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Fluidized-Bed Retorting of Colorado Oil Shale

Topical Report

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For
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ABSTRACT

In support of the research program in converting oil shale into useful forms of energy, the U.S. Department of Energy is developing systems models of oil shale processing plants. These models will be used to project the most attractive combination of process alternatives and identify future direction for R & D efforts. With the objective of providing technical and economic input for such systems models, Foster Wheeler was contracted to develop conceptual designs and cost estimates for commercial scale processing plants to produce syncrude from oil shales via various routes.

This topical report summarizes the conceptual design of an integrated oil shale processing plant based on fluidized bed retorting of Colorado oil shale. The plant has a nominal capacity of 50,000 barrels per operating day of syncrude product, derived from oil shale feed having a Fischer Assay of 30 gallons per ton. The scope of the plant encompasses a grassrooots facility which receives run of the mine oil shale, delivers product oil to storage, and disposes of the processed spent shale. In addition to oil shale feed, the battery limits input includes raw water, electric power, and natural gas to support plant operations. Design of the individual processing units was based on non-confidential information derived from published literature sources and supplemented by input from selected process licensors.

The integrated plant design is described in terms of the individual process units and plant support systems. The estimated total plant investment is similarly detailed by plant section and an estimate of the annual operating requirements and costs is provided. In addition, the process design assumptions and uncertainties are documented and recommendations for process alternatives, which could improve the overall plant economics, are discussed.

ACKNOWLEDGEMENTS

In performing this conceptual design study, technical consultation and assistance was provided by Mr. J. F. McMahon, of the J. M. Chemical Engineering Corp., as subcontractor to Foster Wheeler. His efforts and guidance in developing the retorting system design are gratefully acknowledged.

Conceptual Design of Commercial Oil Shale Plants

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1.0 EXECUTIVE SUMMARY

Under contract to the U.S. Department of Energy, Foster Wheeler developed a conceptual design and cost estimate for a commercial scale oil shale plant, employing fluidized-bed surface retorting of Colorado oil shale. The plant was designed to produce a nominal 50,000 barrels of syncrude oil per operating day at an unspecified site in western Colorado.

The primary objective of this work was to provide a technical and economic data base for use by the U.S. Department of Energy in systems modeling and analysis of oil shale processing facilities. Another objective of this conceptual design effort was to identify process alternatives which could potentially improve the economics of extracting hydrocarbon liquids from oil shale.

The overall scope of Foster Wheeler's effort included the selection, conceptual process design, and technical assessment of the individual processing steps required for an integrated commercial oil shale plant. Design of the component processing systems was based on non-confidential information derived from published literature and Foster Wheeler in-house sources and supplemented by input from selected process licensors. The conceptual design also included specification of the utilities systems and general facilities needed to support the operation of the processing plant. Estimates of the total capital investment and annual operating costs were developed, based on the conceptual plant design and the corresponding operating requirements.

1.1 Basis of Design

The commercial oil shale plant was designed as a grassroots facility located adjacent to a mine site in western Colorado. Run-of-mine oil shale, raw water, electric power, and natural gas were assumed to be available at the plant battery limits in sufficent quantities to satisfy the overall operating requirements.

Characteristics of the oil shale feed, from a Colorado Green River deposit, were as follows:

Fischer Assay, gal/ton	30.0
Organic Matter, wt % (dry)	16.7
Inorganic Matter, wt % (dry)	83.3
Mineral Carbonate, wt % Inorganics	48.0
Ultimate Analysis, wt % Organics	
Carbon	80.5
Hydrogen	10.3
Nitrogen	2.4
Sulfur	1.0
Oxygen	5.8
Surface Moisture, wt %	2.0
Water of Hydration, wt %	1.0
Higher Heating Value, BTU/lb (dry)	2,528

Table 1.1

Plant Processing and Support Systems

Unit	Description	No. Trains	Train Capacity
Process Facilities			
100	Retorting	6	12,000 TPD
200	Raw Oil Recovery	6	8,600 BPD
300	Gas Treating	2	66 MMSCFD
400	Raw Oil Hydrotreating	2	26,000 BPD
500	Hydrotreated Oil Fractionation	2	26,000 BPD
600	Hydrogen Plant	2	35 MMSCFD
700	Sour Water Treating	2	800 GPM
800	Sulfur Recovery	2	35 TPD
900	Spent Shale Moisturizing	6	9,200 TPD
1000	Feed Preparation	2	120,000 TPD
1100	Spent Shale Disposal	-	55,200 TPD

Unit	Description	No. Trains	Total Capacity
Support Facilities			
2000	Raw Water Treatment	2	1,440 GPM
2100	Steam and Power Generation	2	160 MW
2200	Cooling Water System	3	253,000 GPM
2300	Plant and Instrument Air	3	5,800 SCFM
2400	Waste Water Treatment	2	1,930 GPM
2500	Inert Gas System	2	300,000 SCFM
2600	Flare System	5	
2700	Plant Fuel System	1	4,600,000 Lb/Hr
2800	Storage Facilities	-	-
2900	General Plant Facilities	-	-

The retorting yield structure, based on 105% of the Fischer Assay yield, was provided by DOE and was used as the basis for the retorting system design. Other design criteria for the integrated plant included:

- Fluidized-bed retorting of the crushed shale feed, without fines separation, and lift pipe combustion of the retorted shale.
- Use of natural gas to satisfy the plant fuel requirements in order to avoid consumption of product oil as fuel.
- Plant capacity based on an integral number of retorting trains sufficient to produce the nominal 50,000 BPD of syncrude product.
- Upgrading of raw oil to obtain a residual nitrogen level of 1000 ppm in the syncrude product.
- Zero water discharge from the plant with suitable treating of aqueous effluents for moisturizing spent shale.
- Use of air cooling to minimize raw water consumption.
- Environmental control systems to limit plant emissions in accordance with the applicable federal and Colorado state regulations.

Preliminary process information for design of the raw oil hydrotreater was provided by Unocal. The sulfur recovery section, based on the LO-CAT Process, was treated as a complete process package suppled by ARI Technologies Inc. Conceptual designs for all other plant sections were developed by Foster Wheeler.

1.2 Plant Description

The battery limits scope of the oil shale plant includes crushing of run-of-mine shale ore, retorting and recovery of raw oil and gas, gas purification, hydrotreating of whole raw shale oil to a syncrude product, recovery of by-product sulfur and ammonia, and disposal of spent shale. In addition, the scope includes the plant support systems to provide the utility services and general facilities required for normal operation.

The processing units and support facilities which comprise the grassroots plant are listed in Table 1.1, together with the number of operating trains in each section and the corresponding design capacity. The plant design does not provide for sparing of any process operating trains. Shale retorting, raw oil recovery, and spent shale moisturizing are modularized in six parallel trains, each capable of processing the equivalent of 12,000 TPD of shale feed. All other process units, except for spent shale disposal, are designed as two parallel trains. Feed preparation is sized for 5 days per week operation, with provision for crushed shale storage to permit continuous 7 days per week operation of the process plant.

The hydrotreated oil product is fractionated and stored as naphtha, diesel oil, and heavy oil fractions in product storage facilities which are designed for ten days capacity. Thirty days storage is provided for molten elemental sulfur and liquid anhydrous ammonia, produced as by-products. Spent shale, after moisturized to 14% by weight, is trucked to a nearby disposal site and deposited on a spent shale pile, which is designed for 30 years of plant operation.

Integration of the plant processing systems, Units 100 - 1100, is illustrated on the block flow diagram in Figure 1.1.

1.3 Plant Operating Summary

Operation of the commercial oil shale plant results in the following feed and product summary. These rates are based on a normal operating day; the plant is designed for 330 days a year continuous operation. The blended syncrude product oil contains a maximum of 1000 ppm nitrogen and has a maximum pour point of 30 °F, as adjusted by the addition of a pour point depressant.

Oil Shale Feed, Tons/Day		72,720
Syncrude Product, Bbl/Day		
Naphtha	@ 58.8 °API	6,158
Diesel Oil	@ 36.9 °API	8,207
Heavy Oil	@ 32.4 °API	40,195
		54,560
By-Products, Tons/Day		
Elemental Sulfur		70.6
Anhydrous Ammonia		211.8
Moisturized Spent Shale, Tons/Day		62,847

The normal plant requirements for purchased utilities and materials, corresponding to the above production rates, are as follows:

Natural Gas, MMSCFD	43.7
Diesel Oil, BPD	85.7
Electric Power, KW	18,465
Raw Water, GPM	6,225
Catalyst & Chemicals, $/Day	64,882

The administrative, technical, and operating staff requirements for the plant were estimated at a total of 590 employees:

Management & Administration	48
Technical Staff	27
Shift Supervisors	40
Shift Operators	475
	590

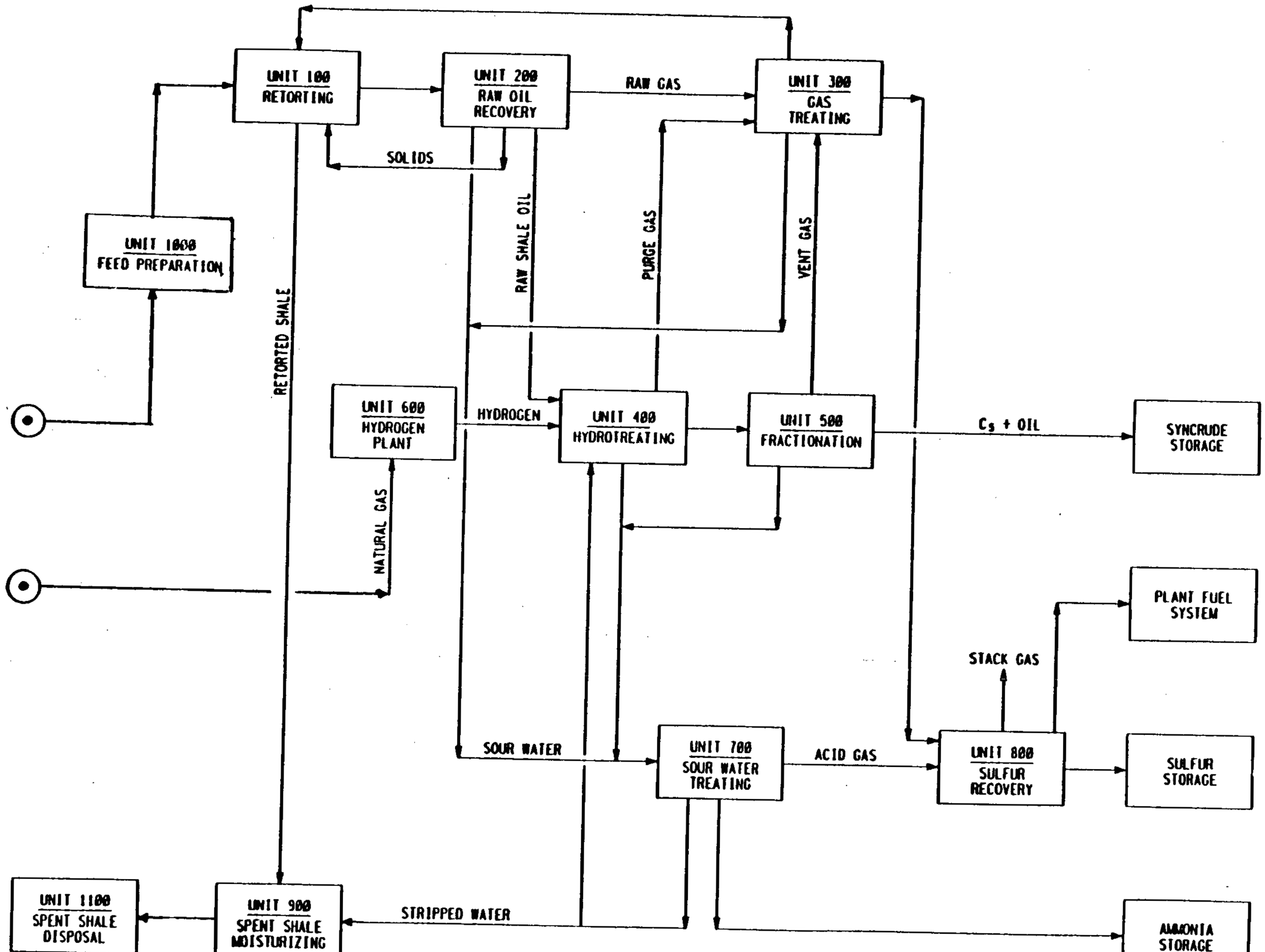


FIGURE 1.1 BLOCK FLOW DIAGRAM

The above staffing requirement excludes maintenance labor and supervision, which was included in the overall annual maintenance cost.

1.4 Plant Investment Cost

Based on the conceptual plant design, and corresponding equipment specifications, the installed plant cost was estimated at $1.92 billion. This estimate is based on mid-1987 costs for a western Colorado site. The costs of the retorting section represents the largest single factor in the installed cost of the physical plant. Retorting accounts for 59% of the total processing units cost and 47% of the total installed cost.

The total plant investment was estimated at $2.39 billion, as summarized in Table 1.2. In addition to the installed plant cost, the total investment includes allowances for project contingency, initial catalyst charge, spare parts, start-up costs, and working capital. In particular, the total investment excludes the cost of land and project owner costs such as project management, environmental monitoring, and permitting.

1.5 Operating Costs

The net annual operating cost for the processing plant was estimated at $351 million, based on 330 operating days per year. As shown in Table 1.3, this cost includes charges for the oil shale feed, as well as by-products credit. Cost of the mined shale ore, charged at $6.00 per ton, represents 64% of the raw materials cost and 40% of the total operating cost, before by-product credit.

Based on the normal syncrude production rate of 54,560 BPD, the net operating cost per barrel of oil product is $19.48.

1.6 Technical Assessment

An assessment of the conceptual plant design was made in terms of the process design assumptions, areas of risk, and potential design alternatives. This assessment focused on the design of the retorting unit, since the cost of this unit represents about half of the total installed plant cost. Furthermore, the conceptual retorting design incorporates major process assumptions, as well as extrapolation of conventional fluidized-bed design practice, which could have major impact on the plant operability and oil yield.

The balance of the processing units and support systems represent adaptations of conventional technologies which have been commercially employed in petroleum refining and the chemical process industries. The presence of trace contaminants, such as heavy metals, chlorides, cyanides and heterocyclic organics, is the primary uncertainty in design of the downstream processing steps. While provisions were included in

Table 1.2

Total Plant Investment Summary

Basis: Mid-1987, Colorado

	Cost $1000
Installed Plant Cost:	
Processing Units	1,522,712
Support Systems	393,756
	1,916,468
Project Contingency @ 15%	287,470
Total Plant Cost	2,203,938
Initial Catalyst & Chemical Inventory	11,532
Spare Parts	15,390
Start-Up Costs	92,743
Working Capital	61,829
Total Plant Investment	2,385,432

Table 1.3

Annual Plant Operating Cost

Basis: 330 Operating Days/Year

Cost Element	Annual Cost $1000
Raw Materials & Consumables	
Oil Shale Ore	143,986
Natural Gas	50,474
Diesel Oil	651
Electric Power	5,700
Raw Water	2,958
Catalyst & Chemicals	21,411
	225,180
Plant Labor	
Direct Labor (Excluding Maintenance)	15,940
Indirect Labor	10,361
Maintenance Labor	42,808
	69,109
Maintenance Materials	42,808
Insurance & Local Taxes	19,164
Mobile Equipment Replacement	7,087
Total Operating Cost	363,348
By-Product Credit	
Sulfur	2,097
Ammonia	10,483
Net Operating Cost	350,768

the conceptual design to protect against catalyst poisoning, the distribution and fate of trace contaminants in the aqueous streams, which ultimately are used to moisturize spent shale, may require more stringent waste water treatment in order to permit acceptable disposal of the shale waste material.

In the design of the retorting unit, the following uncertainties were identified relative to potential impact on oil yield, operability, and energy usage.

- Particle residence time in the retorting zone.
- Degree of solids attrition.
- Dynamic behavior and control of solids flow.
- Mineral carbonate decomposition in both retorting and combustion.
- Formation of carbon monoxide and NO_X during combustion of the retorted shale.

In the present design, the combustor offgas is incinerated to limit the CO emissions to less than 100 ppm. Incineration of the offgas adds significant capital and fuel cost to the retorting plant. Attainment of low CO concentrations directly from combustion of the spent shale would avoid these additional costs. Staged combustion, in combination with a catalytic oxidizer, may be a less costly alternative to thermal incineration as a way to reduce the CO emissions.

Overall thermal efficiency of the retorting process could be improved by preheating the shale feed with partially cooled incinerator flue gas. This would use some of the flue gas energy to reduce the retorting heat requirement, rather then recovering this energy by steam generation. However, the extent of shale preheating that can be accomplished in this manner is limited by the temperature at which shale retorting begins, around 350°F.

The retorting unit design, as developed in the present study using fluidized-bed retorting and lift-pipe combustion, requires elevation of major process equipment of about 300 feet above grade. Consequently, the structural support for this arrangement is a significant cost element. Potential cost savings, from this stand point, could be achieved with a more compact design such as the following:

- Stacked vessel arrangement in which a fluidized-bed combustor, the raw shale feed accumulator, and the retort are positioned in a vertical line.

- Use of fluidized-bed combustion and pneumatic transport of retorted shale solids and hot combusted solids, similar to conventional fluid catalytic cracker designs.

The above alternate arrangements, however, will likely require greater flows of recycle gas or steam, which will impact on downstream processing costs.

2.0 INTRODUCTION

There are a variety of retorting processes, in various stages of development, which have potential commercial application for extracting hydrocarbon liquids from oil shale. In broad terms, these retorting technologies may be categorized as either above ground or in-situ processes. Above ground processing involves first mining and crushing of the shale and then heating the shale in a retort vessel to extract the oil. In-situ processes heat the shale underground, most commonly by injection of air for partial combustion, thereby releasing oil and gaseous products.

Within these two general types of retorting technology, there are a variety of processing concepts which may be employed. The above ground processes can be further classified according to specific retort characteristics, e.g.

- Batch or continuous operation.
- Moving-bed, fluidized-bed, or entrained flow for solids movement.
- Direct heat transfer, via hot solids or gas, or indirect heating.
- Fine versus lump size shale feed.
- With or without combustion of the retorted spent shale.

Although somewhat more limited, the concepts employed for in-situ retorting also have variations, associated with the degree of fracturing or rubblizing the shale seam, partial removal of shale to the surface, and directional movement of the retorting zone. Selection of a particular retorting process for commercial application will therefore affect the recovered oil yield, overall shale resource utilization, downstream processing requirements, plant costs, and environmental impact.

Moreover, similar to coal, oil shale is a highly variable material in terms of its physical and chemical properties. Oil shale deposits in the United States are generally classified as eastern or western shales. The western shales, found in the Green River formation, constitute the major oil shale resource in the United States. These are relatively high grade shales, having assays up to about 40 gallons per ton. Eastern shales represent a smaller resource and are generally lower grade material, having assays up to 20 gallons per ton. Another major difference between the shales is that the western shale has a proportionately higher hydrogen content, which generally translates into a greater oil yield upon retorting. Also, the mineral carbonate, sulfur, and nitrogen contents differ, which impact on the retorting heat load and downstream processing of the oil and gas products. Therefore, the shale feed characteristics are a key factor in selecting a retort technology and generally determine the overall processing sequence and economics for a commercial facility.

In view of the variety of retorting processes and shale feeds which may be considered for commercial applications, the U.S. Department of Energy is interested in developing systems models of oil shale processes. The systems models will be used to determine which process or process alternative gives the best performance in terms of a specific objective, such as lowest pollution emissions, highest thermal efficiency, or lowest capital cost. Various configurations of processing equipment will be analyzed to determine which overall plant design will result in meeting the desired objective and to identify areas for future R & D which could potentially improve the overall economics.

In support of this effort, Foster Wheeler USA Corporation provided architect/engineering services, under contract to the U.S. Department of Energy, to develop conceptual design and cost estimates for commercial scale oil shale plants. These designs will provide detailed technical and cost information for use as a reference data base in DOE's systems modeling and analysis. Another objective of these conceptual designs is to identity process alternatives which have the potential to reduce costs, improve operability, minimize environmental impacts, or increase the quality or quantity of the shale oil products.

The overall scope of Foster Wheeler's contract includes five conceptual design cases, to be executed at DOE's option, for the production of a nominal 50,000 BPD of syncrude based on processing run-of-mine shale in a grassroots facility.

Base Case: Fluidized-bed retorting/combustion of Colorado Mahogany zone shale.

Option 1: Alternate base case design employing an FCC concept of fluidized-bed retorting/combustion of Colorado Mahogany zone shale.

Option-2: Directly heated moving vertical-bed process using Colorado Mahogany zone shale.

Option-3: Fluidized-bed retorting/combustion of eastern U.S. New Albany shale.

Option-4: Directly heated moving vertical-bed process using eastern U.S. New Albany shale.

The technical definition required for each case study includes the following:

- Selection of process units for the overall integrated plant.
- Process unit designs, including process flow diagrams, material and energy balances, equipment specifications, and utilities requirements.
- Identification of process design uncertainties and recommendations for process alternatives.
- Specifications for plant support systems and description of the overall plant layout.
- Estimated capital investment for the integrated plant, detailed by individual process unit.
- Estimated overall operating requirements and annual operating costs for the plant.

This report summarizes the base case design study, as conducted by Foster Wheeler, employing fluidized-bed retorting and combustion of Colorado oil shale.

