Motor	S-1
13-1503	(Spare 13-1501/02)			
13-1504	Stripper Pump	Centrifugal	Motor	S-1
13-1505	(Spare 13-1504)			
13-1506	Reflux Pump	Centrifugal	Motor	S-1
13-1507	(Spare 13-1506)			

EQUIPMENT LIST (Contd)
SULFUR REMOVAL (SELEXOL)

TANKS

Item No.	Description	Design psig @ F	Material
13-1901	Storage Tank	ATM	CS

COMPRESSORS

Item No.	Description	Type	Driver
13-1801	Recycle Compressor	Reciprocating	Motor
13-1802	(Spare 13-1801)		

FILTERS

Item No.	Description	Type	Material
13-2201	Filter	Cartridge type w/string wound cartridges	CS

3.8 SULFUR-RECOVERY PLANT

The sulfur recovery plant consists of two sections. The first section consists of a modified Claus-type unit that converts most of the H S produced to elemental sulfur. The tail gas from the Claus unit is further processed in a Beavon sulfur-recovery unit. The two processes are shown on Process Flow Diagrams R-15-FS-1 and R-15-FS-2, respectively.

Process Description - Claus Sulfur Recovery Unit

The conversion of hydrogen sulfide to sulfur is based on the reaction between hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) in which two parts of H_2S react with one of SO_2 to form sulfur (S) and water (H_2O). The chemical reaction is shown by the equation:

$$2H_2S + SO_2 = 3S + H_2O$$

Generally in Claus plants part of the H_2S is burned with air to provide the SO_2 required. In this plant, the SO_2 needed for the above reaction is formed in the reaction furnace combustion chamber by burning sulfur rather than by burning acid gas. This arrangement is necessary because the H_2S content of the acid gas is too low to support combustion with air. In this plant all of the acid gas bypasses the combustion chamber and there is no thermal sulfur conversion. All of the sulfur is produced in the converters over catalyst. The plant operates at pressures only slightly above atmospheric.

Combustion air is supplied by an air blower and is controlled automatically in proportion to the rate of acid-gas feed to maintain a ratio of H_2S/SO_2 at two to one in the converters. A gas analyzer in the plant tail gas line monitors the H_2S/SO_2 ratio and feeds back a signal to the air controller for close adjustment of air requirements.

The combustion gas containing the SO_2 is cooled in the boiler tubes by generating medium pressure steam from the boiler. The gas then passes to the first condenser. The first condenser cools the gas by generating more medium pressure steam. The gas is combined with acid gas at this point and is then reheated in the first reheater before entering the first converter.

Most of the sulfur is produced in the first converter which is indicated by a larger temperature rise across this catalyst bed than in the other two stages. The gas then flows to the second sulfur condenser where the sulfur is condensed and drained to the sulfur pit.

The second and third stages have similar reheaters, catalyst converters and condensers. The tail gas from the final condenser is then fed to the Beavon sulfur-recovery unit.

Because the acid gas feed contains too little H_2S to be burned in auxiliary burners, the preheating of the acid gas and the reheating of process gas between stages is accomplished by heat exchange with hot therminol heating medium. The therminol system includes a liquid storage drum, circulating pumps, and a fired heater to serve the preheater and reheater. The system is closed to exclude air and the storage drum is blanketed with nitrogen. All sulfur that is produced drains into the sulfur pit which is used for storage. The sulfur product is pumped from the pit to a truck-loading rack to be sold as a liquid product. Sulfur for the sulfur burner is pumped from the same pit.

Equipment sizing in the catalytic-reaction section of the Claus plant is governed chiefly by the quantity of gas flowing through the plant, and is affected only to a secondary extent by the H_2S content. With either low-sulfur or high-sulfur coal the acid gas separated by the SELEXOL process is mainly CO_2 in about the same quantity. Thus, the catalytic section of the Claus plant can be made large enough to handle the acid gas from high-sulfur coal with very minor added investment, and the plant has been designed on this basis.

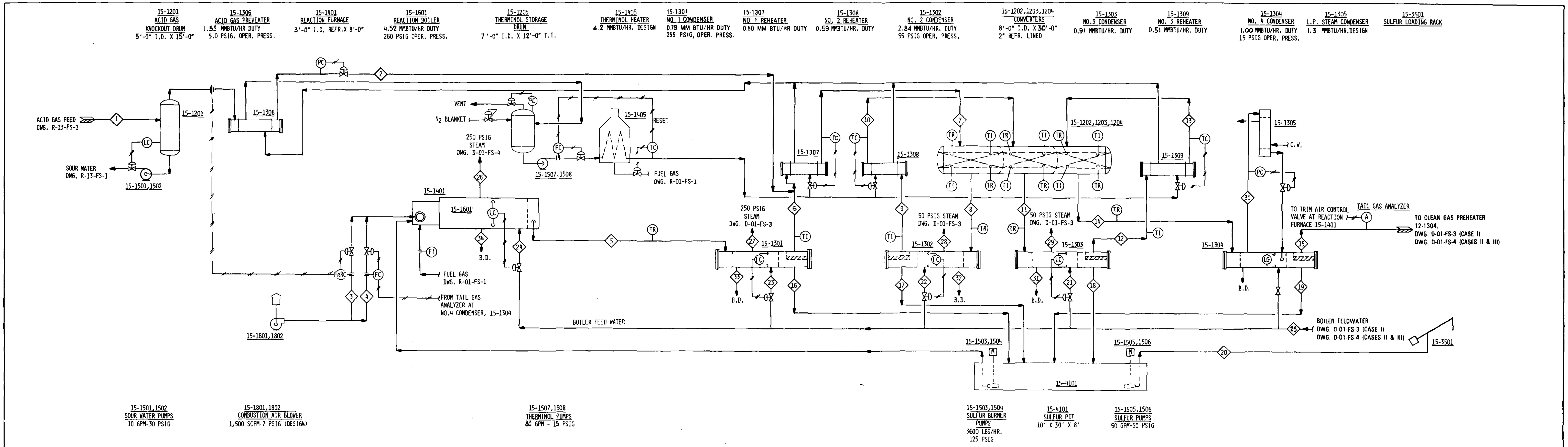
The sizes of the sulfur burner, boiler and associated condenser are governed by the hydrogen-sulfide input, which is five times as high with high-sulfur coal. Even so, the equipment is quite small and the cost increment to make it adequate for high-sulfur coal is nominal. Hence the entire Claus plant has been designed large enough to suit operation on high-sulfur coal.

The Claus plant will recover about 95% of input sulfur from high-sulfur coal feed, and about 90% from low-sulfur coal.

Process Description - Beavon Sulfur-Recovery Unit

The Beavon sulfur-removal process consists of two sections: a hydrogenation section to convert sulfur compounds, including free sulfur, to hydrogen sulfide and a Stretford section to oxidize the hydrogen sulfide in an aqueous solution to elemental sulfur. The elemental sulfur is floated from the solution, melted, and sent to the Claus plant sulfur pit.

The hydrogenation section consists of a reducing gas generator, a hydrogenation reactor and a reactor effluent cooler which generates steam. The reducing gas generator has the dual function of heating the tail gas to a temperature that will permit the desired hydrogenation and hydrolysis reactions to proceed and to



0.7 WT% SULFUR COAL CASE

STREAM	1	3+4	15	20
	ACID GAS	AIR	TAIL GAS	SULFUR PRODUCT
Component, Vol.%				
CO	0.75		0.79	
H_2	0.11		0.11	
CO_2	81.38		85.58	
CH_4	0.01		0.01	
O_2	-	20.37	-	
N_2	-	76.63	5.72	
NH_3	-	-	-	
H_2O	4.45	3.0	7.57	
H_2S	13.08		0.14	
COS	0.22		(73 PPM)	
SO_2	-		0.07	
S_x x = 7.33	-		0.01	
	100.00	100.00	100.00	-
MMSCFD	4.71	2.01	5.01	-
Sulfur, lb/hr	537	-	51	1,058

3.5 WT% SULFUR COAL CASE

STREAM	1	3+4	15	20
	ACID GAS	AIR	TAIL GAS	SULFUR PRODUCT
Component, Vol.%				
CO	0.80		0.62	
H_2	0.12		0.09	
CO_2	79.08		61.75	
CH_4	0.01		0.01	
O_2	-	20.37	-	
N_2	-	76.63	21.79	
NH_3	-	-	-	
H_2O	4.97	3.0	15.34	
H_2S	14.10	-	0.24	
COS	0.92	-	0.03	
SO_2	-	-	0.12	
S_x x = 7.33	-	-	0.01	
	100.00	100.00	100.00	-
MMSCFD	5.46	2.01	6.82	-
Sulfur, lb/hr	2,891		116	5,879

KEY ELEMENTS OF THE PROCESS ILLUSTRATED ARE COVERED BY U.S. PATENTS ASSIGNED TO THE RALPH M. PARSONS COMPANY.

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

PROCESS FLOW DIAGRAM SULFUR RECOVERY UNIT

REV. NO.	CUST. APPR.	DATE	REVISION	BY	PROC. ENGR.	CHECK	CHIEF PROC. ENGR.	CHIEF OPER. ENGR.	PROJ. DIR.
3		4/12/78	REVISED FEED						
2		1-16-77	FOR REPORT						
1		9-19-77	FOR SCE REVIEW						
0		9 SEP 77	FOR RMPC REVIEW						

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

JOB NO. 5815 | DWG. NO. R-15-FS-1 | REV. 3

DC- ST-

0.7 WT % LOW SULFUR WESTERN COAL

STREAM	1	8
COMPONENT, VOL. %		
H_2	0.11	0.73
CO	0.79	0.37
CO_2	85.58	77.73
CH_4	0.01	0.01
N_2 + A	5.72	15.60
H_2S	0.14	(2PPM)
COS	(73PPM)	(40PPM)
SO_2	0.07	-
S_x x= 7.33	0.01	-
H_2O	7.57	5.56
	100.00	100.00

REV. NO.	CUST. APPR.	DATE	REVISION	BY	PROC. ENGR.	CHECK	CHIEF PROC. ENGR.	CHIEF OPER. ENGR.	PROC. DIR.
0		7/27/78	ISSUED FOR FINAL REPORT	LN	WRW	ECW	CLB		
A		4/20/78	ISSUED TO SCE FOR REVIEW & COMMENT	LDS	WRW		CLB		

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE **PROCESS FLOW DIAGRAM**
BEAVON SULFUR REMOVAL UNIT

THE RALPH M. PARSONS COMPANY, PASADENA, CALIFORNIA | JOB NO. 5815 | DWG. NO. R-15-FS-2 | REV. 0

DC- DT-

supply reducing gas (H_2 and CO). The hot combustion products are mixed with the tail gas and the mixture flows to the hydrogenation reactor. The hydrogenation and hydrolysis reactions of the four primary sulfur constituents are as follows:

$$S + H_2 = H_2S$$

$$SO_2 + 3H_2 = 2H_2S + H_2O$$

$$CS_2 + 2H_2O = 2H_2S + CO_2$$

$$COS + H_2O = H_2S + CO_2$$

The hydrogenated tail gas is then cooled in the reactor effluent cooler by generating low pressure steam.

The Stretford section consists of a venturi scrubber, an absorber which includes a reaction tank, an oxidizer tank, and other sulfur separation and melting equipment. A spare venturi scrubber is provided.

The cooled tail gas is first contacted with oxidized Stretford solution in the venturi scrubber, where most of the hydrogen sulfide is absorbed. The gas and solution from the venturi gas scrubber discharge into the bottom section of the absorber and the gas passes up through the absorber where there is a second contact with fresh oxidized Stretford solution. The treated tail gas vents from the top of the absorber to the atmosphere. A combustor is provided in the vent line from the absorber to burn H_2S and other combustibles in case of a shutdown of the Stretford section. The combustor could also be used to incinerate any ammonia from the effluent water treatment plant.

The reduced Stretford solution is held in the bottom of the absorber which is sized to allow sufficient residence time for the sulfur reaction-forming mechanism to go to completion. The overall reaction is:

$$H_2S + 1/2\ O_2 = S + H_2O$$

The solution from the reaction zone in the asorber flows to an oxidizer tank where a turbine aerator disperses air supplied by the sulfur-recovery plant air blower. Sulfur slurry overflows from the oxidizer tank by gravity into the sulfur slurry tank. The oxidized solution flows to the balance tank. Oxidized solution is pumped from the balance tank back to the venturi gas scrubber and absorber. A cooling tower and circulating pump are provided with the balance tank to maintain heat and water balance in the unit.

The sulfur slurry which flows to the slurry tank is agitated gently and deaerated. Slurry from the slurry tank is then pumped to the sulfur melter. The hot dilute solution and molten sulfur flow to the sulfur decanter where the sulfur and solution separate. The sulfur is withdrawn from the bottom of the decanter on level control and flows to the Claus plant sulfur pit. The hot solution is released from the top of the decanter, and returns to the balance tank after being quenched with a stream of cool solution.

Auxiliary equipment necessary for the performance of the unit consists of a makeup pit for preparing fresh Stretford solution and adding makeup chemicals, and an additive injection package for adding diesel fuel or kerosene to the solution to aid in flotation of sulfur crystals in the oxidizer tanks.

Equipment sizing in the Stretford section of the Beavon sulfur-removal plant is governed by the total quantity of sulfur in the Claus tail gas. This section has been designed to handle 13% of the sulfur from low-sulfur coal, a larger than usual margin to allow for upset operation of the plant. Thus, the Stretford section is capable of capturing 0.72 LTD of sulfur, although its normal design loading is only 0.55 LTD.

When processing high-sulfur coal the Claus section will emit about 1.22 LTD of contained sulfur, which exceeds the design Stretford capacity. The Stretford plant can accept a heavy overload for a few hours without serious detriment, but the price of prolonged overloading is degradation of the solution by conversion of vanadium to inactive compounds and formation of abnormally large amounts of sodium thiosulfate. Hence, if high-sulfur coal is to be used for an extended test period, the Claus tail gas must be bypassed to the combustor located in the Beavon plant for incineration. Combustion of the H_2S converts most of the sulfur to SO_2 leaving less than 10 ppm of H_2S in the stack gas.

The design limitation of the Stretford section with regard to handling the Claus tail gas resulting from high-sulfur coal is due strictly to the design criteria which governed the Beavon plant. There is no technological barrier to designing the Stretford section for handling the full output of the Claus section.

Because sizes and duties of equipment in the sulfur-recovery plant are proprietary, these data are not included in the attached equipment list. Although these data are not shown, they were developed and were used in the development of the cost estimate.

EQUIPMENT LIST

SULFUR RECOVERY

VESSELS

Item No.	Description	Material
15-1201	Acid Gas Knockout Drum	CS
15-1202 15-1203 15-1204	Converter Converter Converter	CS, W/2" Refractory Lining at and below Catalyst Beds
15-1205	Therminol Storage Drum	CS

HEAT EXCHANGERS

Item No.	Description	Material
15-1301	No. 1 Condenser	CS
15-1302	No. 2 Condenser	CS
15-1303	No. 3 Condenser	CS
15-1304	No. 4 Condenser	CS
15-1305	L.P. Steam Condenser	CS
15-1306	Acid Gas Preheater	CS

EQUIPMENT LIST

SULFUR RECOVERY (Contd)

HEAT EXCHANGERS (Contd)

Item No.	Description	Material
15-1307	No. 1 Reheater	CS
15-1308	No. 2 Reheater	CS
15-1309	No. 3 Reheater	CS

PUMPS

Item No.	Description	Type	Driver	Material
15-1501	Sour Water Pump	Centrifugal Inline	Motor	C-6
15-1502	(Spare 15-1501)			
15-1503	Sulfur Burner Pump	Vertical Sump	Motor	I-1 Stm. jacketed
15-1504	(Spare 15-1503)			
15-1505	Sulfur Pump	Vertical Sump	Motor	I-1 Stm. jacketed
15-1506	(Spare 15-1505)			
15-1507	Therminol Pump	Centrifugal	Motor	S-1
15-1508	(Spare 15-1507)			

EQUIPMENT LIST

SULFUR RECOVERY (Contd)

BOILERS

Item No.	Description	Material
15-1601	Reaction Boiler	CS

BLOWERS

Item No.	Description	Type	Driver
15-1801	Combustion Air Blower	Centrifugal 7 Stg.	Motor
15-1802	Combustion Air Blower Spare	Centrifugal 7 Stg.	Motor

FURNACES

Item No.	Description
15-1401	Reaction Furnace
15-1405	Therminol Heater

COLUMNS

Item No.	Description	Material
15-1151	Absorber Reaction Tank	CS

EQUIPMENT LIST

SULFUR RECOVERY (Contd)

VESSELS

Item No.	Description	Material
15-1251	Hydrogenation Reactor	CS
15-1252	Decanter	CS

HEAT EXCHANGERS AND CONDENSERS

Item No.	Description	Material
15-1351	Reactor Effluent Cooler	CS

FURNACES, HEATERS, BURNERS AND STACKS

Item No.	Description	Material
15-1451	Reducing Gas Generator	CS
15-1452	Tail Gas Combustor	

PUMPS

Item No.	Description
15-1551	Cooling Tower Circulation Pump
15-1552	Stretford Circulation Pump
15-1553	(Same as 15-1552)

EQUIPMENT LIST

SULFUR RECOVERY (Contd)

PUMPS (Contd)

Item No.	Description
15-1554	Sulfur Slurry Pump
15-1555	(Same as 15-1554)
15-1556	Makeup Pit Pump

COOLING TOWERS

Item No.	Description
15-1751	Cooling Tower

STORAGE TANKS AND SPHERES

Item No.	Description	Material
15-1951	Oxidizer Tank	CS
15-1952	Slurry Tank	CS
15-1953	Balance Tank	CS

AGITATORS, MIXERS AND BLENDERS

Item No.	Description
15-2451	Turbine Aerator
15-2452	Slurry Tank Agitator

EQUIPMENT LIST

SULFUR RECOVERY (Contd)

AGITATORS, MIXERS AND BLENDERS (Contd)

Item No.	Description
15-2453	Balance Tank Agitator
15-2454	Makeup Pit Agitator

OTHER MAJOR EQUIPMENTS

Item No.	Description
15-2851	Additive Injection Package
15-2852	Venturi Scrubber
15-2853	(Same as 15-2852)

CONCRETE WORK AND PILING

Item No.	Description	Material
15-4151	Makeup Pit	Concrete

3.9 STEAM, CONDENSATE AND BOILER FEEDWATER SYSTEM

To maximize efficiency and to minimize cost of the overall plant, an integrated coal gasification/power plant steam, condensate, and boiler feedwater system is provided.

The steam production system has been preliminarily optimized for Case I which represents the ultimate plant configuration. In Case I the high-pressure steam is superheated in the heat recovery steam generator (HRSG) by the combustion turbine exhaust gases. To assure a sufficient approach temperature between the combustion turbine exhaust and the superheated steam temperature the superheated steam temperature is limited to approximately 950°F.

The steam system generates steam at three pressure levels as follows to accommodate the gasification plant requirements:

- A high-pressure steam system delivers 1150 psig, 950° F superheated steam to the oxygen plant for driving the compressors and to the power plant steam turbine-generator for electric power generation.

- An intermediate-pressure steam system delivers 150 psig saturated steam to process services, primarily in the Selexol stripper reboiler. Process coolers in the sulfur-recovery unit generate a small amount of 150 psig steam to partially supply the intermediate-pressure steam system.

- A low-pressure steam system delivers 50 psig saturated steam primarily to the deaerator for feedwater deaeration and to the process for direct stripping. Process coolers in the sulfur-recovery unit generate a small amount of 50 psig steam to partially supply the low-pressure steam system.

Because of the large duties of the oxygen plant turbocompressors and of the power plant turbine-generator, most of the steam consumed by the plant will be condensed and recovered. Cold condensate that is recovered from the vacuum systems is pumped back into the condensate storage tank where makeup from the demineralized water system is added. Cold condensate is then pumped through the HRSG low-pressure economizer where it is preheated and then into the deaerator where it is mixed with returning hot condensate from process users in the gasification plant and deaerated by low-pressure steam. The deaerated feedwater is then pumped to the boilers for steam production through a high-pressure and a low-pressure feedwater systems. Facilities are provided to add chemical treating agents and an oxygen scavenger to the deaerated boiler feedwater supply.

Blowdown water from all boilers is discharged into the cooling tower basin where it is used as partial makeup to the circulating water system.

Case I Description

The steam, condensate and boiler feedwater system for Case I is shown on Process Flow Diagram No. D-01-FS-3.

The high-pressure steam is produced in both the gasification plant syngas coolers and in the HRSG high-pressure evaporation section at 1200 psig. The high-pressure steam is then superheated in the HRSG steam superheating section to 952°F.

The intermediate-pressure steam is produced by the medium-pressure evaporating section of the HRSG and the low-pressure steam is produced by the low-pressure evaporation section of the HRSG. Because more high-pressure steam is produced than is required for the oxygen plant compressor drivers, the rest of the main steam is routed to the power plant steam turbine-generator for electric power generation.

The HRSG is described in section 3.10 of this report.

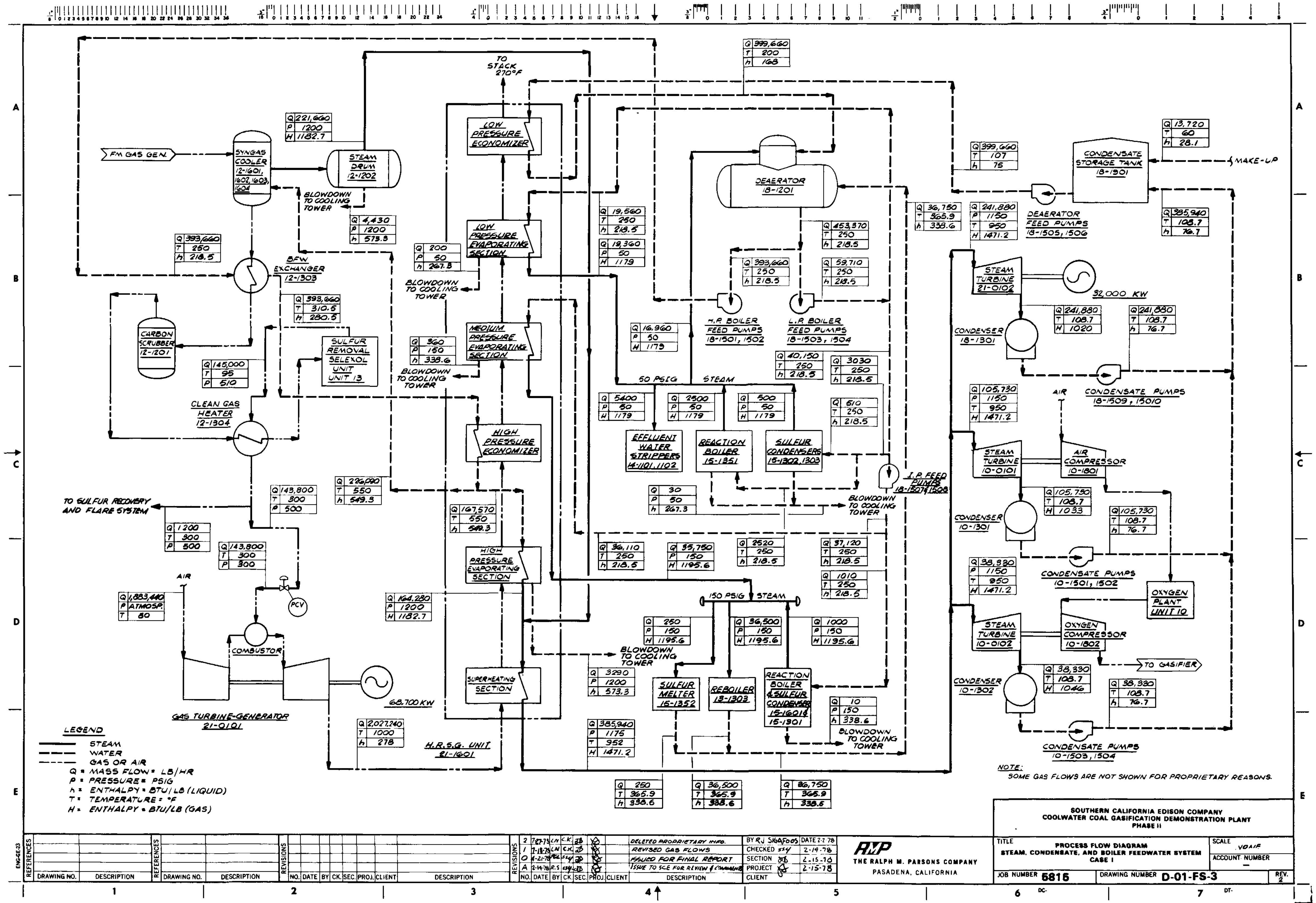
The total high-pressure feedwater flow is preheated first in the gasification plant by the hot product gas and finally in the HRSG economizer section.

Case II Description

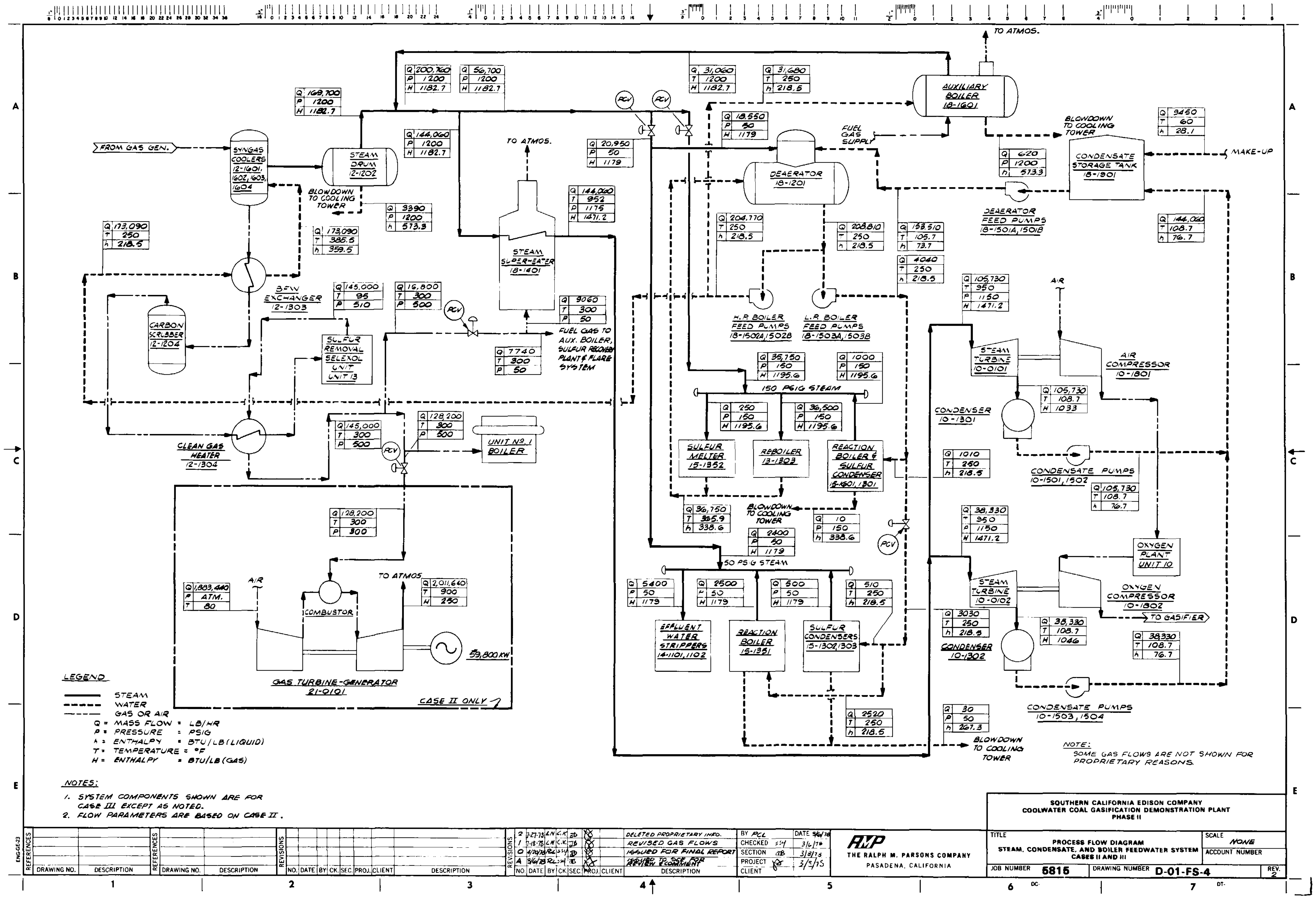
The steam, condensate and boiler feedwater system for Case II is shown on Process Flow Diagram No. D-01-FS-4.

The high-pressure steam is produced only in the gasification plant syngas coolers at 1200 psig. The high-pressure steam required for driving the oxygen plant compressors is then superheated to 952 F in a separate steam superheater fired with product gas from the gasification plant. In addition to providing superheated steam to the oxygen plant, the high-pressure steam system supplies saturated steam to the medium-pressure and low-pressure steam systems through pressure reducing stations.

Because less high-pressure steam is produced in Case II than is required for the oxygen plant compressor drivers and the low-pressure steam systems, an auxiliary boiler is provided. In addition to providing makeup steam for full and partial load operation of the plant, the auxiliary boiler will supply the steam required for plant start-up.



TO STACK 270°F
FM GAS GEN.
SYNGAS COOLER 12-1601, 1602, 1603, 1604
STEAM DRUM 12-1202
BLOWDOWN TO COOLING TOWER
BFW EXCHANGER 12-1303
CARBON SCRUBBER 12-1201
SULFUR REMOVAL SELEXOL UNIT UNIT 13
CLEAN GAS HEATER 12-1304
TO SULFUR RECOVERY AND FLARE SYSTEM
AIR
PCV
COMBUSTOR
GAS TURBINE-GENERATOR 21-0101
68,700 KW
LOW PRESSURE ECONOMIZER
LOW PRESSURE EVAPORATING SECTION
MEDIUM PRESSURE EVAPORATING SECTION
HIGH PRESSURE ECONOMIZER
HIGH PRESSURE EVAPORATING SECTION
SUPERHEATING SECTION
H.R.S.G. UNIT 21-1601
DEAERATOR 18-1201
H.P. BOILER FEED PUMPS 18-1501, 1502
L.P. BOILER FEED PUMPS 18-1503, 1504
I.P. FEED PUMPS 18-1507, 1508
50 PSIG STEAM
EFFLUENT WATER STRIPPERS 14-1101, 1102
REACTION BOILER 15-1351
SULFUR CONDENSERS 15-1302, 1303
150 PSIG STEAM
SULFUR MELTER 15-1352
REBOILER 13-1303
REACTION BOILER & SULFUR CONDENSER 15-1601 & 15-1301
CONDENSATE STORAGE TANK 18-1501
MAKE-UP
DEAERATOR FEED PUMPS 18-1505, 1506
STEAM TURBINE 21-0102
32,000 KW
CONDENSER 18-1301
CONDENSATE PUMPS 18-1509, 15010
STEAM TURBINE 10-0101
AIR COMPRESSOR 10-1801
CONDENSER 10-1301
CONDENSATE PUMPS 10-1501, 1502
OXYGEN PLANT UNIT 10
STEAM TURBINE 10-0102
OXYGEN COMPRESSOR 10-1802
TO GASIFIER
CONDENSER 10-1302
CONDENSATE PUMPS 10-1503, 1504
NOTE: SOME GAS FLOWS ARE NOT SHOWN FOR PROPRIETARY REASONS.
LEGEND
STEAM
WATER
GAS OR AIR
Q = MASS FLOW = LB/HR
P = PRESSURE = PSIG
h = ENTHALPY = BTU/LB (LIQUID)
T = TEMPERATURE = °F
H = ENTHALPY = BTU/LB (GAS)
SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II
TITLE PROCESS FLOW DIAGRAM STEAM, CONDENSATE, AND BOILER FEEDWATER SYSTEM CASE I
RMP THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA
DELETED PROPRIETARY INFO.
REVISED GAS FLOWS
ISSUED FOR FINAL REPORT
ISSUE TO SCE FOR REVIEW & COMMENT
JOB NUMBER 5815
DRAWING NUMBER D-01-FS-3
REV. 2


FROM GAS GEN.
SYNGAS COOLERS 12-1601, 1602, 1603, 1604
STEAM DRUM 12-1202
BLOWDOWN TO COOLING TOWER
TO ATMOS.
STEAM SUPER-HEATER 18-1401
BFW EXCHANGER 12-1303
CARBON SCRUBBER 12-1204
SULFUR REMOVAL SELEXOL UNIT UNIT 13
FUEL GAS TO AUX. BOILER, SULFUR RECOVERY PLANT & FLARE SYSTEM
CLEAN GAS HEATER 12-1304
UNIT NO. 1 BOILER
AIR
COMBUSTOR
GAS TURBINE-GENERATOR 21-0101
59,800 KW
CASE II ONLY
AUXILIARY BOILER 18-1601
FUEL GAS SUPPLY
DEAERATOR 18-1201
DEAERATOR FEED PUMPS 18-1501A,1501B
CONDENSATE STORAGE TANK 18-1801
MAKE-UP
H.P. BOILER FEED PUMPS 18-1502A,1502B
L.P. BOILER FEED PUMPS 18-1503A,1503B
150 PSIG STEAM
SULFUR MELTER 15-1352
REBOILER 13-1303
REACTION BOILER & SULFUR CONDENSER 15-1601,1301
50 PSIG STEAM
EFFLUENT WATER STRIPPERS 14-1101,1102
REACTION BOILER 15-1351
SULFUR CONDENSERS 15-1302,1303
STEAM TURBINE 10-0101
AIR COMPRESSOR 10-1801
CONDENSER 10-1301
CONDENSATE PUMPS 10-1501,1502
OXYGEN PLANT UNIT 10
STEAM TURBINE 10-0102
OXYGEN COMPRESSOR 10-1802
TO GASIFIER
CONDENSER 10-1302
CONDENSATE PUMPS 10-1503,1504
PCV
NOTE: SOME GAS FLOWS ARE NOT SHOWN FOR PROPRIETARY REASONS.
LEGEND
STEAM
WATER
GAS OR AIR
Q = MASS FLOW = LB/HR
P = PRESSURE = PSIG
h = ENTHALPY = BTU/LB (LIQUID)
T = TEMPERATURE = °F
H = ENTHALPY = BTU/LB (GAS)
NOTES:
1. SYSTEM COMPONENTS SHOWN ARE FOR CASE III EXCEPT AS NOTED.
2. FLOW PARAMETERS ARE BASED ON CASE II.
SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II
TITLE
PROCESS FLOW DIAGRAM
STEAM, CONDENSATE, AND BOILER FEEDWATER SYSTEM
CASES II AND III
SCALE NONE
ACCOUNT NUMBER
JOB NUMBER 5815
DRAWING NUMBER D-01-FS-4
REV. 2
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA
DELETED PROPRIETARY INFO.
REVISED GAS FLOWS
ISSUED FOR FINAL REPORT
ISSUED TO SCE FOR REVIEW & COMMENT

The total high-pressure feedwater flow is preheated only in the gasification plant by the hot product gas. To minimize the cost of retrofitting the plant when adding the power plant steam cycle the feedwater heater will be designed to handle the Case I steam flow.