3.0 BASIS OF STUDY

3.1 Scope of Plant Design

The conceptual commercial plant design developed for this study is essentially a grassroots facility, capable of processing run-of-mine oil shale into a synthetic crude oil product. The battery limits design includes all the processing units required for oil shale feed preparation, retorting, oil recovery and upgrading to a syncrude quality, treatment of effluent streams to minimize environmental impact, by-product recovery, and disposal of spent shale. Processing to refine the syncrude oil into final marketable products is excluded from the plant scope. In addition to the processing units, the design scope includes the utilities, support systems, and general facilities required for normal continuous plant operation. Run-of-mine shale ore, raw water, natural gas, and electric power are assumed to be available at the plant battery limits in sufficient quantities to supply the operating requirements. Table 3.1 lists the individual processing units and plant support facilities included in the overall plant design.

The scope of the conceptual plant design effort included:

- Selection of individual process units.
- Process unit designs, including flow diagrams, heat and material balances, estimated operating requirements, and equipment specifications.
- Specifications for the required plant support facilities.
- Overall layout of the plant.
- Estimates of total plant investment cost and annual operating cost.
- Identification of process design uncertanties and potential process alternatives which could impact on the overall plant economics.

With the exception of the retorting area, the technology selected for the individual processing steps represents commercially available processes which have been demonstrated in similar applications. In all cases, the process unit train capacities were established to reflect present engineering practice in equipment design.

Table 3.1

Plant Processing and Support Systems

Unit	Description	No. Trains
Process Facilities		
100	Retorting	6
200	Raw Oil Recovery	6
300	Gas Treating	2
400	Raw Oil Hydrotreating	2
500	Hydrotreated Oil Fractionation	2
600	Hydrogen Plant	2
700	Sour Water Treating	2
800	Sulfur Recovery	2
900	Spent Shale Moisturizing	6
1000	Feed Preparation	2
1100	Spent Shale Disposal	-
Support Facilities		No. Trains
2000	Raw Water Treatment	2
2100	Steam and Power Generation	2
2200	Cooling Water System	3
2300	Plant and Instrument Air	3
2400	Waste Water Treatment	2
2500	Inert Gas System	2
2600	Flare System	5
2700	Plant Fuel System	1
2800	Storage Facilities	-
2900	General Plant Facilities	-

3.2 Overall Plant Description

The block flow diagram in Figure 3.1 shows the integrated process scheme for the grassroots plant facility. Detailed descriptions of the designs developed for the individual process units and support systems are included in Sections 4.0 and 5.0 of this report.

Run-of-mine shale is delivered to the plant by trucks which discharge the ore directly to the feed preparation section, Unit 1000. The ore is crushed in three stages to minus 6mm size particles which is suitable as feed to the retorting unit. Provisions are included for stock piling primary crushed ore and providing an adequate inventory of retort feedstock.

Crushed shale is fed, from storage silos, to the retorting system in Unit 100. The crush shale is pyrolyzed at 930°F and essentially atmospheric pressure in a fluidized-bed retorting system in which recycle product gas from Unit 300 is used as the fluidizing medium. Retorted shale solids are combusted with air in a lift pipe combustor to recover the energy value from the residual char on the shale. Hot solids from the combustor are recycled to the retort to provide the heat required for pyrolysis.

The combusted shale and raw shale fines, recovered from retorting, are moisturized in Unit 900. Moisturized spent shale is discharged via belt conveyors and loaded into dump trucks for haulage to the spent shale disposal site. At the disposal site, the spent shale is deposited and compacted onto a pile which provides storage for 30 years of plant operation. As the spent shale pile grows, the sides are sloped, covered with overburden and topsoil, and revegetated.

Offgas from the retorting system is processed for recovery of the raw shale oil in Unit 200. The gas is quenched and the condensed raw oil is sent to intermediate product storage. Non-condensible gas and sour water streams are delivered to downstream processing units for further treatment. Any oil shale solids entrained in the retort product gas are collected in the bottoms oil from the quench tower. This stream is centrifuged to remove the solids and the resulting oily sludge is recycled to the retorting section.

Raw shale oil is hydrotreated in Unit 400 to reduce the nitrogen content to less than 1000 ppm. The raw oil is reacted with hydrogen over a fixed-bed catalyst system at elevated temperature and pressure. Hydrogen sulfide and ammonia, formed as a result of oil hydroprocessing, are scrubbed from the offgas via a recycle stream of stripped water. The sour water effluent is further treated in Unit 700 while the hydrocarbon purge gas stream is delivered to gas treating in Unit 300.

3.2 Overall Plant Description (Cont'd)

The hydrotreated oil is stablized by fractionation in Unit 500 where the oil shale product is collected as three separate fractions; naphtha, diesel oil, and heavy oil. These fractions are stored separately and may be recombined as a shale oil syncrude or delivered separately to a refinery for further processing. The product oil blending operation provides for the addition of a pour point depressant to facilitate transportation via unheated tank trucks or pipeline.

Make-up hydrogen required for raw oil hydrotreating is produced via steam reforming of natural gas in Unit 600. The hydrogen plant employs molecular sieves for gas purification, after water gas shifting, and thereby produces a high purity, 99+%, hydrogen stream. The make-up hydrogen is compressed and delivered to the hydrotreating section.

The offgas streams from raw oil recovery, oil hydrotreating, and fractionation are compressed and treated in Unit 300. The C_4+ components are removed by oil absorption while the ammonia, plus some H_2S, is removed by water scrubbing. Part of the compressed gas stream, prior to C_4 absorption, is recycled to the retorting section as fluidization gas. The treated gas, which still contains significant H_2S levels, is further processed for sulfur recovery in Unit 800.

Sour water streams containing dissolved CO_2, H_2S, and ammonia are produced in raw oil recovery, gas treating, raw oil hydrotreating, and oil fractionation. These streams are combined and steam stripped in the sour water treating system in Unit 700. The stripped water is recycled, in part, as wash water for the oil hydrotreating unit while the remainder is used as make-up for spent shale moisturization. Within the sour water treating section, a Phosam-W system is used to recover anhydrous ammonia as a by-product from the stripped acid gas stream. After ammonia recovery, the acid gas is delivered to Unit 800 for recovery of sulfur. By-product anhydrous ammonia is sent to pressurized storage tanks.

The acid gas stream from Unit 700 and the sulfur containing offgas from gas treating in Unit 300 are sent to the sulfur recovery unit. This process unit utilizes the LO-CAT^R process to convert H_2S to molten elemental sulfur via a liquid phase redox reaction. By-product molten sulfur is then sent to storage.

Operation of the above processing units is supported by the following utility systems and general plant support facilities.

Unit 2000 - Raw Water Treatment. The source of raw water is Western Colorado river water, which is chemically clarified and filtered and used as industrial water for the plant needs. Part of this water is further purified by activated carbon adsorption and chlorination for use as potable water and sanitary purposes. Filtered water is purified by ion exchange to produce high purity water suitable for high pressure steam generation.

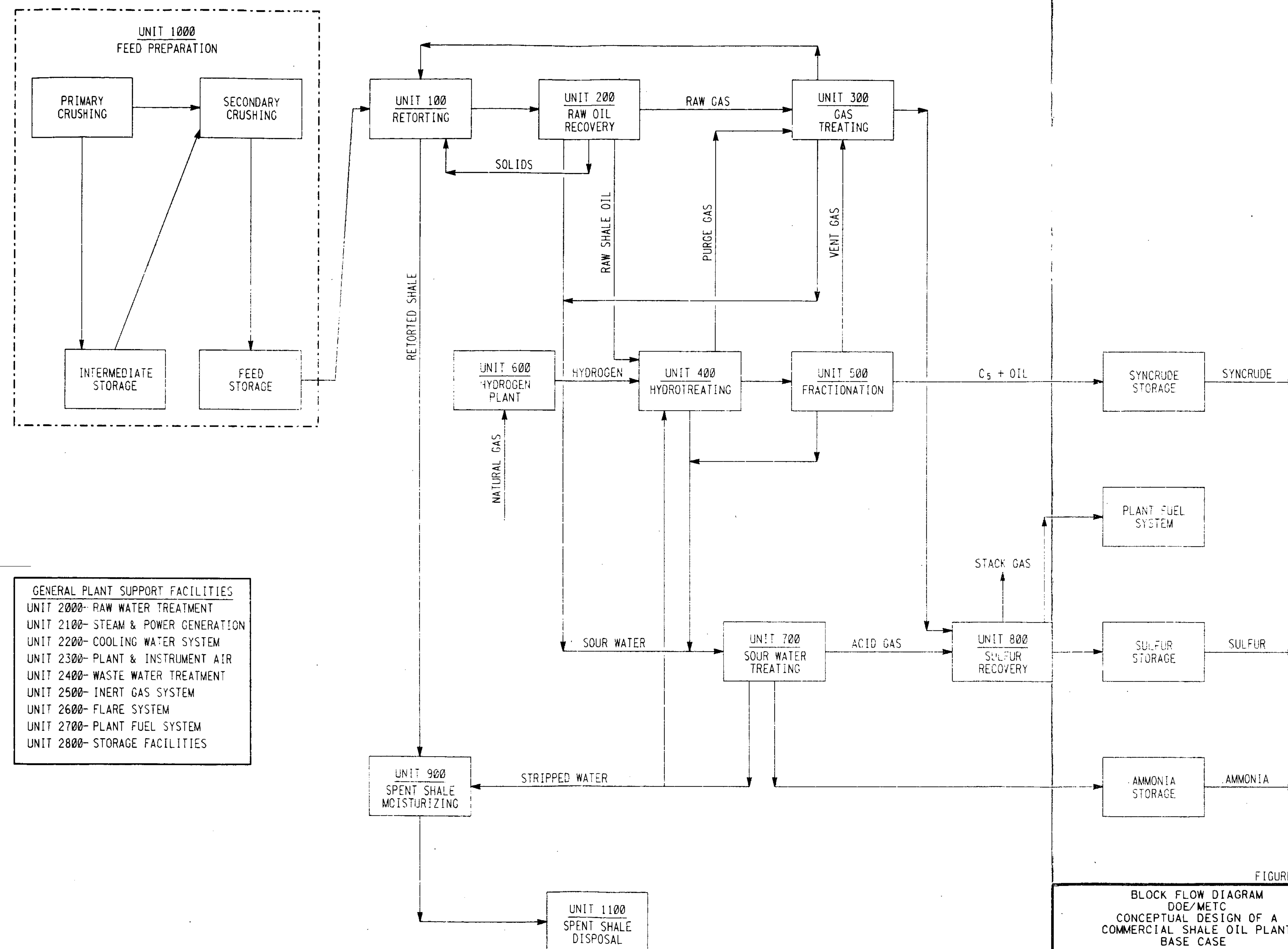


FIGURE 3.1

BLOCK FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE

DRAWN BY:	[illegible]	05-19-87	SCALE:	NONE =1'-0"
CHECKED BY:			DWG. No.	
APPROVED BY:				36265-3-50-1

REVISION

CHARGE No. 11-36265

FW3P

FORM NO. 285-63-M

E050,16313626531.BFD

3.2 Overall Plant Description (Cont'd)

Unit 2100 - Steam and Power Generation. This unit includes the steam distribution system and electric power generators. The amount of steam required for the plant operation is entirely produced in the various processing units, primarily in the CO incinerators located in the retorting unit. For start-up, when no retorting products have to be incinerated, these units will use natural gas fuel and produce the steam required for plant start-up and operation. During plant start-up, no in-plant power generation is contemplated. During normal operation, the processing units overall steam balance is positive and the excess steam is used for generating electric power via turbo generators.

Unit 2200 - Cooling Water System. This unit consits of two cooling water circuits; one for power generation and the other servicing the balance of the plant.

Unit 2300 - Plant and Instrument Air. Air compressors with the required coolers, and drying system produce dry compressed air for utility and instrument services.

Unit 2400 - Waste Water Treatment. This unit is designed to treat plant sewer, sanitary sewer, and rain water run-off from the processing areas to a water quality suitable for reuse in spent shale moisturizing.

Unit 2500 Inert Gas System. This unit supplies inert gas required for purging and blanketing in the processing units. The inert gas is a mixture of N_2 and CO_2, resulting from burning natural gas without excess air.

Unit 2600 - Flare System. This system is designed to handle the vapor released from the processing units during transient operating conditions. The unit consists of three parallel flares, each one handling two retorting modules, and two flares handling the upgrading units.

Unit 2700 - Plant Fuel System. This system includes a surge drum for mixing fuel gas with natural gas as well as the required distribution piping for supplying plant fuel.

Unit 2800 - Storage Facility. Storage tanks for intermediate and final products, chemicals, and additives are provided as well as pumping stations for transfer and blending.

Unit 2900 - General Plant Facilities. These facilities include the fire water system, sewers, buildings, and miscellaneous support systems required for plant operation and maintenance.

3.3 Feed and Product Specifications

The oil shale feedstock is derived from a mahagony zone deposit in Western Colorado and has a Fischer Assay of 30 gallons per ton. Detailed specifications for the oil shale feed are given in Table 3.2

The major product from the processing plant is a transportable syncrude oil. Specifications established for the product oil include a maximum nitrogen content of 1000 ppmw and a pour point of 30°F or lower.

By-products such as elemental sulfur and anhydrous ammonia have specifications corresponding to standard commercial grades.

3.4 Basic Design Criteria

The conceptual oil shale plant design is for a grassroots facility, suitable for the commercial development of an oil shale resource. The design is intended to represent mature commercial technology, rather than a first of a kind processing plant.

The commercial plant was located on an unspecified site in Western Colorado, presumably adjacent to an oil shale mining operation. For the purposes of this study, it was assumed that the site was relatively clear and level and sufficient acreage was available for the physical plant facilities and spent shale disposal.

The nominal capacity of the conceptual plant is 50,000 barrels per stream day of syncrude product. Design of the retorting process section was based on a generic fluidized-bed retorting process incorporating lift pipe combustion of the retorted shale. Design parameters for the retorting unit were derived from published literature sources, which were supplemented by non-confidential data provided by Foster Wheeler. Similarly, downstream processing units were also based on non-confidential process information which, in some cases, was provided by process licensors.

Specific design conditions, relating to the assumed plant site and the design of the plant utilities systems, are listed in Table 3.3. The following design criteria were established as general guidelines for the conceptual plant design:

- Plant capacity is based on an integral number of retorting trains required to approximate production of 50,000 BPD syncrude.

- Retorting feed consists of 100% of mined shale, with no fines separation prior to retorting.

- Natural gas is used as supplemental plant fuel to avoid use of syncrude product.

TABLE 3.2

Characteristics of Colorado Oil Shale

Gross Characteristics	
Fischer Assay, gal/ton	30.0
Oil Gravity, °API	22.7
Organic Matter, Wt. % (Dry Basis)	16.7
Inorganic Matter, Wt. % (Dry Basis	83.3
Characteristics of Organic Matter	
Ultimate Analysis, wt. % of Organic Matter	
Carbon	80.5
Hydrogen	10.3
Nitrogen	2.4
Sulfur	1.0
Oxygen	5.8
Fischer Assay Yields, Wt. % of Organic Matter	
H_2	0.3
CO	0.2
CO_2 (organic)	2.6
H_2O	1.5
H_2S (organic)	0.1
NH_3	(trace)
CH_4	1.6
C_2H_4	0.3
C_2H_6	1.0
C_3H_6	0.6
C_3H_8	0.7
C_4	1.2
C_5	0.9
C_6+ Oil	68.1
Char	20.9
TOTAL	100.0

Inorganic Matter Composition, wt. %

Mineral	Chemical Formula	
Dolomite	$CaCO_3.MgCO_3$	32
Calcite	$CaCO_3$	16
Quartz	SiO_2	15
Illite	$KAl_2.AlSi_3O_{10}(OH)_2$	19
Albite	$NaAlSi_3O_8$	10
K Feldspar	$KAlSi_3O_8$	6
Pyrite	FeS_2	1
Analcime	$NaAlSi_2O_6.H_2O$	1
Kaolinite	$Al_2Si_2O_7.2H_2O$	0
Calcium Sulfate	$CaSO_4$	0
Ferric Sulfate	$FeSO_4.H_2O$	0
TOTAL		100

Table 3.3

Assumed Design Conditions

Plant Location	Western Colorado
Site Elevation	8000 ft
Barometric Pressure	10.5 psia
Ambient Design Temperatures	
Cooling Towers	75°F (Wet Bulb)
Air Coolers	110°F (Dry Bulb)
Winterization	-20°F (Dry Bulb)
Relative Humidity	80%
Prevailing Wind	70 MPH
Frost Penetration	48 inches
Raw Water (River Source)	
PH	8
Calcium as Ca	64 mg/l
Magnesium as Mg	14 mg/l
Bicarbonate as $CaCO_3$	144 mg/l
Sulfate as SO_4	129 mg/l
Chloride as Cl	119 mg/l
Total Solids	454 mg/l
Plant Steam Supply	
High Pressure	600 psig @ 700°F
Medium Pressure	150 psig @ 365°F
Low Pressure	30 psig @ 275°F
Natural Gas	
Vol. % N_2	2.5
CH_4	94.0
C_2H_6	2.3
C_2H_4	1.0
C_3H_8	0.2
Electric Power	
5000 HP and above	13,800 Volts, 3 Phase
250 HP to 5000 HP	4,160 Volts, 3 Phase
1/2 to 250 HP	460 Volts, 3 Phase
Less than 1/2 HP	120 Volts, 1 Phase
Lighting	120 Volts, 1 Phase

3.4 Basic Design Criteria (Cont'd)

- Recycle product gas is used for retort fluidization, in order to minimize production of waste water.
- Plant is designed for zero waste water discharge.
- Air cooling is used where applicable to minimize plant water consumption.
- Control of plant emissions conforms with the applicable federal and Colorado environmental regulations.

4.0 PROCESSING FACILITIES DESIGN

The conceptual designs developed for the individual processing systems, Units 100 - 1100, are described in the following sections. Technical definition for each process unit includes, as appropriate, the basis of design, process description keyed to the process flow diagram, heat and material balances, a summary of normal operating requirements, and a list of major process equipment with corresponding specifications.

4.1 Retorting - Unit 100

- Basis of Design

The retorting unit is designed to process 72,000 tons per operating day of shale feed, crushed to 6 mm top size in Feed Preparation, Unit 1000. Based upon practical design considerations for the retorting vessel sizes, the capacity of a single retorting train was established at 12,000 TPD, so that the total plant requires six parallel operating trains.

Raw shale feed to the retorting system has the following characteristics:

Fischer Assay, gal/ton	30.0
Organic Matter, wt % (dry)	16.7
Inorganic Matter, wt % (dry)	83.3
Mineral Carbonate, wt % Inorganics	48.0
Ultimate Analysis, wt % Organics	
Carbon	80.5
Hydrogen	10.3
Nitrogen	2.4
Sulfur	1.0
Oxygen	5.8
Surface Moisture, wt %	2.0
Water of Hydration, wt % (dry)	1.0
Higher Heating Value, BTU/lb (dry)	2528

The retorting yields were based on achieving 105% of the Fischer Assay yield, with the overall product distribution as shown in Table 4.1 which was provided by DOE. The corresponding inspections on the liquid fractions and char are summarized in Table 4.2.

The conceptual design of the retorting unit is based on fluidized-bed retorting with lift pipe combustion of the retorted shale. Furthermore, in order to minimize the level of CO emissions, the combustor off-gas is incinerated.

Table 4.1

Retorting Yield Structure

Bases: 105% Fischer Assay

Component	Retort Yield Wt. % Organic Matter
Gases:	
H_2	0.3
CO	0.5
CO_2 (organic)	3.1
H_2O	2.2
H_2S (organic)	0.1
NH_3	(trace)
CH_4	1.2
C_2H_4	0.3
C_2H_6	0.8
C_3H_6	0.5
C_3H_8	0.6
C_4H_8	0.7
C_4H_{10}	0.2
Total Gases	10.5
Liquids:	
Naphtha (C5-375°F)	9.9
Light Distillate (375-650°F)	19.0
Heavy Distillate (650-950°F)	35.3
Vacuum Bottoms (950°F+)	6.3
Total Liquids	70.5
Char:	19.0
Total Organic Matter Products	100.0

Table 4.2

Inspections on Retort Liquids and Char

	Char	Naphtha	Light Distillate	Heavy Distillate	Vacuum Bottoms	Total Liquid
Boiling Point, ^oF	-	C_5-375	375-650	650-950	950+	C_5+
Gravity, ^oAPI	-	50	30	20	10.7	22.7
Ultimate Analysis,						
Wt. %, C	88.4	85.2	84.4	83.7	81.9	83.9
H	4.8	11.6	11.5	11.4	10.8	11.4
O	0.0	1.0	1.5	1.8	3.5	1.8
N	4.5	1.8	2.0	2.3	2.8	2.2
S	2.3	0.4	0.6	0.8	1.0	0.7
	100.0	100.0	100.0	100.0	100.0	100.0

4.1 Retorting - Unit 100 (Cont'd)

Basic parameters used for designing the fluidized-bed retort and the lift pipe combustor were primarily derived from published information. The design parameters for the CO incinerator were based upon Foster Wheeler's estimates. Table 4.3 summarizes the basic parameters from which the conceptual design was developed.

Thermal calculations were based on estimates of heats of combustion at 77°F, ideal gas heat capacities, and heat capacity of shale; the latter as reported in the literature (13). Carbonate CO_2 was assigned a negative "heat of combustion" of 1400 BTU per pound of CO_2 evolved and water of hydration in raw shale was assigned a negative "heat of combustion" of 1100 BTU per pound of water vaporized. The use of ideal gas heat capacities for organic and inorganic gases and vapors was justified on the basis that sensible heat changes of solids and heats of chemical reaction, particularly that of carbonate decomposition, dominate the thermal changes that occur.