Case III Description

The steam, condensate and feedwater system for Case III is identical to the Case II system and is shown on Process Flow Diagram No. D-01-FS-4.

EQUIPMENT LIST

STEAM, CONDENSATE, AND BOILER FEEDWATER SYSTEM

CASE I

Item No.	Quantity	Description
18-1301	1	Steam turbine condenser - designed for 238 x 10^6 Btu/hr. duty with 20,300 ft effective area, two passes and 5750, 7/8", 90-10 Cu-Ni tubes 16 ft. long.
18-1201	1	Deaerator - direct-contact, tray type deaerating heater with a horizontal storage tank, designed for 50 psig @ 670°F and fabricated per ASME Section VIII, Division I.
18-1901	1	Condensate storage tank - 250,000 gallon capacity, vertical steel tank with internal epoxy lining and dome roof - 36 ft. diameter by 34 ft. high.
18-1501 (18-1502 Spare)	2	H.P. boiler feed pumps - 100% capacity, horizontal, centrifugal type pumps rated for 870 gpm @ 3000 ft. TDH and driven by 1000 hp electric motors.
18-1503 (18-1504 Spare)	2	L.P. boiler feed pumps - 100% capacity, horizontal, centrifugal type pumps rated for 135 gpm @ 425 ft. TDH and driven by 35 hp electric motors.
18-1505 (18-1506 Spare)	2	Deaerator feed pumps - 100% capacity, hotizontal, centrifugal type pumps rated for 880 gpm @ 250 ft. TDH and driven by 75 hp electric motors.
18-1507 (18-1508 Spare)	2	I.P. boiler feed pumps - 100% capacity, horizontal, centrifugal type pumps rated for 10 gpm @ 410 ft. TDH and driven by 2 hp electric motors.
18-1509 (18-1510 Spare)	2	Condensate pumps - 100% capacity, vertical, centrifugal type pumps rated for 540 gpm @ 100 ft. TDH and driven by 25 hp electric motors.

EQUIPMENT LIST

STEAM, CONDENSATE, AND BOILER FEEDWATER SYSTEM

CASE II

(A) INITIAL PHASE

Item No.	Quantity	Description
18-1501A (18-1501B - Spare)	2	Deaerator feed pumps - 100% capacity, horizontal, centrifugal type pumps rated for 350 gpm @ 250 ft. TDH and driven by 30 hp electric motors.
18-1502A (18-1502B - Spare)	2	H.P. boiler feed pumps - 100% capacity, horizontal, centrifugal type pumps rated for 450 gpm @ 3,000 ft. TDH and driven by 700 hp electric motors.
18-1503A (18-1503B)	2	I.P. boiler feed pumps - 100% capacity, horizontal, centrifugal type pumps rated for 10 gpm @ 410 ft. TDH and driven by 2 hp electric motors.
18-1201	1	Deaerator - direct-contact, tray-type, deaerating heater with a horizontal storage tank, designed for 50 psig @ 670°F and fabricated per ASME Section VIII Division I code.
18-1901	1	Condensate storage tank - 250,000 gallon capacity, vertical, steel tank with internal epoxy lining and dome roof - 36 ft. Dia. x 34 ft. high.
18-1601	1	Auxiliary boiler - forced-draft, packaged type boiler designed to produce 210,000 lb/hr. of 1200 psig saturated steam. Forced-draft fan to be driven by a 300 hp electric motor.

EQUIPMENT LIST

STEAM, CONDENSATE, AND BOILER FEEDWATER SYSTEM

CASE II (Contd)

(A) INITIAL PHASE (Contd)

Item No.	Quantity	Description
18-1401	1	Steam superheater - Vertical, cylindrical type heater with finned tube convection section designed to superheat 210,000 lb/hr of 1200 psig saturated steam to 952°F. with a total abs. duty of 60.6 x 10 Btu/hr.

(B) ADD-ON PHASE

Item No.	Quantity	Description
18-1301	1	Steam turbine condenser - designed for 238 x 10^6 Btu/hr duty with 20,300 ft. effective area, two passes and 5750, 7/8", 90-10 Cu-Ni tubes 16 ft. long.
18-1501C	1	Deaerator feed pump - horizontal, centrifugal type pump rated for 350 gpm @ 250 ft. TDH and driven by 30 hp electric motor.
18-1502C	1	H.P. boiler feed pump - horizontal, centrifugal type pump rated for 450 gpm @ 3000 ft. TDH and driven by a 700 hp electric motor.
18-1504A (18-1504B - Spare)	2	L.P. boiler feed pumps - 100% capacity, horizontal, centrifugal type pump rated for 135 gpm @ 425 ft TDH and driven by 35 hp electric motors.
18-1505A (18-1505B - Spare)	2	Condensate pumps - 100% capacity, vertical, centrifugal type pumps rated for 540 gpm @ 100 ft. TDH and driven by 25 hp electric motors.

EQUIPMENT LIST

STEAM, CONDENSATE, AND BOILER FEEDWATER SYSTEM

CASE III

(A) INITIAL PHASE

Item No.	Quantity	Description
18-1501A (18-1501B - Spare)	2	Deaerator feed pumps - 100% capacity, horizontal, centrifugal type pumps rated for 350 gpm @ 250 ft. TDH and driven by 30 hp electric motors.
18-1502A (18-1502B - Spare)	2	H.P. boiler feed pumps - 100% capacity, horizontal, centrifugal type pumps rated for 450 gpm @ 3,000 ft. TDH and driven by 700 hp electric motors.
18-1503A (18-1503B - Spare)	2	I.P. boiler feed pumps - 100% capacity, horizontal, centrifugal type pumps rated for 10 gpm @ 410 ft. TDH and driven by 2 hp electric motors.
18-1201	1	Deaerator - direct-contact, tray-type, deaerating heater with a horizontal storage tank, designed for 50 psig @ 670° F and fabricated per ASME Section VIII Division I code.
18-1901	1	Condensate storage tank - 250,000 gallon capacity, vertical, steel tank with internal epoxy lining and dome roof - 36 ft. Dia. x 34 ft. high.
18-1601	1	Auxiliary boiler - forced-draft, packaged type boiler designed to produce 210,000 lb/hr. of 1200 psig saturated steam. Forced-draft fan to be driven by a 300 hp electric motor.

EQUIPMENT LIST

STEAM, CONDENSATE, AND BOILER FEEDWATER SYSTEM

CASE III (Contd)

(A) INITIAL PHASE (Contd)

Item No.	Quantity	Description
18-1401	1	Steam superheater - Vertical, cylindrical type heater with finned tube convection section designed to superheat 210,000 lb/hr of 1200 psig saturated steam to 952°F. with a total abs. duty of 60.6 x 10 Btu/hr.

(B) ADD-ON PHASE

Item No.	Quantity	Description
18-1301	1	Steam turbine condenser - designed for 238 x 10^6 Btu/hr duty with 20,300 ft. effective area, two passes and 5750, 7/8", 90-10 Cu-Ni tubes 16 ft. long.
18-1501C	1	Deaerator feed pump - horizontal, centrifugal type pump rated for 350 gpm @ 250 ft. TDH and driven by 30 hp electric motor.
18-1502C	1	H.P. boiler feed pump - horizontal, centrifugal type pump rated for 450 gpm @ 3000 ft. TDH and driven by a 700 hp electric motor.
18-1504A (18-1504B - Spare)	2	L.P. boiler feed pumps - 100% capacity, horizontal, centrifugal type pump rated for 135 gpm @ 425 ft. TDH and driven by 35 hp electric motors.
18-1505A (18-1505B - Spare)	2	Condensate pumps - 100% capacity, vertical, centrifugal type pumps rated for 540 gpm @ 100 ft. TDH and driven by 25 hp electric motors.

3.10 POWER GENERATION

The power plant will use the clean gas produced by the gasification plant as fuel to be burned in a combustion turbine to generate electricity. The exhaust from the turbine is used by the heat recovery steam generator (HRSG) to produce steam which is combined with the steam produced by the gasification plant syngas coolers to supply process steam to the oxygen, gasification and sulfur removal and recovery plants. The total steam produced by the power and gasification plants is more than required by the process and the excess is used to produce additional electricity via a steam turbine.

The power plant arrangement is shown on Drawings D-01-GA-7 and D-01-GA-8 which are included with subsection 3.1. The gas turbine-generator is rated at 75 MW ISO and the steam turbine-generator is rated at approximately 35 MW. A detailed description of the power plant is presented for Case I as well as the differences for Case II and Case III.

Case I Description

Major components of the power plant for Case I consist of the following:

- Combustion Turbine-Generator
- Heat Recovery Steam Generator (HRSG)
- Steam Turbine-Generator

Combustion Turbine-Generator. The combustion turbine-generator is a base-mounted, simple cycle, turbine-generator unit rated at approximately 75 MW ISO.

Because the fuel gas produced by the coal gasification plant is a medium Btu gas, the combustion turbine will have to be modified. The modifications required in order to burn medium gas efficiently and cleanly are as follows:

- New combustion liners and fuel nozzles.
- New fuel gas supply system to accommodate the high volume of gas required.
- Possibly a new first row of power vanes to ensure that increased compressor-pressure ratio will not cause surge problems.

Because of the limited experience in burning medium Btu gas in combustion turbines, it is recommended that a testing program be implemented by the turbine manufacturer to test the combustor liner and fuel nozzle design prior to fabrication. Several design configurations of the new liner and nozzle will be fabricated and checked in a testing facility built for this purpose. During the test, lightoff capability, mechanical performance, thermal performance, emission performance, and design capability of the new parts will be analyzed.

The combustion turbine-generator consists of:

- Turbine section, with:

  --Single-shaft combustion turbine

  --Multistage axial-flow compressor

  --Combustion system

  --Multistage power turbine

  --Water-injection system for NO_x emissions control

  --Accessory drive system with accessory gear and continuously lubricated coupling

  --Turning gear assembly

  --Dual fuel system to inject medium-Btu gas (normal operation) or diesel fuel oil (startup operation)

  --Starting and cooldown systems

  --Dual-ignition system

  --Electrohydraulic turbine control and protection system

  --Closed forced-feed lubrication and hydraulic supply system

  --Inlet and exhaust plenums

  --Inlet silencing and transition ducting, with bracing and supports

  --Inlet filter house, with inertial separator filter and high-efficiency second-stage filter

  --Exhaust breeching with bypass damper, bypass stack, bracing, and supports

- Generator section, with:

  --Cylindrical rotor, 3,600-rpm, 3-phase, 60-Hz generator:

  --Generator auxiliary and excitation equipment

- Combustion turbine-generator control section.

- Full outdoor enclosure, complete with heating and ventilating, as required, and fire protection system

In addition, the combustion turbine-generator is also provided with a remote combustion turbine starting and supervisory control panel that will be located in the central plant control room.

Heat Recovery Steam Generator. The HRSG is designed to the ASME Code and, as shown on Process Flow Diagram D-01-FS-3 in subsection 3.9, is composed of six suitably proportioned convection sections classified as:

- Steam-superheating section

- High-pressure steam evaporation section

- High-pressure economizer section

- Medium-pressure steam evaporation section

- Low-pressure steam evaporation section

- Low-pressure economizer section

The steam-superheating section superheats the combined high-pressure steam produced by the HRSG and syngas coolers to 950° F. The high-pressure steam evaporation section produces approximately half of the total 1,200 psig saturated steam produced by the overall plant (the other half is produced by the syngas coolers). The high-pressure steam evaporation section includes a high-pressure steam drum and two recirculation pumps. The high-pressure economizer section does final preheating of the total plant high-pressure feedwater.

The medium-pressure steam evaporation section produces 150 psig saturated steam for process uses, primarily in the Selexol stripper reboiler.

The low-pressure steam evaporation section produces the low-pressure saturated steam required to deaerate the total plant condensate flow and the 50 psig saturated steam required by the sulfur plant and the gasification process effluent water treating plant.

The low-pressure economizer section preheats the cold condensate prior to deaeration.

Steam Turbine-Generator. The steam turbine-generator is a standard, base-mounted unit, rated at approximately 35 MW, which consists of:

- Straight condensing steam turbine directly connected to the generator shaft, complete with electro-hydraulic turbine control and protection system, closed forced-feed lubrication, hydraulic supply system, and shaft-packing seal system.
- Generator, incorporating the same features as the combustion turbine-driven generator.
- Steam turbine-generator local control panel, with steam turbine controls, generator controls, exciter controls, annunciator, and protection relays.
- Full outdoor enclosure, complete with heating and ventilating, as required, and fire protection system.

A combined HRSG/steam turbine-generator remote-control panel is provided, and is to be located in the central plant control room.

Case II Description

The Case II power plant consists primarily of a combustion turbine-generator, which burns the clean fuel gas produced by the gasification plant. The combustion turbine-generator will be identical to that described for Case I.

The combustion turbine exhausts directly to atmosphere through the combustion turbine stack. The turbine will be located as shown in Drawing D-01-GA-7 to allow future addition of the HRSG and steam turbine-generator.

Case III Description

Case III does not include a power plant. The clean fuel gas produced by the gasification plant is burned in the existing Unit I boiler. The area occupied by the power plant, as shown in Drawing D-01-GA-7, will be reserved for future installation of power-generation equipment.

EQUIPMENT LIST

POWER GENERATION PLANT

CASE I

STEAM, CONDENSATE & BOILER FEEDWATER SYSTEM

Item No.	Quantity	Description
21-0101	1	Combustion turbine-generator unit rated at approximately 75 MW ISO complete with outdoor enclosure. - Combustion turbine is designed to burn medium Btu fuel gas and is provided with dual fuel system. - 3 phase, 60 hertz, 13,300 volts, hydrogen-cooled generator.
21-0102	1	Steam turbine-generator unit rated at 35 MW complete with outdoor enclosure. - 1200 psig - 950°F. steam turbine throttle conditions. - 3 phase, 60 hertz, 13,800 volts, hydrogen-cooled generator.
21-1601	1	Heat recovery steam generator unit includes: - Steam-superheating section - High-pressure steam evaporation section with steam drum and recirculation pumps. - High-pressure economizer section. - Medium-pressure steam evaporation section. - Low-pressure steam evaporation section. - Low-pressure economizer section

EQUIPMENT LIST

POWER GENERATION PLANT

CASE II

A. INITIAL PHASE

Item No.	Quantity	Description
21-0101	1	Combustion turbine-generator unit rated approximately at 75 MW ISO complete with outdoor enclosure. - Combustion turbine is designed to burn medium Btu fuel gas and is provided with dual-fuel system. - 3 phase, 60 hertz, 13,300 volts, hydrogen-cooled generator.

B. ADD-ON PHASE

Item No.	Quantity	Description
21-0102	1	Steam turbine-generator unit rated at 35 MW complete with outdoor enclosure. - 1200 psig - 950° F. steam turbine throttle conditions. - 3 phase, 60 hertz, 13,800 volts, hydrogen-cooled generator.
21-1601	1	Heat recovery steam generator unit includes: - Steam-superheating section - High-pressure steam evaporation section with steam drum and recirculation pumps. - Low-pressure economizer section. - High-pressure economizer section. - Medium-pressure steam evaporation section. - Low-pressure steam evaporation section.

EQUIPMENT LIST

POWER GENERATION PLANT

CASE III

A. INITIAL PHASE

Item No.	Quantity	Description
B. ADD-ON PHASE		
21-0101	1	Combustion turbine-generator unit rated approximately at 75 MW ISO complete with outdoor enclosure. - Combustion turbine is designed to burn medium Btu fuel gas and is provided with dual-fuel system. - 3 phase, 60 hertz, 13,800 volts, hydrogen-cooled generator.
21-0102	1	Steam turbine-generator unit rated at 35 MW complete with outdoor enclosure. - 1200 psig - 950° F. steam turbine throttle conditions. - 3 phase, 60 hertz, 13,800 volts, hydrogen-cooled generator.
21-1601	1	Heat recovery steam generator unit includes: - Steam-superheating section - High-pressure steam evaporation section with steam drum and recirculation pumps. - Low-pressure economizer section. - High-pressure economizer section. - Medium-pressure steam evaporation section. - Low-pressure steam evaporation section.

3.11 INTEGRATED PLANT COOLING WATER SYSTEM

General Description

The integrated plant cooling water system provides cooling water to remove the heat loads generated in the coal gasification plant, the oxygen plant, and the power-generation equipment.

The integrated plant cooling water system consists of the following subsystems:

- Circulating water system
- Closed cooling water system
- Chlorination system

The circulating water system provides circulating water to the steam turbine condensers in the power plant and the oxygen plant, and to the closed cooling water system heat exchangers for heat dissipation. In addition, the circulating water system is also used for disposal of blowdown from the steam, condensate, and boiler feedwater system. Makeup to the circulating water system is provided by the plant makeup water system.

The closed cooling water system provides corrosion inhibited, demineralized, cooling water to the power plant, coal gasification plant, and oxygen plant auxiliary equipment. Heat loads generated in this closed-loop system are removed from the cooling water heat exchangers by the circulating water system.

Chlorine solution is injected intermittently in the circulating water system for algae control. A maximum chlorine concentration of 5 ppm will be maintained in the circulating water system.

Detailed Description - Case I

The integrated plant cooling water system for Case I is shown on Process Flow Diagram D-19-FS-1. Each of the three subsystems is described in the following subsections.

Circulating Water System. A closed-loop circulating water system, utilizing a mechanical-draft, evaporative cooling tower, is provided to remove approximately 386 x 10^6 Btu/hr of heat from the condensers in the oxygen plant and the power plant. In addition, 112.5 x 10^6 Btu/Hr of heat load from the closed cooling water system is also removed by the circulating water system. Clarified water, averaging approximately 1,050 gpm is provided by the plant make-up system to the cooling-tower basin to compensate for losses caused by drift, evaporation, and blowdown from the cooling tower. Blowdown from the steam, condensate, and boiler feedwater system is routed to the cooling tower basin to provide part of makeup and to minimize water consumption.

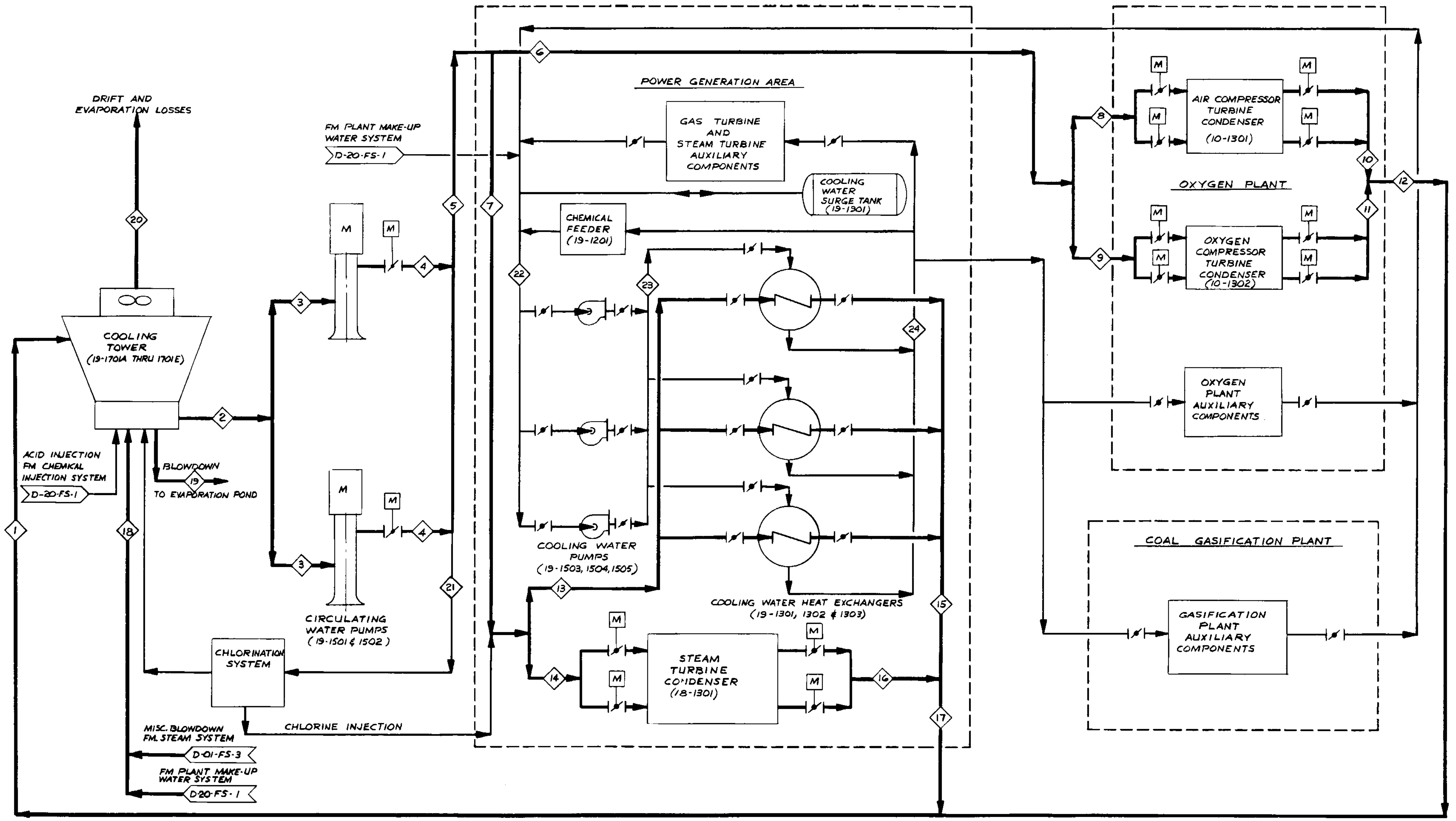
The circulating water system consists of a mechanical-draft cooling tower; two half-capacity, circulating water pumps; and the necessary piping, controls, and instrumentation.

During full-load plant operation, circulating water is delivered to the power generation area and the oxygen plant at 80°F by the two circulating water pumps. Circulating water will be discharged by the cooling water heat exchangers and the main steam turbine condenser at 90°F and 95°F, respectively. Correspondingly, circulating water will be returned from the oxygen plant at 100°F. The average temperature of the circulating water entering the cooling tower will be approximately 94°F.

Chemical treatment required for the circulating water system is provided by the chemical injection system and the chlorination system. Chlorine solution and sulfuric acid are injected to the cooling tower basin. Chlorine solution is also injected to the circulating water at the steam turbine condenser.

Closed Cooling Water System. The closed cooling water system is designed to remove 112.5×10^6 Btu/hr of heat load generated by the gas turbine, steam turbine, coal gasification plant, and oxygen plant auxiliary components. Cooling water is supplied to the various auxiliary equipment at 90°F and the heated cooling water is returned to the shell side of the cooling water heat exchangers at 105°F. The total design flow for the closed cooling water system is 15,000 GPM. Circulating water at 80°F is used to remove the heat load from the tube side of the cooling water heat exchangers. Makeup to the closed cooling water system to make up for leakage losses is provided by the plant makeup water system from the demineralized water storage tank. The system consists of an atmospheric cooling water surge tank; three half-capacity cooling water heat exchangers; three half-capacity cooling water pumps; a chemical feeder; and a closed-loop piping network, with connections to the coal gasification plant, the oxygen plant, and the power plant.

Chlorination System. A fully automatic control, packaged chlorine-injection system, designed for 1,500-ppd capacity, is provided for injecting chlorine solution to the cooling tower and the main steam turbine condenser. The chlorination system consists of two chlorination booster pumps, two one-ton chlorine cylinders, a chlorinator with injector, one evaporator, a gas leak detector, one liquid chlorine expansion chamber, and a control panel plus all the necessary controls and instrumentation.



STREAM Nº	1	2	3	4	5	6	7	8	9	10	11	12
FLUID	CIRC WATER	→										
FLOW, GPM	69,200	69,200	34,600	34,600	69,200	14,400	54,800	10,600	3,800	10,600	3,800	14,400
TEMP, °F	94.4	80	80	80	80	80	80	80	80	100	100	100

STREAM Nº	13	14	15	16	17	18	19	20	21	22	23	24
FLUID					→	MAKE-UP	CIRC WATER	EVAP & DRIFT LOSS	CIRC WATER	CLOSED COOLING WTR		→
FLOW, GPM	22,500	32,300	22,500	32,800	54,800	1,118	152	966	0-NORMAL 100-MAX	15,000	15,000	15,000
TEMP, °F	80	80	90	95	92.3	60	94.4	94.4	80	105	105	90

LEGEND
CIRCULATING WATER SYSTEM
AUXILIARY SYSTEMS

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE: PROCESS FLOW DIAGRAM
INTEGRATED PLANT COOLING WATER SYSTEM
CASE I

SCALE: NONE
ACCOUNT NUMBER

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

BY H. Carlson DATE 2-6-78
CHECKED ssy 2-8-78
SECTION 2-23-78
PROJECT 2-23-78
CLIENT

REVISIONS NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
0	4-20-78						ISSUED FOR FINAL REPORT
A	2-8-78						ISSUED TO SCE FOR REVIEW & COMMENT

REFERENCES: DRAWING NO. / DESCRIPTION

JOB NUMBER 6815
DRAWING NUMBER D-19-FS-1
REV. 0

The chlorination system is housed in a separate chlorination building located adjacent to the cooling tower. The chlorinator, controls, and leak detector are located in an enclosed and ventilated chlorinator room. The evaporator and the chlorine cylinders are installed in the adjacent evaporator room. Liquid chlorine is drawn from one of the one-ton cylinders, with the other chlorine cylinder on standby. The liquid chlorine is then passed through the evaporator, flashed into chlorine gas, and is transported to the chlorine injector by the chlorinator. Circulating water, pressurized by one of the two chlorination booster pumps, flows through the injector and mixes with the gaseous chlorine. The chlorine solution is then injected into the condensers and the cooling tower basin.

Detailed Description - Case II

The integrated plant cooling water system for Case II is shown on Process Flow Diagram D-19-FS-2. The major difference between Case I and Case II is the deletion of the steam turbine-generator unit and its associated auxiliary equipment. The effect on the three subsystems is as follows:

Closed Cooling Water System. The heat loads generated by the steam turbine-generator auxiliary equipment are small in comparison to the total design heat load for the closed cooling water system. The effect of deleting the steam turbine-generator auxiliary equipment heat loads from the Case I closed cooling water system design heat load is minimal. In order to minimize the design modification required when Case I is to be incorporated after the initial Case II configuration, it is assumed that both Case I and Case II closed cooling water systems are identical. Therefore, all major system components for the Case II closed cooling water system are as described in the detailed description for Case I, above. However, additional cooling water supply and return piping will be required for the steam turbine-generator auxiliary equipment when the Case I configuration is implemented.

Chlorination System. The circulating water flow and, consequently, the chlorination requirement for Case II is approximately 50% of Case I. The system is designed for intermittent chlorine solution injection into the circulating water system. The same system can be used for Case II, with the frequency of injection reduced proportionately, thereby avoiding any additional modification to the chlorination system when Case II is modified to the Case I configuration.

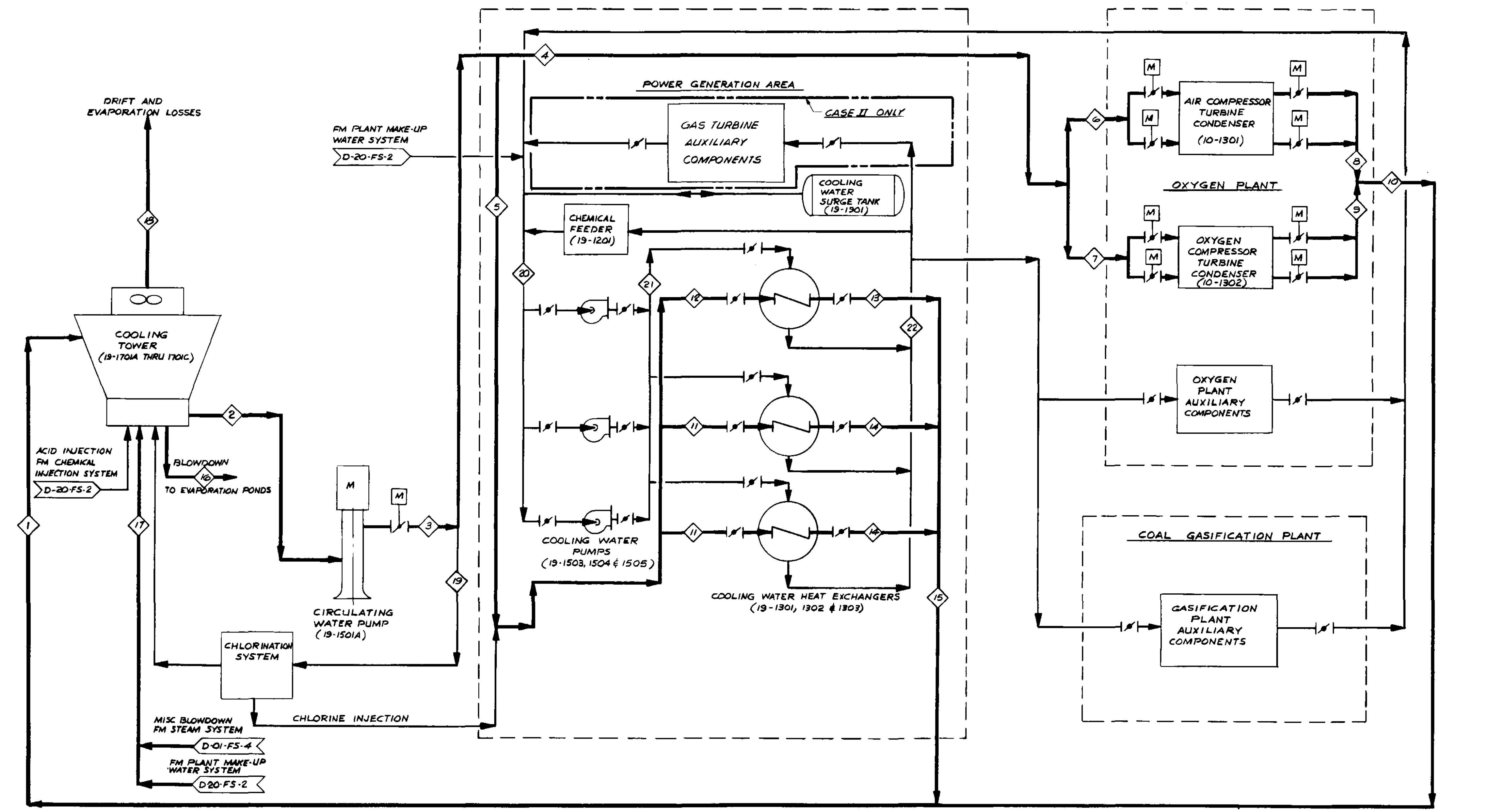
Circulating Water System. The circulating water system flow required for Case II is approximately 50% of Case I. Therefore, the Case II circulating water system is designed to minimize the additional modification to the system when it is upgraded to the Case I configuration. The Case II circulating water system consists of the mechanical-draft cooling tower (three-cells), one circulating water pump, and the necessary piping, controls and instrumentation.

Based on the above discussion, if the Case II configuration is to be constructed first, the integrated plant cooling water system can be modified to meet the final Case I configuration requirement by adding the following components:

- One circulating water pump
- Two additional cells to the cooling tower
- Additional closed cooling water system and circulating water system piping and instrumentation

Detailed Description - Case III

The difference in system-performance requirements between the Case II and Case III integrated plant cooling water systems is the deletion of closed cooling water flow to the gas turbine-generator auxiliary equipment, as indicated on Process Flow Diagram D-19-FS-2. The additional heat load generated is small in comparison to the total system design heat load. Therefore, the integrated plant cooling water system for Case III is designed to meet the Case II requirement so that minimal modifications will be required when the final Case I configuration is implemented from the Case III design.



STREAM N°	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
FLUID	CIRC WATER	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	MAKE-UP	EVAP. & DRIFT LOSS	CIRC. WATER	CLOSED COOLING WATER	→	→
FLOW, GPM	35,600	→	→	14,400	21,200	10,600	3,800	10,600	3800	14,400	10,600	0	0	10,600	21,200	75	561	486	0-NORMAL 100-MAX.	15,000	→	→
TEMP, °F	94	80	→	→	→	→	→	100	→	→	80	—	—	90	→	94	60	94	80	104.1	104.1	90

LEGEND
CIRCULATING WATER SYSTEM
AUXILIARY SYSTEMS

NOTES:
1. SYSTEM COMPONENTS SHOWN ARE FOR CASE III EXCEPT AS NOTED.
2. - FLOW PARAMETERS ARE BASED ON CASE II.

NO.	DATE	BY	CK.	DESCRIPTION
0	4/20/78	PCL		ISSUED FOR FINAL REPORT
A	3/6/78	PCL		ISSUED TO SCE FOR REVIEW & COMMENT

BY PCL DATE 3/2/78
CHECKED 3/2/78

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE
PROCESS FLOW DIAGRAM
INTEGRATED PLANT COOLING WATER SYSTEM
CASES II AND III

SCALE NONE
ACCOUNT NUMBER
JOB NUMBER 5815
DRAWING NUMBER D-19-FS-2
REV. 0

EQUIPMENT LIST

INTEGRATED PLANT COOLING WATER SYSTEM

CASE I

CIRCULATING WATER SYSTEM

Item No.	Quantity	Description
19-1501 19-1502	2	Circulating water pumps - 50%-capacity, vertical, wet-pit mixed-flow type pumps rated for 35,000 gpm @ 85 ft TDH and driven by 900 hp motors.
19-1701A 19-1701B 19-1701C 19-1701D 19-1701E	1	Five cell, in-line, cross-flow, mechanical-draft cooling tower with a total capacity of 70,000 gpm with an approach temperature of 10°F to a 70°F wet bulb at a range of 14.5°F. Each fan to be driven by a 200 hp motor.

CLOSED COOLING WATER SYSTEM

Item No.	Quantity	Description
19-1503 19-1504 (19-1505 Spare)	3	Cooling water pumps - 50%-capacity, horizontal, centrifugal type pumps rated for 7,500 gpm @ 200 ft TDH and driven by 600-hp motors.
19-1301 19-1302 (19-1303 Spare)	3	Cooling water heat exchangers - 50%-capacity, horizontal shell-tube heat exchangers each designed to remove 56 x 10^6 Btu/hr heat load. Each exchanger has 1420 (90-10 Cu-Ni) tubes 41 ft long for a total effective exchanger surface of 13,300 ft .
19-1901	1	Cooling water surge tank - 1500 gallon horizontal steel tank approximately 36" x 30".
19-1201	1	Chemical feeder - corrosion inhibitor chemical feeder.

CHLORINATION SYSTEM

Item No.	Quantity	Description
19-2801	1	Chlorinator - 100% capacity, fully-automatic, multiple rate, solution feed, vacuum-type chlorinator with one 6 kW immersion heater type evaporator. The system will be designed for a maximum capacity of 1500 pounds per day.

EQUIPMENT LIST

INTEGRATED PLANT COOLING WATER SYSTEM

CASE I (Contd)

CHLORINATION SYSTEM (Contd)

19-1506 (19-1507 Spare)	2	Chlorination booster pumps - 100%-capacity, horizontal, centrifugal type pumps each rated for 140 gpm @ 220 ft TDH and driven by 15-hp motor.

EQUIPMENT LIST

INTEGRATED PLANT COOLING WATER SYSTEM

CASE II

A. INITIAL PHASE

CIRCULATING WATER SYSTEM

Item No.	Quantity	Description
19-1501A	1	Circulating water pump - 100%-capacity, vertical, wet-pit, mixed-flow type pump rated for 35,000 gpm @ 85 ft TDH and driven by 900 hp motor.
19-1701A 19-1701B 19-1701C	1	Three cell, in-line, cross-flow, mechanical-draft cooling tower with a total capacity of 41,000 gpm with an approach temperature of 10° F to a 70° F wet bulb at a range of 14.5° F. Each fan to be driven by a 200 hp motor.

CLOSED COOLING WATER SYSTEM

Item No.	Quantity	Description
19-1502 19-1503 (19-1504 Spare)	3	Cooling water pumps - 50%-capacity, horizontal, centrifugal type pumps rated for 7,500 gpm @ 200 ft TDH and driven by 600-hp motors.
19-1301 19-1302 (19-1303 Spare)	3	Cooling water heat exchangers - 50%-capacity, horizontal shell-tube heat exchangers each designed to remove 56 x 10^6 Btu/hr heat load. Each exchanger has 1420 (90-10 Cu-Ni) tubes 41 ft long for a total effective exchanger surface of 13,300 ft .
19-1901	1	Cooling water surge tank - 1500 gallon horizontal steel tank approximately 36" x 30".
19-1201	1	Chemical feeder - corrosion inhibitor chemical feeder.

EQUIPMENT LIST

INTEGRATED PLANT COOLING WATER SYSTEM

CASE II (Contd)

A. INITIAL PHASE (Contd)

CHLORINATION SYSTEM

19-2801	1	Chlorinator - 100% capacity, fully automatic, multiple rate, solution feed, vacuum-type chlorinator with one 6 kW immersion heater type evaporator. The system will be designed for a maximum capacity of 1500 pounds per day.
19-1506 (19-1507 Spare)	2	Chlorination booster pumps - 100%-capacity, horizontal, centrifugal type pumps each rated for 140 gpm @ 220 ft TDH and driven by 15-hp motor.

B. ADD-ON PHASE

CIRCULATING WATER SYSTEM

Item No.	Quantity	Description
19-1501B	1	Circulating water pump - vertical, wet-pit mixed-flow type pump rated for 35,000 gpm @ 85 ft TDH and driven by 900 hp motor.
19-1701D 19-1701E	1	Two cell, in-line, cross-flow, mechanical-draft cooling tower with a total capacity of 29,000 gpm with an approach temperature of 10° F to a 70° F wet bulb at a range of 14.5° F. Each fan to be driven by a 200 hp motor.

EQUIPMENT LIST

INTEGRATED PLANT COOLING WATER SYSTEM

CASE III

A. INITIAL PHASE

CIRCULATING WATER SYSTEM

Item No.	Quantity	Description
19-1501A	1	Circulating water pump - 100%-capacity, vertical, wet-pit, mixed-flow type pump rated for 35,000 gpm @ 85 ft TDH and driven by 900 hp motor.
19-1701A 19-1701B 19-1701C	1	Three cell, in-line, cross-flow, mechanical-draft cooling tower with a total capacity of 41,000 gpm with an approach temperature of 10° F to a 70° F wet bulb at a range of 14.5° F. Each fan to be driven by a 200 hp motor.

CLOSED COOLING WATER SYSTEM

Item No.	Quantity	Description
19-1502 19-1503 (19-1504 Spare)	3	Cooling water pumps - 50%-capacity, horizontal, centrifugal type pumps rated for 7,500 gpm @ 200 ft TDH and driven by 600 hp motors.
19-1301 19-1302 (19-1303 Spare)	3	Cooling water heat exchangers - 50%-capacity, horizontal shell-tube heat exchangers each designed to remove 56 x 10^6 Btu/hr heat load. Each exchanger has 1420 (90-10 Cu-Ni) tubes 41 ft long for a total effective exchanger surface of 13,300 ft .
19-1901	1	Cooling water surge tank - 1500 gallon horizontal steel tank approximately 36" x 30".
19-1201	1	Chemical feeder - corrosion inhibitor chemical feeder.

EQUIPMENT LIST

INTEGRATED PLANT COOLING WATER SYSTEM

CASE III (Contd)

A. INITIAL PHASE (Contd)

CHLORINATION SYSTEM

Item No.	Quantity	Description
19-2801	1	Chlorinator - 100% capacity, fully automatic, multiple rate, solution feed, vacuum type chlorinator with one 6 kW immersion heater type evaporator. The system will be designed for a maximum capacity of 1500 pounds per day.
19-1506 (19-1507 Spare)	2	Chlorination booster pumps - 100%-capacity, horizontal, centrifugal type pumps each rated for 140 gpm @ 220 ft TDH and driven by 15-hp motor.

B. ADD-ON PHASE

CIRCULATING WATER SYSTEM

Item No.	Quantity	Description
19-1501B	1	Circulating water pump vertical, wet-pit mixed-flow type pump rated for 35,000 gpm @ 85 ft TDH and driven by 900 hp motor.
19-1701D 19-1701E	1	Two cell, in-line, cross-flow, mechanical-draft cooling tower with a total capacity of 29,000 gpm with an approach temperature of 10 F° to a 70° F wet bulb at a range of 14.5° F. Each fan to be driven by a 200 hp motor.

3.12 PLANT MAKEUP WATER SYSTEM

General Description

The plant makeup water system is designed to meet the overall water requirements for the integrated coal gasification/power generation plant. The plant makeup water system consists of the following subsystems:

- Well water supply system
- Primary water treatment system
- Service water system
- Demineralized water system
- Chemical injection system
- Waste disposal system

Raw water is supplied by the well water supply system to the primary water treatment system. In addition, the well water supply system is the secondary source of makeup to the circulating water system and the service water system when the primary water treatment is out of service, and is the primary source of makeup to the firewater system.

The raw well water is first clarified in the primary clarifier. The clarified water is then split into two streams, one fed by gravity to the cooling tower basin for makeup to the circulating water system, the other pumped to the primary pressure filters. The filtered water is supplied to the service water system, the gasification plant and the demineralized water system.

Portions of the filtered water is further processed in the demineralized water system which consists of a two bed cation strong base anion primary demineralizer followed by a mixed bed secondary demineralizer.

Effluent output from the demineralized water system is of boiler feedwater quality acceptable for injection to the gas turbine for NOx control. The demineralized water is stored in the demineralized water storage tank for distribution to the gas turbine, closed cooling water system, condensate makeup system and the demineralizer regeneration assembly as required.

Acid, caustic, polymer and lime feed required for the primary water treatment system and the demineralized water system is supplied by the chemical injection system.

Sludge and waste water from the primary water treatment system and the demineralized water system are sent to the waste disposal system for disposal.

Detailed Description - Case I

The integrated plant makeup water system for Case I is designed to provide a continuous supply of up to 100 gpm of demineralized water to the gas turbine for NOx control plus all other plant makeup requirements. 100 gpm is the maximum expected requirement for NOx control and the actual requirement could be considerably less pending further studies by the gas turbine supplier. The system is shown on Process Flow Diagram D-20-FS-1.

Well Water Supply System. The well water supply system provides a supply of raw water to the primary water treatment and firewater systems. The well water supply system consists of two 100%-capacity, deep well pumps and the associated wells, system piping network, controls and instrumentation.

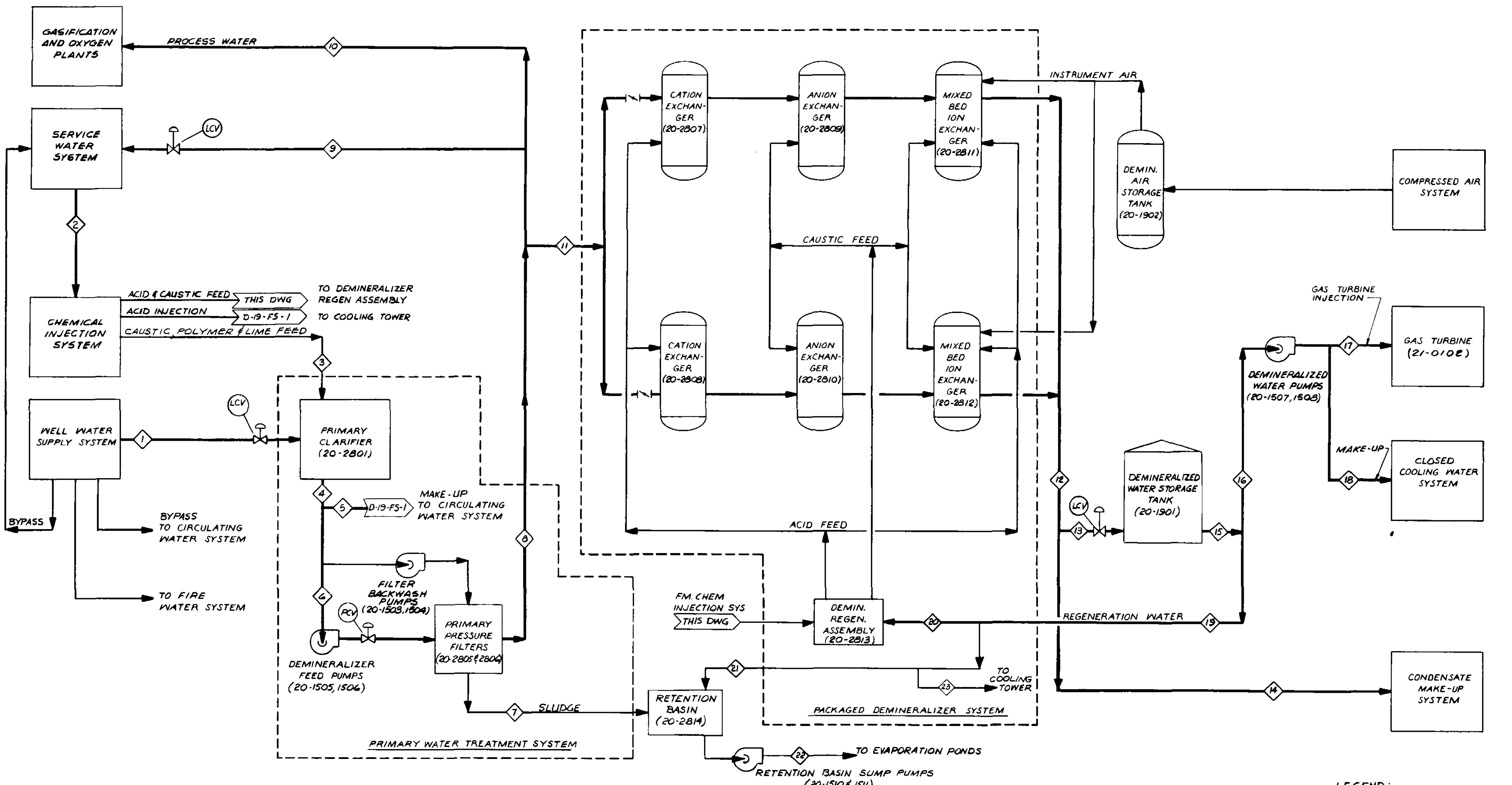
Well water discharged from the well pump is distributed to:

- The water treatment system for treatment and processing.
- Firewater system as needed.
- The circulating water system and/or service water system when the primary water treatment system is out of service and the cooling tower basin or the service water storage tank are at minimum levels.

Primary Water Treatment. The primary water treatment system clarifies the raw water supplied by the well water supply system and filters all the clarified water, with the exception of the cooling tower makeup, as required for proper and efficient plant operation.

The primary water treatment system consists of a lime softener type clarifier, a clearwell, two primary pressure filters, two demineralizer feed pumps, two primary filter backwash pumps, two lime feed assemblies, two caustic feed pumps, a skid mounted polymer feed assembly, piping and the associated controls and instrumentation.

Service Water System. The service water system provides a continuous supply of water for plant utility and domestic uses. The service water system consists of a service water storage tank, two service water pumps, piping and the necessary controls and instrumentation.



STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
FLUID	RAW WATER	SERVICE WATER	CHEMICAL FEED	CLARIFIED WATER	→	→	SLUDGE	FILTERED WATER	→	→	→	DEMIN. WATER	→	→	→	→	→	→	→	→	→	WASTE WATER	DEMIN. WATER
FLOW, GPM	1393	5	5	1398	1051	347	21	326	83	100	148	147	126	21	126	103	100	3	23	4	16	37	8
TEMPERATURE, °F	60	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→

LEGEND:
- PRIMARY TREATMENT & DEMINERALIZED WATER SYSTEMS
- AUXILIARY SYSTEM

NOTE: FLOWRATES ARE EQUIVALENT CONTINUOUS RATES AVERAGED TO INCLUDE INTERMITTENT FLOWS.

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE: PROCESS FLOW DIAGRAM PLANT MAKEUP WATER SYSTEM CASE I

SCALE: NONE

ACCOUNT NUMBER

THE RALPH M. PARSONS COMPANY, PASADENA, CALIFORNIA

BY A.S. POLADIAN DATE 2-6-78; CHECKED 2-8-78; SECTION 2-23-78; PROJECT 2-23-78; CLIENT

REVISIONS: 0 — ISSUED FOR FINAL REPORT; A 2-8-78 — ISSUED TO SCE FOR REVIEW & COMMENT

JOB NUMBER 5815 — DRAWING NUMBER D-20-FS-1 — REV. 0

Service water is distributed to the various plant users by the service water pumps which take suction from the service water storage tank. Normal full load operation will have one pump in service with the other as standby.

Demineralized Water System. The demineralized water system is provided to deionize the water required for NOx emissions control in the combustion turbine and for boiler feedwater makeup.

Substance	ppb Maximum
Total dissolved solids	300
Silica	20

The demineralized water system is fully automatic and consists of two demineralizer trains. Each train consists of a two bed cation strong base anion primary demineralizer followed by a mixed bed secondary demineralizer.

Filtered water from the primary pressure filters is processed by one of the two demineralizer trains and discharged to the demineralized water storage tank. The other demineralizer train is either in regeneration or on standby.

Demineralized water is pumped from the demineralized water storage tank to the gas turbine for NO_x control and as makeup to the closed cooling water system. Two demineralized water pumps are provided. Makeup to the condensate system is fed directly by the demineralizer units to the condensate storage tank.

The demineralized water system is provided with a demineralizer regeneration assembly which consists of two acid feed pump, two caustic feed pumps, an acid dilution water system and a caustic dilution water system.

Chemical Injection System. The chemical injection system provides chemical treatment to the following:

- The circulating water system - sulfuric acid
- The primary water treatment system - caustic, lime and polymer.
- Demineralized water system - caustic and sulfuric acid

The chemical injection system consists of the following subsystems:

- Caustic injection system
- Sulfuric acid injection system
- Lime feed system
- Polymer feed system

Caustic is injected into the primary clarifier and the demineralizer units. The caustic injection system consists of the caustic storage tank and the necessary transfer piping network. Caustic is transferred from the caustic storage tank to the primary clarifier by the caustic feed pumps furnished with the primary water treatment equipment. Similarly, caustic required for the anion exchangers and the mixed bed ion exchangers during regeneration of the demineralizer units is transferred from the caustic storage tank by the caustic feed pumps furnished with the demineralizer trains.

Sulfuric acid treatment is required in the circulating water system to maintain a pH of 6.5-7.5. In addition, sulfuric acid is injected to the cation exchangers and the mixed bed ion exchangers during regeneration of the demineralizer units. The sulfuric acid injection system consists of the acid storage tank, the acid day tank, acid feed pumps and piping network. Sulfuric acid is transferred from the acid storage tank to the acid day tank by the acid feed pumps. Injection of sulfuric acid to the circulating water system is by gravity flow from the acid day tank to the cooling tower basin. Sulfuric acid is injected into the demineralizer units by the demineralizer acid pumps furnished with the demineralizer trains.

Polymer is injected into the primary clarifier by the polymer feed assembly furnished with the primary water treatment equipment. The lime feed system consists of a lime silo and a lime transfer system. Hydrated lime is injected into the primary clarifier by the lime feed assemblies furnished with the primary water treatment equipment.

Waste Disposal System. A waste disposal system is provided to collect, store and then transfer to the evaporation pond all the wastes, sludges and drains from the integrated coal gasification power generation plant other than cooling tower blowdown which is discharged directly by gravity and gasifier effluent water which is treated and discharged separately to the evaporation pond as described in section 5.7. The system consists of a retention basin, a duplex retention basin sump pump and all the necessary underground piping and instrumentation. Waste discharges from the various components in the plant are routed to the retention basin. The accumulated mixture of sludge and drain is periodically transferred by the retention basin sump pump to the evaporation pond for final disposal.

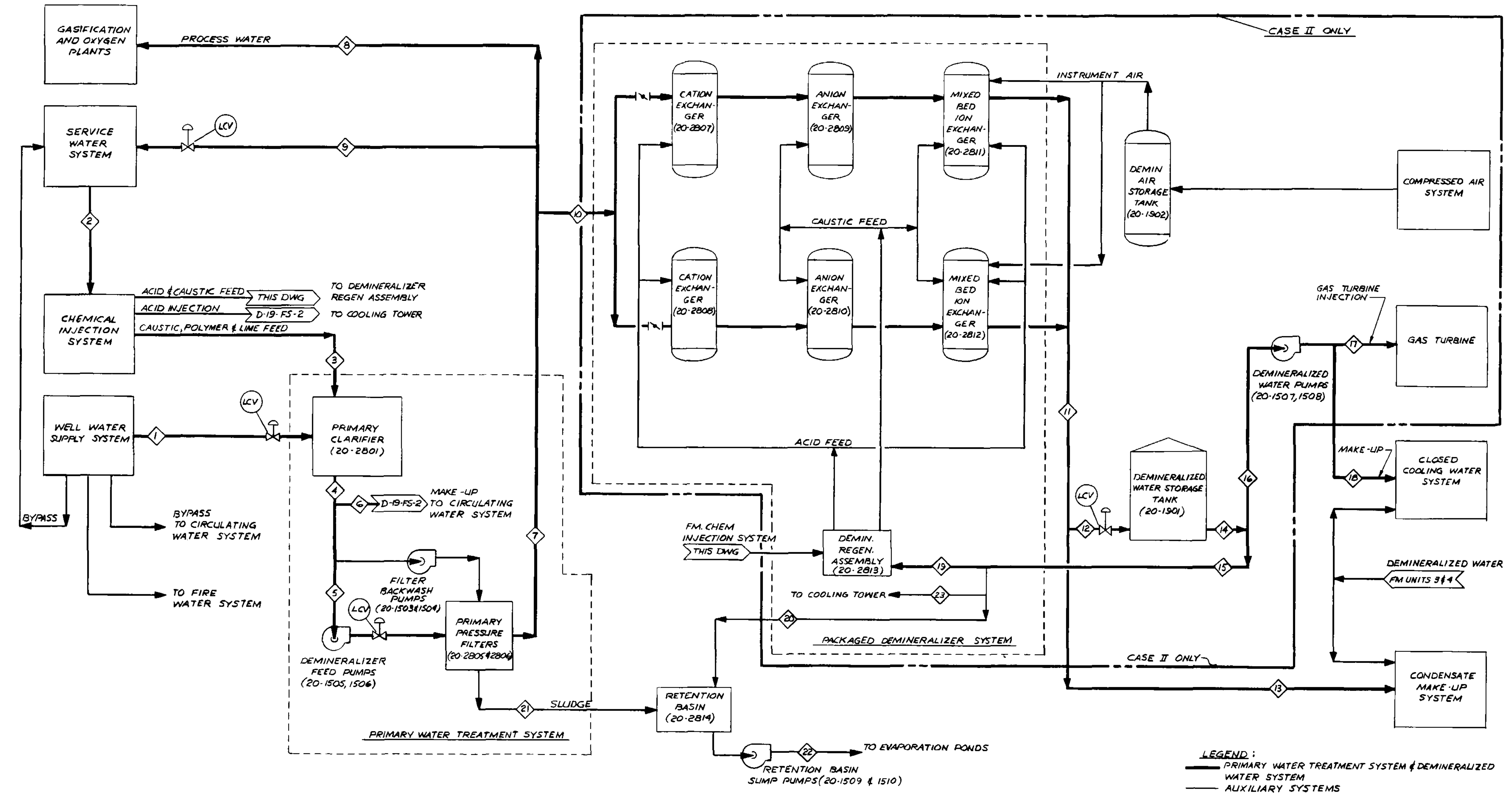
Detailed Description - Case II

The plant makeup water system for Case II consists of the same subsystems as for Case I. The required flow from the plant makeup water system is less than for Case I due mainly to a reduction in cooling tower makeup flow. Because of the anticipated short duration of the Case II overall plant configuration, the Case II makeup water system will be designed to accommodate the final Case I configuration described in the preceding section. This approach will slightly increase auxiliary power consumption during plant testing in the Case II configuration but will greatly reduce the cost of the final Case I configuration by eliminating the need for expensive retrofitting and expansion of the system. The plant makeup water system for Case II is shown in Process Flow Diagram D-20-FS-2.

Detailed Description - Case III

The plant makeup water system for Case III consists of the same subsystems as for Cases I and II. As in Case II, the well water supply system and the primary water treatment system are designed to accommodate the final Case I configuration to eliminate future costly modifications when Case I configuration is implemented. Because Case III configuration does not include the combustion turbine, the requirements for demineralized water are low as they consist only of condensate water and closed cooling water makeup. Therefore, the initial Case III demineralized water requirements will be supplied directly from the existing Units 3 and 4 and the demineralizer units will be added during construction of the final Case I configuration.

The plant makeup water system for Case III is shown in Process Flow Diagram D-20-FS-2.



LEGEND:

- (heavy line) PRIMARY WATER TREATMENT SYSTEM & DEMINERALIZED WATER SYSTEM
- (light line) AUXILIARY SYSTEMS

NOTES:

1. SYSTEM COMPONENTS SHOWN FOR CASE III EXCEPT AS NOTED
2. SYSTEM FLOWS ARE BASED ON CASE II
3. DEMINERALIZED WATER MAKE-UP FOR THE INITIAL PHASE OF CASE III WILL BE PROVIDED BY UNITS 3 & 4 BECAUSE LESS THAN 25 GPM IS REQUIRED.

STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
FLUID	RAW WATER	SERVICE WATER	CHEMICAL FEED	CLARIFIED WATER		→	FILTERED WATER			→	DEMIN WATER									→	SLUDGE	WASTE WATER	DEMIN. WATER
FLOW, GPM	830	4	4	834	315	519	300	100	59	141	145	126	19	126	23	103	100	3	4	16	15	31	3
TEMPERATURE, °F	60																						→

SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

REVISIONS NO.	DATE	BY	CK	SEC	PROJ.	CLIENT	DESCRIPTION
0	4-21-78	ASP					ISSUED FOR FINAL REPORT
A	3-1-78	HC					ISSUED TO SCE FOR REVIEW & COMMENT

BY H. CARLSON DATE 3-1-78
CHECKED DATE 3-2-78
SECTION 3-2-78
PROJECT 3-3-78
CLIENT

RMP THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA

TITLE: PROCESS FLOW DIAGRAM PLANT MAKEUP WATER SYSTEM CASES II AND III

SCALE: NONE

ACCOUNT NUMBER

JOB NUMBER 5815 DRAWING NUMBER D-20-FS-2 REV. 0

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE I

WELL WATER SUPPLY SYSTEM

Item No.	Quantity	Description
20-1511A (20-1512 Spare)	2	Deep well pumps - 100%-capacity vertical pumps rated for 1500 gpm @ 410 ft TDH and driven by 250 hp electric motors.
20-5301 (20-5302 Spare)	2	Water wells - approximately 365 ft deep with 20" well casings.

PRIMARY WATER TREATMENT SYSTEM

Item No.	Quantity	Description
20-2801	1	Primary clarifier - with all internals housed in a 66 ft diameter by 16 ft deep concrete basin - includes rotor and scraper driven by 10 hp and 1 hp (respectively) electric motors.
20-1505 (20-1506 Spare)	2	Demineralizer feed pumps - 100%-capacity horizontal, centrifugal type pumps rated for 400 gpm @ 160 ft TDH, driven by 30 hp electric motors.
20-1503 (20-1504 Spare)	2	Filter backwash pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 1200 gpm @ 35 ft TDH and driven by 20 hp electric motors.
20-2805 20-2806	2	Pressure filters - 10 ft diameter by 5 ft high vertical pressure vessels - ASME stamped - designed for 100 psig pressure.
20-2802 (20-2803 Spare)	2	Lime feed assemblies - 100%-capacity - each includes: - A lime feeder driven by 1/4 hp electric motor - A 100 gallon solution tank (20-1911, 20-1912 - Spare) - A mixer driven by 1/4 hp electric motor

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE I (Contd)

PRIMARY WATER TREATMENT SYSTEM (Contd)

Item No.	Quantity	Description
		- A centrifugal type lime slurry feed pump (20-1529, 20-1530 spare) driven by a 1 hp electric motor.
20-2804	1	Polymer feed assembly including: - A 300 gallon solution preparation tank (20-1910) - A 600 gallon solution dilution tank (20-1909) - Two 100%-capacity metering type solution feed pumps (20-1514, 20-1515 Spare) driven by 3/4 hp electric motors. - Polymer solution transfer pump (20-1516) - 100%-capacity - horizontal centrifugal type pump driven by 1 hp electric motor.
20-1501 (20-1502 Spare)	2	Caustic feed pumps - 100%-capacity, metering type pumps driven by 3/4 hp electric motors.

DEMINERALIZED WATER SYSTEM

Item No.	Quantity	Description
See Individual Exchanger	2	Demineralizer trains - 100%-capacity. Each includes: - A cation exchanger (20-2807, 20-2808) - 9 ft diameter by 10-1/2 ft high pressure vessel - ASME stamped - designed for 100 psig pressure. - An anion exchanger (20-2809, 20-2810) - 9 ft diameter by 10-1/2 ft high pressure vessel - ASME stamped - designed for 100 psig pressure. - A mixed bed ion exchanger (20-2811, 29-2812) - 4-1/2 ft diameter by 10-1/2 ft high pressure vessel - ASME stamped - designed for 100 psig pressure.

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE I (Contd)

DEMINERALIZED WATER SYSTEM (Contd)

Item No.	Quantity	Description
20-2813	1	Demineralizer regeneration assembly - includes: - 2 demineralizer regeneration acid pumps (20-1523, 20-1524) 100%-capacity, diaphragm type pumps driven by 2 hp electric motors. - 2 dimineralizer regeneration caustic pumps (20-1525, 20-1526) - 100%-capacity, diaphragm type pumps driven by 1 hp electric motors. - An acid dilution water system. - A caustic dilution water system that includes a 7-1/2 ft diameter by 8-1/2 ft high hot water tank (20-1903) - Tank is ASME stamped, designed for 100 psig pressure and heated by 2 x 150 kW immersion heaters.
20-1518 (20-1517 Spare)	2	Demineralizer regeneration pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 60 gpm @ 110 ft TDH and driven by 4 hp electric motors.
20-1519 (20-1520 Spare)	2	Demineralizer recycle pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 250 gpm @ 150 ft TDH and driven by 20 hp electric motors.
20-1507 (20-1508 Spare)	2	Demineralized water pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 125 gpm @ 100 ft TDH and driven by 7-1/2 hp electric motors.
20-1901	1	Demineralized water storage tank - 75,000 gallon vertical steel tank with internal epoxy lining and dome roof - 24 ft. diameter by 24 ft. high.

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE I (Contd)

DEMINERALIZED WATER SYSTEM (Contd)

Item No.	Quantity	Description
20-1902	1	Demineralizer air storage tank - 750 ft pressure vessel - 7-1/2 ft diameter by 15 ft - ASME stamped - designed for 150 psig pressure.

SERVICE WATER SYSTEM

Item No.	Quantity	Description
20-1521 (20-1522 Spare)	2	Service water pumps - 100% capacity, horizontal, centrifugal type pumps rated for 150 gpm @ 145 ft TDH and driven by 10 hp electric motors.
20-1904	1	Service water storage tank - 50,000 gallons vertical steel tank with internal lining and dome roof - 24 ft diameter by 16 ft high.

WASTE DISPOSAL SYSTEM

Item No.	Quantity	Description
20-1510 20-1511	2	Retention basis sump pumps - 100% capacity, duplex vertical sump pumps rated for 300 gpm @ 25 ft TDH and driven by 5 hp electric motors.
20-2814	1	Retention basin - with internals housed in a 44 ft diameter by 10 ft deep acid resistant concrete basin.

CHEMICAL INJECTION SYSTEM

Item No.	Quantity	Description
20-1527 (20-1528 Spare)	2	Acid feed pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 15 gpm @ 25 ft TDH and driven by 1 hp electric motors.
20-1903	1	Lime Silo - 21 ft diameter by 50 ft high vertical steel tank - includes: - Vibrating discharge driven by 5 hp electric motor - Lime transfer equipment - Dust collection equipment

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE I (Contd)

CHEMICAL INJECTION SYSTEM (Contd)

Item No.	Quantity	Description
20-1905	1	Caustic storage tank - 85,000 gallon vertical steel tank with internal lining and dome roof - 28 ft diameter by 24 ft high insulated and electrically heat traced.
20-1906	1	Acid storage tank - 35,000 gallon, vertical steel tank with dome roof. 17 ft diameter by 16 ft high.
20-1907	1	Acid day tank - 150 gallon, horizontal steel tank - 30" diameter by 6 ft long.

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE II

(A) INITIAL PHASE

WELL WATER SUPPLY SYSTEM

Item No.	Quantity	Description
20-1511 (20-1512 Spare)	2	Deep well pumps - 100%-capacity vertical pumps rated for 1500 gpm @ 410 ft TDH and driven by 250 hp electric motors.
20-5301 (20-5302 Spare)	2	Water wells - approximately 365 ft deep with 20" well casings.

PRIMARY WATER TREATMENT SYSTEM

Item No.	Quantity	Description
20-2801	1	Primary clarifier - with all internals housed in a 66 ft diameter by 16 ft deep concrete basin - includes rotor and scraper driven by 10 hp and 1 hp electric motors respectively.
20-1505 (20-1506 Spare)	2	Demineralizer feed pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 400 gpm @ 160 ft TDH and driven by 30 hp electric motors.
20-1503 (20-1504 Spare)	2	Filter backwash pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 1200 gpm @ 35 ft TDH and driven by 20 hp electric motors.
20-2805 20-2806	2	Primary pressure filters - 10 ft diameter by 5 ft high vertical pressure vessels - ASME stamped - designed for 100 psig pressure.
20-2802 (20-2803 Spare)	2	Lime feed assemblies - 100%-capacity - each includes: - A lime feeder driven by 1/4 hp electric motor - A 100 gallon solution tank (20-1911, 20-1912 - Spare) - A mixer driven by 1/4 hp electric motor

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE II (Contd)

PRIMARY WATER TREATMENT SYSTEM (Contd)

Item No.	Quantity	Description
		- A centrifugal type lime slurry feed pump (20-1529, 20-1530 spare) driven by a 1 hp electric motor.
20-2804	1	Polymer feed assembly including: - A 300 gallon solution preparation tank (20-1910) - A 600 gallon solution dilution tank (20-1909) - Two 100%-capacity metering type solution feed pumps (20-1514, 20-1515 Spare) driven by 3/4 hp electric motors. - Polymer solution transfer pump (20-1516) - 100%-capacity - horizontal centrifugal type pump driven by 1 hp electric motor.
20-1501 (20-1502 Spare)	2	Caustic feed pumps - 100%-capacity, metering type pumps driven by 3/4 hp electric motors.