Sizing criteria used in design of the major process equipment for the retorting unit are summarized below.

R-101 Retort

The retort is designed to provide four minutes residence time of shale solids at a temperature of 930°F and raw shale throughput of 4000 $lb/hr\text{-}ft^2$. These criteria are based upon published information as referenced in Table 4.3.

V-101 Raw Shale Bin

The Raw Shale Bin provides storage for raw shale in each of the six retorting modules. The bin has a design capacity of 500 tons, equivalent to 8 hours usage of shale at design throughput of the retorting module. This capacity allows for short interruptions of delivery from offsite shale storage.

V-102 Raw Shale Accumulator

Vessel V-102 was designed to recover entrained raw shale from conveying air and to provide 10 minutes residence time for recovered solids. Recovery of raw shale was accomplished by one stage of cyclones using an inlet velocity of 60 feet per second. Diameter of the vessel was determined by a 3.5 to 1 aspect ratio for the contained shale bed. This ratio was selected to achieve uniform downflow of recovered solids over the cross section of the vessel. Solids residence time was selected to allow for momentary upsets in solids flow into or out of the vessel, as well as to provide for instrument control of solids flow.

Table 4.3

Process Basis of Design

Parameter	Design Value	Basis
Fluid Bed Retorting		
Retort Outlet Pressure, psia	15.5	Foster Wheeler
Retorting Temperature, °F	930	Reference (6)
Feed Shale Throughput, $lb/hr\text{-}ft^2$	4000	Reference (4) (5)
Avg. Particle Residence Time, min.	4	Reference (4) (5)
Bottom Stripping Gas, fps	1	Reference (4) (5)
Recycle/Feed Shale Mass Ratio	3	Reference (4) (5)
Mineral Carbonate Decomposition, %	2	DOE/METC
Fines Carryover, % Raw Shale	10	Foster Wheeler
Lift Pipe Combustor		
Temperature, °F	1250	Reference (4) (5)
Char Combustion, %	95	Reference (4) (5)
Mineral Carbonate Decomposition, %	21	Foster Wheeler
Avg. Particle Residence Time, sec.	5	Reference (4) (5)
Molar Ratio CO_2/CO	12.3	Foster Wheeler
NO_x, % Organic Nitrogen	10	Reference (8)
SO_2 Adsorption, %	90	Reference (8)
Flue Gas Incinerator		
Temperature, °F	1700	Foster Wheeler
Mineral Carbonate Decomposition, %	82	Foster Wheeler
Char Combustion, %	100	Foster Wheeler
CO Conversion to CO_2, %	99	Foster Wheeler

4.1 Retorting - Unit 100 (Cont'd)

V-103 Retorted Shale Combustor

The Combustor is designed to heat the mixture of retorted and combusted shale from the retort temperature of 930°F to a temperature of about 1240°F with a solids residence time of 5 seconds in the riser section of the Combustor. The Combustor temperature of 1240°F satisfies the heat balance around the Retort and the Combustor vessels. In operation, the combustor temperature would be controlled by the amount of fuel fired.

V-104 Combusted Shale Separator

Vessel V-104 is designed to separate entrained shale solids from flue gas generated in the combustor. This is accomplished by two stages of cyclones located inside the vessel. Inlet velocities to the first and second stages are 60 and 90 feet per second, respectively, which are considered typical of industrial practice. Diameter of the vessel is determined by the cross section required to position the 16 cyclones in each of the two stages. The lower section of the vessel was designed to provide 4 minutes residence time for solids recovered by the cyclones, which is the minimum considered necessary for satisfactory instrument control of solids flow to the retort. Flow control of these solids is considered critical to proper mixing and contacting in the retort.

V-105 Air Preheater/Shale Cooler

Vessel V-105 is designed primarily to cool the net combusted shale product from the Combustor temperature of 1240°F to a temperature of 350°F. This temperature was selected as the minimum temperature consistent with practical heat recovery from the shale, as well as the maximum temperature suitable for the subsequent step of shale moisturizing and conveyor transport.

A secondary purpose of the Air Preheater/Shale Cooler is to heat combustion air to a temperature of 1000°F. This air temperature is considered adequate to provide rapid initiation of combustion and avoid any quenching of retorted shale which might occur if ambient temperature air were used for combustion. Air preheating also improves the thermal efficiency of the process compared to rejecting the heat in the combusted shale to cooling water. At a preheat temperature of 1000°F, most of the heat in the shale is absorbed by the combustion air; the remainder is absorbed by preheating boiler feed water.

4.1 Retorting - Unit 100 (Cont'd)

V-106 Retorted Shale Separator

Vessel V-106 is designed to separate entrained shale solids from the vapors leaving the retort. This is accomplished by one stage of cyclones using an inlet velocity of 90 feet per second. This velocity was selected as typical for second stage separation, following the primary cyclones inside the retort. The diameter of the vessel was determined by the cross section required to position the 4 cyclones inside the vessel. Residence time of 4 minutes was provided for recovered solids in the lower section of the vessel, as required for instrument control of solids flow.

V-107 Condensate Drum

The V-107 condensate drum was designed to provide 8 hours capacity for condensate from the C-101 steam turbine surface condenser at design flow of 65 gpm. The selected capacity allows for short term fluctuations in condensate flow.

V-108 Condensate Drum

The V-108 condensate drums were designed to provide 4 hours capacity for condensate from E-102 Surface Condensers at design flow of 390 gpm. The selected capacity allows for short term fluctuations in condensate flow.

H-101 Recycle Gas Heater

H-101 is designed to heat recycled gas from the Raw Oil Recovery unit to a temperature of 800°F prior to injection into the retort. This temperature was selected to minimize cooling of shale in the retort near the recycle gas entry point, while avoiding coking in the fired heater tubes due to overheating of olefinic light hydrocarbons and oil vapors in the gas.

H-102 CO Incinerator and B-101 Waste Heat Boiler

The primary purpose of the incinerator is to reduce the carbon monoxide content of the combustor flue gas to a level of about 70 ppmv. This is accomplished by heating the flue gas to a temperature of 1700°F, using natural gas as fuel. A secondary purpose of the incinerator is to recover residual energy from raw shale fines entrained in conveying air, as well as retorted shale fines collected in the retorted shale separator.

4.1 Retorting - Unit 100 (Cont'd)

The incineration temperature was selected on the basis that carbon monoxide is a relatively slow burning compound and a temperature of about 1700^oF is required to achieve low levels of carbon monoxide at practical gas residence times of about one second.

The large amount of gases generated by the Spent Shale Combustor contain approximately 1% carbon monoxide and 400 lb NO_X per hour per train. The Incinerator reduces the CO to less than 100 PPM, and the NO_X to less than 100 lb/hr per train. Simultaneously, the Incinerator combusts the fresh oil shale fines, which bypass the Retort, and char from the Retort flyash (spent fines). Sensible and chemical heat from the feedstock are recovered in the Waste Heat Boiler.

Staged combustion applied to fluidized-bed incineration has been found to reduce the NO_X emission (9) (10). The possible reaction which suppresses the emission of NO_X is the reduction of NO_X by carbonaceous materials. In the present case, most of the NO_X enters with the hot Spent Shale Combustor gases, used to fluidize the Incinerator bed. By staging the air supply to the Incinerator, it is expected that the required NO_X reduction can be achieved by the carbonaceous materials brought in by the oil shale fines.

Retention of fines, for maximum utilization in the system, is achieved by the use of high efficiency hot cyclones and a system to re-inject the cyclone-collect to the Incinerator bed. The circulating fluidized bed technology has the process advantage of equalizing the temperatures throughout the Incinerator.

H-103A/B Startup Air Heater

The startup air heaters were designed to heat air for the Retorted Shale Combustor V-103 during startup of the retort modules. The design outlet temperature of the heaters is the same as that of the Air Preheater/Shale Cooler V-105.

F-101 Baghouse

The purpose of the Baghouse is to filter shale fines from the incinerator flue gas prior to release to the atmosphere. The baghouse method of filtering was selected in preference to wet scrubbing to avoid the necessity of disposing of aqueous slurry and reheating the flue gas prior to entering the stack. The baghouse was selected in preference to an electrostatic precipitator because of the poor resistivity of shale solids.

4.1 Retorting - Unit 100 (Cont'd)

- Process Description

Process flow diagrams for the retorting unit are shown in Figures 4.1 and 4.2. The following description relates to the flow in each of the six retorting modules.

Raw shale is received via the Crushing Plant conveyor at the Raw Shale Bin, V-101. This bin provides eight hour storage for the retorting unit. Raw shale is pneumatically conveyed with air to the Raw Shale Feed Accumulator, V-102, where shale is separated from air in one stage of cyclones. Air from the accumulator, containing a small amount of shale fines, flows to the Incinerator, H-102.

Raw shale is stripped with inert gas and fed at the design rate of one million pounds per hour through four standpipes, each directed to one quadrant in the top of Retort, R-101. Heat required for retorting at a temperature of 930°F is provided by combusted shale at a temperature of 1240°F, which enters the top of the retort from the Combusted Shale Separator, V-104, through four standpipes, each located adjacent to a raw shale inlet. The solids flow downward in a fluidized state, first through a mixing zone and then through a staged retorting zone in which raw shale is retorted to produce oil and gas vapors and retorted shale. The base of the retort is fluidized by recycle gas preheated in Heater, H-101. Heavy oil containing shale fines, recovered in the Raw Oil Recovery unit, is introduced into the middle section of the retort.

Oil and gas products flow through one stage of cyclones located inside the upper section of the retort. The vapors, together with entrained shale fines, then flow to the Retorted Shale Separator, V-106, containing a second stage of cyclones. Overhead vapors from the separator, containing fine solids not separated by cyclones, flow to Raw Oil Recovery, Unit 200. Retorted shale collected by the cyclones is stripped and then sent to the Incinerator, H-102.

Pressure at the outlet of the Retorted Shale Separator, V-106 is maintained at 15.5 psia. This pressure is sufficient to overcome pressure drop in the Raw Oil Recovery Unit up to the inlet of the raw gas compressor.

Retorted and combusted shale flow from the base of the retort to the Retorted Shale Combustor, V-103. The solids are mixed with preheated air in the engager section of the combustor and then conveyed vertically through the lift pipe section. Combustion of char contained in retorted shale occurs in the engager and lift pipe sections and is completed in the separator section. Supplemental fuel gas is introduced, as required, into the Combustor to complete combustion of char and heating of shale to a temperature of 1240°F. Solids are separated from flue gas in two stages of cyclones contained in the separator section of the combustor.

4.1 Retorting - Unit 100 (cont'd)

Hot combusted shale is returned at a controlled rate of three times the raw shale feed rate to the retort. The remainder of the combusted shale flows to the Air Preheater/Shale Cooler, V-105. Flue gas from the separator, containing combusted shale fines not separated by cyclones, flows to the Incinerator, H-102.

Air for the combustor is compressed in Blower C-101 and enters the base of the Air Preheater/Shale Cooler where it flows upward, fluidizing the shale entering the top of the vessel. Three stages are provided in order to approximate countercurrent flow of solids and air in order to maximize the temperature to which air can be preheated. Heat available in the net combusted shale product, not used for air preheating, is recovered by heating boiler feed water inside tubes located in the fluidized beds. Preheated air at a temperature of 1000°F flows from the top of the Air Preheater/Shale Cooler to the engager section of the Combustor. Cooled shale flows via covered conveyor to Spent Shale Moisturizing Plant, Unit 900.

Incinerator H-102 is provided to burn carbon monoxide contained in the flue gas from the Combustor to a level of about 70 ppmv for release to the atmosphere and to recover heat from raw and retorted shale fines. Hot flue gas from the Incinerator is cooled in the Waste Heater Boiler, B-101, where high pressure superheated steam is generated. Ammonia may be added at an appropriate location in the flue gas flow path to reduce the NO_x level to an outlet concentration of about 100 ppmv. Flue gas passes through the Baghouse, F-101, where shale fines are collected, prior to release to the stack.

Common facilities provided for the six retorting modules include steam turbine driven air compressors and start-up air heaters as shown in Figure 4.1. Three 35 percent compressors are provided, each equipped with intercooler and aftercooler. Two air heaters are provided, each capable of heating the air required for retorted shale combustion in one module to 1000°F during startup of the retorting plant.

- Utility Summary

The normal operating requirements for one train of oil shale retorting are summarized below. The total plant contains six identical operating trains.

Utility	Normal Demand*
Boiler Feed Water, lb/hr	306,700
Steam, lb/hr	
High Pressure @ 600 psig/680°F	(297,500)
Low Pressure @ 50 psig/sat'd	6,178
BFW Blowdown, lb/hr	(9,200)
Steam Condensate, GPM	(259)
Cooling Water (ΔT = 30°F) GPM	7,950
Electric Power, KW	467
Inert Gas, SCFH	37,200
Fuel Gas, MMBTU/Hr (LHV)	221

*Parenthesis denotes production rather than consumption.

- Heat and Material Balance

A summary of the hourly mass flows for all process streams in the retorting unit, keyed to the process flow diagram by stream numbers, is given in Table 4.4. This material balance table represents one of six operating trains for oil shale retorting. The absolute enthalpy of each process stream, expressed in million BTU per hour, is also given in this table.

- Process Equipment Summary

Major process equipment required per train of oil shale retorting, as well as for the total plant, are listed in Table 4.5. The corresponding equipment specifications are provided in this table.

Preliminary arrangement drawings, showing the elevation required for the major retorting vessels, are included in Section 6.0. Sketches of the major process vessels are included in Appendix - A of this report.

TABLE 4.4
HEAT AND MATERIAL BALANCE - UNIT 100

STREAM NO.	1	2	3	4
DESCRIPTION	RAW SHALE	PROCESS AIR	STRIPPING GAS	RECYCLE OIL
Temperature, °F	77	77	100	400
Pressure, psia	10.5	10.5	14.4	19
State	Solid	Gas	Gas	Slurry
Moisture	28,445			
Carbonate CO_2	183,905			4,282
Char				744
Ash	632,354			14,974
Organics	165,296			
N_2		416,485	2,900	
O_2		125,390		
H_2				
CO				
CO_2				
H_2O				
H_2S				
SO_2				
NH_3				
NO_2				
CH_4				
C_2H_4				
C_2H_6				
C_3H_6				
C_3H_8				
C_4H_8				
C_4H_{10}				
C5+				8,571
Total, lb/hr	1,010,000	541,875	2,900	28,571
Enthalpy, MMBTU/HR	2,533.2	0	0.1	158.3

TABLE 4.4 - CONTINUED
HEAT AND MATERIAL BALANCE - UNIT 100

STREAM NO.	5	6	7	8
DESCRIPTION	RECYCLE GAS	PROCESS STEAM	TRANSPORT AIR	VENT AIR
Temperature, °F	120	280	100	81
Pressure, psia	52	31.6	20.8	13.9
State	Gas	Gas	Gas	Gas
Moisture				282
Carbonate CO_2				1,821
Char				
Ash				6,261
Organics				1,636
N_2	294		38,814	41,352
O_2			11,686	11,686
H_2	928			
CO	1,551			
CO_2	8,063	6,100		
H_2O	660			
H_2S	313			
SO_2				
NH_3				
NO_2				
CH_4	3,726			
C_2H_4	928			
C_2H_6	2,592			
C_3H_6	1,535			
C_3H_8	2,182			
C_4H_8	2,216			
C_4H_{10}	839			
C5+	8,429			
Total, lb/hr	34,256	6,100	50,500	63,038
Enthalpy, MMBTU/HR	501.3	0.6	0.3	25.1

TABLE 4.4 - CONTINUED
HEAT AND MATERIAL BALANCE - UNIT 100

STREAM NO.	9	10	11	12
DESCRIPTION	SHALE FEED	FLUIDIZATION GAS	STRIPPING STEAM	STRIPPING STEAM
Temperature, °F	81	800	280	280
Pressure, psia	17	31.6	31.6	31.6
State	Solid	Gas	Gas	Gas
Moisture	28,163			
Carbonate CO_2	182,084			
Char				
Ash	626,093			
Organics	163,660			
N_2	363	294		
O_2				
H_2		928		
CO		1,551		
CO_2		8,063		
H_2O		660	3,700	500
H_2S		313		
SO_2				
NH_3				
NO_2				
CH_4		3,726		
C_2H_4		928		
C_2H_6		2,592		
C_3H_6		1,535		
C_3H_8		2,182		
C_4H_8		2,216		
C_4H_{10}		839		
C5+		8,429		
Total, lb/hr	1,000,363	34,256	3,700	500
Enthalpy, MMBTU/HR	2,508.9	515.6	0.3	0.1

TABLE 4.4 - CONTINUED
HEAT AND MATERIAL BALANCE - UNIT 100

STREAM NO.	13	14	15	16
DESCRIPTION	STRIPPING STEAM	STRIPPING STEAM	RECYCLE COMBUSTED SHALE	RETORT OVERHEAD
Temperature, °F	280	280	1241	930
Pressure, psia	31.6	31.6	35	16.6
State	Gas	Gas	Solid	Gas
Moisture				
Carbonate CO_2			552,747	21,557
Char			6,062	3,744
Ash			2,441,191	75,381
Organics				
N_2				657
O_2				
H_2				1,419
CO				2,369
CO_2				16,170
H_2O	200	1,400		36,324
H_2S				477
SO_2				
NH_3				
NO_2				
CH_4				5,690
C_2H_4				1,419
C_2H_6				3,902
C_3H_6				2,353
C_3H_8				3,163
C_4H_8				3,362
C_4H_{10}				1,166
C5+				132,380
Total, lb/hr	200	1,400	3,000,000	311,533
Enthalpy, MMBTU/HR	0.1	0.1	396.3	3051.0

TABLE 4.4 - CONTINUED
HEAT AND MATERIAL BALANCE - UNIT 100

STREAM NO. DESCRIPTION	17 SPENT SHALE	18 COMBUSTION AIR	19 COMPRESSED AIR	20 PREHEATER AIR
Temperature, °F	930	80	140	140
Pressure, psia	39	30	48	43.5
State	Solid	Gas	Gas	Gas
Moisture				
Carbonate CO_2	714,553			
Char	34,157			
Ash	3,006,876			
Organics				
N_2		280,203	280,203	274,599
O_2		84,360	84,360	82,673
H_2				
CO				
CO_2				
H_2O				
H_2S				
SO_2				
NH_3				
NO_2				
CH_4				
C_2H_4				
C_2H_6				
C_3H_6				
C_3H_8				
C_4H_8				
C_4H_{10}				
C5+				
Total, lb/hr	3,755,557	364,563	364,563	357,272
Enthalpy, MMBTU/HR	519.0	0.3	5.6	5.4

TABLE 4.4 - CONTINUED
HEAT AND MATERIAL BALANCE - UNIT 100

STREAM NO. DESCRIPTION	21 PREHEATER OVERHEAD	22 COMBUSTOR AIR	23 COMBUSTOR OVERHEAD	24 COMBUSTOR BOTTOMS
Temperature, °F	1000	140	1241	1241
Pressure, psia	21	21	13.7	35
State	Gas	Gas	Gas	Solid
Moisture				
Carbonate CO_2			553	127,533
Char			6	1,399
Ash			2,441	564,349
Organics				
N_2	274,599	5,476	281,156	
O_2	82,673	1,649	4,015	
H_2				
CO			4,420	
CO_2			119,219	
H_2O			18,365	
H_2S				
SO_2			123	
NH_3				
NO_2			394	
CH_4				
C_2H_4				
C_2H_6				
C_3H_6				
C_3H_8				
C_3H_8				
C_4H_{10}				
C5+				
Total, lb/hr	357,272	7,125	430,692	693,281
Enthalpy, MMBTU/HR	83.1	0.1	153.2	91.8

TABLE 4.4 - CONTINUED
HEAT AND MATERIAL BALANCE - UNIT 100

STREAM NO.	25	26	27	28
DESCRIPTION	NET COMBUSTED SHALE	STRIPPING STEAM	STRIPPING STEAM OVERHEAD	SECOND SEPARATOR
Temperature, °F	350	280	280	930
Pressure, psia	1.1	31.6	31.6	15.5
State	Solid	Gas	Gas	Gas
Moisture				
Carbonate CO_2	127,533			4,354
Char	1,399			756
Ash	564,349			15,223
Organics				
N_2	128			657
O_2	38			
H_2				1,419
CO				2,370
CO_2				16,170
H_2O		267	33	36,590
H_2S				477
SO_2				
NH_3				
NO_2				
CH_4				5,690
C_2H_4				1,419
C_2H_6				3,902
C_3H_6				2,353
C_3H_8				3,163
C_4H_8				3,362
C_4H_{10}				1,166
C5+				132,380
Total, lb/hr	693,561	267	33	231,451
Enthalpy, MMBTU/HR	- 77.9	0.1	0	2993.9

TABLE 4.4 - CONTINUED
HEAT AND MATERIAL BALANCE - UNIT 100

STREAM NO.	29	30	31	32
DESCRIPTION	SECOND SEPARATOR BOTTOMS	INCINERATOR FUEL	INCINERATOR AIR	INCINERATOR FLUE GAS
Temperature, °F	930	80	80	1800
Pressure, psia	25	13	10.5	10.5
State	Solid	Gas	Gas	Gas
Moisture				
Carbonate CO_2	17,204			3,458
Char	2,988			
Ash	60,157			69,013
Organics				
N_2			97,467	420,593
O_2			29,344	5,973
H_2				
CO				44
CO_2				172,765
H_2O				35,183
H_2S				
SO_2				140
NH_3				
NO_2				97
CH_4		5,800		
C_2H_4				
C_2H_6				
C_3H_6				
C_3H_8				
C_4H_8				
C_4H_{10}				
C5+				
Total, lb/hr	80,349	5,800	126,811	707,266
Enthalpy, MMBTU/HR	43.2	124.8	0.1	343.9

TABLE 4.4 - CONTINUED

HEAT AND MATERIAL BALANCE - UNIT 100

STREAM NO.	33	34	35
DESCRIPTION	STACK GAS	BAGHOUSE FINES	COMBUSTOR FUEL
Temperature, °F	350	350	80
Pressure, psia	10.6	10.5	23
State	Gas	Solid	Gas
Moisture			
Carbonate CO_2	3	3,455	
Char			
Ash	69	68,994	
Organics			
N_2	420,210	29	
O_2	5,973		
H_2			
CO	44		
CO_2	172,653	112	
H_2O	35,107		
H_2S			
SO_2	140		
NH_3			
NO_2	97		
CH_4			2,233
C_2H_4			
C_2H_6			
C_3H_6			
C_3H_8			
C_4H_8			
C_4H_{10}			
C5+			
Total, lb/hr	634,293	72,590	2,233
Enthalpy, MMBTU/HR	43.9	4.3	48.1

TABLE 4.5

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 100	EQUIPMENT LIST	NAME OF UNIT: Fluid Bed Retorting Unit	PAGE 1 OF 2

CLIENT: DOE/METC Oil Shale Plant

LOCATION: Western Colorado

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Per Train	Total Plant	72,000 TPD Oil Shale Retorting Unit Primary Sizing Parameters	REV.
	C-102ABC	Process Air Compressor		-	3	287,000. ACFM Air Flow Each Compressor	
	H-102A/B	Startup Air Heater		-	2	80.8 M BTU/Hr Heat Absorption	
	E-102ABC	C-102 Turbine Exhaust Surface condenser		-	3	30,000. Ft^2 Area Each of 3 Condensers	
	E-103ABC	C-102 Compressor Intercooler		-	3	9.1 M BTU/Hr Heat Exchange Each Cooler	
	E-104ABC	C-102 Compressor Aftercooler		-	3	29.0 M BTU/Hr Heat Exchnage Each Cooler	
	F-101ABC	Air Filter		-	3	70,000. Ft^2 Filter Area Each Filter	
	J-102ABC	Vacuum Ejector for E-102		-	3	200. Lb/Hr Inert Gas Flow Each Ejector	
	P-101A-F	Condensate Pump		1	6	1200. GPM, 100 HP Each Pump	
	ST-102ABC	Steam Turbine for C-102		-	3	24,000. HP Each Turbine.	
	V-108ABC	Condensate Drum		-	3	39,250. Ft^3 Volume Each Drum.	
		12,000 TPD Fluidized Bed Oil Shale Retorting Module (6 required - see Page 2)				12,000. TPD Shale Thruput Each Module.	