DEMINERALIZED WATER SYSTEM

Item No.	Quantity	Description
See Individual Exchanger	2	Demineralizer trains - 100%-capacity. Each includes: - A cation exchanger (20-2807, 20-2808) - 9 ft diameter by 10-1/2 ft high pressure vessel - ASME stamped - designed for 100 psig pressure. - An anion exchanger (20-2809, 20-2810) - 9 ft diameter by 10-1/2 ft high pressure vessel - ASME code stamped - designed for 100 psig pressure.

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE II (Contd)

DEMINERALIZED WATER SYSTEM (Contd)

Item No.	Quantity	Description
		- A mixed bed ion exchanger (20-2811, 29-2812) - 4-1/2 ft diameter by 10-1/2 ft high pressure vessel - ASME stamped - designed for 100 psig pressure.
20-2813	1	Demineralizer regeneration assembly - includes: - 2 demineralizer regeneration acid feed pumps (20-1523, 20-1524) 100%-capacity, diaphragm type pumps driven by 2 hp electric motors. - 2 dimineralizer regeneration caustic feed pumps (20-1525, 20-1526) - 100%-capacity, diaphragm type pumps driven by 1 hp electric motors. - An acid dilution water system. - A caustic dilution water system that includes a 7-1/2 ft diameter by 8-1/2 ft high hot water tank (20-1903) - ASME stamped, designed for 100 psig pressure and heated by 2 x 150 kW immersion heaters.
20-1517 (20-1518 Spare)	2	Demineralizer regeneration pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 60 gpm @ 110 ft TDH and driven by 4 hp electric motors.
20-1519 (20-1520 Spare)	2	Demineralizer recycle pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 250 gpm @ 150 ft TDH and driven by 20 hp electric motors.

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE II (Contd)

CHEMICAL INJECTION SYSTEM

Item No.	Quantity	Description
20-1507 (20-1508 Spare)	2	Demineralized water pumps - 100% - capacity, horizontal, centrifugal type pumps rated for 125 gpm @ 100 ft TDH and driven by 7-1/2 hp electric motors.
20-1901	1	Demineralized water storage tank - 75,000 gallon, vertical steel tank with internal epoxy lining and dome roof - 24 ft. diameter by 24 ft. high.
20-1902	1	Demineralizer air storage tank - 750 ft pressure vessel - 7-1/2 ft diameter by 15 ft - ASME stamped - designed for 150 psig pressure.

SERVICE WATER SYSTEM

Item No.	Quantity	Description
20-1521 (20-1522 Spare)	2	Service water pumps - 100% capacity, horizontal, centrifugal type pumps rated for 150 gpm @ 145 ft TDH and driven by 10 hp electric motors.
20-1904	1	Service water storage tank - 50,000 gallon vertical steel tank with internal lining and dome roof - 24 ft diameter by 16 ft high.

WASTE DISPOSAL SYSTEM

Item No.	Quantity	Description
20-1509 20-1510	2	Retention basis sump pumps - 100% capacity, duplex vertical sump pumps rated for 300 gpm @ 25 ft TDH and driven by 5 hp electric motors.
20-2814	1	Retention basin - with internals housed in a 44 ft diameter by 10 ft deep acid resistant concrete basin.

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE II (Contd)

CHEMICAL INJECTION SYSTEM

Item No.	Quantity	Description
20-1527 (20-1528 Spare)	2	Acid feed pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 15 gpm @ 25 ft TDH and driven by 1 hp electric motors.
20-1903	1	Lime Silo - 21 ft diameter by 50 ft high vertical steel tank - includes: - Vibrating discharge driven by 5 hp electric motor - Lime transfer equipment - Dust collection equipment
20-1905	1	Caustic storage tank - 85,000 gallon vertical steel tank with internal lining and dome roof - 28 ft diameter by 24 ft high insulated and electrically heat traced.
20-1906	1	Acid storage tank - 35,000 gallon, vertical steel tank with dome roof. 17 ft diameter by 16 ft high.
20-1907	1	Acid day tank - 150 gallon, horizontal steel tank - 30" diameter by 6 ft long.

(B) ADD-ON PHASE

NONE REQUIRED

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE III

(A) INITIAL PHASE

WELL WATER SUPPLY SYSTEM

Item No.	Quantity	Description
20-1511 (20-1512 Spare)	2	Deep well pumps - 100%-capacity vertical pumps rated for 1500 gpm @ 410 ft TDH and driven by 250 hp electric motors.
20-5301 (20-5302 Spare)	2	Water wells - approximately 365 ft deep with 20" well casings.

PRIMARY WATER TREATMENT SYSTEM

Item No.	Quantity	Description
20-2801	1	Primary clarifier - with all internals housed in a 66 ft diameter by 16 ft deep concrete basin - includes rotor and scraper driven by 10 hp and 1 hp electric motors respectively.
20-1505 (20-1506 Spare)	2	Demineralizer feed pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 400 gpm @ 160 ft TDH and driven by 30 hp electric motors.
20-1503 (20-1504 Spare)	2	Filter backwash pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 1200 gpm @ 35 ft TDH and driven by 20 hp electric motors.
20-2805 20-2806	2	Primary pressure filters - 10 ft diameter by 5 ft high vertical pressure vessels - ASME stamped - designed for 100 psig pressure.
20-2802 (20-2803 Spare)	2	Lime feed assemblies - 100%-capacity - each includes: - A lime feeder driven by 1/4 hp electric motor - A 100 gallon solution tank (20-1911, 20-1912 - Spare) - A mixer driven by 1/4 hp electric motor

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE III (Contd)

PRIMARY WATER TREATMENT SYSTEM (Contd)

Item No.	Quantity	Description
		- A centrifugal type lime slurry feed pump (20-1529, 20-1530 spare) driven by a 1 hp electric motor.
20-2804	1	Polymer feed assembly including: - A 300 gallon solution preparation tank (20-1910) - A 600 gallon solution dilution tank (20-1909) - Two 100%-capacity metering type solution feed pumps (20-1514, 20-1515 Spare) driven by 3/4 hp electric motors. - Polymer solution transfer pump (20-1516) - 100%-capacity - horizontal centrifugal type pump driven by 1 hp electric motor.
20-1501 (20-1502 Spare)	2	Caustic feed pumps - 100%-capacity, metering type pumps driven by 3/4 hp electric motors.

SERVICE WATER SYSTEM

Item No.	Quantity	Description
20-1521 (20-1522 Spare)	2	Service water pumps - 100% capacity, horizontal, centrifugal type pumps rated for 150 gpm @ 145 ft TDH and drive by 10 hp electric motors.
20-1904	1	Service water storage tank - 50,000 gallon, vertical steel tank with internal lining and dome roof - 24 ft diameter by 16 ft high.

WASTE DISPOSAL SYSTEM

Item No.	Quantity	Description
20-1509 (20-1510 Spare)	2	Retention basin sump pumps - 100% capacity, duplex vertical sump pumps rated for 300 gpm @ 25 ft TDH and driven by 5 hp electric motors.

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE III (Contd)

WATER DISPOSAL SYSTEM (Contd)

Item No.	Quantity	Description
20-2814	1	Retention basin - with internals housed in a 44 ft diameter by 10 ft deep acid resistant concrete basin.

CHEMICAL INJECTION SYSTEM

Item No.	Quantity	Description
20-1527 (20-1528 Spare)	2	Acid feed pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 15 gpm @ 25 ft TDH and driven by 1 hp electric motors.
20-1903	1	Lime Silo - 21 ft diameter by 50 ft high vertical steel tank - includes: - Vibrating discharge driven by 5 hp electric motor - Lime transfer equipment - Dust collection equipment
20-1905	1	Caustic storage tank - 85,000 gallon vertical steel tank with internal lining and dome roof - 28 ft diameter by 24 ft high insulated and electrically heat traced.
20-1906	1	Acid storage tank - 35,000 gallon, vertical steel tank with dome roof. 17 ft diameter by 16 ft high.
20-1907	1	Acid day tank - 150 gallon, horizontal steel tank - 30" diameter by 6 ft long.

(B) ADD-ON PHASE

DEMINERALIZED WATER SYSTEM

Item No.	Quantity	Description
See Individual Exchanger	2	Demineralizer trains - 100%-capacity. Each includes: - A cation exchanger (20-2807, 20-2808) - 9 ft diameter by 10-1/2 ft high pressure vessel - ASME Code stamped - designed for 100 psig pressure.

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE III (Contd)

DEMINERALIZED WATER SYSTEM (Contd)

Item No.	Quantity	Description
		- An anion exchanger (20-2809, 20-2810) - 9 ft diameter by 10-1/2 ft high pressure vessel - ASME Code stamped - designed for 100 psig pressure. - A mixed bed ion exchanger (20-2811, 29-2812) - 4-1/2 ft diameter by 10-1/2 ft high pressure vessel - ASME stamped - designed for 100 psig pressure.
20-2813	1	Demineralizer regeneration assembly includes: - 2 demineralizer regeneration acid feed pumps (20-1523, 20-1524) - 100%-capacity, diaphragm type pumps driven by 2 hp electric motors. - 2 diminerali zer regeneration caustic feed pumps (20-1525, 20-1526) - 100%-capacity, diaphragm type pumps driven by 1 hp electric motors. - An acid dilution water system. - A caustic dilution water system that includes a 7-1/2 ft diameter by 8-1/2 ft high hot water tank (20-1903) - ASME Code stamped, designed for 100 psig pressure and heated by 2 x 150 kW immersion heaters.
20-1517 (20-1518 Spare)	2	Demineralizer regeneration pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 60 gpm @ 110 ft TDH and driven by 4 hp electric motors.

EQUIPMENT LIST

PLANT MAKEUP WATER SYSTEM

CASE III (Contd)

DEMINERALIZED WATER SYSTEM (Contd)

Item No.	Quantity	Description
20-1519 (20-1520 Spare)	2	Demineralizer recycle pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 250 gpm @ 150 ft TDH and driven by 20 hp electric motors.
20-1507 (20-1508 Spare)	2	Demineralized water pumps - 100%-capacity, horizontal, centrifugal type pumps rated for 125 gpm @ 100 ft TDH and driven by 7-1/2 hp electric motors.
20-1901	1	Demineralized water storage tank - 75,000 gallon, vertical steel tank with internal epoxy lining and dome roof - 24 ft. diameter by 24 ft. high.
20-1902	1	Demineralizer air storage tank - 750 ft pressure vessel - 7-1/2 ft diameter by 15 ft - ASME Code stamped - designed for 150 psig pressure.

3.13 PLANT ELECTRICAL SYSTEMS

The integrated plant's electric system consists of the following three divisions:

- 13.8 kV generation and connections to the existing 230 kV transmission switchyard.
- 4.16 kV power system - including its connections to the 13.8 kV generation and to the 115/4.16 kV reserve auxiliary power system substation.
- The power supply to the integrated plant's auxiliaries at various voltage levels.

Detailed Description - Case I

The integrated plant's electrical system for Case I is shown on Single Line Diagram No. E-01-EL-1. Each of the three divisions is described in the following subsections:

13.8 kV Generation. The 13.8 kV generation consists of a gas turbine-driven generator and a steam turbine-driven generator; each wye connected and each grounded through a distribution type transformer loaded by a resistor on the secondary side. Each generator will be provided with its excitation and voltage regulation systems, field application equipment, the required current and potential transformers, associated controls, surge protection, synchronizing, protective relaying, metering and alarm circuits. The excitation system will have a high speed response.

Generation Connections to Existing 230 kV Transmission Switchyard. Each 13.8 kV generator will be connected to a 13.8 kV delta winding of the 3-winding main transformer through a generator isolating outdoor air circuit breaker, by means of a metal enclosed, 15 kV segregated bus.

The 230 kV wye windings of the main transformer will be connected by an overhead power line to a spare position in the existing 230 kV transmission switchyard. This position is in the same bay with the outgoing Kramer line. The connection will require the installing of a 230 kV power circuit breaker with its required disconnects.

Each 13.8 kV generator connection, including the main and main auxiliary transformers and the 220 kV power circuit breakers will be provided with the required current and potential transformer, lightning and surge protection, synchronizing check, protective relaying, metering and alarm circuits.

4.16 kV Power System. The 4.16 kV power system has been arranged with two 4.16 kV supply buses, Nos. 1 and 2, each of which can be supplied 4.16 kV power from any of the following three sources:

1. From the gas turbine-driven generator through the main auxiliary transformer.

2. From the 230 kV power system through the main transformer and the main auxiliary transformer.

3. From the 115/4.16 kV reserve auxiliary power system substation.

Each 4.16 kV supply bus will be furnished with two incoming 1200A and six outgoing 1200A air circuit breakers.

The normal power supply to the 4.16 kV power system will be from the main auxiliary transformer. This transformer will be connected to the gas turbine-driven generator's 13.8 kV bus on the main transformer side of the generator's 13.8 kV air circuit breaker, through a disconnecting link, it will be delta-wye connected, with the neutral grounded through a resistor; sized to limit the ground current to approximately 5.2% of the three phase short circuit current, during a phase-to-ground fault condition.

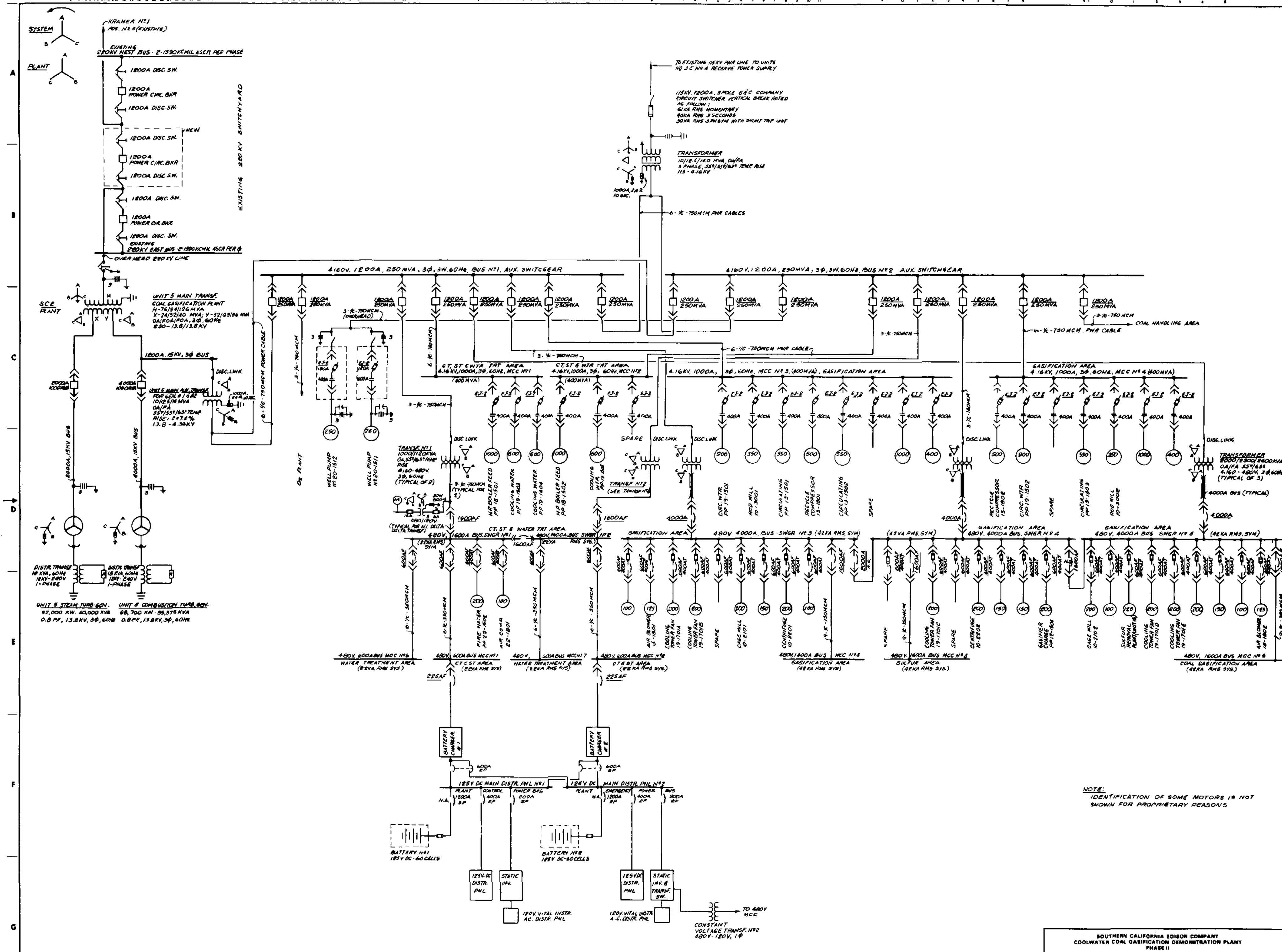
The main auxiliary transformer and the 4.16 kV power feeders to each of the 4.16 kV supply buses will be within the differential protection zone of the main transformer. The loss of this power source will transfer both 4.16 kV power supply buses to the 115/4.16 kV reserve auxiliary power system. The main auxiliary transformer and the 115/4.16 kV reserve auxiliary power system's transformer will not be operated in parallel. The neutral of this transformer will also be grounded through a resistor.

Each 4.16 kV supply bus will be provided with the required current and potential transformers, protective relaying, metering and alarm circuits. Protective relaying will be provided to isolate only the faulted bus.

The plant's auxiliaries will be supplied power as follows:

1. The 4.16 kV motor-driven auxiliaries from four separate 4.16 kV buses; two from each of the two supply buses.

2. The 480 V motor-driven auxiliaries, with motors larger than 100 H.P. but not larger than 200 hp from five 480 V switchgear buses; three from 4.16 kV supply bus No. 1 and two from 4.16 kV supply bus No. 2; each feeder through a 4.16/.48 kV transformer.



SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE: **ELECTRICAL SINGLE-LINE DIAGRAM CASE I**

SCALE: NONE
ACCOUNT NUMBER:
JOB NUMBER: 5816
DRAWING NUMBER: E-01-EL-1
REV. 2

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

3. The 480 V motor driven auxiliaries, with motors 100 hp and smaller, from seven 480 V motor control centers; four from 4.16 kV supply bus No. 1, through 480 V switchgear units Nos. 1, 3 and 5; three from 4.16 kV supply bus No. 2, through 480 V switchgear units Nos. 2 and 4.

Three additional 4.16 kV air circuit breaker positions will be provided in the 4.16 kV switchgear for the following:

1. One from supply bus No. 1, for a 4.16 kV feeder to the oxygen plant.

2. Two from supply bus No. 2; one for a 4.16 kV feeder to the coal handling system and the other one for a 4.16 kV feeder to two remotely located well pumps; the electrical starting equipment for each being located near each pump.

Power Supply to the Integrated Plant's Auxiliaries

4160 V Motor-Driven Auxiliaries. All motors larger than 200 hp will be controlled at 4.16 kV with their controlling equipment located in one of the above four motor control centers. The controlling equipment for each 4.16 kV motor will consist of a combination disconnecting fused switch and an electrically operated controller with:

a. Overload current protection for the motor.

b. Ac-control power transformers supplying the control circuits.

c. Ground protection.

d. Thermal overload protection.

The 4.16 kV motor driven auxiliaries have been divided between the various 4.16 kV motor control centers, as indicated by the single line diagram. This arrangement will prevent the complete loss of any given auxiliary function when the power is interrupted to a given 4.16 kV motor control center.

480 Volt Motor Drive Auxiliaries. Power to each of the five 480V switchgear buses will be supplied, as indicated by the single line diagram, from one of the two 4.16 kV supply buses through a 4.16/.48 kV delta-delta connected transformer. A ground-detecting circuit will be furnished for each 480 V switchgear bus. The incoming 480 V breakers to the 480 V switchgear units and 480 V bus tie breakers will be as follows:

a. Manually operated stored-energy type, with 42 kA interrupting capacity for 480 V switchgear units Nos. 1 and 2.

b. Electrically operated, stored-energy type with 42 kA interrupting capacity for 480 V switchgear units Nos. 3, 4 and 5.

Each 480 V motor, supplied power from a 480 V switchgear unit, will be controlled by an electrically-operated, stored-energy type breaker, each with a 20 kA interrupting capacity and each protected, where required, by a 1000 current-limiting fuse.

Power to each of the seven motor control centers will be supplied, as indicated by the single line diagram, from one of the above five 480 V switchgear units, through a manually-operated, stored-energy type breaker.

Each motor, supplied power from a 480 V motor control center, will be controlled by a combination manually-operated circuit breaker and an electrically-operated starter. The non-rotating loads and equipment with integral controls will be furnished power by a manually-operated circuit breaker.

125 V dc System. The 125 V dc system will consist of two 125 V dc batteries, each with a main 125 V dc distribution panel; a 480 V to 125 V battery charger; a 125 V dc distribution panel and a 125 V dc to 120 V ac static inverter, sized to supply the vital instrument ac requirements.

One battery will be sized to handle the following combined loads:

	Operating Duration (hrs.)
The two generator's emergency seal oil pumps	1
The two turbine's emergency bearing oil pumps	1
Emergency lighting (approximately 50%)	4
Annunciators	4
Vital Instrument ac Generation Area	4

The other battery will be sized to handle the following combined loads:

	Operating Duration (Hrs.)
Emergency Lighting (approximately 50%)	4
Control and Indication	4
Vital Instrument ac Balance of Plant Outside the Generation Area	4

Each battery charger will be furnished to float-charge its battery and supply the normal continuous dc control load. The dc system will be ungrounded and equipped with a ground detector for continuous monitoring of ground-fault current.

Instrument ac System. A 120 V ac vital instrumentation power supply bus will be provided. This will serve vital plant ac instrumentation and controls, and it will be normally powered by the dc/ac static inverter.

A separate 120 V ac regulated bus will be provided for loads requiring regulated ac supply. In addition, this source will be used as a backup supply for the vital instrumentation power supply bus in case of inverter failure.

Instrumentation and controls requiring unregulated ac power will be fed from distribution transformers and panels mounted in MCC, as required.

Lighting System. Lighting and low-energy auxiliary loads will be supplied form the 120/208 V or from 277/480 V solidly grounded lighting system. Lighting for each plant operating area will be supplied from at least two circuits possibly fed from separate power sources to prevent complete loss of lighting on failure of equipment or wiring.

For exits and critical areas, emergency lighting circuits will be transferred automatically to the 125 V dc system on loss of the normal source. Outdoor lighting will be provided for operating areas and will include parking lot lighting and road lighting to match the existing installation at the Coolwater site. Aircraft obstruction lighting will be furnished with the stack and installed in accordance with Federal Aviation Agency (FAA) regulations.

Electrical Power System Control, Instrumentation, Protection and Annunciation. The electrical design for each unit will be based on centralized controls monitoring and protection with a minimum of local control stations and switches.

The Unit No. 5 steam turbine and the combustion turbine generator units will be capable of operating in parallel with each other and the 220 kV grid system. The controls provided will be able to maintain the required output, frequency voltage, and continuity of service demand. At the same time, these controls will also provide protection to plant personnel and equipment under all operating conditions. To obtain maximum operating reliability, the basic design of electrical equipment will be such that the necessity for interlocks is minimized and the requirement for control functions is also minimized. Control devices and monitoring devices necessary for startup, shutdown, normal, and emergency operations will be provided in the control room.

The protective relays for protection of each generator, the main power transformer and the main auxiliary transformer will be centralized and mounted on control and relay panels in the control room.

Protection of electrical equipment will be accomplished by means of coordinated relay systems and circuit-breaker operations. This protection system will be designed to offer maximum service dependability and minimum shutdown time due to electrical disturbances.

An automatic and manual synchronizing system will be provided with:

- Speed matching
- Voltage matching
- Breaker closing

Each generating unit, the main transformer and the main station auxiliary transformer will be provided with protection which includes:

Each generating unit:

- Differential (unit and transformer)
- Negative sequence overcurrent
- Overexcitation
- Loss of field
- Generator neutral overvoltage and transformer neutral overcurrent
- Voltage balance
- Generator field ground

- Stator overtemperature
- Synchrocheck
- Primary and backup lockout relays

Power transformers, main, auxiliary and reserve power, will be provided with protection that includes:

- Differential
- Phase overcurrent
- Neutral overcurrent
- Sudden (fault) pressure
- Overtemperature
- Lockout relay

The 4160 V switchgear buses will be provided with voltage-actuated bus differential protection, bus overcurrent and under-voltage protection, and with a lockout relay for each bus.

4000 V motors will be provided with protection that includes:

- Overcurrent (overload and short circuits)
- Sstator winding protection (thermistor type for motors from 250 hp to 1000 hp inclusive)
- Stator-winding protection (RTD for motors 1250 hp and above)
- Bearing overtemperature

The 480 V switchgear and circuit breakers will be provided with solid-state-type automatic tripping devices having long-time, short-time, and instantaneous characteristics, as may be required. In addition, 480 V switchgear buses will be provided with a bus undervoltage protection.

In 480 V motor control centers, the combination starters will be provided with magnetic-only-type circuit breakers and thermal overloads, and feeder circuit breakers will be provided with thermal-magnetic elements.

The 230 kV line between the main transformer and the switchyard will be included in the main transformer's differential relaying system.

General Electrical Systems

Grounding System. The grounding system shall be a ground grid, consisting of buried bare copper cable meshes and ground wells with copper anodes installed below the water table low level. The grid shall extend throughout all areas, including interconnections to the existing grounding grid for units Nos. 3 and 4 generators and the switchyard.

All electrical equipment, all switchgear ground buses, all electrical motors, building columns, transformer and generator neutrals will be connected to this grounding grid.

Five ground wells will be provided, one in the water treatment and cooling tower areas, two in the coal gasification and oxygen plant areas, and two in the power generation area.

Communication System. Telephone sets and public address speakers, similar to the existing plant equipment and all wiring and raceways, will be provided for intraplant communication. All locations, including the switchyard and outlying areas as dictated by the overall plant operation requirements, will be covered.

A sound-powered telephone system will be installed for testing and maintenance purposes. It will be installed in the control room, cable spreading room, switchyard, switchgear area, coal gasification area, oxygen plant, water treatment, switchgear and motor control enclosure, electrical equipment room and at local control panels.

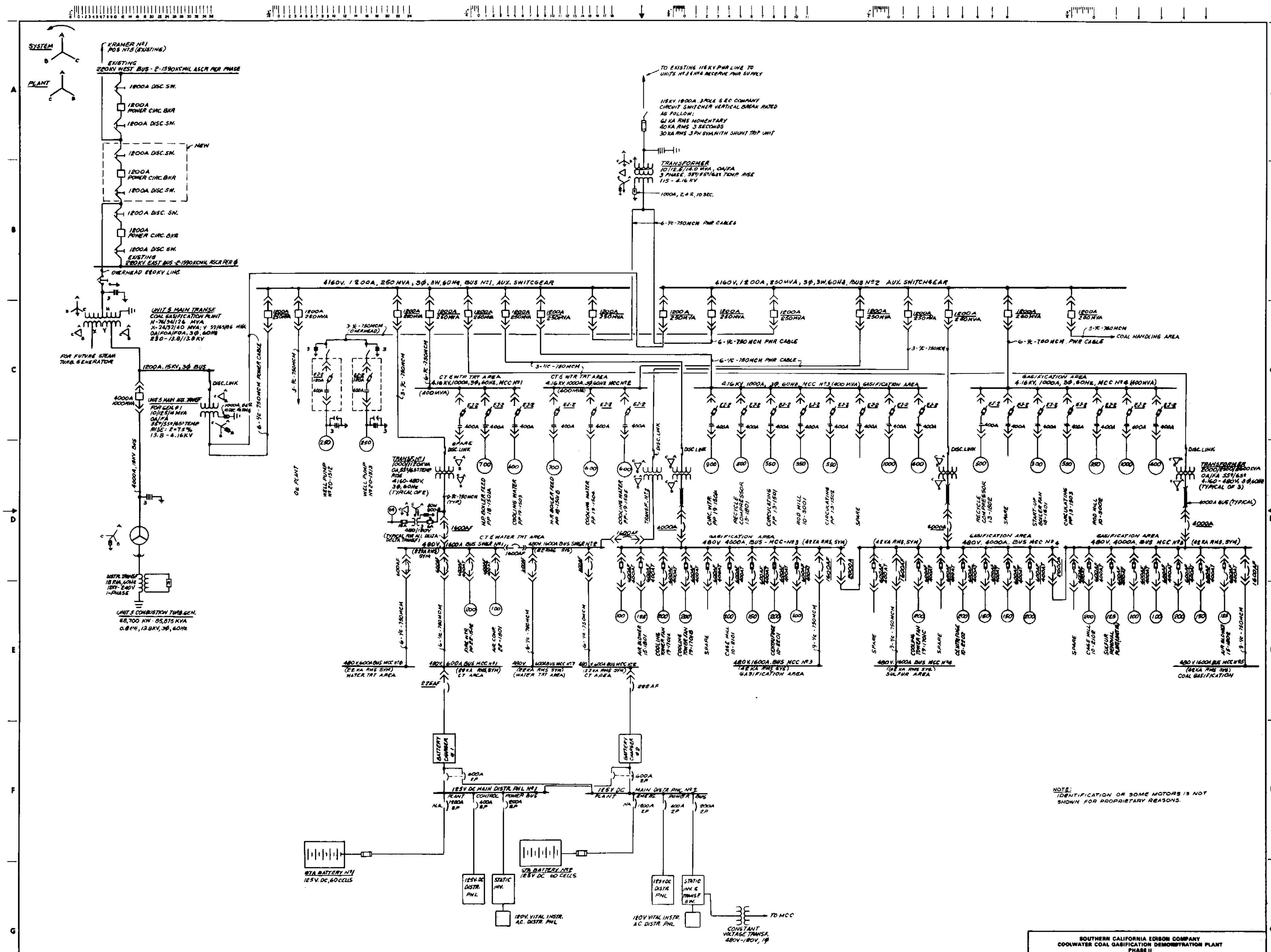
Fire Detection and Alarm Systems. Fire detection or alarm systems will be furnished as required in all areas throughout the plant.

Detailed Description - Case II

The integrated plant's electrical system for Case II is shown on Single Line Diagram No. E-01-E1-2. This electrical system is essentially the same as that described in the foregoing with the following exceptions:

13.8 kV Generation. The 13.8 kV generation consists of the combustion turbine-driven generation only.

Generation Connections to Existing 230 kV Transmission Switchyard. The combustion turbine-driven generator will be connected to the 230 kV switchyard through the main transformer in the same manner outlined above. The only exception being that the main transformer will be furnished with a delta "X" winding for a future steam turbine-driven generator.



SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE: **ELECTRICAL SINGLE-LINE DIAGRAM CASE II**

SCALE: NONE

THE RALPH M. PARSONS COMPANY, PASADENA, CALIFORNIA

JOB NUMBER 5815 — DRAWING NUMBER E-01-EL-2 — REV. 2

NO.	DATE	DESCRIPTION
2		DELETED IDENTIFICATION OF SOME MOTORS
1		REVISED GENERATOR & TRANSF. SIZE
0		ISSUED FOR FINAL REPORT
A		ISSUED TO SCE FOR REVIEW & COMMENTS

4.16 kV Power System. There are no differences between the 4.16 kV system for Case I and Case II. There are, however, several spare 4.16 kV fused motor starters under Case II, which would be available if the plant was expanded to Case I in the future.

480 V Power System. Motor Control Centers Nos. 1 and 2 will be smaller, fewer 480 V combination breaker and motor starters, since the steam turbine and the steam turbine-driven generator auxiliaries will not be required.

125 V dc System; Instrument A.C. System; Lighting System. There are no exceptions for these three systems between Case I and Case II, except that the 125 V dc system will have spare capacity for the future steam turbine and its associated generator.

Electrical Power Systems Control, Instrumentation, Protection and Annunciation. Case II, without the steam turbine driven generator, will require fewer control devices, electrical instruments and protective relays and a smaller annunciator system in the main control room.

Detailed Description - Case III

The integrated plant's electrical system for Case III is shown on Single Line Diagram No. E-01-E1-3. This electrical system is similar to that described above under Case I with the following exceptions:

Generation Connections to Existing 230 kV Transmission Switchyard. There will be no 13.8 kV generation and thus no requirement for a connection to the 230 kV switchyard.

4.16 kV Power System. The 4.16 kV power system will have the same general arrangement as described under Case I, with the main exception that it will have only one power source, with a source of plant shutdown power.

The power source will be the same as the 115/4.16 kV reserve auxiliary power source as outlined under Case I. It consists of a 115/4.16 kV outdoor substation, connected to an existing 115 kV overhead power line, through a 115 kV, 1200 A circuit switcher, 115/4.3 kV, 3 phase, 3 winding power transformer and a 4.16 kV feed to each of two 4.16 kV bus sections, Nos. 1 and 2.

An emergency plant shutdown 4.16 kV power source will be provided by connecting the two incoming 4.16 kV breakers, which under Case I are connected to the main auxiliary transformer, to a common 4.16 kV feeder from the existing 4.16 kV auxiliary bus for generating unit No. GT-4S.

There are also several 4.16 kV fused motor starters under Case III, which would be available if the plant was expanded to Case I in the future.

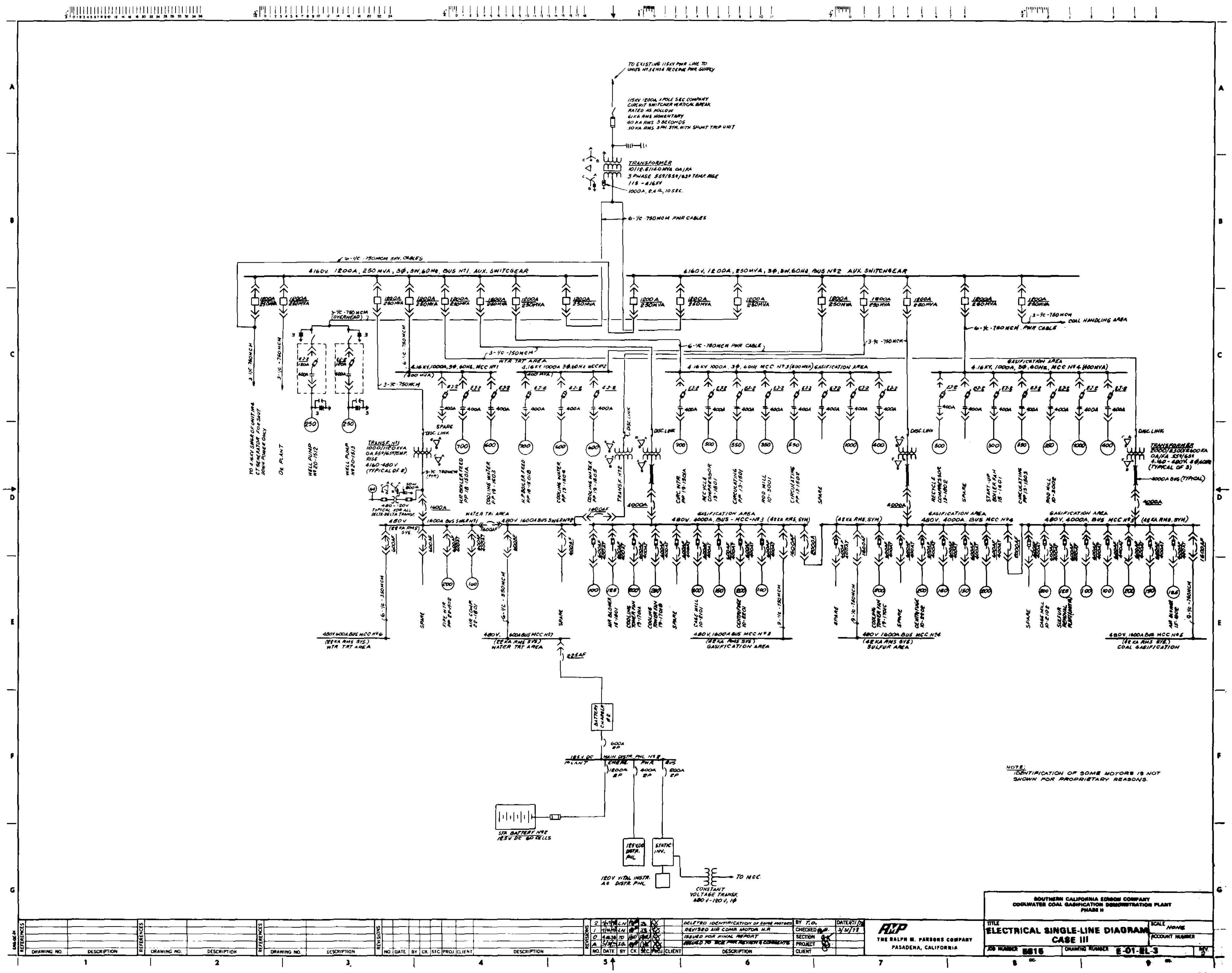
480 V Power System. Motor Control Centers Nos. 1 and 2 will not be required under Case III, since there are no turbines or generators.

125 V dc System; Instrument ac System; Lighting System. One battery and one static inverter, together with their associated battery charger, 125 V dc panels and 120 V vital instrument ac panel, will not be required under Case III.

The remaining battery charger, together with the remaining 125 V dc and 120 V ac systems will receive power from 480 V MCC No. 7.

Electric Power Systems Control Instrumentation, Protection and Annunciation. Case III, without any generation, will require fewer control devices and electrical instruments, a smaller annunciator system and no protective relays, in the main control room.

All required protective relays and auxiliary relays will be mounted on the hinged panels in the 4.16 kV switchgear.


TO EXISTING 115KV PWR LINE TO UNITS Nº3&4 TO RECEIVE PWR SUPPLY
TRANSFORMER
6-1/C-750MCM PWR CABLES
4160V, 1200A, 250MVA, 3Ø, 3W, 60Hz, BUS Nº1, AUX. SWITCGEAR
4160V, 1200A, 250MVA, 3Ø, 3W, 60Hz, BUS Nº2 AUX. SWITCHGEAR
COAL HANDLING AREA
GASIFICATION AREA
WATER TRT AREA
SPARE
WELL PUMP Nº20-1512
WELL PUMP Nº20-1513
480V, 1600A BUS MCC Nº6
480V, 600A BUS MCC Nº7
480V, 1600A BUS MCC Nº8
480V, 1600A BUS MCC Nº5
SULFUR AREA
COAL GASIFICATION
BATTERY CHARGER
STA BATTERY Nº2 125V DC 60 CELLS
120V VITAL INSTR. AC DISTR. PNL
CONSTANT VOLTAGE TRANSF. 480V-120V, 1Ø
TO MCC
NOTE:
IDENTIFICATION OF SOME MOTORS IS NOT SHOWN FOR PROPRIETARY REASONS.
DELETED IDENTIFICATION OF SOME MOTORS
REVISED AIR COMP. MOTOR H.P.
ISSUED FOR FINAL REPORT
ISSUED TO SCE FOR REVIEW & COMMENTS
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA
SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II
TITLE
ELECTRICAL SINGLE-LINE DIAGRAM
CASE III
SCALE NONE
ACCOUNT NUMBER
JOB NUMBER 5615
DRAWING NUMBER E-01-EL-3
REV. 2

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE I

ADDITIONS TO EXISTING 230 kV SWITCHYARD

Item No.	Quantity	Description
1	1	Outdoor floor mounted, 3 tank, 3 pole, 230 kV, 2000 A power circuit breaker.
2	2	Outdoor, pedestal mounted, 3 pole, 230 kV, group operated, center break, 1200 A disconnect switches.

AT THE MAIN TRANSFORMER STRUCTURE

Item No.	Quantity	Description
3	1	Outdoor pedestal mounted, 3 pole, 230 kV, group operated, center break, 1200 A disconnect switch.
4	3	Outdoor, pedestal mounted, 180 kV single phase lightning arresters.
5	1	Outdoor oil immersed, 3 winding, 3, 60 HZ, power transformer - 230-13.8/13.8 kV - with four 2-1/2% voltage taps in the high voltage winding-rated. Wye H - Winding 76/94/126 MVA; Delta X - Winding 24/32/40 MVA; Delta Y - Winding 52/69/86 MVA — OA/FA/FA, 55° Temp. Rise Basic Impulse Level - 1050 kV

GENERATORS 15 kV BUSES AND BREAKERS

Item No.	Quantity	Description
6	1	Outdoor, 15 kV power circuit breaker enclosure - with a drawout type, 13.8 kV, 2000 A, 3 pole, air circuit breaker. Rated at 1000 MVA.
7	1	Outdoor, 15 kV power circuit breaker enclosure - with a drawout type, 13.8 kV, 4000 A, 3 pole, air circuit breaker. Rated at 1000 MVA.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE I (Contd)

GENERATORS 15 kV BUSES AND BREAKERS (CONTD)

Item No.	Quantity	Description
8	(Approx. 100 ft.)	Outdoor, 15 kV, 2000A, 3 phase, metal enclosed, self-cooled - non-segregated bus - with insulated buses and rated 80 kA; from ST. Generator Unit No. 5 to the main transformer, through the 2000 A generator breaker.
9	(Approx. 160 ft.)	Outdoor, 15 kV, 4000A, 3 phase, metal enclosed, self-cooled - non-segregated bus - with insulated buses and rated 80 kA. From GT Generator Unit No. 5 to the main transformer, through the 4000 A generator breaker.
10	(Approx. 20 ft.)	Outdoor, 15 kV, 1200A, 3 phase metal enclosed, self-cooled, non-segregated bus - with insulated buses, a 3 pole disconnecting link and rated 80 kA. From 4000 A bus tap to the main auxiliary transformer.

MAIN AUXILIARY TRANSFORMER AND 4.16 kV SWITCHGEAR

Item No.	Quantity	Description
11	1	Outdoor, oil immersed, 2 winding, main auxiliary transformer. Rated 10/12.5/14 MVA. OA/FA, 3 phase, 13.8/4.16 kV-delta-wye connected, with four 2-1/2% voltage taps in the high voltage winding - 55°/55°/65° temperature rise.
12	1	Indoor, 5 kV drawout type, metal clad switchgear assembly, rated at 250 MVA and furnished with: Two - 1200 A bus sections Four - 1200 A incoming air circuit breaker compartments; two/bus section. Twelve - 1200 A outgoing air circuit breaker compartments, six/bus section.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE I (Contd)

MAIN AULIXIARY TRANSFORMER AND 4.16 kV SWITCHGEAR (CONTD)

		Each compartment to be furnished with a hinged panel with protective relays, control switches, indicating lights, etc. All incoming and outgoing air circuit breakers rated at 250 MVA.

4.16 kV RESERVE POWER SUPPLY SUB-STATION

13	1	Outdoor, pedestal mounted, 3 pole, 115 kV, 1200 A, group operated, vertical break, shunt tripped, S & C circuit switcher.
14	3	Outdoor, pedestal mounted, 90 kV single phase lighting arresters.
15	1	Outdoor, oil immersed, 3 winding, 3 phase, 60 HZ power transformer, 115/4.16 kV wye-wye connected, with a 2.4 kV delta tertiary winding, with four 2-1/2% voltage taps in the high voltage winding - rated 10/12.5/14 MVA OA/FA - 55°/55°/65° temperature rise. Basic impulse level 550 kV.
16	2	Outdoor, frame mounted, 5 kV transformer neutral grounding resistors. Each with mounting frame and rated at 1000 A, 2.4 ohms - 10 seconds.

4.16 kV MOTOR CONTROL CENTERS NOS. 1 AND 2

17	2	Indoor, floor mounted, self supporting, 4.16 kV motor control center assemblies. Each complete with a 1000A, 3 phase bus, with terminating lugs for 6-1/C - 750 MCM 5 kV incoming power cables - 2/phase and the following: Three - Outgoing 4.16 kV fused switch motor controller combination compartments, each rated

4.16 kV MOTOR CONTROL CENTERS NOS. 1 AND 2 (Contd)

Item No.	Quantity	Description
		400 A and each with a hinged panel with protective relays, control switches, indicating lights, etc.
		Each motor control assembly rated for 400 MVA.

4.16 kV MOTOR CONTROL CENTERS NOS. 3 AND 4

Item No.	Quantity	Description
18	2	Indoor, floor mounted, self-supporting 4.16 kV motor control center assemblies. Each complete with a 1000 A, 30 bus, with terminating lugs for 6 - 1/C - 750 MCM, 5 kV incoming power cables, 2/phase and the following:
		For 4.16 kV Motor Control Center No. 3 Seven - Outgoing 4.16 kV fused switch motor controller combination compartments. Each rated 400 A and each with a hinged panel with protective relays, control switches, indicating lights, etc.
		For 4.16 kV Motor Control Center No. 4 Six - Outgoing 4.16 kV fused switch motor controller combination compartments. Each as outlined above.
		Each motor control assembly rated at 400 MVA.

4.16 kV MOTOR CONTROL EQUIPMENT FOR WELL PUMPS

Item No.	Quantity	Description
19	2	Outdoor 4.16 kV, 3 phase, fused switch motor controller combinations. Each rated at 400 A and 400 MVA. Each to

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE I (Contd)

4.16 kV MOTOR CONTROL EQUIPMENT FOR WELL PUMPS (Contd)

Item No.	Quantity	Description
19	2	be furnished with an outdoor, floor mounted, self- supporting, weatherproof enclosure.
20	6	Outdoor, 4.16 kV single phase surge protective units - each rated at 3240 V. rating.
21	6	Outdoor, 4.16 kV pole mounted lightning arresters, surge protection units, single phase, rated at 3240 V.
22	6	Outdoor, 4.16 kV single pole, hook stick operated, cross-arm mounted, 600 A disconnect switches.

4.16/.48 kV POWER TRANSFORMERS

Item No.	Quantity	Description
23	2	Outdoor, oil immersed, 2-winding, 3, 60 HZ, power transformers. Each 4.16/.48 kV delta. Delta connected, with four 2-1/2% voltage taps in the high voltage winding. Each rated 1000/1120 KVA OA - with 55°/65° temperature rise. Complete with a 3 pole 600 A disconnecting link on the 4.16 kV side.
24	3	Outdoor, oil immersed, 2 winding, 3, 60 HZ, power transformers. Each 4.16/.48 kV delta. Delta connected, with four 2-1/2% voltage taps in the high voltage winding. Each rated 2000/2300/2600 KVA. OA/FA with a 55°/55°/65° temperature rise and complete with a 3 pole, 600 A disconnecting link on the 4.16 kV side.
25	(Approx. 60 ft.)	Outdoor, 600 V, 4000A, 3 phase, metal enclosed, self-cooled, non-segregated bus ducts.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE I (Contd)

480 V SWITCHGEAR UNITS NOS. 1 AND 2

26	1	Indoor, 480 V, 3 phase, floor mounted, self-supporting, draw out type, double ended switchgear unit.

480 V SWITCHGEAR UNITS NOS. 3, 4 AND 5

27	3	Indoor, 480 V, 3 phase, floor mounted, self-supporting, draw out type, switchgear unit.

480 V MOTOR CONTROL CENTERS NOS. 1 TO 7

28	7	480 V, indoor floor mounted, self-supporting motor control centers.
29	2	480 V, 3-phase, 60 HZ, to 125 V dc. Indoor, self-supporting, floor mounted battery chargers. Each rated at 400 A, 130 V dc.
30	2	125 V dc 60 cell station batteries, each rated at 900 A hour, on an eight hour base; each complete with intercell connectors and a battery rack.
31	2	125 V dc main distribution panels, Nos. 1 and 2.
32	2	125 V dc distribution panels.
		Each of the above dc panels to be floor mounted, self-supporting metal enclosed panels.

120 V INSTRUMENT ac SYSTEM

33	2	125 V dc to 120 V ac 60 HZ, single phase 7.5 kV static inverters, floor mounted, metal enclosed and self-supporting.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE I (Contd)

480 V MOTOR CONTROL CENTERS NOS. 1 TO 7 (Contd)

Item No.	Quantity	Description
34	2	120 V ac 60 HZ, vital instrument ac distribution panels. Each with a wall mounted, metal enclosure.
35	2	480/120 V ac single phase dry type, wall mounted, 15 KVA transformers, for 1, 120 V ac instrument power.
36	2	120 V ac 60 HZ, one phase instrument ac distribution panel. Each complete with a metal enclosure for wall mounting.

240 - 120 V SINGLE PHASE ac SYSTEM

37	3	480/240-120 V 1, 25 MVA dry type, wall mounted transformers, for 1, 240-120 V ac power.
38	3	240-120 V ac single phase power distribution panels. Each complete with a wall mounted, metal enclosure.

MAIN GENERATOR'S NEUTRAL GROUNDING SYSTEM

39	2	15 KVA, 12/.24 kV, single phase, 60 HZ, distribution transformers. For grounding neutral point of each 13.8 kV electric generators.
40	2	240 V neutral grounding resistors.

ELECTRICAL CONTROL AND RELAY PANELS

41	8	Electrical control and relay panels, to be floor mounted, self-supporting. Each complete with protective relays, electrical indicating and recording instruments,

ELECTRICAL CONTROL AND RELAY PANELS (Contd)

Item No.	Quantity	Description
		control switches, synchronizing equipment and indicating lights.

LIGHTING SYSTEM

Item No.	Quantity	Description
42	4	75 kVA 3 phase, 60 HZ, 480/120-208 V dry type lighting transformers.
43	4	120-208 V, 3 phase, lighting panels with a 120 volt ac distribution section and a 125 V dc distribution section, and a 120 V ac to 125 V dc transfer switch controlled by the 120 V ac voltage.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE II

(A) INITIAL PHASE

ADDITIONS TO EXISTING 230 kV SWITCHYARD

Item No.	Quantity	Description
1	1	Outdoor floor mounted, 3 tank, 3 pole, 230 kV, 2,000 A power circuit breaker.
2	2	Outdoor, pedestal mounted, 3 pole, 230 kV, group operated, center break, 1200 A disconnect switches.

AT THE MAIN TRANSFORMER STRUCTURE

3	1	Outdoor pedestal mounted, 3 pole, 230 kV, group operated, center break, 1200 A disconnect switch.
4	3	Outdoor, pedestal mounted, 180 kV single phase lightning arresters.
5	1	Outdoor oil immersed, 3 winding, 3 phase, 60 HZ, power transformer - 230-13.8/13.8 kV - with four 2-1/2% voltage taps in the high voltage winding-rated. Wye H - Winding 76/94/126 MVA) Delta X - Winding 24/32/40 MVA) OA/FA/FA Delta Y - Winding 52/69/86 MVA) 55 Temp. Rise Basic Impulse Level - 1050 kV

GENERATORS 15 KV BUSES AND BREAKERS

Item No.	Quantity	Description
6	1	Outdoor, 15 kV power circuit breaker enclosure - with a drawout type, 13.8 kV, 2000 ampere, 3 pole, air circuit breaker. Rated at 1000 MVA.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE II (Contd)

GENERATORS 15 KV BUSES AND BREAKERS (Contd)

Item No.	Quantity	Description
7	(Approx. 160 Ft.)	Outdoor, 15 kV, 4000A, 3 phase, metal enclosed, self-cooled - non-segregated bus - with insulated buses and rated 80 kA. From GT Generator Unit No. 5 to the main transformer, through the 4000 A generator breaker.
8	(Approx. 20 Ft.)	Outdoor, 15 kV, 1200A, 3 phase, metal enclosed, self-cooled, non-segre- gated bus - with insulated buses, a 3 pole disconnecting link and rated 80 kA. From 4000 A bus tap to the main auxiliary transformer.

MAIN AUXILIARY TRANSFORMER AND 4.16 kV SWITCHGEAR

Item No.	Quantity	Description
9	1	Outdoor, oil immersed, 2 winding, main auxiliary transformer. Rated 10/12.5/14 MVA. OA/FA, 3 phase, 13.8/4.16 kV-Delta-Wye connected, with four 2-1/2% voltage taps in the high voltage winding - $55^\circ/55^\circ/65^\circ$ temperature rise.
10	1	Indoor, 5 kV drawout type, metal clad switchgear assembly, rated at 250 MVA and furnished with: Two - 1200 A bus sections Four - 1200 A incoming air circuit breaker compartments; two/bus section. Twelve - 1200 A outgoing air circuit breaker compartments, six/bus section. Each compartment to be furnished with a hinged panel with protective relays, control switches, indicating lights, etc. All incoming and outgoing air circuit breakers rated at 250 MVA.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE II (Contd)

MAIN AUXILIARY TRANSFORMER AND 4.16 KV SWITCHGEAR (Contd)

Item No.	Quantity	Description
4.16 KV RESERVE POWER SUPPLY SUB-STATION		
11	1	Outdoor, pedestal mounted, 3 pole, 115 kV, 1200 A, group operated, vertical break, shunt tripped, S & C circuit switcher.
12	3	Outdoor, pedestal mounted, 90 kV single phase lighting arresters.
13	1	Outdoor, oil immersed, 3 winding, 3 phase, 60 HZ power transformer, 115/4.16 kV wye-wye connected, with a 2.4 kV delta tertiary winding, with four 2-1/2% voltage taps in the high voltage winding - rated 10/12.5/14 MVA OA/FA - 55°/55°/65° temperature rise. Basic impulse level 550 kV.
14	2	Outdoor, frame mounted, 5 kV transformer neutral grounding resistors. Each with mounting frame and rated at 1000 amperes, 2.4 ohms - 10 seconds.
4.16 KV MOTOR CONTROL CENTERS NOS. 1 AND 2		
15	2	Indoor, floor mounted, self supporting, 4.16 kV motor control center assemblies. Each complete with a 1000 A, 3 phase bus, with terminating lugs for 6-1/C - 750 MCM 5 kV incoming power cables - 2/phase and the following: Three - Outgoing 4.16 kV fused switch motor controller combination compartments, each rated 400 A and each with a hinged panel with protective relays, control switches, indicating lights, etc.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE II (Contd)

4.16 kV MOTOR CONTROL CENTERS NOS. 1 AND 2 (Contd)

Item No.	Quantity	Description
		Each motor control assembly rated for 400 MVA.

4.16 kV MOTOR CONTROL CENTERS NOS. 3 AND 4

Item No.	Quantity	Description
16	2	Indoor, floor mounted, self-supporting 4.16 kV motor control center assemblies. Each complete with a 1000 A, 3 phase bus, with terminating lugs for 6 - 1/C - 750 MCM, 5 KV incoming power cables, 2/phase and the following: For 4.16 kV Motor Control Center No. 3 Eight - Outgoing 4.16 kV fused switch motor controller combination compartments. Each rated 400 A and each with a hinged panel with protective relays, control switches, indicating lights, etc. For 4.16 kV Motor Control Center No. 4 Six - Outgoing 4.16 kV fused switch motor controller combination compartments. Each as outlined above. Each motor control assembly rated at 400 MVA.

4.16 kV MOTOR CONTROL EQUIPMENT FOR WELL PUMPS

Item No.	Quantity	Description
17	2	Outdoor 4.16 kV, 3 phase, fused switch motor controller combinations. Each rated at 400 A and 400 MVA. Each to be furnished with an outdoor, floor mounted, self-supporting, weather- proof enclosure.
18	6	Outdoor, 4.16 kV single phase surge protective units - each rated at 3240 V.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE II (Contd)

4.16 kV MOTOR CONTROL EQUIPMENT FOR WELL PUMPS (Contd)

Item No.	Quantity	Description
19	6	Outdoor, 4.16 kV pole mounted lightning arresters, surge protection units, single phase, rated at 3240 V.
20	6	Outdoor, 4.16 kV single pole, hook stick operated, cross-arm mounted, 600 A disconnect switches.

4.16/.48 kV POWER TRANSFORMERS

Item No.	Quantity	Description
21	2	Outdoor, oil immersed, 2-winding, 3 phase, 60 HZ, power transformers. Each 4.16/.48 kV delta. Delta connected, with four 2-1/2% voltage taps in the high voltage winding. Each rated 1000/1120 KVA OA - with 55° /65° temperature rise. Complete with a 3 pole 600 A disconnecting link on the 4.16 kV side.
22	3	Outdoor, oil immersed, 2-winding, 3 phase, 60 HZ, power transformers. Each 4.16/.48 kV delta. Delta connected, with four 2-1/2% voltage taps in the high voltage winding. Each rated 2000/2300/2600 KVA. OA/FA with a 55° /55° /65° temperature rise and complete with a 3 pole, 600 A disconnecting link on the 4.16 kV side.
23	(Approx. 60 ft.)	Outdoor, 600 Volt, 4000A, 3 phase, metal enclosed, self-cooled, non-segregated bus ducts.

480 V SWITCHGEAR UNITS NOS. 1 AND 2

Item No.	Quantity	Description
24	3	Indoor, 480 V, 3 phase, floor mounted, self-supporting, draw out type, double ended switchgear unit.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE II (Contd)

480 V MOTOR CONTROL CENTERS NOS. 1 TO 7

Item No.	Quantity	Description
26	7	480 V, indoor floor mounted, self-supporting motor control centers.

125 V dc SYSTEM

Item No.	Quantity	Description
27	2	480 V, 3 phase, 60 HZ, to 125 V dc Indoor, self-supporting, floor mounted battery chargers. Each rated at 400 A, 130 volts dc
28	2	125 V dc 60 cell station batteries, each rated at 900 A hour, on an eight hour base; each complete with intercell connectors and a battery rack.
29	2	125 V dc main distribution panels, Nos. 1 and 2.
30	2	125 V dc distribution panels.
		Each of the above dc panels to be floor mounted, self-supporting metal enclosed panels.

120 V INSTRUMENT ac SYSTEM

Item No.	Quantity	Description
31	2	125 V dc to 120 V ac 60 HZ, single phase 7.5 kV static inverters, floor mounted, metal enclosed and self-supporting.
32	2	120 V ac, 60 HZ, vital instrument A.C. distribution panels. Each with a wall mounted, metal enclosure.
33	1	480/120 V ac, single phase dry type, wall mounted, 15 KVA transformer, for 10, 120 V ac instrument power.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE II (Contd)

120 VOLT A.C. SYSTEM (Contd)

Item No.	Quantity	Description
34	2	120 V ac, 60 HZ, one phase instrument ac distribution panel. Each complete with a metal enclosure for wall mounting.

240 - 120 V SINGLE PHASE ac SYSTEM

Item No.	Quantity	Description
35	3	480/240-120 V 1Ø, 25 MVA dry type, wall mounted transformers, for 1Ø, 240-120 V ac power.
36	3	240-120 V ac, single phase power distribution panels. Each complete with a wall mounted, metal enclosure.

MAIN GENERATOR'S NEUTRAL GROUNDING SYSTEM

Item No.	Quantity	Description
37	1	15 KVA, 12/.24 kV, single phase, 60 HZ, distribution transformers. For grounding neutral point of each 13.8 kV electric generators.
38	1	240 V neutral grounding resistor.

ELECTRICAL CONTROL AND RELAY PANELS

Item No.	Quantity	Description
39	6	Electrical control and relay panels, to be floor mounted, self-supporting. Each complete with protective relays, electrical indicating and recording instruments, control switches, synchronizing equipment and indicating lights.

LIGHTING SYSTEM

Item No.	Quantity	Description
40	4	75 kVA, 3 phase, 60 HZ, 480/120-208 V dry type lighting transformers.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE II (Contd)

LIGHTING SYSTEM (Contd)

Item No.	Quantity	Description
41	4	120-208 V, 3 phase, lighting panels with a 120 V ac distribution section and a 125 V dc distribution section, and a 120 V ac to 125 V dc transfer switch controlled by the 120 V ac voltage.

B. ADD-ON PHASE

ST GENERATOR 15 kV BUS AND BREAKER

Item No.	Quantity	Description
42	1	Outdoor, 15 kV power ciruict breaker enclosure, with a drawout type, 13.8 kV, 2000 A, 3 pole, air circuit breaker. Rated at 1000 MVA.
43	(Approx. 100 ft.)	Outdoor, 15 kV, 2000A, 3 phase, metal enclosed, self-cooled, non-segregated bus - with insulated conductors and rated 80 KA. From ST Generator Unit No. 5 to the main transformer, through the 2000 A generator breaker.

ST GENERATOR'S NEUTRAL GROUNDING SYSTEM

Item No.	Quantity	Description
44	1	15 kVA, 12/.24 kV, single phase, 60 hertz, distribution transformers. For grounding neutral point of each 13.8 kV electric generators.
50	1	240 V neutral grounding resistors - to be installed on the secondary side of each neutral grounding transformer.

ELECTRICAL CONTROL AND RELAY PANELS

Item No.	Quantity	Description
46	2	Electrical control and relay panels, to be floor mounted, self-supporting. Each complete with protective relays, electrical indicating and recording instruments, control switches, synchronizing equipment and indicating lights.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III

(A) INITIAL PHASE

4.16 kV SWITCHGEAR

Item No.	Quantity	Description
1	1	Indoor, 5 kV drawout type, metal clad switchgear assembly, rated at 250 MVA and furnished with: Two - 1200 A bus sections Four - 1200 A incoming air circuit breaker compartments; two/bus section. Twelve - 1200 A outgoing air circuit breaker compartments, six/bus section. Each compartment to be furnished with a hinged panel with protective relays, control switches, indicating lights, etc. All incoming and outgoing air circuit breakers rated at 250 MVA.

4.16 kV RESERVE POWER SUPPLY SUB-STATION

2	1	Outdoor, pedestal mounted, 3 pole, 115 kV, 1200 A, group operated, vertical break, shunt tripped, S & C circuit switcher.
3	3	Outdoor, pedestal mounted, 90 kV single phase lighting arresters.
4	1	Outdoor, oil immersed, 3 winding, 3 phase, 60 HZ power transformer, 115/416 kV wye-wye connected, with a 2.4 kV delta tertiary winding, with four 2-1/2% voltage taps in the high voltage winding - rated 10/12.5/14 MVA OA/FA - 55°/55°/65° temperature rise. Basic impulse level 550 kV.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III (Contd)

4.16 KV RESERVE POWER SUPPLY SUB-STATION (Contd)

Item No.	Quantity	Description
5	2	Outdoor, frame mounted, 5 kV transformer neutral grounding resistors. Each with mounting frame and rated at 1000 A, 2.4 ohms - 10 seconds.

4.16 kv MOTOR CONTROL CENTERS NOS. 1 AND 2

Item No.	Quantity	Description
6	2	Indoor, floor mounted, self supporting, 4.16 kV motor control center assemblies. Each complete with a 1000 A, 3 phase bus, with terminating lugs for 6-1/C - 750 MCM 5 kV incoming power cables - 2/phase and the following: Three - Outgoing 4.16 kV fused switch motor controller combination compartments, each rated 400 A and each with a hinged panel with protective relays, control switches, indicating lights, etc. Each motor control assembly rated for 400 MVA.

4.16 kV MOTOR CONTROL CENTERS NOS. 3 AND 4

Item No.	Quantity	Description
7	2	Indoor, floor mounted, self-supporting 4.16 kV motor control center assemblies. Each complete with a 1000 A, 3 phase bus, with terminating lugs for 6 - 1/C - 750 MCM, 5 kV incoming power cables, 2/phase and the following: For 4.16 KV Motor Control Center No. 3 Seven - Outgoing 4.16 KV fused switch motor controller combination compartments. Each rated 400 A and each with a hinged panel with the protective relays, control switches, indicating lights, etc.

4.16 KV MOTOR CONTROL CENTERS NOS. 3 AND 4 (Contd)

Item No.	Quantity	Description
		terminating lugs for 6 - 1/C - 750 MCM, 5 kV incoming power cables, 2/phase and the following: For 4.16 kV Motor Control Center No. 3 Seven - Outgoing 4.16 kV fused switch motor controller combination compartments. Each rated 400 A with protective relays, control switches, indicating lights, etc. For 4.16 kV motor Control Center No. 4 Six - Outgoing 4.16 kV fused switch motor controller combination compartments. Each as outlined above. Each motor control assembly rated at 400 MVA.

4.16 kV MOTOR CONTROL EQUIPMENT FOR WELL PUMPS

Item No.	Quantity	Description
8	2	Outdoor 4.16 kV, 3 phase fused switch motor controller combinations. each rated at 400 A and 400 MVA. Each to be furnished with an outdoor, floor mounted, self-supporting, weatherproof enclosure.
9	6	Outdoor, 4.16 kV single phase surge protective units - each rated at 3240 V.
10	6	Outdoor, 4.16 kV pole mounted lightning arresters, surge protection units, single phase, rated at 3240V. unit.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III (Contd)

4.16 kV MOTOR CONTROL EQUIPMENT FOR WELL PUMPS

Item No.	Quantity	Description
11	6	Outdoor, 4.16 kV single pole, hook stick operated, cross-arm mounted, 600A disconnect switches.

4.16/.48 kV POWER TRANSFORMERS

Item No.	Quantity	Description
12	2	Outdoor, oil immersed, 2-winding, 3 phase, 60 HZ, power transformers, Each with four 2-1/2% voltage taps in the high voltage winding. Each rated 1000/1120 kVA OA - with 55°/65° temperature rise. Complete with a 3 pole 600A disconnecting link on the 4.16 kV side.
13	3	Outdoor, oil immersed, 2 winding, 3 phase, 60 HZ, power transformers. Each 4.16/.48 KV delta. Delta connected, with four 2-1/2% voltage taps in the high voltage winding. Each rated 2000/2300/2600 KVA. OA/FA with a 55° /55° /65° temperature rise and complete with a 3 pole, 600 A disconnecting link on the 4.16 kV side.
14	(Approx. 60 ft.)	Outdoor, 600 V, 4000 A, 3 phase, metal enclosed, self-cooled, non-segregated bus ducts.

480 V SWITCHGEAR UNITS NOS. 1 AND 2

Item No.	Quantity	Description
15	1	Indoor, 480 V, 3 phase, floor mounted, self-supporting, draw out type, double ended switchgear unit.

480 V SWITCHGEAR UNITS NOS. 3, 4 AND 5

Item No.	Quantity	Description
16	3	Indoor, 480 V, 3 phase, floor mounted, self-supporting, draw out type, switchgear units.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III (Contd)

480 VOLT MOTOR CONTROL CENTERS NOS. 3 TO 7

Item No.	Quantity	Description
17	5	480 V, indoor floor mounted, self-supporting motor control centers.

125 V dc SYSTEM

Item No.	Quantity	Description
18	1	480 V, 3 phase, 60 hZ, to 125 V dc. Indoor, self-supporting, floor mounted battery charger. Rated at 400 A, 130 V dc.
19	1	125 V dc 60 cell station battery, rated at 900 A hour, on an eight hour base; complete with intercell connectors and a battery rack.
20	1	125 V dc main distribution panel, No. 2.
21	1	125 V dc distribution panel.
		Each of the above dc panels to be floor mounted, self-supporting metal enclosed panels.

120 V INSTRUMENT ac SYSTEM

Item No.	Quantity	Description
22	1	125 V dc to 120 V ac 60 hertz, single phase 7.5 kV static inverter, floor mounted, metal enclosed and self-supporting.
23	1	120 V ac, 60 hertz, vital instrument ac distribution panels, with a wall mounted, metal enclosure.
24	1	480/120 V ac, single phase, dry type, wall mounted, 15 KVA transformers, for 10, 120 V ac instrument power.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III (Contd)

240 - 120 V SINGLE PHASE ac SYSTEM (Contd)

Item No.	Quantity	Description
25	1	120 V ac 60 hertz, one phase instrument ac distribution panel. Complete with a metal enclosure for wall mounting.

240 - 120 VOLT SINGLE PHASE ac SYSTEM

Item No.	Quantity	Description
26	2	480/240-120 V, single phase, 25 MVA dry type, wall mounted transformers, for 10, 240-120 V ac power.
27	2	240-120 V ac single phase power distribution panels. Each complete with a wall mounted, metal enclosure.

ELECTRICAL CONTROL AND RELAY PANELS

Item No.	Quantity	Description
28	3	Electrical control panels, to be floor mounted, self-supporting. Each complete with electrical indicating and recording instruments, control switches, and indicating lights.

LIGHTING SYSTEM

Item No.	Quantity	Description
29	2	75 kVA 30, 60 hertz, 480/120-208 V dry type lighting transformers.
30	2	120-208 V, 30, lighting panels with a 120 V ac distribution section and a 125 V dc distribution section, and a 120 V ac to 125 V dc transfer switch controlled by the 120 V ac voltage.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III (Contd)

4.16 kV POWER SUPPLY FOR EMERGENCY SHTUDOWN

Item No.	Quantity	Description
31	1	One indoor, 5 kV, drawout type metal clad switchgear compartment, addition to the existing indoor, 5 kV auxiliary switchgear unit No. 4, for existing generator GT-4S. The additional compartment shall be rated at 250 MVA.