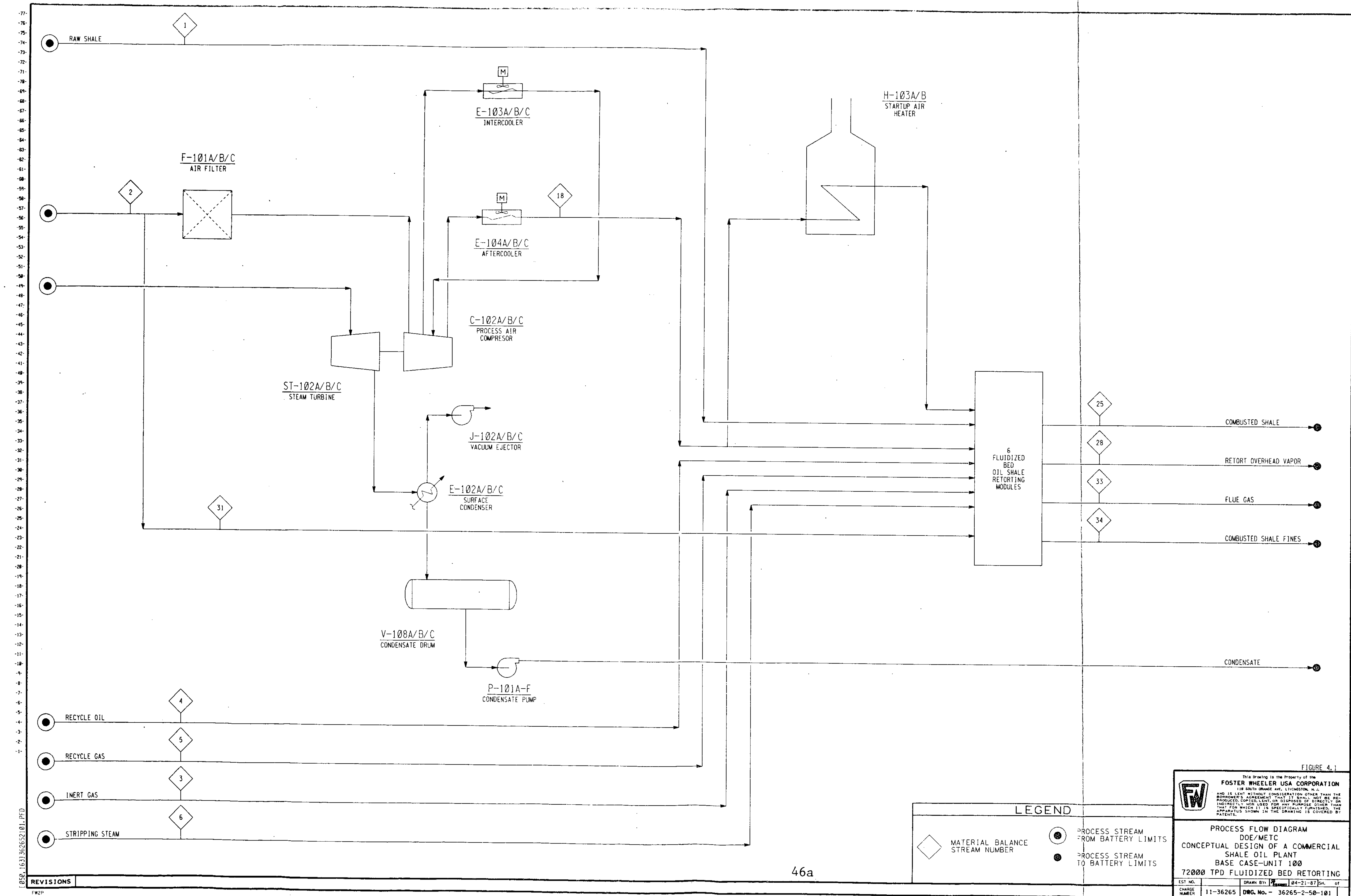

RAW SHALE
1
2
F-101A/B/C
AIR FILTER
E-103A/B/C
INTERCOOLER
M
E-104A/B/C
AFTERCOOLER
18
C-102A/B/C
PROCESS AIR
COMPRESOR
ST-102A/B/C
STEAM TURBINE
J-102A/B/C
VACUUM EJECTOR
E-102A/B/C
SURFACE
CONDENSER
31
V-108A/B/C
CONDENSATE DRUM
P-101A-F
CONDENSATE PUMP
H-103A/B
STARTUP AIR
HEATER
6
FLUIDIZED
BED
OIL SHALE
RETORTING
MODULES
25
COMBUSTED SHALE
28
RETORT OVERHEAD VAPOR
33
FLUE GAS
34
COMBUSTED SHALE FINES
CONDENSATE
4
RECYCLE OIL
5
RECYCLE GAS
3
INERT GAS
6
STRIPPING STEAM
LEGEND
MATERIAL BALANCE
STREAM NUMBER
PROCESS STREAM
FROM BATTERY LIMITS
PROCESS STREAM
TO BATTERY LIMITS
This Drawing is the Property of the
FOSTER WHEELER USA CORPORATION
110 SOUTH ORANGE AVE. LIVINGSTON, N. J.
AND IS LENT WITHOUT CONSIDERATION OTHER THAN THE BORROWER'S AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT, OR DISPOSED OF DIRECTLY OR INDIRECTLY NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED. THE APPARATUS SHOWN IN THE DRAWING IS COVERED BY PATENTS.
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A COMMERCIAL
SHALE OIL PLANT
BASE CASE-UNIT 100
72000 TPD FLUIDIZED BED RETORTING
EST NO.
DRAWN BY:
04-21-87
SH. of
CHARGE NUMBER
11-36265
DWG. No. - 36265-2-50-101
THIS DRAWING SUPERSEDES
CAD Rev No 2
14-MAY-87
REVISIONS
[050,163]36265210I.PFD

FIGURE 4.1

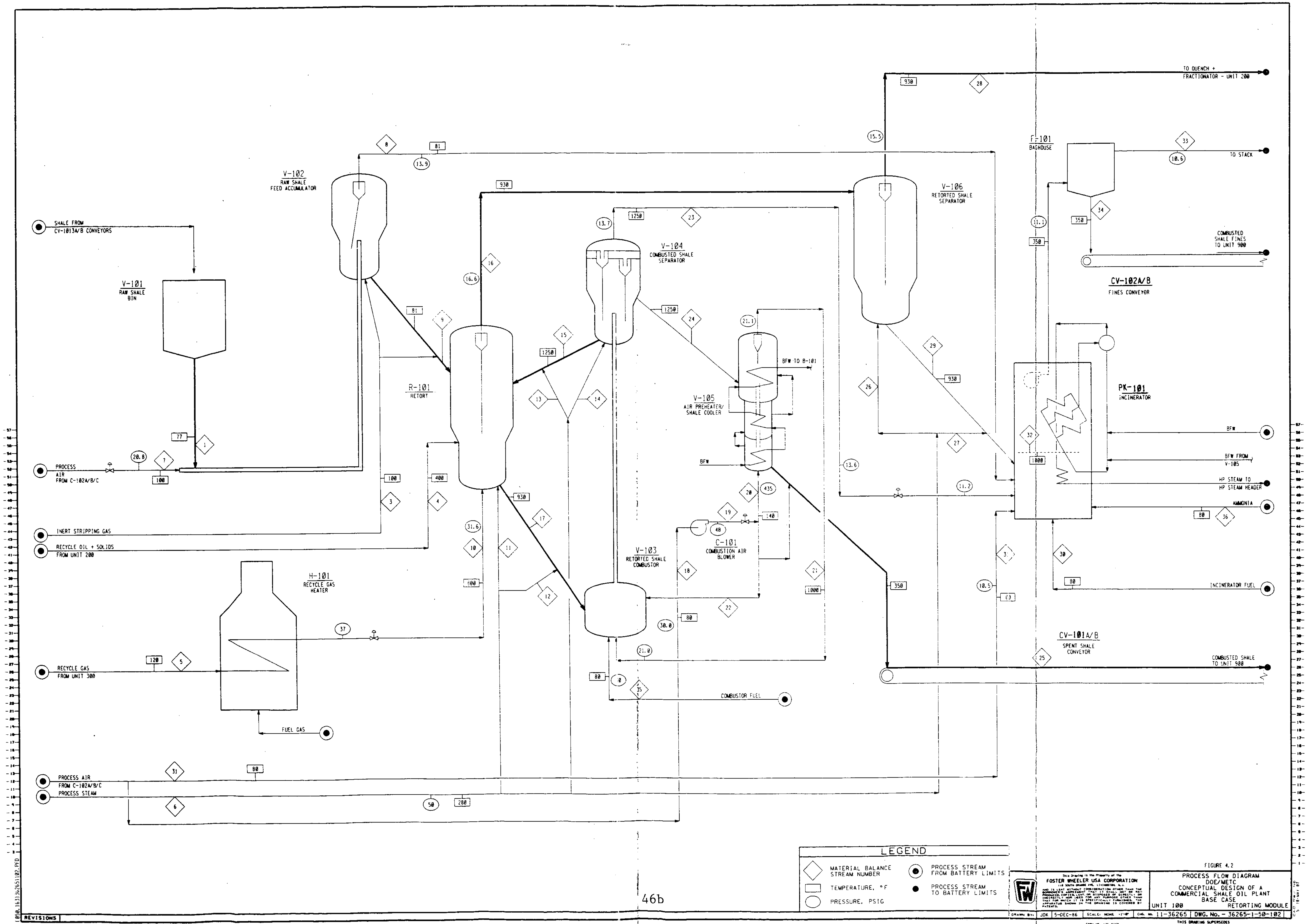

SHALE FROM
CV-1013A/B CONVEYORS
V-101
RAW SHALE BIN
V-102
RAW SHALE FEED ACCUMULATOR
R-101
RETORT
V-104
COMBUSTED SHALE SEPARATOR
V-105
AIR PREHEATER/ SHALE COOLER
BFW TO B-101
V-103
RETORTED SHALE COMBUSTOR
C-101
COMBUSTION AIR BLOWER
V-106
RETORTED SHALE SEPARATOR
F-101
BAGHOUSE
TO QUENCH + FRACTIONATOR - UNIT 200
TO STACK
COMBUSTED SHALE FINES TO UNIT 900
CV-102A/B
FINES CONVEYOR
PK-101
INCINERATOR
BFW
BFW FROM V-105
HP STEAM TO HP STEAM HEADER
AMMONIA
INCINERATOR FUEL
CV-101A/B
SPENT SHALE CONVEYOR
COMBUSTED SHALE TO UNIT 900
PROCESS AIR FROM C-102A/B/C
INERT STRIPPING GAS
RECYCLE OIL + SOLIDS FROM UNIT 200
H-101
RECYCLE GAS HEATER
RECYCLE GAS FROM UNIT 300
FUEL GAS
COMBUSTOR FUEL
PROCESS AIR FROM C-102A/B/C
PROCESS STEAM
LEGEND
MATERIAL BALANCE STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM FROM BATTERY LIMITS
PROCESS STREAM TO BATTERY LIMITS
FIGURE 4.2
This Drawing is the Property of the
FOSTER WHEELER USA CORPORATION
110 SOUTH ORANGE AVE. LIVINGSTON, N.J.
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 100
RETORTING MODULE
DRAWN BY: JDK
5-DEC-86
SCALE: NONE
CHG. No. 11-36265
DWG. No. - 36265-1-50-102
FORM NO. 135-931M
THIS DRAWING SUPERSEDES
THIS DRAWING SUPERSEDED BY
REVISIONS

TABLE 4.5 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 100	EQUIPMENT LIST	NAME OF UNIT Fluid Bed Retorting Module	PAGE 2 OF 2

CLIENT: DOE/METC Oil Shale Plant	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: Western Colorado	DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Per Train	Total Plant	12,000 TPD Oil Shale Retorting Module Primary Sizing Parameter	REV.
	C-101	Combustion Air Compressor		1	6	41,300. ACFM Air Flow.	
	H-101	Recycle Gas Heater		1	6	10.M BTU/HR Heat Absorption.	
	R-101	Fluid Bed Retort		1	6	19,300. Ft^3 T/T Volume.	
	V-101	Raw Shale Bin		1	6	132,000. Ft^3 T/T Volume.	
	V-102	Raw Shale Feed Accumulator		1	6	5,300. Ft^3 T/T Volume.	
	V-103	Retorted Shale Combustor		1	6	18,900. Ft^3 T/T Volume Engager + Lift Pipe.	
	V-104	Combusted Shale Separator		1	6	78,000. Ft^3 T/T Volume.	
	V-105	Air Preheater/Shale Cooler		1	6	54,800. Ft^3 T/T Volume.	
	V-106	Retorted Shale Separator		1	6	11,800. Ft^3 T/T Volume.	
	V-107	Condensate Drum		1	6	4,520. Ft^3 T/T Volume.	
	PK-101	Incinerator/Waste Heat Boiler		1	6	199.5 M BTU/HR Heat Release.	
	PK-102	Flue Gas Baghouse		1	6	92,000. Ft^2 Filter Area.	
	CV-101A/B	Spent Shale Conveyor		2	12	42" Wide Conveyors.	
	CV-102A/B	Fines Conveyor		2	12	24" Wide Conveyors.	
	E-101	C-101 Turbine Exhaust Surface Conden.		1	6	5000. Ft^2 Surface Area.	
	J-101	Vacuum Ejector for E-101		1	6	50. Lb/Hr Inert Gas Flow.	
	E-102	C-102 Turbine Exhaust Surface Conden.			3	5000. Ft^2 Surface Area.	
	P-101A/B	Condensate Pump		2	12	100. GPM, 10. HP Each Pump.	

4.2 Raw Oil Recovery - Unit 200

- **Basis of Design**

The raw oil recovery unit consist of six parallel processing trains. Each train is designed to process the raw product gas from a dedicated 12,000 TPD retorting module in Unit 100. Practical considerations in manifolding and valving multiple retort modules to a single train of raw oil recovery led to the single train design approach in integrating this unit with the retorting operation. In addition, this one-on-one configuration offers advantages from an operational viewpoint, in terms of turn down capability and emergency shutdown of one or more retorting modules. In addition to the retorting raw gas, the raw oil recovery unit is designed to process a rich sponge oil stream delivered from Gas Treating, Unit 300.

Retort product gas enters the raw oil recovery unit at a temperature of 930°F and a pressure of 5 psig. Componential breakdown of the retort product gas is as follows:

Component	Flow, Lb/Hr
H_2	1,419
CO	2,369
CO_2	16,170
H_2O	36,590
H_2S	477
NH_3	-
C_1	5,690
C_2=	1,419
C_2	3,902
C_3=	2,353
C_3	3,164
C_4=	3,362
C_4	1,166
N_2	657
C_5+	132,380
Solids	20,333
Total	231,451

4.2 Raw Oil Recovery - Unit 200 (Cont'd)

The fractionating tower design includes a quench section for rapid heat removal to cool the vapor and help prevent cracking. Heat removal is distributed between the overhead condenser, bottom pumparound cooler and mid-pumparound cooler in order to obtain heavy oil, naphtha, and sponge oil cuts. Limitations on the quantity of heat removed in a particular section is dictated by tray loading.

The quench section of the tower contains shed trays which facilitate the bottom pumparound reflux in washing out any entrained solids. The fractionation section contains sieve trays which have less tendency to foul in a distillation system with potential solids entrainment.

Fractionation of the C_5+ material results in heavy oil, heavy naphtha and sponge oil products which exhibit the following characteristics:

	Heavy Naphtha	Heavy Oil	Sponge Oil
Molecular Wt.	119.9	380	235
Density (°API)	40.8	15.5	25.0
TBP Range (°F)	202-495	650+	495-650
Watson K	11.3	11.5	11.3
Production Rate, BPOD	1,865	4,852	3,144

Part of the sponge oil is sent to Gas Treating, Unit 300, and recycled back as rich sponge oil. The heavy oil, heavy naphtha, and remaining sponge oil are combined to produce a raw oil product at the rate of 8,666 BPOD per train, equivalent to an overall plant rate of 51,996 BPOD. Characteristics of the blended raw oil product are given in Table 4.6.

Rich sponge oil is delivered from Gas Treating, Unit 300, at a rate of 23,213 Lbs/Hr and has the following composition:

Component	Mole %
H_2	1.1
CO	0.3
CO_2	3.3
H_2S	0.1
C_1	1.3
C_2	2.7
C_3	4.5
C_4=	1.2
C_4	4.4
Heavy Naphtha	25.9
Sponge Oil	55.2
Total	100.0

TABLE 4.6

INSPECTIONS ON WHOLE RAW SHALE OIL PRODUCT

Gravity, °API	22.7
Viscosity @ 100°F, SUS	70
@ 210°F, SUS	34
Pour Point (Freezing), °F	80
IBP, °F	202
BS and Water, Vol.%	1.0
Ash, Wt.%	0.32
Salt, LB/100 BBL	250.0
Rams Carbon Residue, Wt.%	2.4
Con. Carbon, Wt.%	3.2
Gross Heating Value, Btu/Lb	19,150
Bromine No.	51
Maleic Anhydride No.	43.9
Hydrocarbons Types, Vol.%	
Paraffins	28.7
Olefins	2.3
Naphthenes	28.5
Aromatics	40.5
Elemental Analysis, Wt.%	
Carbon	83.8
Hydrogen	11.4
Oxygen	1.84
Nitrogen	2.24
Total Sulfur	0.72
Mercaptan Sulfur	111 PPMW
Arsenic	29.5 PPMW
Iron	68.2 PPMW

TBP Distillation*

Vol.%	°F
10	390
30	595
50	722
70	820
90	940

4.2 Raw Oil Recovery - Unit 200 (Cont'd)

Make gas produced in the Raw Oil Recovery Unit has the following composition:

Component	Mole %
H_2	29.04
CO	3.50
CO_2	15.00
H_2O	14.72
H_2S	0.58
NH_3	-
C_1	14.68
C_2=	2.08
C_2	5.49
C_3=	2.29
C_3	3.20
C_4=	2.53
C_4	1.07
N_2	0.96
C_5+	4.86
Total	100.00

- Process Description

The process flow diagram for the raw oil recovery unit is shown in Figure 4.3. Retort product gas from Retorting - Unit 100 enters the bottom quench section of the Fractionator, T-201. Condensed heavy oil is then centrifuged, in PG-201, to reduce the solids content in centrate oil to a maximum 0.5 wt% . The heavy oil/solids slurry is recycled to Retorting, Unit 100. Heavy oil centrate is cooled in the Bottom Pumparound Cooler, E-205, by exchanging heat with boiler feedwater to produce medium pressure steam. Cooled heavy oil is then recycled above the shed tray section of the fractionator. Reflux in the shed section additionally serves to wash entrained shale particles from the vapor.