ADDITIONS TO EXISTING 230 kV SWITCHYARD

32	1	Outdoor floor mounted, 3 tank, 3 pole, 230 kV, 2,000 A power circuit breaker.
33	2	Outdoor, pedestal mounted, 3 pole, 230 kV, group operated, center break, 1200 A disconnect switches.

AT THE MAIN TRANSFORMER STRUCTURE

34	1	Outdoor pedestal mounted, 3 pole, 230 kV, group operated, center break, 1200 A disconnect switch.
35	3	Outdoor, pedestal mounted, 180 kV single phase lightning arresters.
36	1	Outdoor oil immersed, 3 winding, 3 phase, 60 hertz, power transformer - 230-13.8/13.8 kV - with four 2-1/2% voltage taps in the high voltage winding-rated.

Wye H - Winding)
76/94/126 MVA)
Delta X - Winding) OA/FA/FA
24/32/40 MVA)
Delta Y - Winding) 55° Temp. Rise
52/69/86 MVA)

Basic Impulse Level - 1050 kV

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III (Contd)

GENERATORS 15 kV BUSES AND BREAKERS

Item No.	Quantity	Description
37	1	Outdoor, 15 kV power circuit breaker enclosure - with a drawout type, 13.8 kV, 2000 A, 3 pole, air circuit breaker. rated at 1000 MVA.
38	1	Outdoor, 15 kV power circuit breaker enclosure - with a drawout type, 13.8 kV, 4000 A, 3 pole, air circuit breaker. Rated at 1000 MVA.

GENERATORS 15 kV BUSES AND BREAKERS

Item No.	Quantity	Description
39	(Approx. 100 Ft.)	Outdoor, 15 kV, 2000 A, 3 phase, metal enclosed, self-cooled, non-segregated bus, with insulated buses and rated 80 kA; from ST. Generator Unit No. 5 to the main transformer, through the 2000 A generator breaker.
40	(Approx. 160 Ft.)	Outdoor, 15 kV, 4000 A, 3 phase, metal enclosed, self-cooled, non-segregated bus, with insulated buses and rated 80 kA. From GT Generator Unit No. 5 to the main transformer, through the 4000 A generator breaker.
41	(Approx. 20 Ft.)	Outdoor, 15 kV, 1200 A, 3 phase, enclosed, self-cooled, non-segregated bus, with insulated buses, a 3 pole disconnecting link and rated 80 kA. From 4000 A bus tap to the main auxiliary transformer.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III (Contd)

MAIN AUXILIARY TRANSFORMER

Item No.	Quantity	Description
42	1	Outdoor, oil immersed, 2 winding, main auxiliary transformer. Rated 10/12/5/14 MVA. OA/FA, 3 phase, with four 2-1/2% voltage taps in the high voltage winding - 55° / 55° /65° temperature rise.

480 VOLT MOTOR CONTROL CENTERS NOS. 1 AND 2

43	1	480 V, indoor floor mounted, self-supporting motor control center.

125 V dc SYSTEM

44	1	480 V, 3 phase, 60 hertz, to 125 V dc Indoor, self-supporting, floor mounted battery charger. Rated at 400 A, 130 V dc
45	1	125 V dc 60 cell station battery, rated at 900 A hour, on an eight hour base; complete with intercell connectors and a battery rack.
46	1	125 V dc main distribution panel, No. 1.
47	1	125 V dc distribution panel.
		Each of the above dc panels to be floor mounted, self-supporting metal enclosed panels.

120 V INSTRUMENT ac SYSTEM

48	1	125 V dc to 120 V ac 60 hertz, single phase 7.5 kV static inverter, floor mounted, metal enclosed and self-supporting.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III (Contd)

120 V INSTRUMENT ac SYSTEM (Contd)

Item No.	Quantity	Description
49	1	120 V ac, 60 hertz, vital instrument ac distribution panel, with a wall mounted, metal enclosure.
50	1	480/120 V ac, single phase, dry type, wall mounted, 15 KVA transformer, for 10, 120 V ac instrument power.
51	1	120 V ac 60 hertz, one phase instrument ac distribution panel, complete with a metal enclosure for wall mounting.

240 - 120 V SINGLE PHASE ac SYSTEM

52	1	480/240-120 V, single phase, 25 MVA dry type, wall mounted transformer, for 10, 240-120 V ac power.
53	1	240-120 V ac, single phase power distribution panel, complete with a wall mounted, metal enclosure.

MAIN GENERATOR'S NEUTRAL GROUNDING SYSTEM

54	2	15 KVA, 12/.24 kV, single phase, 60 HZ, distribution transformers. For grounding neutral point of each 13.8 kV electric generators.
55	2	240 V neutral grounding resistors - to be installed on the secondary side of each neutral grounding transformer.

EQUIPMENT LIST

PLANT ELECTRICAL SYSTEM

CASE III (Contd)

ELECTRICAL CONTROL AND RELAY PANELS

Item No.	Quantity	Description
56	5	Electrical control and relay panels, to be floor mounted, self- supporting. Each complete with protective relays, electrical indicating and recording instruments, control switches, synchronizing equipment and indicating lights.

3.14 OTHER PLANT SUPPORTING SYSTEMS AND FACILITIES

The proper and efficient operation of the integrated coal gasification/power plant requires other supporting systems and facilities in addition to the systems described in Sections 3.2 through 3.13. This section will briefly describe the miscellaneous support systems and facilities that are essential to the operation of the plant but have not been included in the previous sections. The description of each supporting system and facility is applicble to all three cases under investigation except as noted specifically in each respective subsection.

Clean Gas Surge and Flare System

The clean gas surge and flare system, which consists of a clean gas surge tank and a flare gas system, is shown on Process Flow Diagram D-22-FS-1.

The clean gas surge tank balances the system demand during load variation between the gasification plant and the power plant. The surge tank is designed to accomodate a 20% load variation over a 5-min. period. The flare gas system is provided to dispose of any excess product gas.

Air and Nitrogen System

The plant requires instrument air, utility air and a supply of nitrogen for purging equipment. A 900 scfm nitrogen compressor together with receivers is provided the oxygen plant and that compressor will supply dry nitrogen at 125 psig for utility, instrument and purging services during normal plant operation.

A 6,000 gallon liquid nitrogen storage reservoir with a vaporizer is also provided with the oxygen plant for plant cooldown, purging and instrument air backup.

In addition, a 300 scfm utility air compressor is provided to supply air at 125 psig for utility and instrument services when the oxygen plant is not operating. The air will be dried to a dewpoint of -40° F in a fully automatic desiccant type drier that is rated for 200 scfm. The air and nitrogen system components are located in the oxygen plant area.

Diesel Fuel System

Diesel fuel is the alternate fuel for the integrated coal gasification/power plant. It will be used for the following:

- Gas turbine during startup and when fuel gas is not available.

- Diesel engine-driven fire water pump when needed.
- Startup boiler and fired superheater for Cases II and III during startup and when fuel gas is not available.

The diesel fuel system will be interconnected with the existing diesel fuel system at Units 3 and 4 and will include one forwarding pump to supply the diesel fuel from the existing diesel fuel oil tank.

Propane Gas System

Propane gas required for the flare system pilot and the gasifier LPG tank during startup and when fuel gas is not available will be supplied by the Units 3 and 4 propane gas system. Liquid propane is vaporized and supplied by the propane gas system at a discharge pressure of 100 psig.

Slag Disposal System

Slag produced in the coal gasification process will be conveyed to a bin that is conveniently located for truck loading. The slag will be removed by trucks as required and dumped at an approved solids disposal site.

Fire Protection System

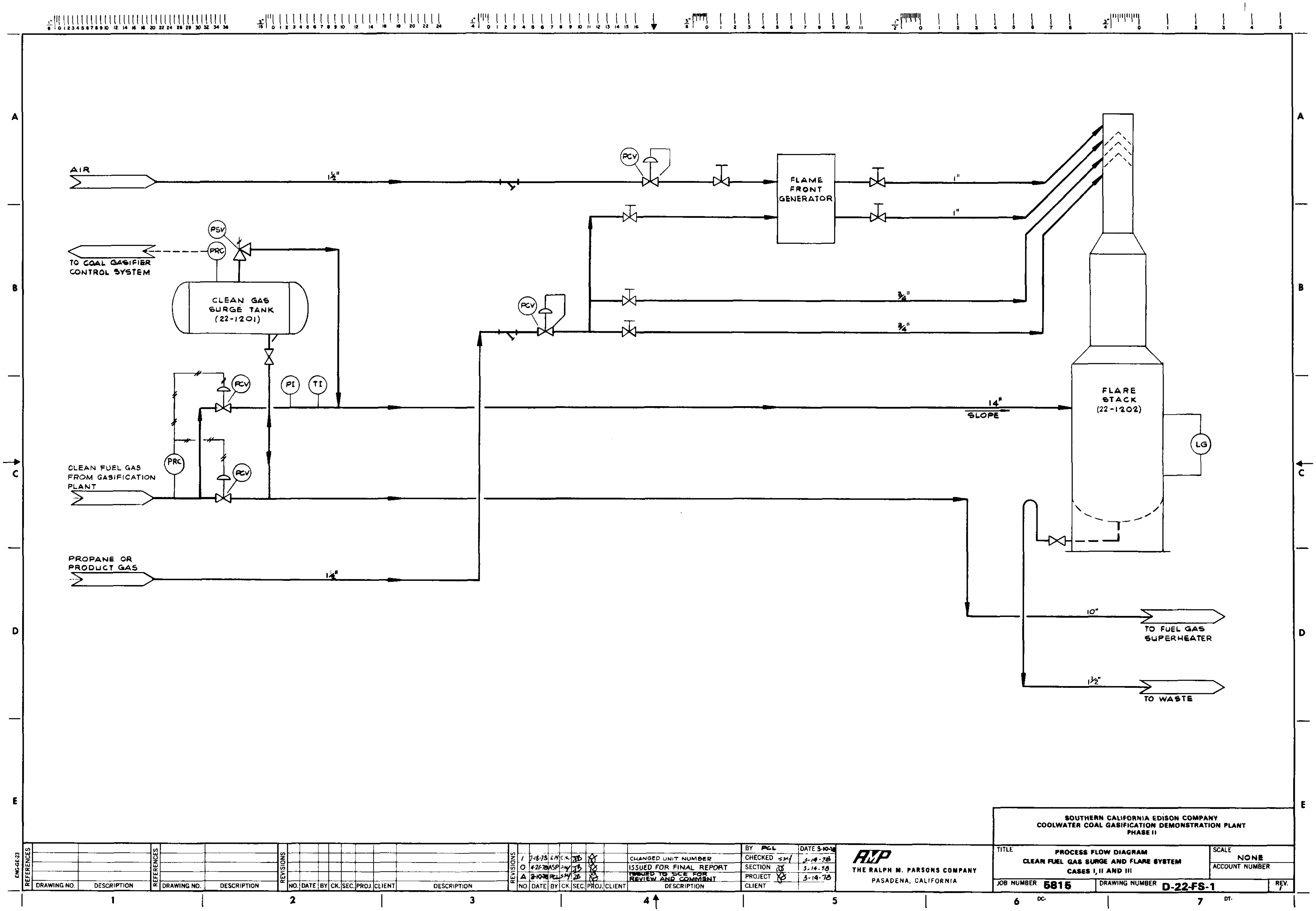
A separate fire protection system is provided for the integrated coal gasification/power plant. The fire protection system consists of two fire water pumps; one electric motor-driven the other diesel engine-driven; a fire water jockey pump; a fire water reservoir; and underground piping loop serving fire hydrants around each major plant area.

During normal operation, the well water supply system is the primary source of supply to the fire water reservoir which is located next to the intake structure. If well water is not available, circulating water will be transferred from the intake structure to the fire water reservoir if needed.

The fire water system is maintained at approximately 100 psig pressure by the fire water jockey pump.

Lube Oil Conditioning System

A lube oil conditioning system is provided for the collection, storage, purification and transfer of lube oil for use in the combustion and steam turbine lube oil systems.


AIR
1½"
PCV
FLAME FRONT GENERATOR
1"
1"
PSV
PRC
TO COAL GASIFIER CONTROL SYSTEM
CLEAN GAS SURGE TANK (22-1201)
PCV
¾"
¾"
PRC
PCV
PI
TI
14"
SLOPE
FLARE STACK (22-1202)
LG
PRC
PCV
CLEAN FUEL GAS FROM GASIFICATION PLANT
PROPANE OR PRODUCT GAS
1½"
10"
TO FUEL GAS SUPERHEATER
1½"
TO WASTE
SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II
TITLE
PROCESS FLOW DIAGRAM
CLEAN FUEL GAS SURGE AND FLARE SYSTEM
CASES I, II AND III
SCALE NONE
ACCOUNT NUMBER
JOB NUMBER 5815
DRAWING NUMBER D-22-FS-1
REV.
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA
CHANGED UNIT NUMBER
ISSUED FOR FINAL REPORT
ISSUED TO SCE FOR REVIEW AND COMMENT
BY PCL
CHECKED
SECTION
PROJECT
CLIENT
DATE 3-10-78
3-14-78
3-14-78
3-14-78
NO. DATE BY CK. SEC. PROJ. CLIENT DESCRIPTION
DRAWING NO. DESCRIPTION
REFERENCES
REVISIONS

The lube oil conditioning system consists of a clean oil storage tank, a dirty oil storage tank, a centrifuge type oil purifier, a lube oil transfer pump and all necessary instruments, valves and interconnecting piping.

Lube oil is transferred from the unit reservoir to the dirty oil tank by the positive-displacement type lube oil transfer pump and is returned from the clean oil tank to the reservoir by the purifier. The lube oil purifier is a self-contained unit with built-in feed pump and all required appurtenances. Moisture and particulate contaminants are removed from the turbine lube oil by the purifier.

The lube oil system is not applicable to Case III.

Sampling System

A sampling system is provided for automatic sampling and analysis of selected fluid streams in the steam, condensate and feedwater system, demineralized water system, circulating water system and in the gasification plant. Special sampling provisions are provided for testing and demonstration purposes. Capability for taking grab samples of each stream is also provided. The sampling system provided for the original Cases II and III configuration will be expended when the final Case I configuration is implemented.

Evaporation Pond

A 70 acre evaporation pond is provided for disposal of all waste water discharge from the plant.

Miscellaneous Buildings

The following buildings are provided:

- Gasification plant local control house.
- Oxygen plant auxiliary building to house the MCC, storage and service areas. This building is provided by the oxygen plant subcontractor.
- Integrated plant control building including central control room, electrical equipment room and laboratory room.
- Chlorination building.
- Maintenance shop and warehouse building.
- Integrated plant switchgear and MCC building.

The integrated plant control building and switchgear and MCC building provided for the original Cases II and III configuration will be expended when the final Case I configuration is implemented.

EQUIPMENT LIST

PLANT SUPPORTING SYSTEMS

CASE I

CLEAN GAS SURGE AND FLARE SYSTEM

Item No.	Quantity	Description
22-1201	1	Clean gas surge tank - horizontal pressure vessel, 10 ft diameter by 65 ft long. ASME Code stamped designed for 600 psig pressure.
22-1202	1	Flare stack-composed of a 48 in diameter by 38 ft section and a 24 in diameter by 20 ft section. - Design pressure: 10 psig - Design temperature: 350° F

AIR AND NITROGEN SYSTEM

22-1801	1	Utility air compressor - rated for 300 scfm @ 125 psig driven by a 100 hp motor includes aftercoolers, prefilters, afterfilters, dryer and air receiver.

FIRE PROTECTION SYSTEM

22-1502	1	Fire water pump - 100%-capacity, vertical, centrifugal type pump rated for 2000 gpm @ 125 psi and driven by a 200 hp electric motor.
22-1503	1	Fire water pump - 100%-capacity, vertical, centrifugal type pump rated for 2000 gpm @ 125 psi and driven by a 200 hp diesel engine.
22-1504	1	Fire water jockey pump - regenerative turbine type pump rated for 5 gpm @ 100 psi and driven by a 1 hp electric motor.

LUBE OIL CONDITIONING SYSTEM

22-1901	1	Clean lube oil storage tank - 10,000 gallon, horizontal, steel tank approximately 8.5 ft x 25 ft.

EQUIPMENT LIST

PLANT SUPPORTING SYSTEMS

CASE I (Contd)

LUBE OIL CONDITIONING SYSTEM

Item No.	Quantity	Description
22-1902	1	Dirty lube oil storage tank - 10,000 gallon, horizontal, steel tank approximately 8.5 ft x 25 ft.
22-1505	1	Lube oil transfer pump - horizontal, positive displacement type pump rated for 40 gpm 25 psi and driven by a 1.5 hp electric motor.
22-2801	1	Lube oil purifier - self contained, centrifuge type designed for 1,000 gph @ 25 psig including a 5 hp feed pump.

DIESEL FUEL OIL SYSTEM

22-1501	1	Diesel fuel oil forwarding pump - horizontal, centrifugal type pump rated for 500 @ 150 ft TDH driven by a 15 HP electric motor.

SAMPLING SYSTEM

22-0601	1	Fluid sampling analyzing panel - complete with coolers, analyzers, recorders and all necessary control and instrumentations.

EQUIPMENT LIST

PLANT SUPPORTING SYSTEMS

CASE II

CLEAN GAS SURGE AND FLARE SYSTEM

Item No.	Quantity	Description
22-1201	1	Clean gas surge tank - horizontal pressure vessel, 10 ft diameter by 65 ft long. ASME Code stamped designed for 600 psig pressure.
22-1202	1	Flare stack-composed of a 48 in diameter by 38 ft section and a 24 in diameter by 20 ft section. - Design pressure: 10 psig - Design temperature: 350° F

AIR AND NITROGEN SYSTEM

22-1801	1	Utility air compressor - rated for 300 scfm @ 125 psig driven by a 100 hp motor includes aftercoolers, prefilters, afterfilters, dryer and air receiver.

FIRE PROTECTION SYSTEM

22-1502	1	Fire water pump - 100%-capacity, vertical, centrifugal type pump rated for 2000 gpm @ 125 psi and driven by a 200 hp electric motor.
22-1503	1	Fire water pump - 100%-capacity, vertical, centrifugal type pump rated for 2000 gpm @ 125 psi and driven by a 200 hp diesel engine.
22-1504	1	Fire water jockey pump - regenerative turbine type pump rated for 5 gpm @ 100 psi and driven by a 1 hp electric motor.

LUBE OIL CONDITIONING SYSTEM

22-1901	1	Clean lube oil storage tank - 10,000 gallon, horizontal, steel tank approximately 8.5 ft x 25 ft.

EQUIPMENT LIST

PLANT SUPPORTING SYSTEMS

CASE II (Contd)

LUBE OIL CONDITIONING SYSTEM

Item No.	Quantity	Description
22-1902	1	Dirty lube oil storage tank - 10,000 gallon, horizontal, steel tank approximately 8.5 ft x 25 ft.
22-1505	1	Lube oil transfer pump - horizontal, positive displacement type pump rated for 40 gpm 25 psi and driven by a 1.5 hp electric motor.
22-2801	1	Lube oil purifier - self contained, centrifuge type designed for 1,000 gph @ 25 psig including a 5 hp feed pump.

DIESEL FUEL OIL SYSTEM

22-1501	1	Diesel fuel oil forwarding pump - horizontal, centrifugal type pump rated for 500 @ 150 ft TDH driven by a 15 HP electric motor.

SAMPLING SYSTEM

22-0601	1	Fluid sampling analyzing panel - complete with coolers, analyzers, recorders and all necessary control and instrumentations.

B. ADD-ON PHASE

SAMPLING SYSTEM

22-0602	1	Fluid sampling analyzing panel. Complete with cooler analyzers, recorders and all necessary control and instrumentation.

EQUIPMENT LIST

PLANT SUPPORTING SYSTEMS

CASE III

CLEAN GAS SURGE AND FLARE SYSTEM

Item No.	Quantity	Description
22-1201	1	Clean gas surge tank - horizontal pressure vessel, 10 ft diameter by 65 ft long. ASME Code stamped designed for 600 psig pressure.
22-1202	1	Flare stack-composed of a 48 in diameter by 38 ft section and a 24 in diameter by 20 ft section. - Design pressure: 10 psig - Design temperature: 350° F

AIR AND NITROGEN SYSTEM

22-1801	1	Utility air compressor - rated for 300 scfm @ 125 psig driven by a 100 hp motor includes aftercoolers, prefilters, afterfilters, dryer and air receiver.

DIESEL FUEL OIL SYSTEM

22-1501	1	Diesel fuel oil forwarding pump - horizontal, centrifugal type pump rated for 500 gpm @ 150 ft TDH and driven by a 15 hp electric motor.

FIRE PROTECTION SYSTEM

22-1502	1	Fire water pump - 100%-capacity, vertical, centrifugal type pump rated for 2000 gpm @ 125 psi and driven by a 200 hp electric motor.
22-1503	1	Fire water pump - 100%-capacity, vertical, centrifugal type pump rated for 2000 gpm @ 125 psi and driven by a 200 hp diesel engine.
22-1504	1	Fire water jockey pump - regenerative turbine type pump rated for 5 gpm @ 100 psi and driven by a 1 hp electric motor.

EQUIPMENT LIST

PLANT SUPPORTING SYSTEMS

CASE III (Contd)

Item No.	Quantity	Description
SAMPLING SYSTEM		
22-0601	1	Fluid sampling analyzing panel - complete with coolers, analyzers, recorders and all necessary control and instrumentation.
B. ADD-ON PHASE		
LUBE OIL CONDITIONING SYSTEM		
22-1901	1	Clean lube oil storage tank - 10,000 gallon, horizontal, steel tank approximately 8.5 ft x 25 ft.
22-1902	1	Dirty lube oil storage tank - 10,000 gallon, horizontal, steel tank approximately 8.5 ft x 25 ft.
22-1505	1	Lube oil transfer pump - horizontal, positive displacement type pump rated for 40 gpm @ 25 psi driven by a 1.5 hp electric motor.
22-2801	1	Lube oil purifier - self contained, centrifuge type designed for 1000 gph @ 25 psig including a 5 hp feed pump.
SAMPLING SYSTEM		
22-0602	1	Fluid sampling analyzing panel - complete with coolers, analyzers, recorders and all necessary control and instrumentation.

3.15 PLANT OPERATION AND CONTROL

General

This section outlines the procedures and concepts for start-up, normal opertion and shutdown of the integrated coal gasification-power plant. Concepts for load following control of the gasification plant are also presented.

Start-Up - Case I

The integrated coal gasification-power plant systems will be started in the following order:

- Makeup Water Treatment System
- Integrated Plant Cooling Water System and Steam Supply System
- Power Plant and Steam Supply System
- Oxygen Plant
- Coal Grinding and Slurrying System
- Coal gasification plant
- Sulfur Removal and Recovery Plant
- Gasifier Effluent Water Treatment

Makeup Water Treatment System. The water treatment plant requires some start-up attention to establish levels, chemical dosages, slurry concentration, slurry recirculation rate and proper operation at the filters in the primary water treatment system. When the softened water quality is within acceptable limits, the service water tank and cooling tower basin are filled and the demineralized water system is started. Demineralized water is recycled until quality is acceptable and then discharged to the demineralized water and condensate storage tanks.

Integrated Plant Cooling Water System. After the plant makeup water treatment system is operating the plant cooling water system is started and cooling water flows are established to the steam turbine condensers and plant auxiliaries.

Power Plant and Steam Supply System. Once the water treatment plant is in operation and water for boiler feed and cooling is available, the power plant is started. Since fuel gas is not available, the gas turbine will be started using alternate fuel (diesel oil) until the gasifier is in service. When the gas turbine is operating and the heat recovery boiler produces enough superheated steam to run the oxygen plant compressors, the rest of the plant can be started.

Oxygen Plant. For the initial start-up and for any start-up after the plant has been down for any period of time, a supply of liquid nitrogen will be required for which storage provisions have been made in the design. The nitrogen is used for the initial chilling of the cold sections. Start-up of the oxygen plant will take approximately 16 hours.

Since the main compressor drives in this plant are condensing steam turbines, the power plant steam system must be operating to supply steam for these machines. With this steam available, the oxygen plant can be started and the products vented to the atmosphere until the gasifier is ready to accept the oxygen feed.

Coal Grinding and Slurrying. The coal grinding and slurrying unit involves mechanical operations of conveying, grinding, classification and slurrying. An initial fill of water will be established in the centrifuge effluent sump and sufficient water will be added to the slurry make-up tank to cover the agitator impeller. The mechanical equipment in the train will be started successively as coal progresses through the system. Water circulation will be started when the coal arrives at the rod mill and the centrifuge can be started shortly thereafter. The agitator in the mix tank will be started when the centrifuge is producing a filter cake and the slurry will be circulated as slurry density builds up. The initial slurry production may be slightly dilute until the system can be lined out. When the slurry reaches the required specifications, it will be pumped into the slurry mix tanks, and from these into the gasifier unit slurry run tank. Operation and control of performance in this unit lies somewhere between an art and a science. It will be necessary, therefore, to develop in this plant the operating parameters that will provide the slurry concentration desired for the gasifier feed in a pumpable condition. The operators will eventually learn and record the degree of grinding that is required to balance the slurry consistency range that will be optimum.

Gasifier. For the initial start-up of the gasifier, or any subsequent start-up after the unit has been down for a period of several hours, it is necessary to heat the refractory in the gasifier reactor and antechambers to the operating temperature. This is accomplished by inserting a startup burner fired with an alternate fuel into the reactor inlet nozzle. When refractory in the reactor reaches 2,400-3,600°F, the start-up burner is manually withdrawn and the process burner is inserted into the reactor nozzle and bolted in place.

During the warm-up operations, the boiler feedwater systems will have been established up to the steam drum and circulation through the reactor effluent coolers will have been started. Some steam will be produced. The water circulation systems for gas guenching and scrubbing will also have been activated. As soon as the process burner is ready for operation, coal slurry and oxygen feed is started to the reactor. Ignition occurs from the glowing refractory. The reactor is then brought up to operating pressure under controlled conditions with the flare system used to control pressure rise.

Sulfur Removal. While the gasifier is being started up, the product will bypass the SELEXOL absorber, and the outlet block valve will be closed. When the gasifier pressure level is sufficient to pressure the SELEXOL absorber to the point where rich solution will flow from the absorber back to the stripping column, the SELEXOL circulating pump is started and solution flow is established in the system. The stripper reboiler is activated and at this point gas flow can be diverted through the absorber by opening the block valve and closing the bypass. From this point on, the system is simply lined out at the desired solution circulation rate and stripper reboiler heat load. The recycle compressor will be activated while the unit is being lined out. Acid gas from the SELEXOL stripped reflux drum will vent to the sulfur recovery plant for further processing.

Sulfur Recovery. Prior to receipt of acid gas from the SELEXOL unit, the sulfur plant is brought up to operating temperature by burning propane. During this period, the sulfur plant air blowers will be operated and the refractory in the combustion chambers will be brought up to temperature in a manner similar to the gasifier warmup. When acid gas is received, the propane fuel is cut out and is supplanted by sulfur from the sulfur pit and ammonia from the effluent water treating unit. During the warm-up period, the therminol system will also be brought up to temperature on propane and circulation will be established. As soon as the acid gas is received, sulfur production will begin.

The primary adjustments for this plant will be to establish the proper acid gas and air ratios for the chemical reactions. It is usually necessary to control start-up operations very carefully to avoid refractory damage because air-fuel ratios can get into a region where high combustion temperatures would occur. Steam can be used to moderate temperatures if necessary.

The reactor in the Beavon sulfur removal section will also be heated during the warm-up period of the Claus plant and circulation will be established in the Stretford portion of the unit. As soon as the tail gas reaches this section from the Claus unit, it is ready for operation and the tail gas should be meeting effluent requirements almost immediately after the feed is introduced.

Gasifier Effluent Water Treating. The effluent water treating section requires little start-up attention other than to establish levels and chemical dosages in the treating tanks, stripping rates in the strippers and proper operation of the filters.

Normal Operation - Case I

Water Treatment Plant. Normal operation of the water treatment plant is relatively simple. Water flow through each plant system is automatically adjusted by level controllers in the various storage tanks and basins. Bypasses are provided, as required, to insure minimum flow through each system. Since chemical dosage, slurry concentration and slurry recirculation rate is set by the actual well water analysis, any change in the quality of the well water will require resetting these.

Backwashing of the primary water treatment filters is initiated, through a backwash programmer control switch, by the operator when pressure drop across the filters is excessive. Upon initiation of the backwash system, the filters are automatically backwashed and returned to service by the backwash programmer.

The demineralized water system has four modes of operation: standby, recycle, service and regeneration. In normal operation, one demineralizer train is either in service or recycle while the other train is in regeneration or standby. Start and stop of each mode of operation is automatically initiated with pushbutton override for regeneration.

Power Plant. During normal operation of the integrated plant proper matching of the steam produced by the gasification plant syngas coolers and of the steam produced by the power plant heat recovery steam generator will be provided by a master pressure controller in the main steam header.

Each boiler will be provided with a separate standard three-element feedwater control system to maintain correct water level in the steam drum and match feedwater flow with steam demand.

Because the oxygen plant requires practically constant steam flow and steam quality at all operating loads, supplementary firing is provided in the exhaust duct of the combustion turbine to insure proper superheated steam temperature during partial load operation of the combustion turbine.

Steam flow to the oxygen plant is controlled by the compressor demands while any excess high pressure steam is routed to the steam turbine generator for power generation.

Oxygen Plant. Operation of the oxygen plant should be a routine matter and the only attention required will be surveillance of the compressor operations to determine that supporting systems for this machinery is functioning properly. It is also necessary from time to time to check the inlet filters and operation of the gel traps.

The principal components in this plant are the centrifugal air compressor and the centrifugal oxygen compressor. It will not be possible to turn down the capacity of these machines to much less than 80% of their rated capacity due to compressor surge problems. Compressor output must be recirculated or vented for operation at lower capacities.

Coal Grinding and Slurrying. Normal operation in this plant will involve the establishment of stable operating conditions in the grinding sections and in the centrifuge and overseeing the slurry density control system to be sure that the controls are maintaining the desired slurry concentration. Alarms and automatic shutdown systems will be provided to prevent damage to the grinding equipment in the train because of the failure of that component. There are two full size trains in the plant so that one train will be capable of carrying the load if the other is down for maintenance.

Gasifier. Normal operation of the gasifier is controlled by maintaining the proper ratio of oxygen to coal slurry feed and the proper slurry feed concentration. The coal slurry concentration will be adjusted in the grinding and slurrying section while filling either of two slurry mix tanks in that unit. When the proper slurry concentration has been obtained in these mix tanks, the contents are then pumped into the gasifier unit run tank. The run tank will be replenished from the grinding unit mix tanks so that there will be only a gradual change, if any, in the slurry composition being charged to the gas generator as the run tank make-up operations proceed.

Experience in existing gasifier pilot plants indicates that it should be possible for the unit to respond quite rapidly to changes in load demand. Coal and oxygen feed rates are adjusted to increase or decrease gas production in response to changes in power generation demand. Unless there is a very large change in feed capacity, it will not usually be necessary to make other adjustments in the plant since these functions will be handled by automatic controls. If large changes are made, it may be necessary to monitor the action of the controls on other systems to determine that they are within the control range and have responded properly. In order to level the performance of the gasifier unit and its response to load changes by the consumer or to changes in gasifier feed composition, a clean gas surge tank is provided at the outlet of the gasification plant. During normal operation the pressure within the gasifier system will be held constant by a back pressure controller at the outlet of the fuel gas superheater. Under normal operating conditions, the controller will hold a back pressure of approximately 500 psig at this point. The product gas surge drum is downstream of the back pressure controller and the pressure in this zone will be held at approximately 400 psig. The pressure in the surge volume will vary as fuel demand or production decreases or increases. The pressure in the surge system can vary through a range of 500 psig maximum down to approximately 300 psig.

The rate of response of the gasifier need not be great since the initial demand on fuel will be supplied from the surge volume. The gasifier output will be adjusted eventually so that pressure in the surge section is again at the desired level and stabilized. The reverse will occur on a decrease in production demand. If the gasifier output cannot be decreased rapidly enough as in the case of a boiler or gas turbine trip, the plant controls will start to flare excess fuel gas production when the system pressure builds up to above 500 psig.

During normal operation of the gasifier unit, slag is accumulated in the gasifier lock hopper and dumped intermittently. This operation should become routine and should present no particular problems in operation.

As with any high pressure boiler system, it will be necessary to maintain a continuous surveillance of the syn-gas coolers to insure that proper levels and circulation rates are maintained and that blowdown and chemical treatment of feedwater are at the proper levels.

It is extremely important in this plant that recycle gas circulation be continuous because the quenching action is needed to protect the cyclones in the antechambers and the first section of the gas cooling equipment. If failure occurs in the recycle system, the gasifier must be shut down.

Performance of the gasifier unit will be monitored by thermo-couples in the gas generator and by continuous analyzers which will report the composition of the fuel gas product. Alarms and shutdown controls will be provided to warn the operator of impending problems and to shut down the unit safely if a hazardous condition develops.

Without special controls, it is not practical to operate below about 60 percent of gasifier design capacity. Below this point, flow instrument output and readings are too low on scales to give an accurate indication or response to operating conditions. Provision will be made in this plant for dual instruments on critical services to measure and control flows down to about 40 percent of design capacity. In addition to special flow instrumentation, it will be necessary to reduce pressure when operating below 60 percent of capacity to increase velocity in the gas scrubbing equipment to offset the decrease in efficiency because of low velocity.

Sulfur Removal. Normal operation of the sulfur removal unit is relatively simple to control, the primary variables being the solution circulation rate and the amount of heat supplied to the stripper reboiler. Under normal conditions, these rates are usually set high enough to take care of normal swings, up or down, and they need to be adjusted only if there are large changes in feed rate. The pressure in this plant should be as stable as possible and this is easily controlled by the product gas pressure regulator. The plant will be sensitive to a sudden decrease in pressure; however, a pressure increase should not cause any particular problems. The effect of a sudden pressure decrease can be the same as an overload which could cause the absorber to flood and produce an unstable condition to the plant.