Quenched vapor flows through the fractionating trays as condensed heavy oil enters the bottom pumparound system to be drawn off as a product. The heavy oil product is then cooled in the Bottoms Cooler, E-206, by the exchange of heat with boiler feedwater. Preheated boiler feedwater is used in the Bottom Pumparound Cooler, E-205, for medium pressure steam production.

Heavy oil is blended with the naphtha and sponge oil products and the skimmed oil from Unit 300. The blended raw oil is further cooled in the Bottoms Aftercooler, E-207, and sent to intermediate storage.

Sponge oil is drawn off the Fractionator, T-201, as mid-pumparound and product streams. The hot oil is cooled in the Mid-Pumparound Cooler, E-202, via the exchange of heat with preheated boiler feedwater from the Sponge Oil Cooler, E-203, to produce low pressure steam. A portion of the sponge oil pumparound is returned to a wash tray, located above the flash zone, and the remainder is returned above the draw tray as mid-circulating reflux. The net sponge oil draw-off exchanges heat with cold boiler feedwater in the Sponge Oil Cooler, E-203. A portion of the sponge oil is then cooled in the Sponge Oil Aftercooler, E-204, and is sent to Gas Treating, Unit 300, while the remainder is blended into the raw oil product. Rich sponge oil from Gas Treating is returned above the mid-pumparound section of the Fractionator, T-201, where absorbed light naphtha and gases are flashed into the overhead system.

Overhead vapor leaving the Fractionator, T-201, is partially condensed in the Overhead Condenser, E-201. The mixed phase is separated in the Fractionator Overhead Drum, D-201, and the vapor product is sent to Gas Treating - Unit 300. Sour water is drawn-off the drum and a portion is recycled through the Overhead Condenser, E-201, as a corrosion retarding wash. The net sour water stream from the overhead separator drum is sent to Sour Water Treating, Unit 700.

A portion of the naphtha from the drum is refluxed back to the Fractionator, T-201, and the remainder is blended with cooled heavy oil and sponge oil products to be sent to intermediate storage.

4.2 Raw Oil Recovery - Unit 200 (Cont'd)

- Utilities Summary

The normal operating utilities requirement for one train of raw oil recovery are summarized below. The overall processing plant contains six identical trains.

Utility	Battery Limits Conditions	Normal Demand*
Boiler Feed Water, lb/hr		
E-202	200 psig/215°F	21,070
E-205	(Nominal)	66,100
		87,170
Steam, lb/hr		
E-202	60 psig/303°F	(20,060)
E-205	150 psig/364°F	(62,950)
Tracing	150 psig/364°F	80
Steam Condensate, lb/hr		(80)
BFW Blowdown, lb/hr		
E-202		(1,010)
E-205		(3,150)
		(4,160)
Cooling Water, GPM	80 pisg/80°F	42
Corrosion Inhibitor, lb/day		55

* Parenthesis denotes production rather than consumption

4.2 Raw Oil Recovery - Unit 200 (Cont'd)

Electric Power	Normal kW	Connected kW
E-201	211	304
E-204	6	9
E-207	13	18
P-201A	138	162
P-201B	-	162
P-202A	128	162
P-202B	-	162
P-203A	18	25
P-203B	-	25
P-204A	10	13
P-204B	-	13
P-205A	12	18
P-205B	-	18
PG-201A	139	162
PG-201B	139	162
PG-201C	139	162
PG-201D	139	162
PG-202	-	
CR-201A	9	13
CR-201B	9	13
CR-201C	9	13
CR-201D	9	13
IF-201A	9	13
IF-201B	9	13
IF-201C	9	13
IF-201D	9	13
Instruments and Lighting	10	10
Total	1174	

- Heat and Material Balance

  A summary of process stream flows for the raw oil recovery unit, keyed to the process flow diagram by stream numbers, is given in Table 4.7. This material balance table represents one of six operating trains for raw oil recovery.

- Process Equipment Summary

  Major process equipment required per train of raw oil recovery as well as for the total plant, are listed in Table 4.8. The corresponding equipment specifications are provided in Table 4.9.

TABLE 4.7

UNIT: Raw Oil Recovery	SECTION NO.: 200	FOSTER WHEELER USA CORPORATION	
CUSTOMER: DOE/METC SHALE OIL PLANT	REF. DWG.:		PG. NO.: 1 of 3
LOCATION: Western Colorado	CONTRACT NO.: 11-36265	DATE 5/11/87	REV. NO.:

STREAM NO. & UNITS		201	202	203	204	205	206
STREAM DESCRIPTION		Retort Vapor From Unit 100	Raw Oil To Storage	Solids To Retorting	Sponge Oil To Raw Gas Treating	Sour Water To Waste Water Treating	Raw Gas To Raw Gas Treating
FLUID STATE		Vapor	Liquid	Slurry	Liquid	Liquid	Vapor
TEMPERATURE (°F)		930	160	590	120	120	120
PRESSURE (PSIG)		5	60	50	185	60	0.3
LIQUID (LB/HR)			115,901	8,571	17,867	30,490	
VAPOR (LB/HR)		211,118					63,432
SOLIDS (LB/HR)		20,333	333	20,000			
TOTAL (LB/HR)		231,451	116,234	28,571	17,867	30,490	63,432
MOLECULAR WEIGHT (SOLIDS FREE)		46					26.1
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016	703.9					705.3
CARBON MONOXIDE	28.01	84.6					85.0
CARBON DIOXIDE	44.01	367.4				7.5	364.3
WATER	18.016	2031.0				1673.7	357.3
HYDROGEN SULFIDE	34.086	14.0				0.1	14.1
AMMONIA	17.034	-					-
METHANE	16.042	354.7					356.4
ETHYLENE	28.052	50.6	0.87		0.13		50.6
ETHANE	30.068	129.8					133.4
PROPYLENE	42.078	55.9					55.7
PROPANE	44.094	71.7					77.7
BUTENE	56.104	59.9					61.4
BUTANE	58.12	20.1					26.0
NITROGEN	28.02	23.4					23.4
HEAVY NAPHTHA	119.9	268.3	202.1				118.0
SPONGE OIL	235.0	100.2	100.2		76.0		
HEAVY OIL	380.0	201.7	179.2	22.5			
TOTAL (LB - MOL/HR)		4537.2	482.37	22.5	76.13	1681.3	2428.6

110 - 18 FOR TABULATION

TABLE 4.7 (Cont'd)

UNIT: Raw Oil Recovery	SECTION NO.: 200	FOSTER WHEELER USA CORPORATION
CUSTOMER: DOE/METC SHALE OIL PLANT	REF. DWG.:	PG. NO.: 2 of 3
LOCATION: Western Colorado	CONTRACT NO.: 11-36265	DATE 5/11/87 REV. NO.:

STREAM NO. & UNITS		207	208	209	210	211	212
STREAM DESCRIPTION		Wash Water	Reflux	Mid Pumparound	Bottom Pumparound	Gross Overhead Vapor	Heavy Naphtha Product
FLUID STATE		Liquid	Liquid	Liquid	Liquid	Vapor	Liquid
TEMPERATURE (°F)		120	120	360	430	270	120
PRESSURE (PSIG)		2.5	2.5	3	4	2.5	85
LIQUID (LB/HR)		15,220	35,958	542,500	473,490		22,325
VAPOR (LB/HR)						152,205	
SOLIDS (LB/HR)					2,315		
TOTAL (LB/HR)		15,220	35,958	542,500	475,805	152,205	22,325
MOLECULAR WEIGHT (SOLIDS FREE)						33.1	
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016						
CARBON MONOXIDE	28.01						
CARBON DIOXIDE	44.01	3.7					
WATER	18.016	835.6					
HYDROGEN SULFIDE	34.086	0.1					
AMMONIA	17.034						
METHANE	16.042						
ETHYLENE	28.052		0.8	4.2	1.9	3993.2	0.5
ETHANE	30.068						
PROPYLENE	42.078						
PROPANE	44.094						
BUTENE	56.104						
BUTANE	58.12						
NITROGEN	28.02						
HEAVY NAPHTHA	119.9		299.6			603.6	186.0
SPONGE OIL	235.0			2307.7			
HEAVY OIL	380.0				1245.8		
TOTAL (LB-MOL/HR)		839.4	300.4	2311.9	1247.7	4596.8	186.5

110 - 18 FOR TABULATION

TABLE 4.7 (Cont'd)

UNIT: Raw Oil Recovery	SECTION NO.: 200 — FOSTER WHEELER USA CORPORATION
CUSTOMER: DOE/METC SHALE OIL PLANT	REF. DWG.: — PG. NO.: 3 of 3
LOCATION: Western Colorado	CONTRACT NO.: 11-36265 — DATE 5/11/87 — REV. NO.:

STREAM NO. & UNITS		213	214	215	216		
STREAM DESCRIPTION		Heavy Oil Product	Rich Sponge Oil From Raw Gas Treating	Sponge Oil Product	Skimmed Oil From Unit 300		
FLUID STATE		Liquid	Liquid	Liquid	Liquid		
TEMPERATURE (°F)		225	156	290	120		
PRESSURE (PSIG)		85	3	85	85		
LIQUID (LB/HR)		68,090	23,213	23,556	1,930		
VAPOR (LB/HR)							
SOLIDS (LB/HR)		333					
TOTAL (LB/HR)		68,423	23,213	23,556	1,930		
MOLECULAR WEIGHT (SOLIDS FREE)							
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016		1.5				
CARBON MONOXIDE	28.01		0.4				
CARBON DIOXIDE	44.01		4.5				
WATER	18.016						
HYDROGEN SULFIDE	34.086		0.2				
AMMONIA	17.034						
METHANE	16.042		1.8				
ETHYLENE	28.052	0.2		0.17			
ETHANE	30.068		3.7				
PROPYLENE	42.078						
PROPANE	44.094		6.2				
BUTENE	56.104		1.6				
BUTANE	58.12		6.0				
NITROGEN	28.02						
HEAVY NAPHTHA	119.9		35.7		16.1		
SPONGE OIL	235.0		76.0	100.2			
HEAVY OIL	380.0	179.2					
TOTAL (LB-MOL/HR)		179.4	137.6	100.37	16.1		

TABLE 4.8

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION
PROCESS PLANTS DIVISION

CONTRACT: 11-36265
SECTION: 200

EQUIPMENT LIST

NAME OF UNIT: Raw Oil Recovery

PAGE 1 OF 2

CLIENT: U.S. DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: WESTERN COLORADO	DATE	2/11/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO TRAIN	TOTAL		REV.
TOWERS	T-201	FRACTIONATOR		1	6		
DRUMS	D-201	FRACTIONATOR OVERHEAD DRUM		1	6		
	D-202	CENTRATE ACCUMULATOR		1	6		
EXCHANGERS	E-201	OVERHEAD CONDENSER		1	6		
	E-202	MID PUMPAROUND COOLER		1	6		
	E-203	SPONGE OIL COOLER		1	6		
	E-204	SPONGE OIL AFTERCOOLER		1	6		
	E-205	BOTTOM PUMPAROUND COOLER		1	6		
	E-206	BOTTOMS COOLER		1	6		
	E-207	BOTTOMS AFTERCOOLER		1	6		
PUMPS	P-201A	CENTRATE PUMP		1	6		
	P-201B	SPARE FOR P-201A		1	6		
	P-202A	MID PUMPAROUND PUMP		1	6		
	P-202B	SPARE FOR P-202A		1	6		
	P-203A	REFLUX PUMP		1	6		
	P-203B	SPARE FOR P-203A		1	6		
	P-204A	SOUR WATER PUMP		1	6		
	P-204B	SPARE FOR P-204A		1	6		
	P-205A	SPONGE OIL BOOSTER PUMP		1	6		
	P-205B	SPARE FOR P-205A		1	6		

TABLE 4.8 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 200	EQUIPMENT LIST	NAME OF UNIT: Raw Oil Recovery	PAGE 2 OF 2

CLIENT: U.S. DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: WESTERN COLORADO	DATE	2/11/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO TRAIN	TOTAL		REV.
PACKAGE ITEMS	PG-201A	CENTRIFUGE PACKAGE		1	6		
	PG-201B	CENTRIFUGE PACKAGE		1	6		
	PG-201C	CENTRIFUGE PACKAGE		1	6		
	PG-201D	CENTRIFUGE PACKAGE		1	6		
	PG-202	CORROSION INHIBITOR PACKAGE		1	6		
FEEDERS	CR-201A	SCREW FEEDER		1	6		
	CR-201B	SCREW FEEDER		1	6		
	CR-201C	SCREW FEEDER		1	6		
	CR-201D	SCREW FEEDER		1	6		
	IF-201A	SOLID CAKE INJECTION FEEDER		1	6		
	IF-201B	SOLID CAKE INJECTION FEEDER		1	6		
	IF-201C	SOLID CAKE INJECTION FEEDER		1	6		
	IF-201D	SOLID CAKE INJECTION FEEDER		1	6		

TABLE 4.9

UNIT 200 - RAW OIL RECOVERY EQUIPMENT SPECIFICATIONS

Towers

Item No.	Description	Dia/Height	Design Pressure	Internals	Material of Construction
T-201	Fractionator	12'-6"/71'-6"	50 Psig	15-Sieve Trays 9-Shed Trays	Shell C.S. Btm-32 ft. 410 S Clad 1/8" Sieve Trays C.S. Shed Trays 410 S

Drums

Item No.	Description	Position	Dia/Height or Length	Design Pressure Psig	Material of Construction
D-201	Fractionator Overhead Drum	Vert.	10'-0"/12'-6"	50	C.S.
D-202	Centrate Accumulator	Horiz.	7'-6"/26'-0"	50	C.S. 410 S Clad 1/8"

Exchangers

Item No.	Description	TEMA Type	Area Ft^2	Duty MMBTU/HR	Material of Construction Shell/Tube
E-201	Overhead Condenser	Air Cooler (Forced Draft)	20,110	49.06	316 SS
E-202	Mid Pump-around Cooler	Shell/Tube (BKU)	2,330	18.68	C.S./C.S.
E-203	Sponge Oil Cooler	Shell/Tube (AES)	254	1.74	C.S./C.S.
E-204	Sponge Oil Aftercooler	Air Cooler (Forced Draft)	312	1.55	C.S.
E-205	Bottom Pump-around Cooler	Shell/Tube (BKU)	4,705	57.39	C.S./5Cr-1/2 Mo
E-206	Bottoms Cooler	Shell/Tube (AES)	1,655	7.83	C.S./C.S.
E-207	Bottoms After-cooler	Air Cooler (Forced Draft)	690	3.48	C.S.

TABLE 4.9 (Cont'd)

UNIT 200 - RAW OIL RECOVERY EQUIPMENT SPECIFICATIONS

Pumps

Item No.	Description	Type	Flow GPM	Discharge Pressure Psig	Material of Construction
P-201A	Centrate Pump and Spare	Centrif.	1780	146	Case and Impeller 12 Cr
P-202A/B	Mid Pumparound Pump and Spare	Centrif.	1895	143	Case-C.S. Imp.-C.I.
P-203A/B	Reflux Pump and Spare	Centrif.	176	115	Case-C.S. Imp.-Ni Resist
P-204A/B	Sour Water Pump and Spare	Centrif.	111	99	Case-C.S. Imp. Ni Resist
P-205A/B	Sponge Oil Booster Pump and Spare	Centrif.	50	223	Case-C.S. Imp. - Ni Resist

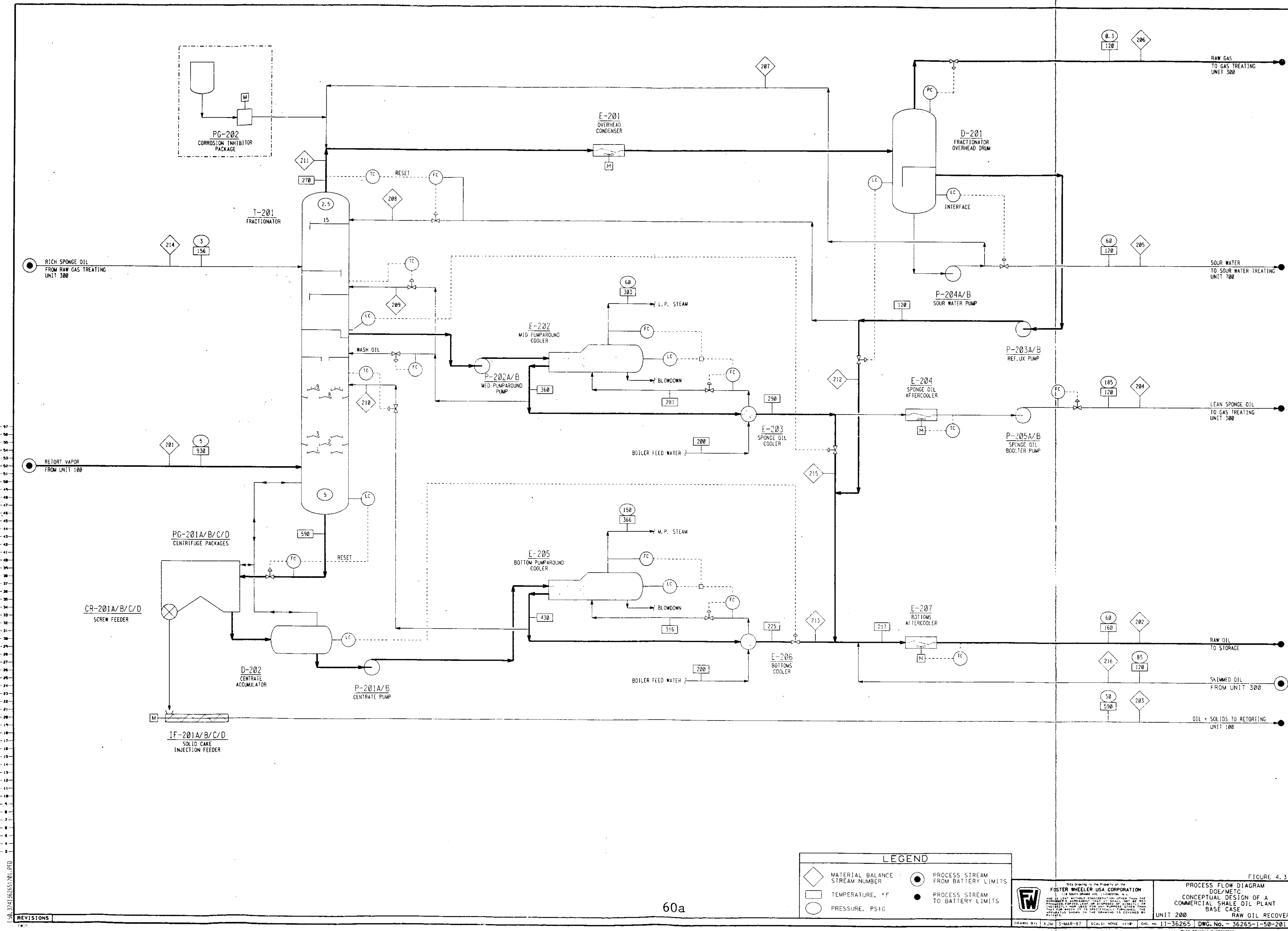
Package Items

Item No.	Description	Unit Capacity GPM	Operating Temperature °F	Operating Pressure Psig	Motor HP	Material of Construction
PG-201A/B/C/D	Centrifuge Packages and Spare	510	590	5	200	304L S.S.
PG-202	Corrosion Inhibitor Package	0-30	--- (polysulfide Injection) (vessel and pump) ---------			

Feeders

Item No.	Description	Unit Capacity GPM	Percent Solids	Operating Temperature °F	Motor HP	Material of Construction
CR-201A/B/C/D	Screw Feeders and Spare	14	70%	590	15	304L S.S.
IF-201A/B/C/D	Solid Cake Injection Feeders and Spare	14	70%	590	15	304L S.S.

Note: Item IF-201A/B/C/D inlet pressure = 0 psig and outlet pressure = 50 psig


PG-202
CORROSION INHIBITOR PACKAGE
E-201
OVERHEAD CONDENSER
D-201
FRACTIONATOR OVERHEAD DRUM
T-201
FRACTIONATOR
RESET
INTERFACE
RAW GAS
TO GAS TREATING UNIT 300
RICH SPONGE OIL
FROM RAW GAS TREATING UNIT 300
SOUR WATER
TO SOUR WATER TREATING UNIT 700
P-204A/B
SOUR WATER PUMP
L.P. STEAM
E-202
MID PUMPAROUND COOLER
WASH OIL
BLOWDOWN
P-202A/B
MID PUMPAROUND PUMP
P-203A/B
REFLUX PUMP
E-204
SPONGE OIL AFTERCOOLER
LEAN SPONGE OIL
TO GAS TREATING UNIT 300
E-203
SPONGE OIL COOLER
P-205A/B
SPONGE OIL BOOSTER PUMP
BOILER FEED WATER
RETORT VAPOR
FROM UNIT 100
PG-201A/B/C/D
CENTRIFUGE PACKAGES
M.P. STEAM
E-205
BOTTOM PUMPAROUND COOLER
CR-201A/B/C/D
SCREW FEEDER
E-207
BOTTOMS AFTERCOOLER
RAW OIL
TO STORAGE
D-202
CENTRATE ACCUMULATOR
P-201A/B
CENTRATE PUMP
E-206
BOTTOMS COOLER
SKIMMED OIL
FROM UNIT 300
OIL + SOLIDS TO RETORTING
UNIT 100
IF-201A/B/C/D
SOLID CAKE INJECTION FEEDER
LEGEND
MATERIAL BALANCE STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM FROM BATTERY LIMITS
PROCESS STREAM TO BATTERY LIMITS
REVISIONS
FOSTER WHEELER USA CORPORATION
FIGURE 4.3
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 200
RAW OIL RECOVERY
3-MAR-87
DWG. No. - 36265-1-50-201

4.3 Gas Treating - Unit 300

- Basis of Design

The processing plant contains two parallel trains of gas treating. Each train is designed to treat 66.4 MMSCFD of raw make gas, representing the total produced in three trains of Raw Oil Recovery, Unit 200. Raw gas, having the following composition, is delivered to gas treating at 120°F and essentially atmospheric pressure:

Components	Volume %
H_2	29.04
CO	3.50
CO_2	15.00
H_2O	14.72
H_2S	0.58
NH_3	-
C_1	14.68
$C_2{=}$	2.08
C_2	5.49
$C_3{=}$	2.29
C_3	3.20
$C_4{=}$	2.53
C_4	1.07
N_2	0.96
C_5+	4.86
Total	100.00
Molecular Weight	26.12

After initial compression, a portion of the raw gas feed is recycled to Retorting, Unit 100, for use as fluidization gas. The balance of the raw gas treating unit is designed to remove C_5+ components and ammonia from the net gas stream. This unit also processes an off-gas stream from Unit 400 for ammonia removal. Sponge oil absorption on the net gas stream is designed to remove more than 95% of the C_5+ components. Ammonia contained in the treated gas is reduced to a level of 100 ppm via water scrubbing.

4.3 Gas Treating - Unit 300 (Cont'd)

Prior to sponge oil absorption and ammonia removal, the gas is compressed to about 120 psig. This pressure level is set by the required pressure drop through downstream processing units.

Treated gas is delivered at 120°F and 100 psig for subsequent sulfur recovery in Unit 800. The composition and flow rate of treated gas from a single processing train is as follows:

Flow, MMSCFD	23.32
Components	**Volume %**
H_2	44.95
CO	3.72
CO_2	14.86
H_2O	1.47
H_2S	0.89
NH_3	0.01
C_1	16.01
$C_2^=$	2.24
C_2	5.71
$C_3^=$	2.47
C_3	2.87
$C_4^=$	2.54
C_4	0.50
N_2	1.65
C_5+	0.11
Total	100.00
Molecular Weight	18.6

4.3 Gas Treating - Unit 300 (Cont'd)

- Process Description

The process flow diagram for the raw gas treating unit is shown in Figure 4.4.

Raw make gas is delivered from Raw Oil Recovery, Unit 200, at 120°F and 0.3 psig. The feed gas flows through the Feed Knockout Drum, D-301, and is compressed to 50 psig via the First and Second Stage Compressors, C-301 and C-302.

After passing through the Second Stage Knockout Drum, D-303, the cooled product gas is split so that 62% is diverted as recycle gas to Retorting, Unit 100. The net gas stream is then compressed to 121 psig via the Third Stage Compressor, C-303, cooled to 120°F in the Aftercooler, E-303, and separated from condensate in the Third Stage Knockout Drum, D-304.

Compressed gas from the knockout drum is delivered to the Sponge Oil Absorber, T-301, at 120°F and 115 psig. The Sponge Oil Absorber, T-301, is designed to remove more than 95% of the C_5+ hydrocarbons from the gas stream to minimize carryover of heavy hydrocarbons to the sulfur recovery plant. The gas enters the bottom section of the Sponge Oil Absorber and is contacted counter-currently with lean sponge oil supplied from Raw Oil Recovery, Unit 200. Rich sponge oil is withdrawn from the bottom of the tower at 156°F and is returned to the raw oil recovery tower in Unit 200. Sponged gas leaves the top of the absorber at 131°F and is cooled to 120°F in the Absorber Gas Cooler, E-304. After separating any hydrocarbon and water condensate in the Absorber Gas Separator, D-305, the gas is combined with the off-gas from Unit 400 and sent to the Ammonia Scrubber, T-302.

The combined gas enters the bottom of the Ammonia Scrubber, T-302, at 120°F and 107 psig. The gas is scrubbed counter-currently in a packed section with stripped sour water introduced at the top of the tower. The Ammonia Scrubber, T-302, is designed to reduce the ammonia content to 100 ppmv. Aqueous ammonia is withdrawn from the bottom of the scrubber and is sent to Sour Water Treating, Unit 700. Treated gas from the top of the scrubber is delivered to Sulfur Recovery, Unit 800, at 120°F and 100 psig.

Condensate streams from the gas separator and knockout drums are collected in the Settling Drum, D-306. The hydrocarbon layer is skimmed off and sent to Raw Oil Recovery, Unit 200, while the aqueous phase is sent to Sour Water Treating, Unit 700. Flashed gas from the Settling Drum, D-306, is recycled to the raw gas feed stream from Unit 200.

4.3 Gas Treating - Unit 300 (Cont'd)

- Utilities Summary

Presented below are the estimated normal utilities and chemical requirements for the Raw Gas Treating Unit. The summary corresponds to one train processing 66.4 MMSCFD of raw gas. The overall plant will contain two identical trains of this capacity.

Electric Power	Normal KW	Connected KW
E-301	60	70
E-302	76	101
E-303	25	35
E-304	4	4
P-301A	1	3
P-301B	-	3
P-302A	4	7
P-302B	-	7
P-303A	3	4
P-303B	-	4
C-301A	3743	3926
C-301B	-	3926
C-302A	3573	3926
C-302B	-	3926
C-303A	998	1192
C-303B	-	1192
Instruments and Lighting	10	10
Total	8497	

Cooling Water (80 psig/80°F)

Service	Consumption, GPM
Pumps Cooling (@ 30°FΔT)	5
Compressor lube and seal oil cooling (@ 30°FΔT)	95
Total	100

4.3 Gas Treating - Unit 300 (Cont'd)

- Heat and Material Balance

A summary of process stream flows for the gas treating unit, keyed to the process flow diagram by stream numbers, is given in Table 4.10. This material balance table represents one of two operating trains for gas treating.

- Process Equipment Summary

Major process equipment required per train of gas treating, as well as for the total plant, are listed in Table 4.11. The corresponding equipment specifications are provided in Table 4.12.

UNIT: Gas Treating | SECTION NO.: 300 | **FOSTER WHEELER USA CORPORATION**

CUSTOMER: DOE/METC SHALE OIL PLANT | REF. DWG.: | PG. NO.: 1 of 3

LOCATION: Western Colorado | CONTRACT NO.: 11-36265 | DATE 5/12/87 | REV. NO.: '

STREAM NO. & UNITS		301	302	303	304	305	306
STREAM DESCRIPTION		Make Gas From Raw Oil Recovery	First Stage K.O. Drum Vapor	Second Stage K.O. Drum Vapor	Recycle Gas	Feed To Third Stage Compressor	Third Stage K.O. Drum Vapor
FLUID STATE		Vapor	Vapor	Vapor	Vapor	Vapor	Vapor
TEMPERATURE (°F)		120	120	120	120	120	120
PRESSURE (PSIG)		0.3	13.6	50	50	50	115
LIQUID (LB/HR)							
VAPOR (LB/HR)		190,296	178,211	169,865	105,601	64,264	62,161
SOLIDS (LB/HR)							
TOTAL (LB/HR)		190,296	178,211	169,865	105,601	64,264	62,161
MOLECULAR WEIGHT (SOLIDS FREE)		26.1	26.7	26.7	26.7	26.7	26.4
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016	2115.9	2115.9	2115.9	1315.4	800.5	800.5
CARBON MONOXIDE	28.01	255.0	255.0	255.0	158.5	96.5	96.5
CARBON DIOXIDE	44.01	1092.9	1092.9	1092.9	679.4	413.5	413.5
WATER	18.016	1071.9	467.8	177.5	110.3	67.2	31.7
HYDROGEN SULFIDE	34.086	42.3	42.3	42.3	26.3	16.0	16.0
AMMONIA	17.034	-	-	-	-	-	-
METHANE	16.042	1069.2	1069.2	1069.2	664.7	404.5	404.5
ETHYLENE	28.052	151.8	151.8	151.8	94.4	57.4	57.4
ETHANE	30.068	400.2	400.2	400.2	248.8	151.4	151.4
PROPYLENE	42.078	167.1	167.1	167.1	103.9	63.2	63.2
PROPANE	44.094	233.1	233.1	233.1	144.9	88.2	88.2
BUTENE	56.104	184.2	184.2	184.2	114.5	69.7	69.7
BUTANE	58.12	78.0	78.0	78.0	48.5	29.5	29.5
NITROGEN	28.02	70.2	70.2	70.2	43.7	26.5	26.5
HEAVY NAPHTHA	119.9	354.0	344.0	318.0	197.7	120.3	108.1
SPONGE OIL	235.0						
TOTAL (LB-MOL/HR)		7285.8	6671.7	6355.4	3951.0	2404.4	2356.7

TABLE 4.10 (Cont'd)

UNIT: Gas Treating		SECTION NO.: 300		FOSTER WHEELER USA CORPORATION			
CUSTOMER: DOE/METC SHALE OIL PLANT		REF. DWG.:				PG. NO.: 2 of 3	
LOCATION: Western Colorado		CONTRACT NO.: 11-36265		DATE May 12, 1987		REV. NO.:	
STREAM NO. & UNITS		307	308	309	310	311	312
STREAM DESCRIPTION		Condensate From K.O. Drums	Overhead From Sponge Absorber	Lean Sponge Oil From Raw Oil REcovery	Rich Sponge Oil To Raw Oil Recovery	Treated Gas To Sulfur Recovery	Stripped Water
FLUID STATE		Liquid	Vapor	Liquid	Liquid	Vapor	Liquid
TEMPERATURE (°F)		120	131	120	156	120	120
PRESSURE (PSIG)		15	110	115	80	105	135
LIQUID (LB/HR)		22,534		53,597	69,638		30,200
VAPOR (LB/HR)			46,120			47,712	
SOLIDS (LB/HR)							
TOTAL (LB/HR)		22,534	46,120	53,597	69,638	47,712	30,200
MOLECULAR WEIGHT (SOLIDS FREE)			21.2			18.6	
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016		796.0		4.5	1150.7	
CARBON MONOXIDE	28.01		95.3		1.2	95.3	
CARBON DIOXIDE	44.01		400.0		13.5	380.6	
WATER	18.016	929.9	31.7		-	37.5	1676.2
HYDROGEN SULFIDE	34.086		15.4		0.6	22.8	
AMMONIA	17.034		-				
METHANE	16.042		399.1		5.4	0.2	
ETHYLENE	28.052		57.4			409.9	
ETHANE	30.068		140.3		11.1	57.4	
						146.1	
PROPYLENE	42.078		63.2			63.2	
PROPANE	44.094		69.6		18.6	73.5	
BUTENE	56.104		65.1	0.2	4.8	65.1	
BUTANE	58.12		11.6	0.1	18.0	12.9	
NITROGEN	28.02		26.5			42.3	
HEAVY NAPHTHA	119.9	48.2	1.0		107.1	1.0	
SPONGE OIL	235.0			228.0	228.0		
HYD. HEAVY NAPHTHA	174.9					1.9	
TOTAL (LB-MOL/HR)		978.1	217[illegible].2	228.3	412.8	2560.4	1676.2

TABLE 4.10 (Cont'd)

UNIT: Gas Treating	SECTION NO.: 300	FOSTER WHEELER USA CORPORATION
CUSTOMER: DOE/METC SHALE OIL PLANT	REF. DWG.:	PG. NO.: 3 of 3
LOCATION: Western Colorado	CONTRACT NO.: 11-36265 DATE 5/12/87	REV. NO.:

STREAM NO. & UNITS		313	314	315	316	317	
STREAM DESCRIPTION		Sour Water From Ammonia Scrubber	Sour Water To Sour Water Treating	Skimmed Oil To Unit 200	Vent Gas From Settling Drum	Off-Gas From Section 300	
FLUID STATE		Liquid	Liquid	Liquid	Vapor	Vapor	
TEMPERATURE (°F)		120	120	120	120	134	
PRESSURE (PSIG)		65	65	85	1	120	
LIQUID (LB/HR)		31,586	16,755	5,779			
VAPOR (LB/HR)						2,978	
SOLIDS (LB/HR)							
TOTAL (LB/HR)		31,586	16,755	5,779		2,978	
MOLECULAR WEIGHT (SOLIDS FREE)					44.5	6.8	
COMPONENTS (LB-MOL/HR)	MW				Approximately 3 to 4 Mol/Hr (Mostly C_2, C_3, and C_4's)		
HYDROGEN	2.016					354.7	
CARBON MONOXIDE	28.01						
CARBON DIOXIDE	44.01	19.4	Trace				
WATER	18.016	1674.6	929.9			4.2	
HYDROGEN SULFIDE	34.086	0.9	Trace			8.3	
AMMONIA	17.034	31.2				31.4	
METHANE	16.042					10.8	
ETHYLENE	28.052						
ETHANE	30.068					5.8	
PROPYLENE	42.078						
PROPANE	44.094					3.9	
BUTENE	56.104						
BUTANE	58.12					1.3	
NITROGEN	28.02					15.8	
HEAVY NAPHTHA	119.9			48.2			
SPONGE OIL	235.0						
HYD. HEAVY NAPHTHA	174.9					1.9	
TOTAL (LB-MOL/HR)		1726.1	929.9	48.2		438.1	

TABLE 4.11

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION
PROCESS PLANTS DIVISION

CONTRACT: 11-36265
SECTION: 300

EQUIPMENT LIST

NAME OF UNIT: Gas Treating

PAGE 1 OF 2

CLIENT: U.S. DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: WESTERN COLORADO	DATE	2/11/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO TRAIN	TOTAL		REV.
TOWERS	T-301	SPONGE OIL ABSORBER		1	2		
	T-302	AMMONIA OIL SCRUBBER		1	2		
DRUMS	D-301	FEED KNOCKOUT DRUM		1	2		
	D-302	FIRST STAGE KNOCKOUT DRUM		1	2		
	D-303	SECOND STAGE KNOCKOUT DRUM		1	2		
	D-304	THIRD STAGE KNOCKOUT DRUM		1	2		
	D-305	ABSORBER GAS SEPARATOR		1	2		
	D-306	SETTLING DRUM		1	2		
EXCHANGERS	E-301	FIRST STAGE AFTERCOOLER		1	2		
	E-302	SECOND STAGE AFTERCOOLER		1	2		
	E-303	THIRD STAGE AFTERCOOLER		1	2		
	E-304	ABSORBER GAS COOLER		1	2		
COMPRESSORS	C-301A	FIRST STAGE COMPRESSOR		1	2		
	C-301B	SPARE FOR C-301A		1	2		
	C-302A	SECOND STAGE COMPRESSOR		1	2		
	C-302B	SPARE FOR C-302A		1	2		
	C-303A	THIRD STAGE COMPRESSOR		1	2		
	C-303B	SPARE FOR C-303A		1	2		

TABLE 4.11 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 300	EQUIPMENT LIST	NAME OF UNIT: Gas Treating	PAGE 2 OF 2

CLIENT: U.S. DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: WESTERN COLORADO	DATE	2/11/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO. TRAIN	TOTAL		REV.
PUMPS	P-301A	FEED KNOCKOUT DRUM PUMP		1	2		
	P-301B	SPARE FOR P-301A		1	2		
	P-302A	SOUR WATERPUMP		1	2		
	P-302B	SPARE FOR P-302A		1	2		
	P-303A	SKIMMED OIL PUMP		1	2		
	P-303B	SPARE FOR P-303A		1	2		

TABLE 4.12

UNIT 300 - GAS TREATING EQUIPMENT SPECIFICATIONS

Towers

Item No.	Description	Dia/Height or Length	Design Pressure	Internals	Material of Construction Shell/Tube
T-301	Sponge Oil Absorber	4'-6"/65'-0"	140 psig	25-Valve Trays	Shell-C.S. Trays-410S
T-302	Ammonia Scrubber	3'-6"/24'-0"	135 psig	$125 ft^3$ packing 1 inch pall rings	Shell-C.S. packing: metal pall rings

Drums

Item No.	Description	Position	Dia/Height or Length	Design Pressure Psig	Material of Construction
D-301	Feed Knockout Drum	Vert.	13'-6:/12'-0"	30	C.S. (Stress Relieved)
D-302	First Stage Knockout Drum	Vert.	10'-6"/11'-0"	45	C.S. (Stress Relieved)
D-303	Second Stage Knockout Drum	Vert.	8'-0"/11'-0"	80	C.S. (Stress Relieved)
D-304	Third Stage Knockout Drum	Vert.	4'-6"/11'-0"	146	C.S. (Stress Relieved)
D-305	Absorber Gas Separator	Vert.	4'-0"/10'-0"	135	C.S.
D-306	Settling Drum	Horiz.	4'-6"/10'-0"	50	C.S.

TABLE 4.12 (Cont'd)

UNIT 300 - GAS TREATING EQUIPMENT SPECIFICATIONS

Exchangers

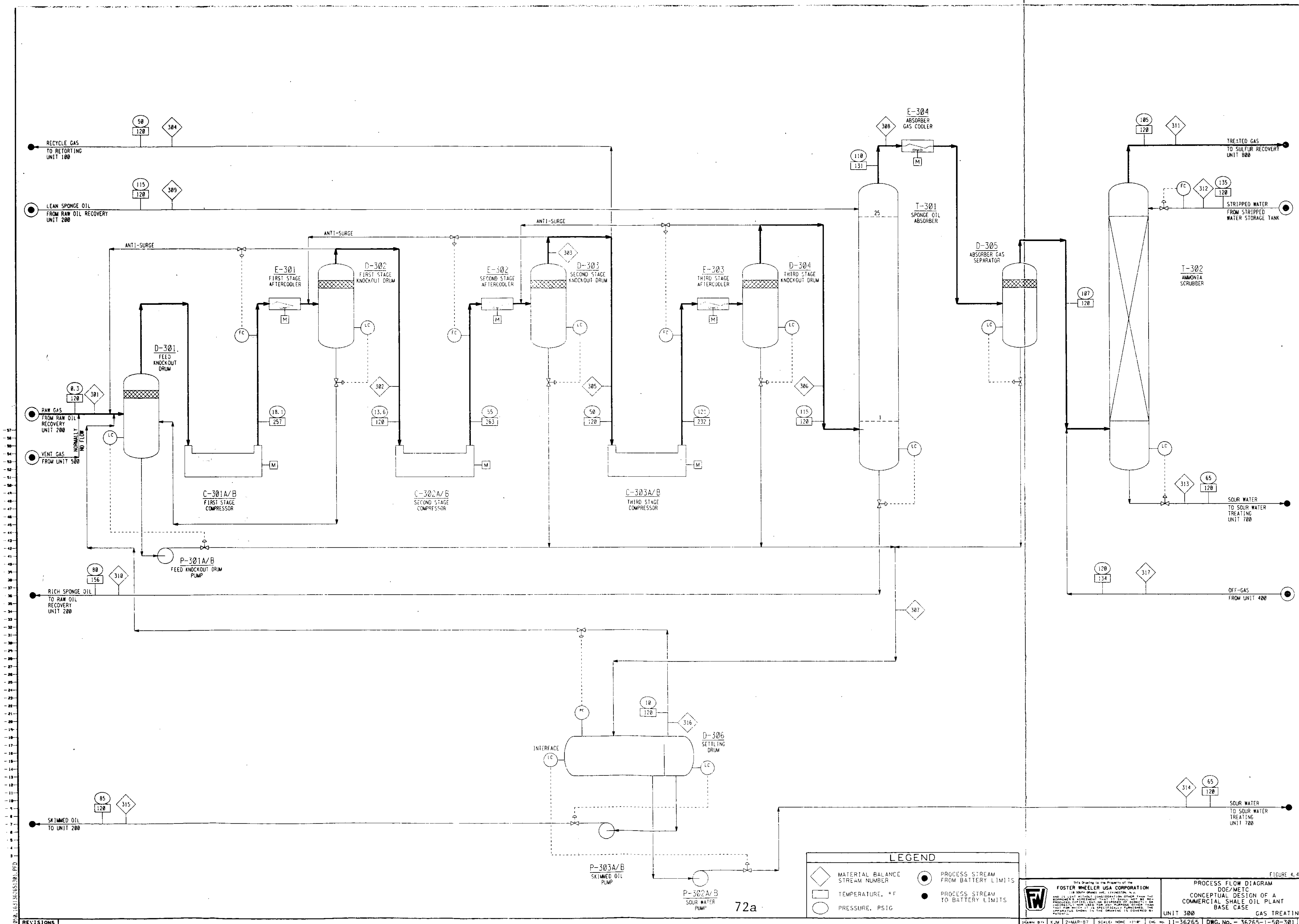
Item No.	Description	Type	Area Ft^2	Duty 10^6BTU/HR	Material of Construction Shell/Tube
E-301	First Stage Aftercooler	Air Cooler (Forced Draft)	6,203	22.81	Seamless C.S. Tubes (Heavy Gauge)
E-302	Second Stage Aftercooler	Air Cooler (Forced Draft)	4,622	17.02	Seamless C.S. Tubes (Heavy Gauge)
E-303	Third Stage Aftercooler	Air Cooler (Forced Draft)	1,176	4.2	Seamless C.S. Tubes (Heavy Gauge)
E-304	Absorber Gas Cooler	Air Cooler (Forced Draft)	110	0.2	C.S.