The only routine surveillance required will be to monitor product gas sulfur content, the solution filter and the solution concentration which can be changed by picking up water from the feed gas or losing water in the product gas or stripper overhead. Any changes in solution strength can be adjusted by adjusting temperatures in the system.

Sulfur Recovery. Routine operation of the sulfur recovery unit is relatively straightforward. The primary control of this plant is the ratio of air to acid gas feed which is adjusted automatically by an analyzer at the Claus plant outlet to maintain a 2:1 ratio of $H_2S:SO_2$ at this point. The only other items that need attention is an occasional examination of the water in the coolers to determine that solids concentration is not building up.

Front-end control of the Beavon sulfur removal section is similar to the Claus plant in that the fuel gas to air ratio is controlled to produce heating and partial combustion for a reducing atmosphere in the rector. Operation of the balance of the plant is set on flow control and needs little attention other than to assure that the systems are functioning properly. A tail gas combustor is provided at the top of Stretford Absorber 15-1102. This combustor will be fired only in the event that there is an upset in either the Claus or the Beavon units that alows H_2S to vent from the Stretford absorber.

Effluent Water Treating. Normal operation of this unit should require little operator attention other than to determine that the systems are functioning properly. Primary controls will be automatic so that continuous surveillance should not be necessary.

Plant Shutdown

Oxygen Plant. The oxygen plant is shut down by shutting off the oxygen and air compressors and venting the system to ambient pressures. Automatic shutdown of the plant will be caused by failure of either the air or oxygen compressors, or by plugging in the cold box heat exchangers or gel traps.

Coal Grinding and Slurrying. In a normal shutdown of the coal grinding and slurrying unit, coal feed is stopped and the unit is run to clear any coal remaining in the system. Coal slurry lines are purged with water so that the slurry will not set up.

Automatic shutdown of the unit will be triggered by an unbalance in the cage mill or centrifuge, or by failure of any of the mechanical equipment. The coal feed will be stopped if tramp iron is detected on the cage mill feed belt.

Gasification. Coal slurry feed and oxygen feed to the gasifier are immediately stopped to stop the reaction during any normal shutdown of the gasification unit or automatic shutdown under abnormal conditions. Detailed procedures for safe shutdown and restart after shutdown of gasification units have been developed by Texaco through many years of commercial and pilot plant operatonal experience and involve a number of mandatory operations necessary for safety. Details regarding these operations are considered proprietary by Texaco and cannot be described herein.

Sulfur Removal. When shutting down the SELEXOL unit, gas flow through the absorber is stopped and the solution is circulated until all of the solvent is regenerated. At this point, the solution circulation pump is shut off and the absorber liquid is drained through the flash drum into the stripping column and pumped into the surge tank. The absorber column can then be vented to the flare along with the gasifier unit.

Sulfur Recovery. When the Claus plant is shut down, the acid gas is shut off and air from the blower is used to purge and cool the unit. In the Stretford section at the Beavon unit, the solution circulation is shut down and the sulfur froth tank is circulated until most of the sulfur has been removed.

The primary cause for an emergency trip of the sulfur recovery unit would be a flame failure in the reaction furnaces.

Effluent Water Treatment. Shutdown of the gasifier effluent water treating system is a routine matter of processing fresh water through the train to clear the contaminated process water.

Power Generation Plant. A trip of the power plant will cause flaring of the fuel gas product by the gasification plant until the gasifier is shut down in an orderly manner.

Plant Operation - Cases II and III

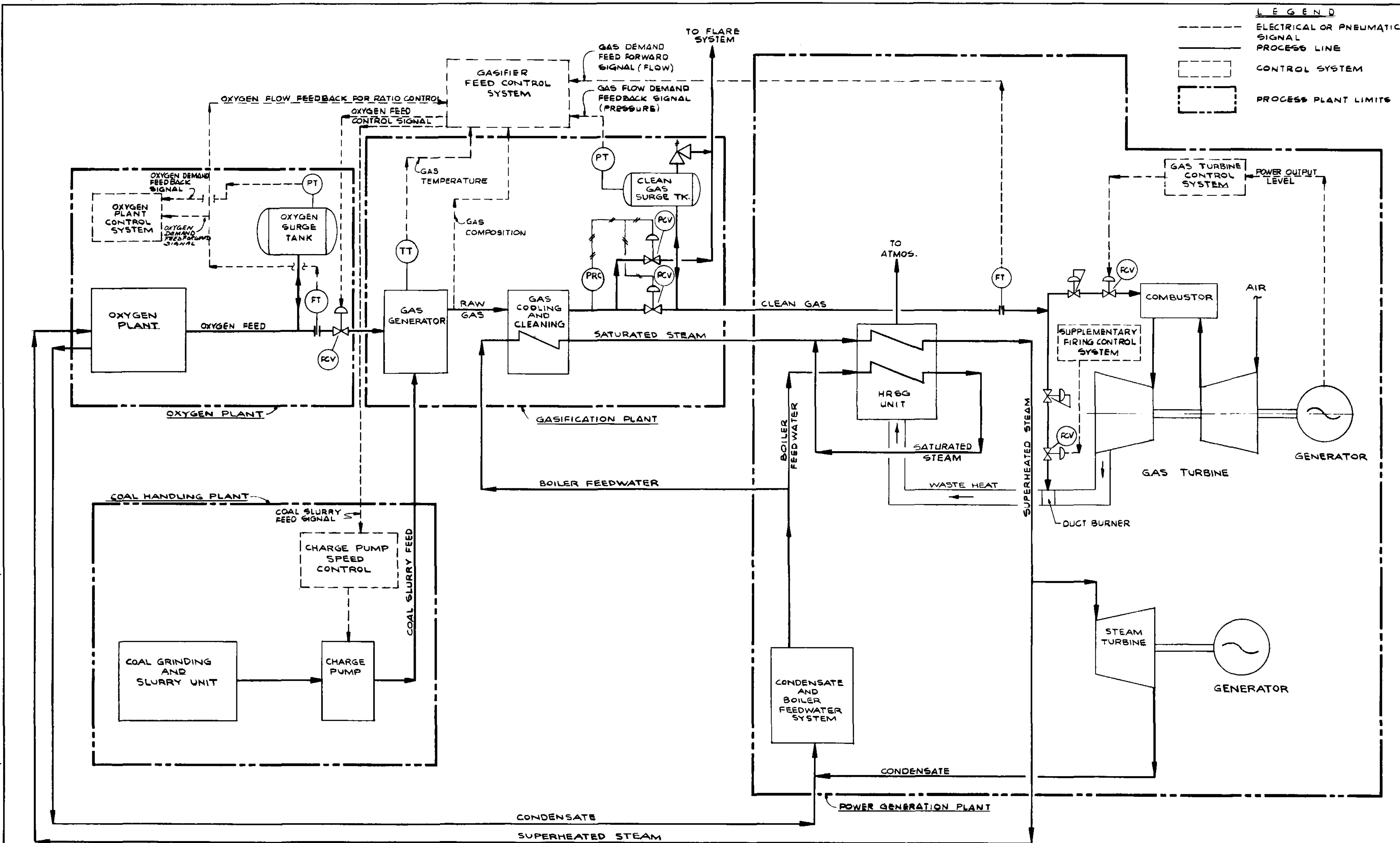
Plant startup and operation for Cases II and III is essentially the same as that described in the foregoing with the exception that, prior to installation of the power plant steam system during the add-on phase, an auxiliary steam supply system consisting of an auxiliary boiler and steam superheater is provided to furnish steam for plant startup and to supplement the steam produced by the syn-gas coolers during plant operation. The auxiliary steam supply system will be started up prior to startup of the oxygen plant to provide the required superheated steam to the oxygen plant compressor drivers.

Matching of the steam produced by the syn-gas coolers and that produced by the auxiliary boiler will be provided by a master pressure controller in the saturated steam header. The auxiliary boiler will be equipped with a standard three-element feedwater control system to maintain correct water level in the steam drum and match feedwater flow with steam demand.

Automatic Load Following

At the present time, Texaco does not have any experience with automatic load following where changes in demand automatically control the feed rates to the gasifier. Present plants are operated under manual control or some form of semi-automatic control for load changes. Automatic control of the correct ratio of coal feed and oxygen feed has been a key problem area with regard to automatic load following control due to the present early state of development of reliable coal slurry metering and flow measurement devices. It is assumed that the coal slurry feed rate will be regulated by the speed of the positive-displacement slurry pumps in this plant. However, ongoing development work may make more accurate and positive methods possible by the time the plant is placed in operation.

Since one of the objectives of the demonstration program is to demonstrate automatic load-following of the gasification plant in response to electric power generation demand, controls for accomplishing this will be incorporated into the plant. Drawing D-01-IN-1 shows a concept of a control system which incorporates the essential features for automatic load-following in response to power generation demand. A change in power generation demand causes a corresponding change in product gas flow to the boiler or gas turbine. This change in flow is translated into a demand signal to the gasifier feed control system which adjusts the oxygen and coal slurry feeds in response to the demand signal. To make the oxygen supply control system more practical, an oxygen surge tank will be located downstream of the oxygen plant to provide a surge volume in the event of a large change in oxygen flow demand. The surge tank will supply or store the oxygen until the oxygen supply control system is readjusted. A gas pressure signal from the clean gas surge tank provides a feedback signal to the feed control system which will add the necessary trim to the demand signal to maintain or reestablish the gas pressure level in the product gas header. The feed control system maintains the required ratio of oxygen and coal slurry feeds by trimming the oxygen and slurry feed rates in response to the product gas analysis since this analysis is very sensitive to the coal to oxygen feed ratio. A gas temperature signal provides backup to the gas analysis signal since gas temperature is also very sensitive to the feed ratio.



SOUTHERN CALIFORNIA EDISON COMPANY
COOLWATER COAL GASIFICATION DEMONSTRATION PLANT
PHASE II

TITLE	INTEGRATED PLANT CONTROL SCHEMATIC- CASE I
SCALE	NONE
ACCOUNT NUMBER	
JOB NUMBER	5815
DRAWING NUMBER	D-01-IN-1
REV.	0

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

BY	CK/PCL	DATE 4/19/78
CHECKED		4-17-78
SECTION		4-13-78
PROJECT		4-24-78
CLIENT		

NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
0	7-24-78	LN	FK				ISSUED FOR FINAL REPORT
A	4-24-78	PCL					ISSUED TO SCE FOR REVIEW AND COMMENTS

Section 4

TECHNICAL FEASIBILITY

This section presents a discussion regarding the technical feasibility of the proposed demonstration plant from the standpoint of the technical development status of the various systems and components included in the plant. This plant will be the first of a kind. There are presently no coal gasification plants using the Texaco process in commercial operation and no integrated coal gasification combined cycle power plants in operation in the United States even on a pilot scale. Since the plant will be the first of a kind, it is expected that the detailed engineering phase will present some unique technical problems to be solved and that unforeseen problems will arise during the demonstration program. However, as discussed below, the Texaco Coal Gasification Process has undergone many years of development and successful pilot plant operation and most of the other systems and components in the plant have been used successfully in commercial applications. Therefore, no insurmountable technical problems in placing such a plant in operation for demonstration purposes are expected. Integration of the various subsystems in a manner that will permit automatic load following is expected to be a key technical challenge in the design of the plant and demonstration of this feature will be a major objective of the demonstration program.

Many of the systems and components used in the plant are conventional designs commonly used in utility power plants and no further discussion of these with regard to technical development status is required. Systems and components falling into this category include the coal receiving and handling system, the cooling water system, the makeup water treatment system, the plant electrical systems, the steam turbine-generator, the auxiliary boiler and the heat recovery steam generator. The technical development status of the other systems and components used in the plant are discussed in further detail in the subsections which follow.

COAL GRINDING AND SLURRYING

All of the equipment selected for the coal grinding and slurrying unit has been used commercially for similar operations with coal. What remains to be demonstrated is the ability to consistently produce a pumpable slurry containing the required solids content for efficient performance of the gasification process. It is known that the particle size distribution in the slurry can have an important effect on pumpability of high slurry concentrations required. The selection of grinding system equipment is expected to provide a high degree of control on particle size and water balance in the product.

OXYGEN PLANT

Oxygen plants of this capacity have been thoroughly demonstrated in many installations throughout the country that are producing oxygen on a commercial basis. The principal point of investigation in this area will be the ability of the oxygen plant to respond to load demand changes of the gasifier in following the requirements of the electric power generation system.

TEXACO COAL GASIFICATION PROCESS

Texaco Development Corporation, a wholly owned subsidiary of Texaco Inc., has been engaged in the development and licensing of the Texaco Synthesis Gas Generation Process since 1945. Synthesis gas is a mixture predominately of hydrogen and carbon monoxide, which is used as a starting material for the production of ammonia, methanol, hydrogen, oxo products, reducing gas, fuel gas, and Fischer-Tropsch liquid hydrocarbons.

Over 75 Texaco synthesis gas generation plants have been licensed since the early 1950's involving some 150 gasifiers. These units have now logged over sixteen hundred generator years of operation. Early units were natural-gas fired. Later, liquid fuels such as naphtha and heavy fuel oil were introduced. The majority of plants now in operation utilize heavy residual oils.

Generator size has steadily increased, with present units producing twenty times the output of the early commercial units. Operating pressure has risen from 350 psig in initial plants to 1200 psig in one plant in operation since 1968. Commercial operation as low as 30 psig has also been demonstrated. Pilot unit operation on residual fuels has been conducted at 2500 psig. Syngas coolers have been used in 15 commercial plants, while the remainder have used direct quench.

The Texaco Coal Gasification Process is a modification of the Texaco Synthesis Gas Generation Process, producing generally the same type of synthesis gas for the same commercial applications. Development work on coal gasification was started in 1948, and has involved large scale pilot unit operation on some twenty solid fuels including lignites, bituminous coals, anthracites, coal-liquefaction residues and petroleum cokes.

A demonstration plant was erected at the Morgantown Ordinance Works in West Virginia in 1956. This unit charged 100 tons per day of an Eastern bituminous coal in water slurry and was in operation for two years. This plant confirmed gasifier scaleup criteria and demonstrated the ash handling system.

At the Montebello Research Laboratory, extensive facilities are available for the gasification of solid fuels. These include a complete 350 psig gasifier train, with spare generator, capable of handling one ton of coal per hour. Included as part of the existing facilities are a synthesis gas cooler for use in heavy oil gasification, a system for sour gas removal, shift conversion and waste water treatment. A gasifier designed for 1200 psig will be in service shortly.

A number of variables that affect the success of the coal gasification process in connection with electric power generation remain to be evaluated in the Coolwater Demonstration Plant. These are:

- Gasifier thermal performance.
- Effectiveness of ash removal and carbon recycle systems.
- The pumpability of high solids content slurries.
- Effectiveness of gas quenching on reducing molten slag to the solid state and evaluating the temperature level at which this occurs.
- Assessment of unexpected corrosion, erosion, and refractory life.
- Operation of syngas coolers with gases containing ash.
- Adaptability to load following service under full automatic control.

There is no convincing evidence at this time that it will be possible to continuously maintain a slurry concentration of the 61 wt % assumed in this study under all conditions. Excess fines or changes in the types of coal can lower the slurry concentration that can be handled. It is a goal of the demonstration plant to develop the proper slurry preparation and handling methods so that the required concentrations can be pumped. The triplex pumps selected for high pressure charge service have been tested in slurry service and have been adequate for this severe service.

The recycle gas compressors used in the process will be designs that have been used commercially and proved to be reliable.

The demonstration plant is expected to verify Texaco's experience with particulate removal from the product gas and the ability of the process system to recover and recycle unburned carbon.

The gasification plant design will incorporate all of the technology developed by Texaco for the process so that a minimum of problems with materials of construction are expected. If unexpected results occur, methods will be developed during the demonstration operations to correct the problems.

SULFUR REMOVAL

The SELEXOL sulfur removal process has been demonstrated in many commercial applications and no problems are anticipated in designing or operating the process to treat the product gas. All equipment used in this process is of tested commercially-proven design and construction. No significant corrosion problems are expected.

SULFUR RECOVERY

The sulfur recovery unit is a modified Claus process design developed by Parsons to treat acid gas that is rich in carbon dioxide and lean in hydrogen sulfide content. The basic process has been used commercially for many years in hundreds of plants. The modified process has been tested commercially by Parsons and found to be effective.

The Beavon process used to recover sulfur from the Claus point tail gas is identical to that used in many successful commercial applications and no problems are expected in the design or operation of the unit.

GASIFIER EFFLUENT WATER TREATING

The process used for treating effluent water was developed by Texaco and will be effective in reducing the wastes to a condition that will not be harmful to the environment or objectionable to persons exposed to it.

STEAM SUPERHEATER

The steam superheater required for Case II and III is a conventionally designed fired heater commonly found in the petroleum refining and chemical processing industries.

COMBUSTION TURBINE

The combustion turbine used will be a standard frame design modified to burn the medium Btu product gas. With the exception of the combustor, the turbine will incorporate state-of-the-art component designs. The first stage inlet temperature to the power turbine and the exhaust temperature will be limited to those presently being offered for commercial service (approximately 2000° F and 1000° F, respectively). It is recognized that increases in the hot gas flow path temperatures can result in improvements in overall plant efficiency. However, it is intended that the impact of the combustion turbine as a limiting factor on the successful implementation and operation of the demonstration plant be held to a minimum insofar as possible.

All of the domestic manufacturers of large combustion turbines have done some work in the development of combustors for medium and low Btu synthetic gas and the general approaches to the design of combustors for such applications are well known. However, extensive development and testing work will still have to be done by the turbine manufacturer to produce a reliable combustor for this specific application. This is allowed for in the implementation schedules given in Section 6 and the cost estimates given in Section 7.

Section 5

EMISSIONS AND WASTE PRODUCTS

The environmental objectives of this plant are to demonstrate that gas produced from coal can be used to replace oil in existing power generating units with no increase in total SO_x, NO_x or particulate emissions. Additionally, it is a goal of the project to show that liquid and solid waste products from the gasification plant can be disposed of in an environmentally acceptable manner.

SULFUR EMISSIONS

The fuel gas produced in the gasification plant will be treated to remove sulfur to a level of 0.0073% (73 ppm) by volume for the design case of 0.7% sulfur coal and to a level of 0.03% by volume for the alternate case of 3.5% sulfur coal in the clean gas product. The gas will be thoroughly scrubbed to remove all solid particulate matter. The sulfur compounds that are removed from the raw gas produced in the gasification plant are processed in the sulfur recovery unit which converts most of the sulfur to elemental sulfur in a liquid state. The sulfur in this form is a useful commodity which will be trucked from the site and marketed as a finished product.

Sulfur will be discharged to atmosphere from two separate sources. One source is the flue gas produced by combustion of the clean fuel gas, principally in the gas turbine or in the Unit 1 boiler and in various process heaters. The other source is the vent gas from the sulfur recovery plant.

Some of the sulfur compounds produced in the gasification plant will be removed along with the slag as solid particulate matter. No credit has been taken for this small quantity of sulfur in the design of the sulfur-removal and -recovery systems or in the sulfur balance data presented in this section.

Sulfur Emissions For The Plant Using 0.7% Sulfur Coal As Feedstock

Figure 5-1 shows the sulfur balance for the plant using 0.7% sulfur coal as feedstock. As shown, sulfur emissions are expected to be 17 lb/hr in the flue gas (mostly as SO_2) and 0.8 lb/hr in vent gas (as H_2S and COS) for a total of 17.8 lb/hr of sulfur for the integrated plant. This emission level is equivalent to that which would result from firing the combustion turbine with

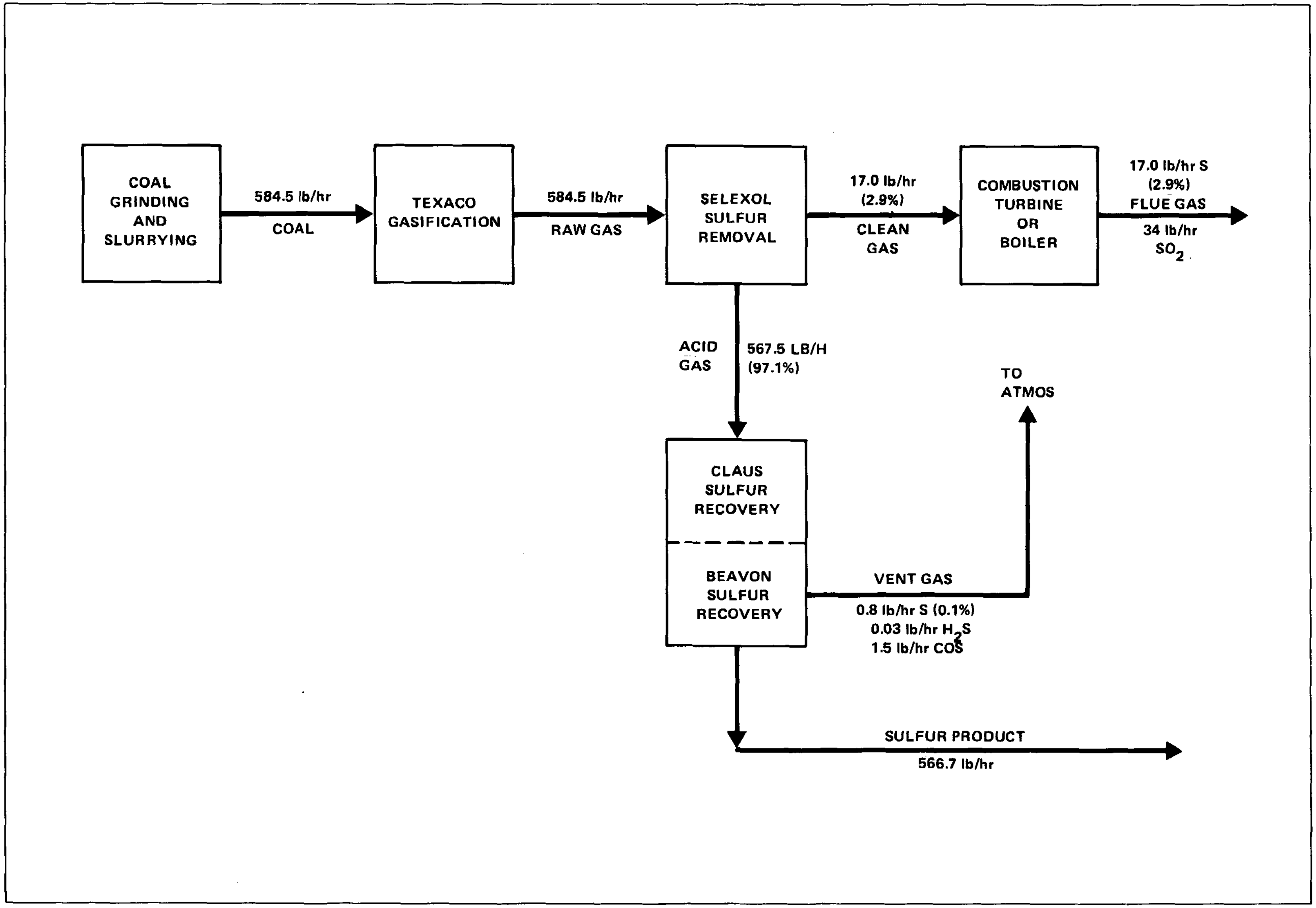


Figure 5.1 - Sulfur Balance for 0.7 wt% Low Sulfur Western Coal

fuel oil containing about 0.05 wt % sulfur to generate an equivalent amount of power.

Sulfur Emissions For The Plant Using 3.5% Sulfur Coal As Feedstock

Figure 5-2 shows the sulfur balance for the plant using 3.5% sulfur coal as feedstock. As shown, sulfur emissions are expected to be 75 lb/hr in flue gas (mostly as SO_2) and 114 lb/hr in vent gas (mostly as SO_2) for a total of 189 lb/hr for the integrated plant. This emission level is equivalent to that which would result from firing the combustion turbine with fuel oil containing about 0.5 wt % sulfur.

The numbers given above correspond to using 3.5% sulfur coal as feedstock for extended periods of time. In this case, as described in section 3.8 of this report, the Beavon sulfur recovery unit has to be bypassed and the vent gas (tail gas from the Claus sulfur recovery unit) has to be incinerated.

NO_x EMISSIONS

NO_x, which is generated whenever combustion occurs, will be produced principally in the combustion turbine or in the Unit 1 boiler. NO_x production is a function of both gas composition and combustor or burner design.

Estimated NO_x emission levels for the combustion turbine burning the product gas with 80 F ambient air temperature, without water injection, are as follows:

- at 0% relative humidity: 165 ppm or 470 lb/hr
- at 20% relative humidity: 142 ppm or 405 lb/hr
- at 40% relative humidity: 121 ppm or 346 lb/hr

NO_x emission level in the combustion turbine can be reduced by water or steam injection. Water can be added to the fuel gas by partial resaturation with condensate water extracted in the sulfur removal unit or directly into the combustion turbine combustor cans.

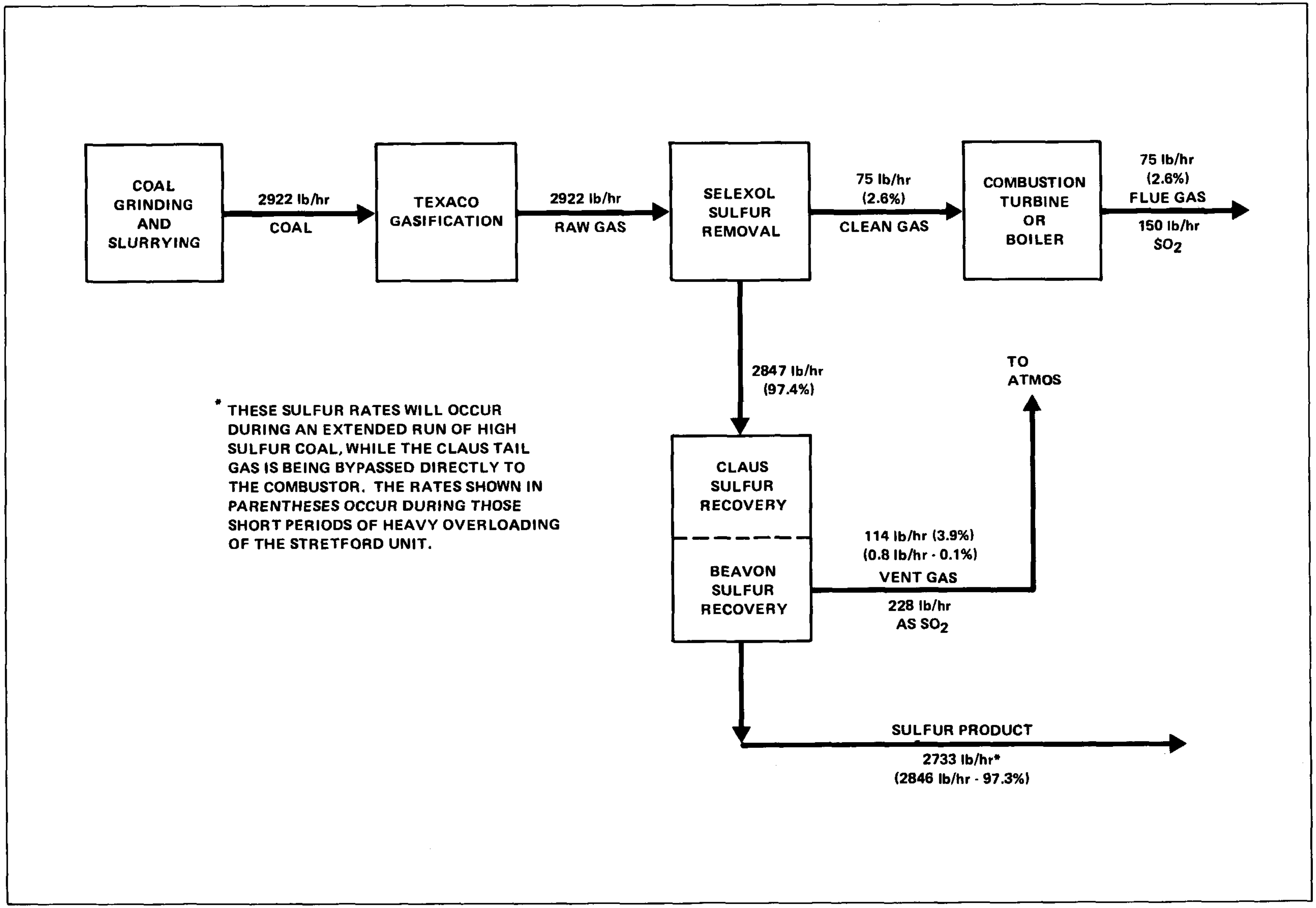


Figure 5-2 - Sulfur Balance for 3.5 wt% High Sulfur Coal

It is to be noted that combustion turbine manufacturers are presently developing a dry combustor that will be able to meet existing regulations without need of water or steam. Because there is no actual experience in burning medium Btu gas with the specified composition in combustion turbines and there is no guarantee that a dry combustor can be developed within the time allocated for the construction of the plant, a water injection system is provided to ensure that NO_x emission level will not exceed maximum level set by existing regulations. One of the test program objectives will be to evaluate NO_x emissions and to optimize combustion for producing minimum NO_x. This will include burner modification in Unit 1 boiler and tests with combustor modifications and water injection in the combustion turbine.

PARTICULATE EMISSIONS

Particulate emissions include sulfur, ash and contaminants in the combustion air stream and in the water to be injected for NO_x control if water injection becomes necessary.

Sulfur to be measured as particulate emissions, which is a by-product of sulfur combustion (as SO_3), is expected to be:

- 1.7 lb/hr in the flue gas for the case of 0.7% sulfur coal
- 7.5 lb/hr in the flue gas and 11.4 lb/hr in the vent gas for the case of 3.5% sulfur coal.

Because of the efficiency of the gas scrubbing equipment in the plant, particulate emissions attributable to ash should be insignificant. Particulate emissions due to contaminants in the combustion air stream is estimated to be between 0.4 and 2.0 lb/hr based on field data from other projects. It is to be noted that only approximately 0.1% of the contaminants contained in the aspirated combustion air is released back to atmosphere as 99.9% efficient filter is provided at the air inlet of the combustion turbine.

Particulate emissions due to contaminants in the water injected for NO_x control is estimated to be less than 0.1 lb/hr as the water to be injected is demineralized.

WASTE WATER

All waste water from the integrated plant is disposed of in the new evaporation pond to be built for this purpose. None will leave the plant site.

All waste water from the coal gasification plant is treated in the gasification process effluent water treatment system. The effluent water treatment system coverts potentially harmful dissolved compounds to harmless insoluble compounds. The water treatment unit will produce a maximum of 60 gpm of waste water containing 3000 to 4000 ppm of dissolved solids and approximately 800 lbs/day of filter cake. The waste water will be discharged to the lined evaporation pond and the filter cake will be disposed of with the slag in a suitable lined disposal area.

All other waste water from the plant is discharged directly to the evaporation pond and consists of the following:

- Cooling tower blowdown.

  A stream of water is withdrawn continuously from the circulating water system to limit the amount of dissolved solids in the circulating water.

Quantity:	152 gpm (based on 7 cycles of concentration)
Dissolved solids:	4400 ppm
Silica:	245 ppm

- Retention basin waste

  Miscellaneous plant waste water from drains, primary water treatment sludge removal system, demineralizer regeneration system, are accumulated and neutralized as necessary in the retention basin before final disposal to the evaporating pond.

SLAG

Slag from the plant will be trucked to an approved solids disposal area. Estimated quantity will be approximately 110 to 200 tons/day including 25 wt % moisture. Slag formed in the gasification unit will be a generally insoluble glassy-type material with the consistency of pea gravel with some larger material up to approximately 1 in. in size and some finer particles. The slag will be wet. The slag should contain no toxic material, nor should it create an odor problem. There is no indication that there would be a problem of leaching inorganic salts into the ground or surface streams from a slag disposal site.

NITROGEN

Approximately 3,710 tons/day of nitrogen that is separated from air in the oxygen plant will be returned to the atmosphere.

SULFUR

This byproduct is a useful commodity that will be trucked from the Coolwater Demonstration Plant as a liquid product. The approximate quantities produced will be as follows:

567 lb/hr with 0.7% sulfur coal

2733 lb/hr with 3.5% sulfur coal

STRETFORD SOLUTION

Used Stretford solution from the Beavon sulfur recovery unit can be trucked for disposal in a Class 1 dump or delivered to a large refinery that has facilities for treating the solution in their waste water treating facilities.

DUST

Effective controls will be provided to eliminate dust emissions from the coal handling and grinding facilities. A self-cleaning bag filter system with an exhaust fan are the principal elements of the dust control system. A sump is provided in the coal grinding areas to collect spills. All coal conveyors are provided with dust enclosure.

OILY WATER

An oily water sewer system will be provided to collect water and oil from pump and equipment lubrication systems. The final interceptor will have a seal to trap oil which can be removed as necessary by a vacuum truck.