Compressors

Item No.	Description	Type	Flow GPM	Pressure, psig Inlet/Outlet	Material of Construction
C-301A/B	First Stage Compressor and Spare	Centrif.	70,013	0.3/18.6	C.S. Case 17-4 PH Impeller
C-302A/B	Second Stage Compressor and Spare	Centrif.	28,837	13.6/55	C.S. Case 17-4 PH Impeller
C-303A/B	Third Stage Compressor	Centrif.	4,135	50/121	C.S.

Pumps

Item No.	Description	Type	Flow GPM	Discharge Pressure Psig	Material of Construction
P-301A/B	Feed Knockout Drum Pump and Spare	Centrif.	30	39	316 SS
P-302A/B	Sour Water Pump and Spare	Centrif.	41	102	316 SS
P-303A/B	Skimmed Oil Pump and Spare	Centrif.	18	120	C.S. Case C.I. Impeller


RECYCLE GAS TO RETORTING UNIT 100
LEAN SPONGE OIL FROM RAW OIL RECOVERY UNIT 200
ANTI-SURGE
E-301 FIRST STAGE AFTERCOOLER
D-302 FIRST STAGE KNOCKOUT DRUM
E-302 SECOND STAGE AFTERCOOLER
D-303 SECOND STAGE KNOCKOUT DRUM
E-303 THIRD STAGE AFTERCOOLER
D-304 THIRD STAGE KNOCKOUT DRUM
D-301 FEED KNOCKOUT DRUM
RAW GAS FROM RAW OIL RECOVERY UNIT 200
VENT GAS FROM UNIT 500
NORMALLY NO FLOW
C-301A/B FIRST STAGE COMPRESSOR
C-302A/B SECOND STAGE COMPRESSOR
C-303A/B THIRD STAGE COMPRESSOR
P-301A/B FEED KNOCKOUT DRUM PUMP
RICH SPONGE OIL TO RAW OIL RECOVERY UNIT 200
E-304 ABSORBER GAS COOLER
T-301 SPONGE OIL ABSORBER
D-305 ABSORBER GAS SEPARATOR
T-302 AMMONIA SCRUBBER
TREATED GAS TO SULFUR RECOVERY UNIT 800
STRIPPED WATER FROM STRIPPED WATER STORAGE TANK
SOUR WATER TO SOUR WATER TREATING UNIT 700
OFF-GAS FROM UNIT 400
D-306 SETTLING DRUM
INTERFACE
SKIMMED OIL TO UNIT 200
P-303A/B SKIMMED OIL PUMP
P-302A/B SOUR WATER PUMP
LEGEND
MATERIAL BALANCE STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM FROM BATTERY LIMITS
PROCESS STREAM TO BATTERY LIMITS
FIGURE 4.4
This Drawing is the Property of the FOSTER WHEELER USA CORPORATION
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 300 GAS TREATING
DRAWN BY: KJM 2-MAR-87 SCALE: NONE
CHG. No. 11-36265 DWG. No. - 36265-1-50-301
THIS DRAWING SUPERSEDES
THIS DRAWING SUPERSEDED BY
REVISIONS

4.4 Raw Oil Hydrotreating - Unit 400

- Basis of Design

The hydrotreating unit contains two parallel processing trains, each designed to process 26,000 BPOD of whole raw shale oil and produce a hydrotreated oil product having a maximum nitrogen content of 1000 ppmw. The design is based on preliminary process information, supplied by Unocal, on product yield distribution, hydrogen consumption, and catalyst usage. Foster Wheeler developed the process flow scheme and equipment specifications, based on in-house information typical of refinery hydroprocessing technology.

The raw shale oil feed, as produced in Raw Oil Recovery, Unit 200, has the following inspection:

Gravity, ^{o}API	22.7
Sulfur, ppm	7,200
Oxygen, ppm	18,400
Nitrogen, ppm	22,400
Arsenic, ppm	$<$ 30
Iron, ppm	$<$ 70

Design of the hydrotreater includes the use of a guard bed to adsorb the heavy metals contained in the oil feed. This is required to prevent rapid poisoning of the hydrotreating catalyst. The following parameters formed the design basis for the hydrotreating unit:

Space Velocity, LHSV, hr^{-1}		0.4
Reactor H_2 Partial Pressure, psia		2,000
Make-up H_2 Purity, %		99.6
Chemical H_2 Consumption, SCF/BBL		1,250
Process Yields, Wt. % Feed		
	H_2O	2.07
	H_2S	0.77
	NH_3	2.60
	C_1	0.05
	C_2	0.05
	C_3	0.05
	iC_4	0.01
	nC_4	0.03
	C_5+	96.46
		102.09

4.4 Raw Oil Hydrotreating - Unit 400 (Cont'd)

The hydrotreated product oil has the following inspections:

Gravity, °API	37.5
Sulfur, ppm	15
Oxygen, ppm	130
Total Nitrogen, ppm	1,000

- Process Description

The process flow diagrams for one train of hydrotreating are shown in Figure 4.5 and 4.6.

The hydrotreating unit consists of the reactor section where hydrogen and shale oil are heated and reacted in the presence of a denitrification catalyst, and the stripping section where H_2S and light gases are separated from the hydrotreated shale oil product.

The shale oil feed is delivered from Raw Oil Recovery, Unit 200, or from intermediate storage at 150°F. The oil feed is pumped by the Feed Pump, P-401, to a pressure of 2990 psig. High pressure oil is then combined with the recycle and make-up hydrogen and heated in the Feed/Effluent Exchanger, E-401, and the Reactor Charge Heater, H-401.

The heated reactor feed stream first passes through one of two parallel Reactor Guard Beds, R-401A/B. Each of the guard bed reactors contain a single bed graded catalyst system designed to remove metals carried over from upstream processes. The feed then flows to the main reactors. There are two reactors in series R-402 and R-403. Each reactor contains multiple catalyst beds with provisions for injecting cold recycle gas between beds to control the exothermic reactions. When the mixture leaves the reactors, it is cooled in the Feed/Effluent Exchanger, E-401, and the Reactor Effluent/Stripper Feed Exchanger, E-402. Water is injected into the effluent stream before it is cooled further in the Effluent Cooler, E-403. The water prevents the precipitation of ammonium salts in the effluent cooler tubes. A polysulfide solution is also injected at this point to minimize corrosion.

4.4 Raw Oil Hydrotreating - Unit 400 (Cont'd)

The cooled effluent flows to the High Pressure Separator, D-401, where the hydrogen-rich gas stream, the liquid reaction products, and condensed water are split into separate streams. Part of the gas stream from the High Pressure Separator, D-401, is bled as purge gas, while the remainder goes to the suction of the Recycle Compressor, C-401. The compressed recycle gas is then divided into two streams; the quench stream, which is injected between beds in the reactor, and the recycle gas stream, which is combined with the make-up hydrogen stream before mixing with the oil feed.

The aqueous condensate from the High Pressure Separator, D-401, is sent to Sour Water Treating, Unit 700, for hydrogen sulfide and ammonia removal. The oil phase from the High Pressure Separator, D-401 is let down in pressure via a power recovery turbine, RT-401. Recovered power supplies partial drive for the Feed Pump, P-401.

In the Low Pressure Separator, D-407, gases released by the pressure reduction are separated from the oil stream. The gases combine with the bleed stream from the reactor section and are sent to Gas Treating, Unit 300. The oil stream is heated in the Reactor Effluent/Stripper Feed Exchanger, E-402, and then sent to the H_2S Stripper, T-401, which is a steam-stripped packed column. The oil stream is fed above the packing and flows downward where it is contacted with the stripping steam. The overhead gases from the column partially condense in the Stripper Condenser, E-404, and flow to the Stripper Reflux Drum, D-408. The uncondensed gases are sent to Gas Treating, Unit 300, and the water phase is separated and sent to the Sour Water Treating, Unit 700. The oil stream is pumped back to the column above the packing as reflux.

The stripped hydrotreated oil, from the bottom of T-401, is delivered to the fractionation section in Unit 500 at 390°F.

4.4 Raw Oil Hydrotreating - Unit 400 (Cont'd)

- Utilities Summary

The normal operating requirements for one train of the raw oil hydrotreating plant are summarized below. The total plant contains two identical operating trains.

Utilities	Battery Limits Conditions	Normal* Demand
Steam, lb/hr		
C-401	600 psig/700°F	115,300
T-401	150 psig/364°F	2,818
D-402	150 psig/364°F	(11,000)
C-401	150 psig/364°F	(115,300)
Boiler Feed Water, lb/hr	200 psig/215°F	11,550
BFW Blowdown, lb/hr		(550)
De-aerated Condensate, GPM	30 psig/104°F	218
Cooling Water, GPM	80 psig/80°F	
Pump Cooling		15
Compressor Seal Oil Cooling		25
		40
Fuel Gas, MMBTU/Hr (LHV)		
H-301		38.2

Catalyst Consumption	Initial	Annual Usage
Hydrotreating Catalyst	$2.3 MM	$523,500
Guard Bed Catalyst	1700 CF	3400 CF

* Parenthesis denotes production rather than consumption

4.4 Raw Oil Hydrotreating - Unit 400 (Cont'd)

Electric Power	Normal KW	Connected Load KW
E-403	120	155
E-404	33	43
P-401A	582**	991
P-401B	582**	991
P-401C	-	991
P-404A	339	402
P-404B	-	402
P-405A	4	7
P-405B	-	7
P-406A	11	18
P-406B	-	18
PG-401	1	2
PG-402	27	33
Instruments and Lighting	10	10
Total	1709	

** Net electric power requirement. Power recovery turbine, RT-401, supplies 35% of the total driving power required.

- Heat and Material Balance

A summary of process stream flows for the raw oil hydrotreating unit, keyed to the process flow diagram by stream numbers, is given in Table 4.13. This material balance table represents one of two operating trains for raw oil hydrotreating.

- Process Equipment Summary

Major process equipment required per train of raw oil hydrotreating, as well as for the total plant, are listed in Table 4.14. The corresponding equipment specifications are provided in Table 4.15.

TABLE 4.13

UNIT: Hydrotreating	**SECTION NO.:** 400		**FOSTER WHEELER USA CORPORATION**			
CUSTOMER: DOE/METC SHALE OIL PLANT	**REF. DWG.:**			**PG. NO.:** 1 of 2		
LOCATION: Western Colorado	**CONTRACT NO.:** 11-36265		**DATE** 5/11/87	**REV. NO.:**		

STREAM NO. & UNITS		401	402	403	404	405	
STREAM DESCRIPTION		Whole Shale Oil Feed	Make-Up Hydrogen	Superheated Steam	Reactor Effluent Injection Water	Sour Water To Sour Water Treating	
FLUID STATE		Liquid	Vapor	Vapor	Liquid	Liquid	
TEMPERATURE (°F)		150	253	560	120	150	
PRESSURE (PSIG)		100	3,005	150	16	250	
LIQUID (LB/HR)		347,703			105,780	124,128	
VAPOR (LB/HR)			8,352	2,830			
SOLIDS (LB/HR)		999					
TOTAL (LB/HR)		348,702	8,352	2,830	105,780	124,128	
MOLECULAR WEIGHT (SOLIDS FREE)			2.12	18.016	18.016	18.1	
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016		3923.2				
CARBON MONOXIDE	28.01						
CARBON DIOXIDE	44.01						
WATER	18.016			157.1	5871.4	6266.3	
HYDROGEN SULFIDE	34.086					69.7	
AMMONIA	17.034					499.3	
METHANE	16.042						
ETHYLENE	28.052						
ETHANE	30.068						
PROPYLENE	42.078						
PROPANE	44.094						
BUTENE	56.104						
BUTANE	58.12						
NITROGEN	28.02		15.8				
HYD. HEAVY NAPHTHA	174.9						
HYD. HEAVY OIL	217.7					12.6	
NON CONDENSIBLES							
TOTAL (LB – MOL/HR)			3939.0	157.1	5871.4	6847.9	

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110 – 18 FDP TUBULATION

TABLE 4.13 (Cont'd)

UNIT: Hydrotreating | SECTION NO.: 400 | FOSTER WHEELER USA CORPORATION

CUSTOMER: DOE/METC SHALE OIL PLANT | REF. DWG.: | PG. NO.: 2 of 2

LOCATION: Western Colorado | CONTRACT NO.: 11-36265 | DATE 5/11/87 | REV. NO.:

STREAM NO. & UNITS		406	407	408			
STREAM DESCRIPTION		Off-Gas to Section 300	Condensate To Waste Water Treatment	C_5+ Hydro-treated Oil Product			
FLUID STATE		Vapor	Liquid	Liquid			
TEMPERATURE (°F)		134	120	390			
PRESSURE (PSIG)		120	120	100			
LIQUID (LB/HR)			1452	336,107			
VAPOR (LB/HR)		2,978					
SOLIDS (LB/HR)				999			
TOTAL (LB/HR)		2,978	1452	337,106			
MOLECULAR WEIGHT (SOLIDS FREE)		6.8	18.1	208.0			
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016	354.7					
CARBON MONOXIDE	28.01						
CARBON DIOXIDE	44.01						
WATER	18.016	4.2	80.2	77.3			
HYDROGEN SULFIDE	34.086	8.3	Trace				
AMMONIA	17.034	31.4					
METHANE	16.042	10.8					
ETHYLENE	28.052						
ETHANE	30.068	5.8					
PROPYLENE	42.078						
PROPANE	44.094	3.9		0.1			
BUTENE	56.104						
BUTANE	58.12	1.3		1.1			
NITROGEN	28.02	15.8					
HYD. HEAVY NAPHTHA	174.9	1.9					
HYD. HEAVY OIL	217.7			1537.2			
TOTAL (LB - MOL/HR)		438.1	80.2	1615.7			

110 - 18 FOR TABULATION

TABLE 4.14

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION
PROCESS PLANTS DIVISION

CONTRACT: 11-36265
SECTION: 400

EQUIPMENT LIST

NAME OF UNIT: Hydrotreating

CLIENT: U.S. DOE/METC
LOCATION: WESTERN COLORADO

REVISION	ORIGINAL	1	2	3	4	5
DATE	2/18/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO TRAIN	TOTAL		REV.
REACTORS	R-401A	REACTOR GUARD BED		1	2		
	R-401B	REACTOR GUARD BED		1	2		
	R-402	FIRST STAGE REACTOR		1	2		
	R-403	SECOND STAGE REACTOR		1	2		
TOWERS	T-401	H_2S STRIPPER		1	2		
DRUMS	D-401	HIGH PRESSURE SEPARATOR		1	2		
	D-402	STEAM DRUM		1	2		
	D-403	KNOCKOUT DRUM		1	2		
	D-406	CONDENSATE DRUM		1	2		
	D-407	LOW PRESSURE SEPARATOR		1	2		
	D-408	STRIPPER REFLUX DRUM		1	2		
HEATERS	H-401	REACTOR CHARGE HEATER		1	2		
EXCHANGERS	E-401	FEED/EFFLUENT EXCHANGER		1	2		
	E-402	REACTOR EFFLUENT/STRIPPER FEED EXCHANGER		1	2		
	E-403	EFFLUENT COOLER		1	2		
	E-404	STRIPPER CONDENSER		1	2		
COMPRESSORS	C-401A	RECYCLE COMPRESSOR		1	2		
	C-401B	SPARE FOR C-401A		1	2		

TABLE 4.14 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 400	EQUIPMENT LIST	NAME OF UNIT: Hydrotreating	PAGE 2 OF 2

CLIENT: U.S. DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: WESTERN COLORADO	DATE	2/18/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO TRAIN	TOTAL		REV.
PUMPS	P-401A	FEED PUMP		1	2		
	P-401B	FEED PUMP		1	2		
	P-401C	COMMON SPARE FOR P-401A/401B		1	2		
	P-404A	INJECTION WATER PUMP		1	2		
	P-404B	SPARE FOR P-404A		1	2		
	P-405A	REFLUX PUMP		1	2		
	P-405B	SPARE FOR P-405A		1	2		
	P-406A	BOILER FEEDWATER PUMP		1	2		
	P-406B	SPARE FOR P-406A		1	2		
TURBINES	RT-401A	POWER RECOVERY TURBINE		1	2		
	RT-401B	POWER RECOVERY TURBINE		1	2		
MISCELLANEOUS	PG-401	POLYSULFIDE PACKAGE INJECTION		1	2		
	PG-402	SULFIDE PACKAGE INJECTION		1	2		

<u>TABLE 4.15</u>

<u>UNIT 400 - RAW OIL HYDROTREATING EQUIPMENT SPECIFICATIONS</u>

Reactors

Item No.	Description	Dia./Height	Design Pressure psig	Internals	Material of Construction
R-401A	Reactor Guard Bed	10'-6"/20'-0"	3115	1700 cu ft catalyst	2 1/4 Cr-1Mo 347 SS Clad
R-4018	Reactor Guard Bed	10'-6"/20'-0"	3115	1700 cu ft catalyst	2 1/4 Cr-1Mo 347 SS clad
R-402	First Stage Reactor	10'-6"/85'-0"	3115		2 1/4 Cr-1Mo 347 SS clad
R-403	Second Stage Reactor	10'-6"/85'-0"	3115		2 1/4 Cr-1Mo 347 SS clad

Towers

Item No.	Description	Dia./Height	Design Pressure	Internals	Material of Construction
T-401	H2S Stripper	5'-6"/47'-0"	150	950 cu ft packing 2 inch pall rings	Shell: C.S. Stress relieved packing: 410 SS pall rings

Drums

Item No.	Description	Position	Dia./Height or Length	Design Pressure Psig	Material of Construction
D-401	High Pressure Separator	Vert.	6'-6"/25'-0"	2680	C.S.
D-402	Steam Drum	Horiz.	6'-6"/26'-0"	190	C.S.
D-403	Knockout Drum	Vert.	6'-6"/10'-0"	2680	C.S.
D-404	Sulfiding Drum	Vert.	11'-6"/34'-0"	28	C.S.
D-405	Polysulfide Drum	Vert.	3'-6"/12'-0"	28	C.S.
D-406	Condensate Drum	Vert.	4'-6"/11'-6"	28	C.S.
D-407	Low Pressure Separator	Vert.	5'-0"/25'-0"	200	C.S.
D-408	Stripper Reflux Drum	Horiz.	4'-0"/10'-0"	145	C.S.

Heaters

Item No.	Description	Type	Duty MMBTU/HR	Coil Material	Outlet Temperature °F
H-401	Reactor Charge Heater	Vertical-Cylindrical	21.1 Process 11.4 Steam Coil	321 SS 0.1CA	825

TABLE 4.15 (Cont'd)

UNIT 400 - RAW OIL HYDROTREATING EQUIPMENT SPECIFICATIONS

Exchangers

Item No.	Description	TEMA Type	Area Ft^2	Duty MMBTU/HR	Material of Construction Shell/Tube
E-401	Feed/Effluent Exchanger	AES with Internal Expansion Joint	20,640	204.0	2 1/4 Cr-1Mo/321 SS
E-402	Reactor Effluent/ Stripper Feed Exchanger	AES	9,230	55.5	C.S./304 SS
E-403	Effluent Cooler	Air Cooler (Forced Draft)	15,750	100.9	304 SS
E-404	Stripper Condenser	Air Cooler (Forced Draft)	1,926	10.3	C.S.

Compressors

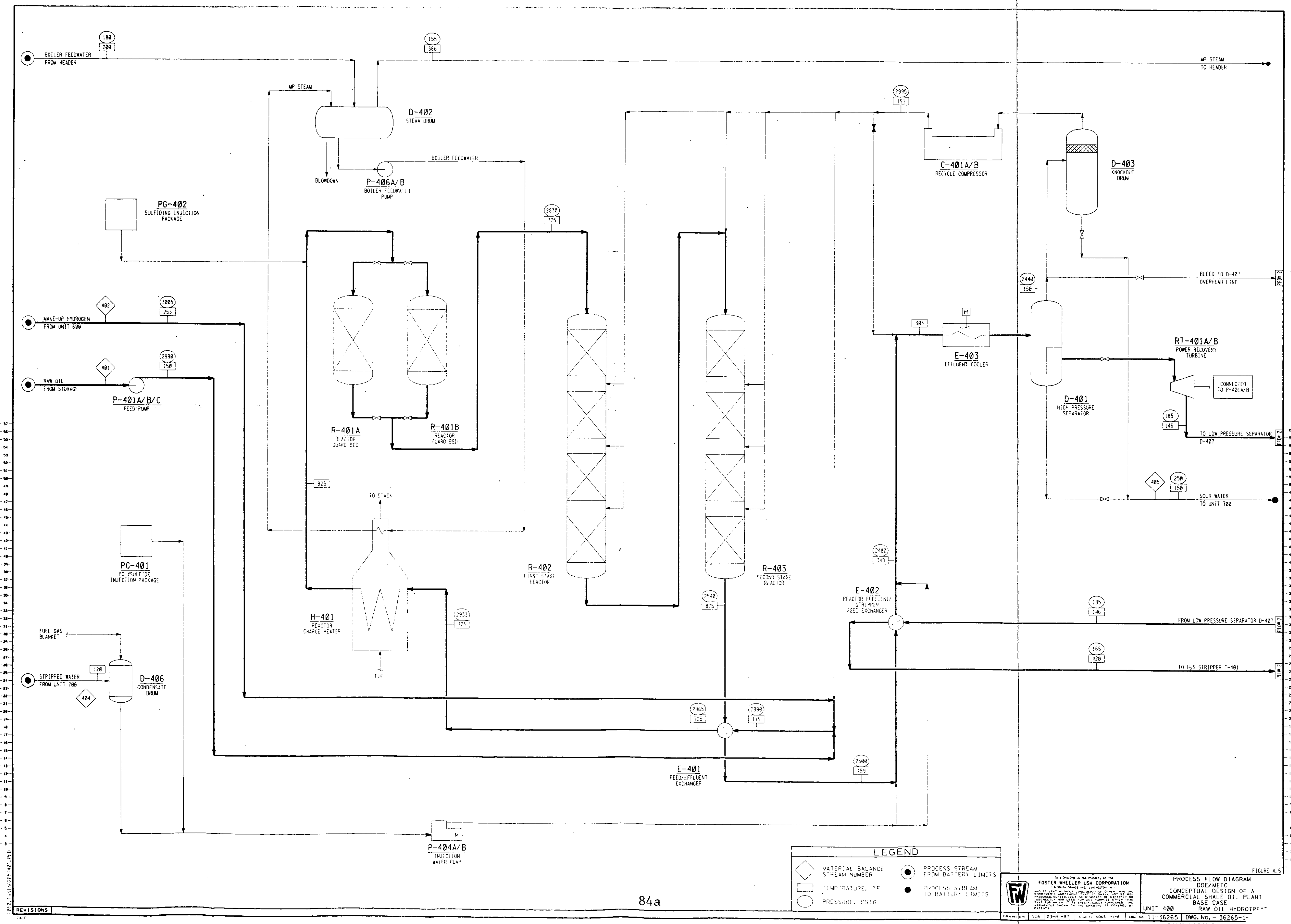
Item No.	Description	Flow Type	Pressure,Psig GPM	Inlet/Outlet	Material of Construction
C-401A/B	Recycle Compressor and Spare	Centrif.	2542	2440/2995	C.S. Or C.I.