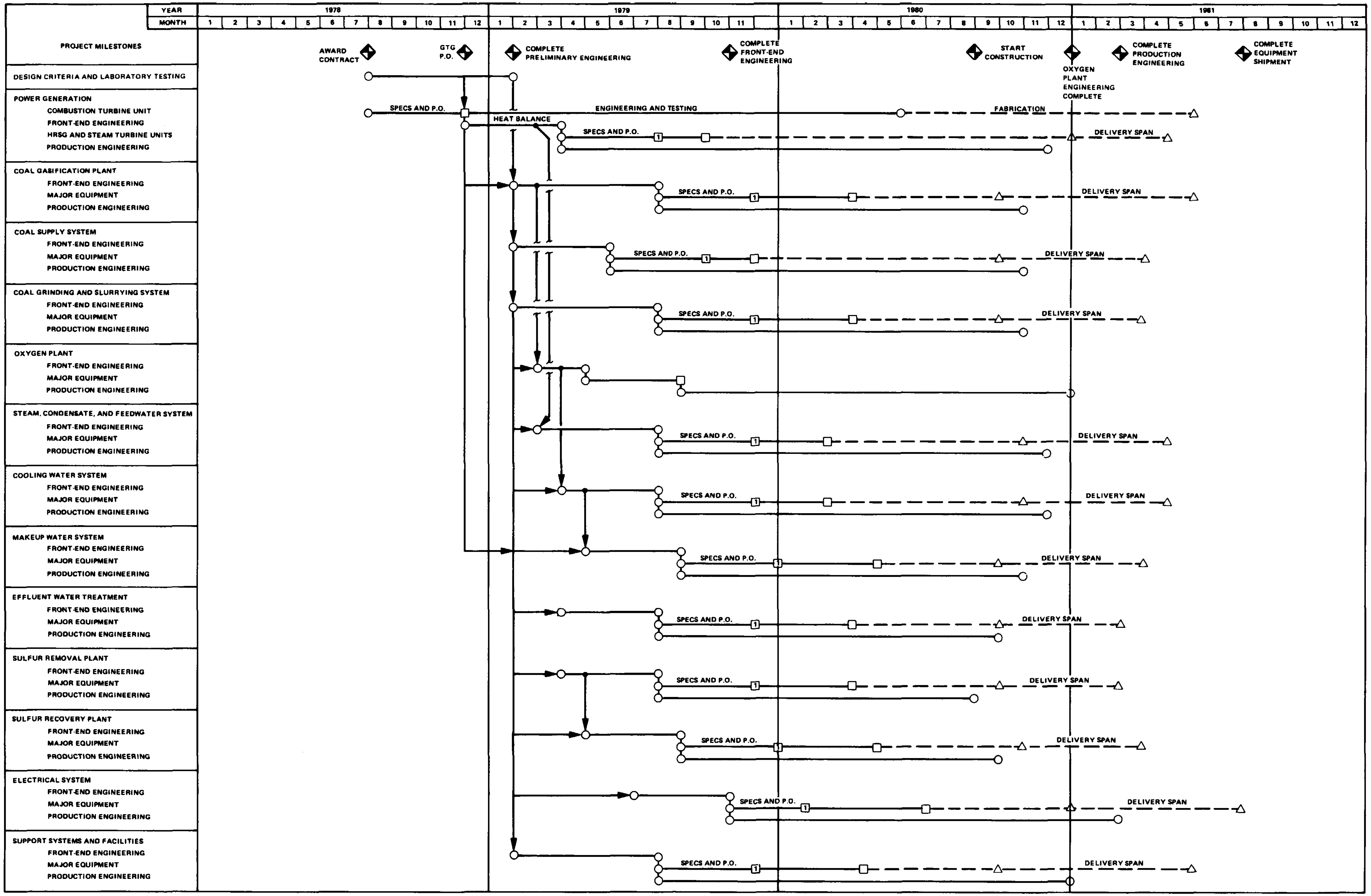
Section 6

IMPLEMENTATION SCHEDULES

The preliminary schedules for detailed engineering, procurement and construction of the plant are presented in this section. These schedules are based on a contract award date for the detailed engineering of August 1, 1978. Figures 6-1 and 6-2 show the engineering and procurement schedule and the construction schedule, respectively, for the Case I approach to implementation of the plant. Figures 6-3 and 6-4 and Figures 6-5 and 6-6 are the equivalent schedules for Case II and Case III, respectively.

Due to the first-of-kind nature of the plant a considerable amount of conservatism has been used in the scheudles. The construction schedules are based on detailed engineering being fully completed for each phase of the construction program prior to the start of construction. While this approach causes a lengthening of the overall implementation schedule, it will allow better control of project costs by minimizing rework due to design changes.

The Case II and III approaches to implementation of the plant result in implementation of the fully integrated plant approximately 3-1/2 years later than the Case I approach. This is primarily due to the procurement lead time and additional construction period required for the add-on facilities for Cases II and III.



LEGEND:
◆ = PROJECT MILESTONES
□ = EQUIPMENT PURCHASE ORDER
△ = SHIPMENT OF EQUIPMENT

Figure 6-1 - Engineering and Procurement Schedule — Case I

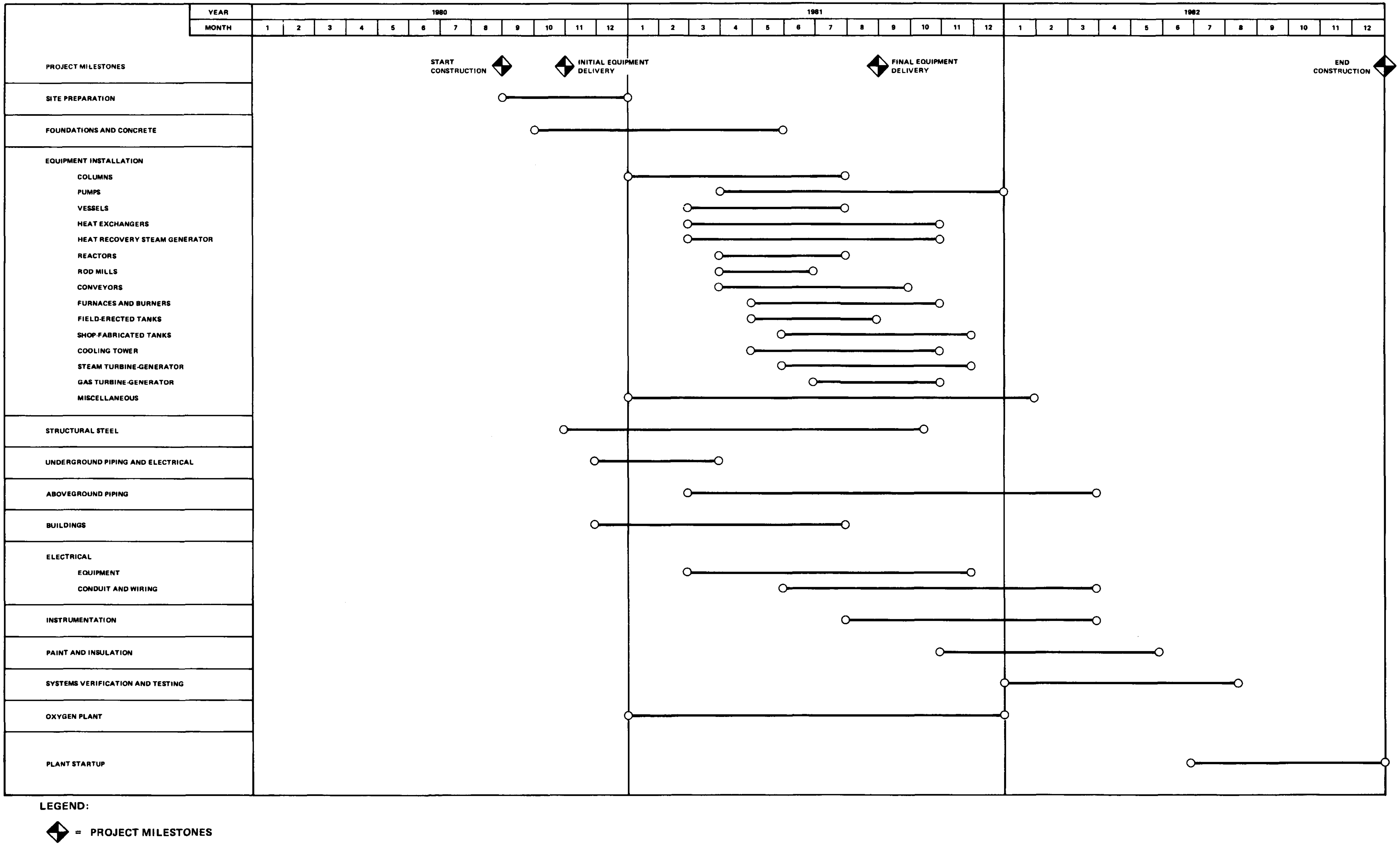


Figure 6-2 - Construction Schedule — Case I

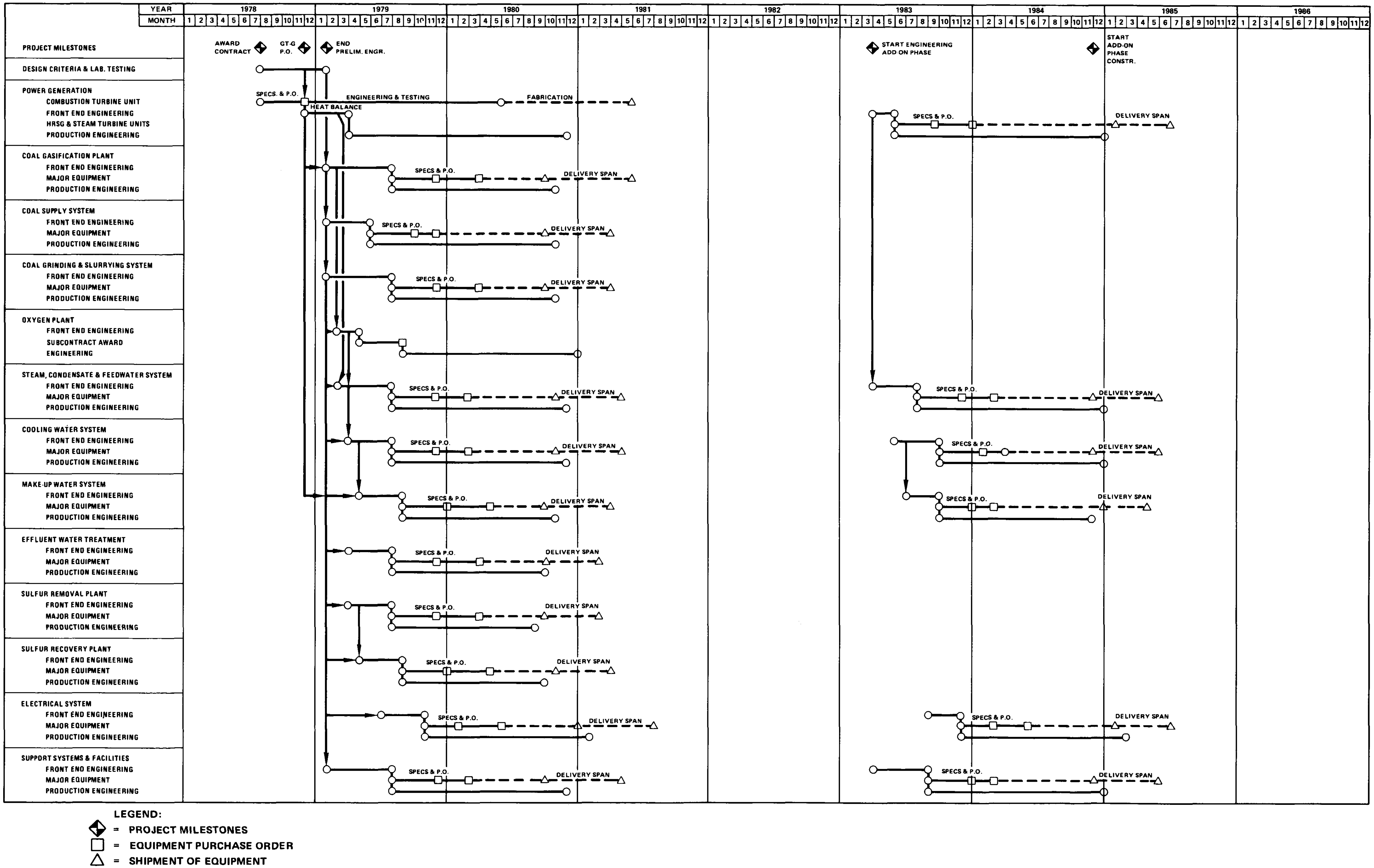
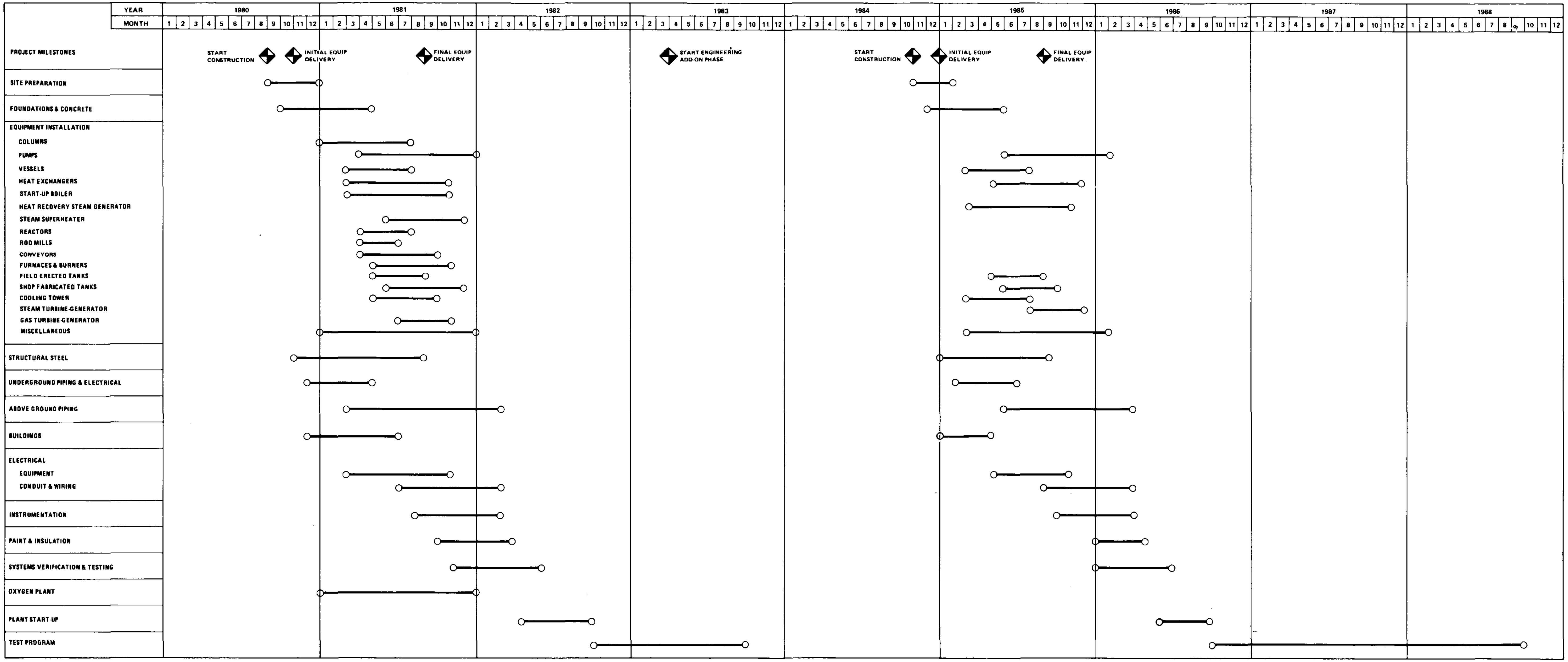


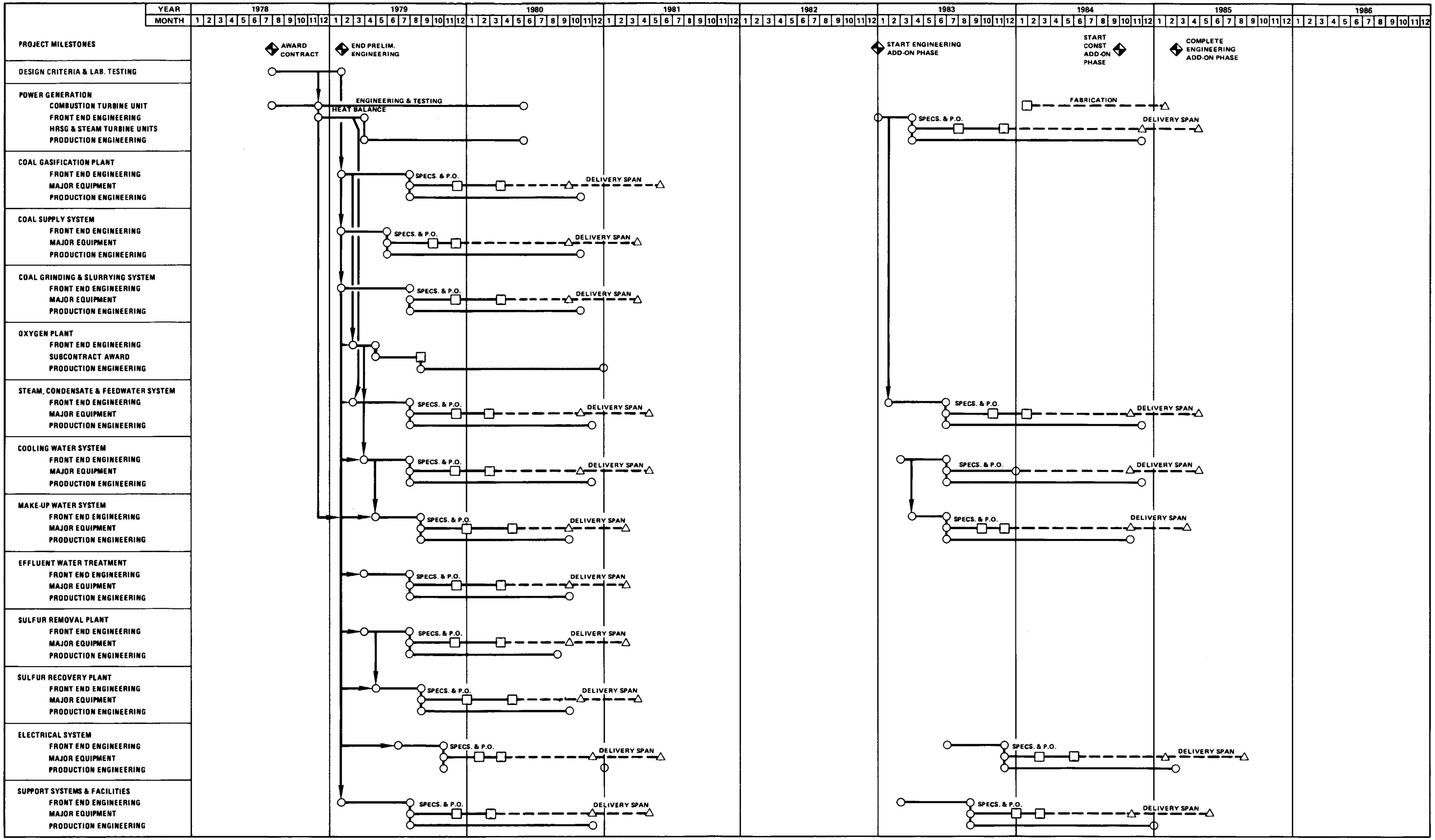
Figure 6-3 - Engineering and Procurement Schedule — Case I



LEGEND:

◆ = **PROJECT MILESTONES**

Figure 6-4 - Construction Schedule – Case II



LEGEND:
◆ = PROJECT MILESTONES
□ = EQUIPMENT PURCHASE ORDER
△ = SHIPMENT OF EQUIPMENT

Figure 6-5 - Engineering and Procurement Schedule — Case III

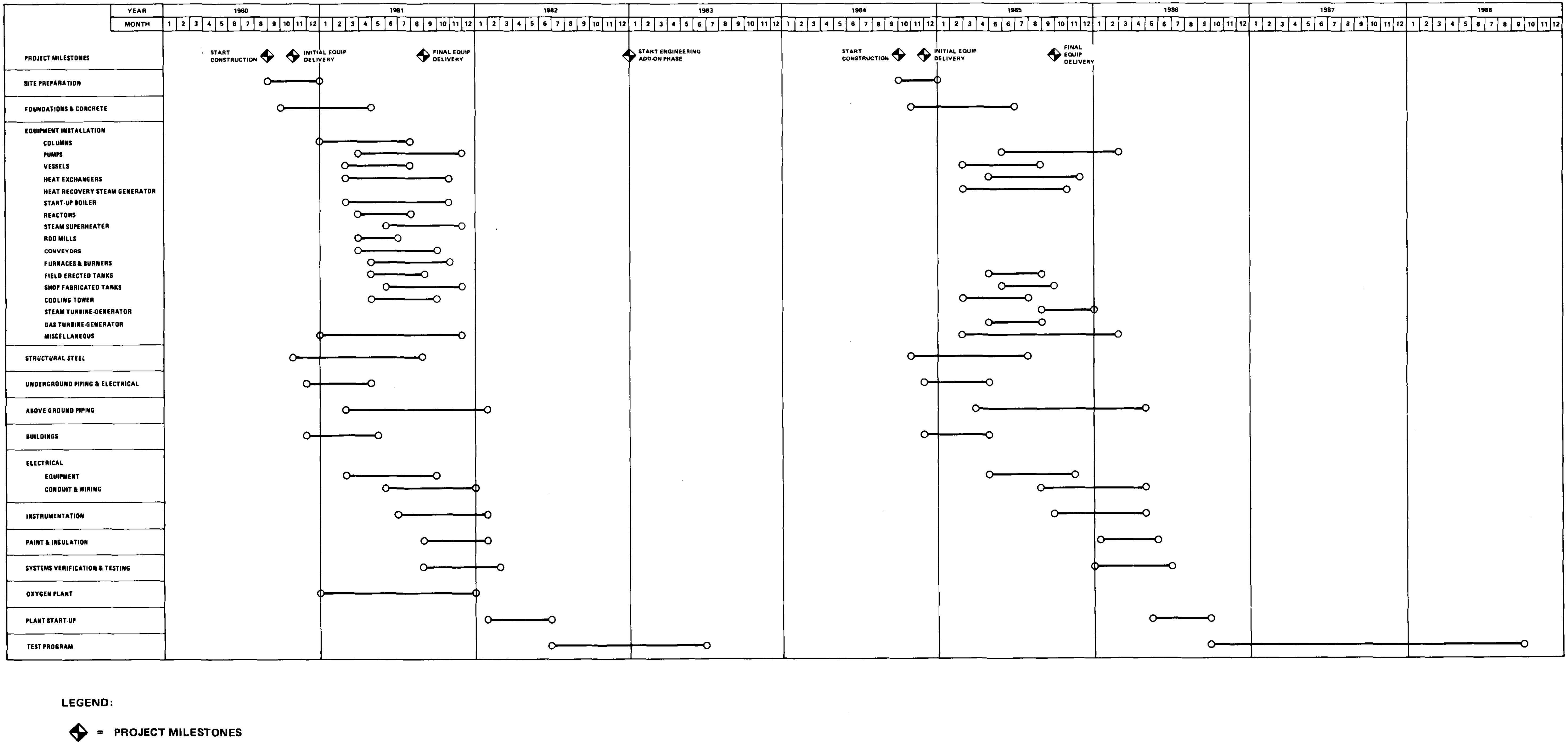


Figure 6-6 - Construction Schedule – Case III

Section 7

COST ESTIMATES

This section presents cost data for each of the three approaches to implementation of the plant considered in the study. Tables 7-1, 7-2 and 7-3 show the estimated costs for Case I, II and III, respectively. The estimated cost for the initial implementation phase as well as the total estimated cost for the final integrated coal gasification combined cycle power plant configuration are shown for the Case II and III approaches to implementation of the plant. As might be expected, the total cost of the plant becomes progressively higher in moving from Case I to Case III. However, as also expected, the initial financial commitment required for implementation of the plant using the Case II or III approaches is significantly less than that for the Case I approach.

The estimates are based on the drawings, equipment lists and system descriptions contained in Section 3 and the engineering, procurement and construction schedules contained in Section 6 of the report. The estimates are intended to include all costs associated with construction and placing in operation of a grassroots plant other than land acquisition and transmission facilities. The plant will be constructed on land already owned by the Southern California Edison Company and transmission facilities from the site are already in place.

SYSTEM COST BREAKDOWN

The costs are shown by units or systems corresponding essentially to the individual system descriptions included in Section 3 of the report. In general, the costs for piping and valves are included with the associated system. However, an allowance for interconnecting piping between systems for piping that cannot be directly related to any one system is included.

The costs shown for plant electrical include all electrical equipment and materials in the plant except the motor control centers and feeders from the motor control centers to the individual loads. The costs for the later are included in the individual process systems.

The Unit 1 interface includes the cost of converting the Unit 1 boiler for firing with the product gas as a part of the demonstration program.

Table 7-1

COST ESTIMATE SUMMARY - CASE I
(All costs in $000's)

ITEM	BASE TOTAL	CONTINGENCY	ESCALATION	TOTAL
COAL RECEIVING, STORAGE AND TRANSFER	8,780	1,800	2,650	13,230
COAL GRINDING AND SLURRYING	4,970	990	1,490	7,450
OXYGEN PLANT	20,650	0	5,160	25,810
COAL GASIFICATION	18,170	3,630	5,450	27,250
GASIFICATION PROCESS EFFLUENT WATER TREATMENT	1,170	230	350	1,750
SULFUR REMOVAL	5,440	1,090	1,630	8,160
SULFUR RECOVERY	3,110	620	930	4,660
STEAM, CONDENSATE AND FEEDWATER SYSTEM	3,190	640	960	4,790
INTEGRATED PLANT COOLING WATER SYSTEM	6,700	1,340	2,010	10,050
PLANT MAKE-UP WATER SYSTEM	3,310	660	990	4,960
POWER GENERATION EQUIPMENT	25,550	5,110	7,660	38,320
PLANT ELECTRICAL	4,520	900	1,360	6,780
INTERCONNECTING PIPING BETWEEN SYSTEMS	3,520	700	1,060	5,280
OTHER SUPPORTING SYSTEMS AND FACILITIES	2,530	510	760	3,800
EVAPORATION POND	2,880	290	790	3,960

Table 7-1 (Cont)

ITEM	BASE TOTAL	CONTINGENCY	ESCALATION	TOTAL
UNIT I INTERFACE	250	50	80	380
START-UP	1,500	300	450	2,250
SUBTOTAL	116,240	18,860	33,780	168,880
ENGINEERING AND ROYALTIES				21,000
ALLOWANCE FOR FUNDS DURING CONSTRUCTION				21,500
OTHER OWNER'S COSTS				22,600
TOTAL COST				233,980

Table 7-2

COST ESTIMATE SUMMARY - CASE II
(All costs in $000's)

ITEM	BASE TOTAL	CONTINGENCY	ESCALATION	TOTAL
INITIAL PHASE				
COAL RECEIVING, STORAGE AND TRANSFER	8,780	1,800	2,650	13,230
COAL GRINDING AND SLURRYING	4,970	990	1,490	7,450
OXYGEN PLANT	20,650	0	5,160	25,810
COAL GASIFICATION	18,170	3,630	5,450	27,250
GASIFICATION PROCESS EFFLUENT WATER TREATMENT	1,170	230	350	1,750
SULFUR REMOVAL	5,440	1,090	1,630	8,160
SULFUR RECOVERY	3,110	620	930	4,660
STEAM, CONDENSATE AND FEEDWATER SYSTEM	6,710	1,340	1,960	10,010
INTEGRATED PLANT COOLING WATER SYSTEM	5,060	1,020	1,520	7,600
PLANT MAKE-UP WATER SYSTEM	2,980	600	900	4,480
POWER GENERATION EQUIPMENT	13,410	2,680	4,020	20,110
PLANT ELECTRICAL	3,860	770	1,160	5,790
INTERCONNECTING PIPING BETWEEN SYSTEMS	2,520	500	760	3,780
OTHER SUPPORTING SYSTEMS AND FACILITIES	1,850	370	560	2,780

Table 7-2 (Cont)

ITEM	BASE TOTAL	CONTINGENCY	ESCALATION	TOTAL
EVAPORATION POND	2,880	290	790	3,960
UNIT I INTERFACE	250	50	80	380
START-UP	1,350	270	410	2,030
SUBTOTAL	103,160	16,250	29,820	149,230
ENGINEERING AND ROYALTIES				18,080
ALLOWANCE FOR FUNDS DURING CONSTRUCTION				18,420
OTHER OWNER'S COSTS				19,870
TOTAL COST FOR INITIAL PHASE				205,600
ADD-ON PHASE				
STEAM, CONDENSATE AND FEEDWATER SYSTEM	1,400	280	1,010	2,690
INTEGRATED PLANT COOLING WATER SYSTEM	1,650	330	1,190	3,170
PLANT MAKE-UP WATER SYSTEM	330	70	240	640
POWER GENERATION EQUIPMENT	12,240	2,450	8,810	23,500
PLANT ELECTRICAL	660	130	470	1,260
INTERCONNECTING PIPING BETWEEN SYSTEMS	1,000	200	720	1,920
OTHER SUPPORTING SYSTEMS AND FACILITIES	680	140	490	1,310

Table 7-2 (Cont)

ITEM	BASE TOTAL	CONTINGENCY	ESCALATION	TOTAL
START-UP	300	60	220	580
SUBTOTAL	18,260	3,660	13,150	35,070
ENGINEERING				5,190
ALLOWANCE FOR FUNDS DURING CONSTRUCTION				7,030
OTHER OWNER'S COSTS				5,820
TOTAL COST FOR ADD-ON PHASE				53,110
TOTAL COST FOR CASE II				258,710

Table 7-3

COST ESTIMATE SUMMARY - CASE III
(All costs in $000's)

ITEM	BASE TOTAL	CONTINGENCY	ESCALATION	TOTAL
<u>INITIAL PHASE</u>				
COAL RECEIVING, STORAGE AND TRANSFER	8,780	1,800	2,650	13,230
COAL GRINDING AND SLURRYING	4,970	990	1,490	7,450
OXYGEN PLANT	20,650	0	5,160	25,810
COAL GASIFICATION	18,170	3,630	5,450	27,250
GASIFICATION PROCESS EFFLUENT WATER TREATMENT	1,170	230	350	1,750
SULFUR REMOVAL	5,440	1,090	1,630	8,160
SULFUR RECOVERY	3,110	620	930	4,660
STEAM, CONDENSATE AND FEEDWATER SYSTEM	6,710	1,340	1,960	10,010
INTEGRATED PLANT COOLING WATER SYSTEM	5,060	1,020	1,520	7,600
PLANT MAKE-UP WATER SYSTEM	1,620	320	490	2,430
POWER GENERATION EQUIPMENT	2,200	440	660	3,300
PLANT ELECTRICAL	1,250	250	380	1,880
INTERCONNECTING PIPING BETWEEN SYSTEMS	2,270	450	680	3,400
OTHER SUPPORTING SYSTEMS AND FACILITIES	1,850	370	560	2,780

Table 7-3 (Cont)

ITEM	BASE TOTAL	CONTINGENCY	ESCALATION	TOTAL
EVAPORATION POND	2,880	290	790	3,960
UNIT I INTERFACE	250	50	80	380
START-UP	1,220	240	370	1,830
SUBTOTAL	87,600	13,130	25,150	125,880
ENGINEERING AND ROYALTIES				15,210
ALLOWANCE FOR FUNDS DURING CONSTRUCTION				15,400
OTHER OWNER'S COSTS				16,700
TOTAL COST FOR INITIAL PHASE				173,190
ADD-ON PHASE				
STEAM, CONDENSATE AND FEEDWATER SYSTEM	1,400	280	1,010	2,690
INTEGRATED PLANT COOLING WATER SYSTEM	1,650	330	1,190	3,170
PLANT MAKE-UP WATER SYSTEM	1,560	310	1,120	2,990
POWER GENERATION EQUIPMENT	23,450	4,690	16,880	45,020
PLANT ELECTRICAL	3,290	660	2,370	6,320
INTERCONNECTING PIPING BETWEEN SYSTEMS	1,250	250	900	2,400
OTHER SUPPORTING SYSTEMS AND FACILITIES	680	140	490	1,310

Table 7-3 (Cont)

ITEM	BASE TOTAL	CONTINGENCY	ESCALATION	TOTAL
START-UP	430	90	520	1,040
SUBTOTAL	33,710	6,750	24,480	64,940
ENGINEERING				9,160
ALLOWANCE FOR FUNDS DURING CONSTRUCTION				9,150
OTHER OWNER'S COSTS				10,240
TOTAL COST FOR ADD-ON PHASE				93,490
TOTAL COST FOR CASE III				266,680

The auxiliary boiler and steam superheater required for the initial phases of Case II and Case III are included in the estimated cost of the steam, condensate and feedwater system for these cases.

STARTUP COSTS

The startup costs cover the initial filling of catalysts and chemicals and other consumables used during startup. In addition, the startup costs include a supply of coal based on 14 days of operation at 50% load and 3 days of operation at 100% load.

The startup costs also include approximately 10,000 manhours for crafts and supervision. The manhours for engineering, technical direction, and operating the plant during the startup period are not included in these startup costs. Engineering and technical direction are included in the engineering costs and operating costs are included in owner's costs.

BASE TOTAL COSTS

The base total costs shown are the estimated April 1, 1978 costs for the following:

- Equipment and materials
- Installation labor
- Field indirect costs
- Sales tax at 6 percent of equipment costs
- Construction contractor's overhead and fee

These costs were derived by a factored estimating approach. Vendors were contracted for budget prices on major units of equipment. Parsons' in-house cost data was used to price other equipment and materials. The total equipment costs or each cost account established the dollar value to which cost factors based on Parsons' experience were applied to derive the total cost for the various systems.

CONTINGENCY

A contingency factor of 10 to 20 percent was applied to each system based on Parsons' experience on similar projects, the complexity of the unit and whether the respective unit is state-of-the-art or in a developmental stage.

ESCALATION

Escalation is based on the following factors:

- 9.9 percent per year for labor costs
- 6.3 percent per year for equipment and material costs

Appropriate midpoints based on the schedules contained in Section 6 were selected to calculate the total estimated escalation for each line item.

ENGINEERING AND ROYALTIES

This item includes costs for engineer-constructor services and royalties for proprietary processes. The costs for engineering include all home office costs, field support labor costs, overhead and fee.

ALLOWANCE FOR FUNDS DURING CONSTRUCTION AND OTHER OWNER'S COSTS

Allowance for funds during construction is based on an interest rate of 7% per annum. Other owner's costs include all of the other costs accruing to the owners of the plant, up to the point when the plant is placed into operation. These include costs associated with obtaining the necessary permits and project management costs.