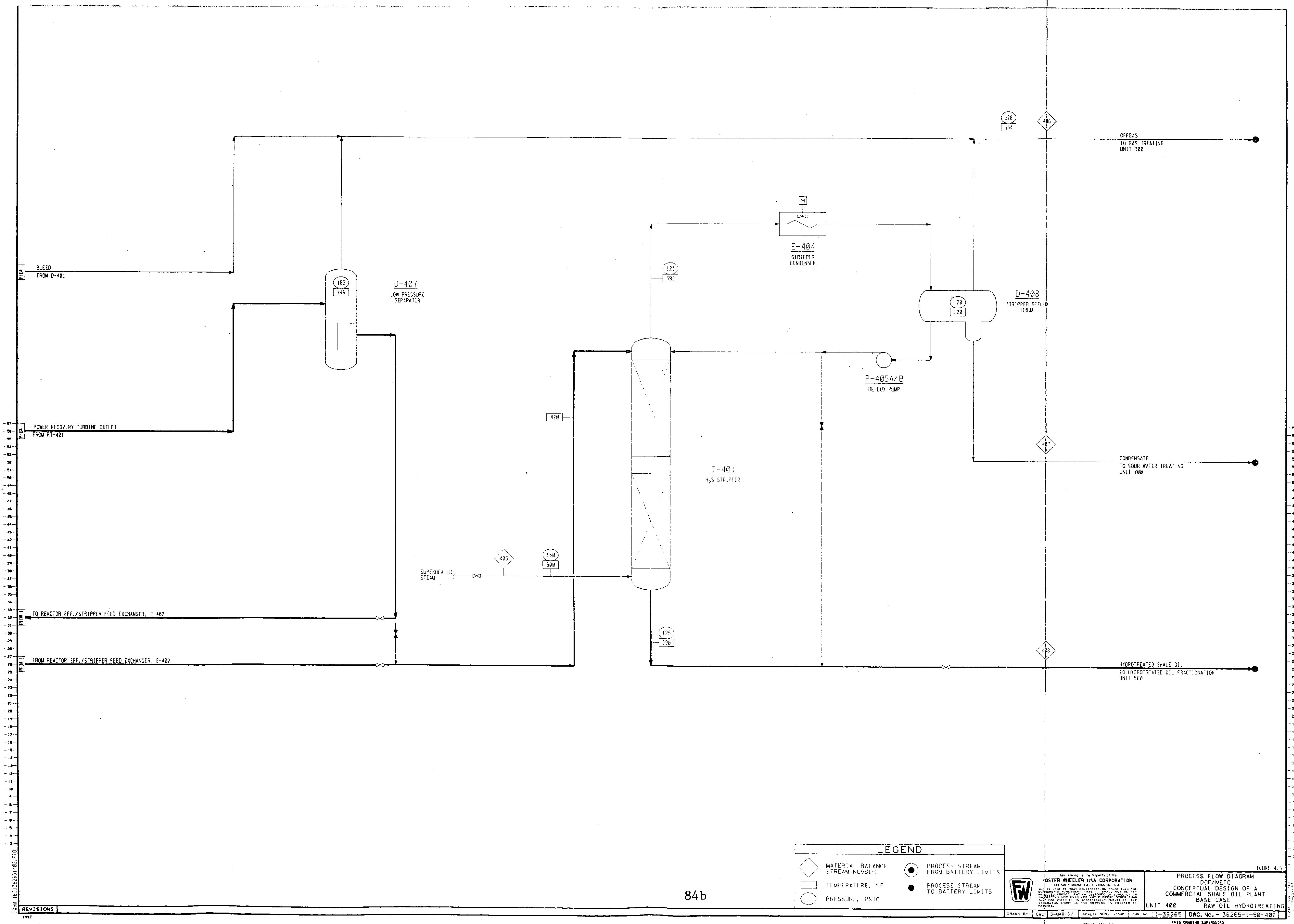
Pumps

Item No.	Description	Type	Flow GPM	Discharge Pressure Psig	Material of Construction
P-401A/B/C	Feed Pumps and Spare	Centrif.	435(each)	2990	C.S. Case C.I. Impeller
P-402	Sulfiding Pump	Proportioning	3-15	2990	316 SS
P-403	Polysulfide Pump	Proportioning	10-60 Gal/Day	20	316 SS
P-404A/B	Injection Water Pump and Spare	Proportioning	230	2510	C.S.
P-405A/B	Reflux Pump and Spare	Centrif.	104	161	C.S.
P-406A/B	Boiler Feed Water Pump and Spare	Centrif.	335	277	C.S.

Turbines

Item No.	Description	Flow GPM	Pressure, Psig Inlet/Outlet	Power Recovered	Material of Construction
RT-401A/B	Power Recovery Turbines	457(each)	2440/185	360(each)	C.S.


BOILER FEEDWATER
FROM HEADER
MP STEAM
D-402
STEAM DRUM
BLOWDOWN
P-406A/B
BOILER FEEDWATER PUMP
BOILER FEEDWATER
MP STEAM
TO HEADER
PG-402
SULFIDING INJECTION PACKAGE
C-401A/B
RECYCLE COMPRESSOR
D-403
KNOCKOUT DRUM
MAKE-UP HYDROGEN
FROM UNIT 600
RAW OIL
FROM STORAGE
P-401A/B/C
FEED PUMP
R-401A
REACTOR GUARD BED
R-401B
REACTOR GUARD BED
BLEED TO D-407
OVERHEAD LINE
E-403
EFFLUENT COOLER
RT-401A/B
POWER RECOVERY TURBINE
CONNECTED TO P-401A/B
D-401
HIGH PRESSURE SEPARATOR
TO LOW PRESSURE SEPARATOR D-407
SOUR WATER
TO UNIT 700
TO STACK
PG-401
POLYSULFIDE INJECTION PACKAGE
R-402
FIRST STAGE REACTOR
R-403
SECOND STAGE REACTOR
E-402
REACTOR EFFLUENT/STRIPPER FEED EXCHANGER
FROM LOW PRESSURE SEPARATOR D-407
H-401
REACTOR CHARGE HEATER
FUEL
FUEL GAS BLANKET
STRIPPED WATER
FROM UNIT 700
D-406
CONDENSATE DRUM
TO H2S STRIPPER T-401
E-401
FEED/EFFLUENT EXCHANGER
P-404A/B
INJECTION WATER PUMP
LEGEND
MATERIAL BALANCE STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM FROM BATTERY LIMITS
PROCESS STREAM TO BATTERY LIMITS
FIGURE 4.5
This Drawing is the Property of the
FOSTER WHEELER USA CORPORATION
110 SOUTH ORANGE AVE. LIVINGSTON, N.J.
AND IS LENT WITHOUT CONSIDERATION OTHER THAN THE BORROWER'S AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT, OR DISPOSED OF DIRECTLY OR INDIRECTLY NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED. THE APPARATUS SHOWN IN THE DRAWING IS COVERED BY PATENTS.
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 400 RAW OIL HYDROTREAT
DRAWN BY: VDV 03-02-87 SCALE: NONE
CHG. No. 11-36265
DWG. No. - 36265-1-
THIS DRAWING SUPERSEDES
THIS DRAWING SUPERSEDED BY
REVISIONS


BLEED
FROM D-401
POWER RECOVERY TURBINE OUTLET
FROM RT-401
TO REACTOR EFF./STRIPPER FEED EXCHANGER, E-402
FROM REACTOR EFF./STRIPPER FEED EXCHANGER, E-402
D-407
LOW PRESSURE SEPARATOR
185
146
E-404
STRIPPER CONDENSER
123
392
420
T-401
H2S STRIPPER
SUPERHEATED STEAM
403
150
500
125
390
D-408
STRIPPER REFLUX DRUM
120
120
P-405A/B
REFLUX PUMP
120
134
406
OFFGAS
TO GAS TREATING
UNIT 300
407
CONDENSATE
TO SOUR WATER TREATING
UNIT 700
408
HYDROTREATED SHALE OIL
TO HYDROTREATED OIL FRACTIONATION
UNIT 500
LEGEND
MATERIAL BALANCE STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM FROM BATTERY LIMITS
PROCESS STREAM TO BATTERY LIMITS
REVISIONS
FIGURE 4.6
This Drawing is the Property of the
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PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 400 RAW OIL HYDROTREATING
DRAWN BY: CWJ 3-MAR-87 SCALE: NONE
CHG. No. 11-36265 DWG. No. - 36265-1-50-402
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4.5 Hydrotreated Oil Fractionation - Unit 500

- **Basis of Design**

The hydrotreated oil fractionation unit contains two identical processing trains. Each fractionation train is designed to process 27,533 BPSD of hydrotreated shale oil, delivered from Raw Oil Hydrotreating, Unit 400, at 390°F. Composition of the hydrotreated oil feed is as follows:

Composition	Lb/Hr	Wt%
H_2O	1,392	0.41
C_3	4	-
iC_4	17	0.01
nC_4	47	0.01
C_5 - 180°F	5,738	1.71
180 - 315°F	21,911	6.52
315 - 500°F	82,850	24.65
500 - 650°F	95,823	28.51
650°F+	128,325	38.18
Total	336,107	100.00
Molecular Weight	208.0	
°API	37.5	
TBP Distillation °F		
5 LV%	230	
10/30	310/465	
50	580	
70/90	690/880	
End	1000 +	

4.5 Hydrotreated Oil Fractionation - Unit 500 (Cont'd)

The fractionation unit is designed to produce an overhead naphtha product, a side draw diesel oil product, and a bottoms product. Inspection for the three product streams are as follows:

Naphtha

Production Rate, BPSD/Train	3079
Gravity, °API	58.8
TBP Distillation, °F	
5 LV%	38
50	240
95	355

Diesel Oil

Production Rate, BPSD/Train	4104
Gravity, °API	36.9
TBP Distillation, °F	
5 LV%	250
50	405
90	695

Bottoms Product

Production Rate, BPSD/Train	20,098
Gravity, °API	32.4
TBP Distillation, °F	
5 LV%	465
50	640
90	927

4.5 Hydrotreated Oil Fractionation - Unit 500 (Cont'd)

- Process Description

The process flow diagram for the fractionation unit is shown in Figure 4.7.

Hydrotreated oil, delivered from Raw Oil Hydrotreating, Unit 400, at 390°F, is preheated to 500°F in the Feed/Product Exchanger, E-501. Preheated oil is then fed to the Fractionator, T-501, where fractionation into an overhead naphtha stream, a side draw diesel cut, and bottoms product is made.

The Fractionator, T-501 is designed to operate at 5 psig in the overhead drum and 10 - 15 psig in the tower. Reboiler duty is provided by heating the tower bottoms from 537°F to 610°F in the Fractionator Reboiler, H-501.

Overhead from the tower is cooled to 157°F in the Fractionator Overhead Condenser, E-503, and water is separated from the condensate in the Fractionator Overhead Drum, D-501. The aqueous condensate is sent to Sour Water Treating, Unit 700. Naphtha is refluxed to the tower via the Fractionator Reflux Pump, P-501, and the net naphtha product, after cooled to 120°F in E-507, is sent to storage.

The diesel oil cut, withdrawn from the tower at 405°F, is cooled to 120°F in the Diesel Product Cooler, E-504 and sent to storage.

Net bottoms product is withdrawn from the tower at 610°F. The bottoms product is first cooled to 452°F in the Feed/Product Exchanger, E-501 and then to 350°F in the Bottoms Product/LP Steam Generator, E-506 where low pressure steam is produced. Preheating of boiler feed water in E-502 further cools the bottoms product to 242°F. The bottoms product is finally cooled to 140°F in the Fractionator Bottoms Cooler, E-505 and sent to storage.

Medium pressure steam is generated in the convection coil of the Fractionator Reboiler, H-501.

4.5 Hydrotreated Oil Fractionation - Unit 500 (Cont'd)

o Utilities Summary

The normal utilities requirement for one train of oil fractionation are summarized below. The total plant contains two identical trains.

Electric Power	Normal KW	Connected Load KW
E-503	102	127
E-504	19	26
E-505	32	52
E-507	8	13
P-501A	51	62
P-501B	-	62
P-502A	1	2
P-502B	-	2
P-503A	9	13
P-503B	-	13
P-504A	66	82
P-504B	-	82
P-505A	84	102
P-505B	-	102
P-506A	9	13
P-506B	-	13
Instruments and Lighting	10	10
Total	391	

	Battery Limit Conditions	Normal* Demand
Boiler Feed Water, lb/hr		
(E-502)	750 psig/215°F	140,120
Export	740 psig/310°F	(130,060)
(E-506)	200 psig/215°F	16,610
Steam, lb/hr		
(D-502)	150 psig/364°F	(9,580)
(E-506)	60 psig/303°F	(15,820)

* Parenthesis denotes production rather than assumption

4.5 Hydrotreated Oil Fractionation - Unit 500 (Cont'd)

	Battery Limit Conditions	Normal* Demand
BFW Blowdown, lb/hr		
(D-502)		(480)
(E-506)		(790)
Cooling Water, GPM	80 psig/80°F	
(Pumps Cooling)	30°F ΔT	24
Fuel Gas, MMBTU/HR (LHV)	100 psig/AMB	
(H-501)		92.3

- **Heat and Material Balance**

A summary of process stream flows for the oil fractionation unit, keyed to the process flow diagram by stream numbers, is given in Table 4.16. This material balance table represents one of two operating trains for oil fractionation.

- **Process Equipment Summary**

Major process equipment required per train of oil fractionation, as well as for the total plant, are listed in Table 4.17. The corresponding equipment specifications are provided in Table 4.18.

TABLE 4.16

FOSTER WHEELER USA CORPORATION

UNIT: Fractionator
CUSTOMER: DOE/METC SHALE OIL PLANT
LOCATION: Western Colorado
SECTION NO.: 500
REF. DWG.:
CONTRACT NO.: 11-36265
DATE May 11, 1987
PG. NO.: 1 of 2
REV. NO.:

STREAM NO. & UNITS		501	502	503	504	505	506
STREAM DESCRIPTION		Hydrotreated Shale Oil Feed	Gross Overhead	Reflux	Sour Water To Sour Water Treating	Diesel Fuel To Storage	Bottoms Product To Storage
FLUID STATE		Liquid	Liquid	Liquid	Liquid	Liquid	Liquid
TEMPERATURE (°F)		390	301	157	157	120	120
PRESSURE (PSIG)		23	10	10	50	50	50
LIQUID (LB/HR)		336,107	315,177	280,425	1392	50,035	251,320
VAPOR (LB/HR)							
SOLIDS (LB/HR)		999					999
TOTAL (LB/HR)		337,106	315,177	280,425	1392	50,035	252,319
MOLECULAR WEIGHT (SOLIDS FREE)		208.0	109.4	112.0	18.016	169.4	265.9
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016						
CARBON MONOXIDE	28.01						
CARBON DIOXIDE	44.01						
WATER	18.016	77.3	77.3		77.3		
HYDROGEN SULFIDE	34.086						
AMMONIA	17.034						
METHANE	16.042						
ETHYLENE	28.052						
ETHANE	30.068						
PROPYLENE	42.078						
PROPANE	44.094	0.1	0.7	0.6		Trace	
i-BUTANE	58.12	0.3	3.5	3.2		0.025	
n-BUTANE	58.12	0.8	7.8	7.0		0.010	
NITROGEN	28.02						
HYD. NAPHTHA			2790.5	2493.8			
HYD. HEAVY OIL		1537.2					945.2
DIESEL FUEL OIL						295.0	
TOTAL (LB - MOL/HR)		1615.7	2879.8	2504.6	77.3	295.3	945.2

TABLE 4.16 (Cont'd)

UNIT: Fractionation	SECTION NO.: 500	FOSTER WHEELER USA CORPORATION
CUSTOMER: DOE/METC SHALE OIL PLANT	REF. DWG.:	PG. NO.: 2 of 2
LOCATION: Western Colorado	CONTRACT NO.: 11-36265 DATE May 11, 1987	REV. NO.:

STREAM NO. & UNITS		507	508	509	510	511	512
STREAM DESCRIPTION		NAPHTHA PRODUCT TO STORAGE	TOWER BOTTOMS TO REBOILER	BFW TO UNIT 600	MP STEAM EXPORT	STEAM DRUM BLOWDOWN	LP STEAM EXPORT
FLUID STATE		Liquid	Liquid	Liquid	Vapor	Liquid	Vapor
TEMPERATURE (°F)		120	537	310	366	366	303
PRESSURE (PSIG)		50	15	740	155	155	60
LIQUID (LB/HR)		33,360	653,445	130,060		480	
VAPOR (LB/HR)					9580		15,820
SOLIDS (LB/HR)			2,600				
TOTAL (LB/HR)		33,360	656,045	130,060	9580	480	15,820
MOLECULAR WEIGHT (SOLIDS FREE)		112.0		18.016	18.016	18.016	18.016
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016						
CARBON MONOXIDE	28.01						
CARBON DIOXIDE	44.01						
WATER	18.016			7219.1	531.7	26.6	878.1
HYDROGEN SULFIDE	34.086						
AMMONIA	17.034						
METHANE	16.042						
ETHYLENE	28.052						
ETHANE	30.068						
PROPYLENE	42.078						
PROPANE	44.094	0.1					
i-BUTANE	58.12	0.3					
n-BUTANE	58.12	0.8					
NITROGEN	28.02						
HYD. NAPHTHA		296.7					
HYD. HEAVY OIL			3273.5				
DIESEL FUEL OIL							
TOTAL (LB - MOL/HR)		297.9	3273.5	7219.1	531.7	26.6	878.1

TABLE 4.17

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION
PROCESS PLANTS DIVISION

CONTRACT: 11-36265
SECTION: 500

EQUIPMENT LIST

NAME OF UNIT: Fractionation

PAGE 1 OF 1

CLIENT: DOE/METC Shale Oil Plant
LOCATION: Western Colorado

REVISION	ORIGINAL	1	2	3	4	5
DATE	3/2/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
Towers	T-501	Fractionator		1	2		
Drums	D-501	Fractionator Overhead Drum		1	2		
	D-502	Steam Drum		1	2		
Heaters	H-501	Fractionator Reboiler		1	2		
Exchangers	E-501	Feed/Product Exchanger		1	2		
	E-502	Boiler Feedwater Preheater		1	2		
	E-503	Fractionator Overhead Condenser		1	2		
	E-504	Diesel product Cooler		1	2		
	E-505	Fractionator Bottoms Cooler		1	2		
	E-506	Bottoms Product/Lp Steam Generator		1	2		
	E-507	Naphtha Product Cooler		1	2		
Pumps	P-501A	Fractionator Reflux Pump		1	2		
	P-501B	Spare for P-501A		1	2		
	P-502A	Sour Water Pump		1	2		
	P-502B	Spare for P-502A		1	2		
	P-503A	Diesel Product Pump		1	2		
	P-503B	Spare for P-503A		1	2		
	P-504A	Bottoms Product Pump		1	2		
	P-504B	Spare for P-504A		1	2		
	P-505A	Fractionator Reboiler Pump		1	2		
	P-505B	Spare for P-505A		1	2		
	P-506A	BFW Recirculation Pump		1	2		
	P-506B	Spare for P-506A		1	2		

TABLE 4.18

UNIT 500 - HYDROTREATED OIL FRACTIONATION

EQUIPMENT SPECIFICATIONS

Towers

Item No.	Description	Dia./Height	Design Pressure	Internals	Material of Construction
T-501	Fractionator	16'-6"/87'-0"	40 psig	24-bubble cap trays	Shell-C.S. Trays-410 SS

Drums

Item No.	Description	Position	Dia./Height or Length	Design Pressure Psig	Material of Construction
D-501	Fractionator Overhead Drum	Horiz.	9'-6"/20'-0"	30	C.S.
H-502	Steam Drum	Horiz.	6'-6"/26'-0"	190	C.S.

Heaters

Item No.	Description	Type	Duty 10^6BTU/HR	Coil Material	Outlet Temperature °F
H-501	Fractionator Reboiler	Box	79.3	1 1/4 Cr-1/2Mo CS 800°F	615

Exchangers

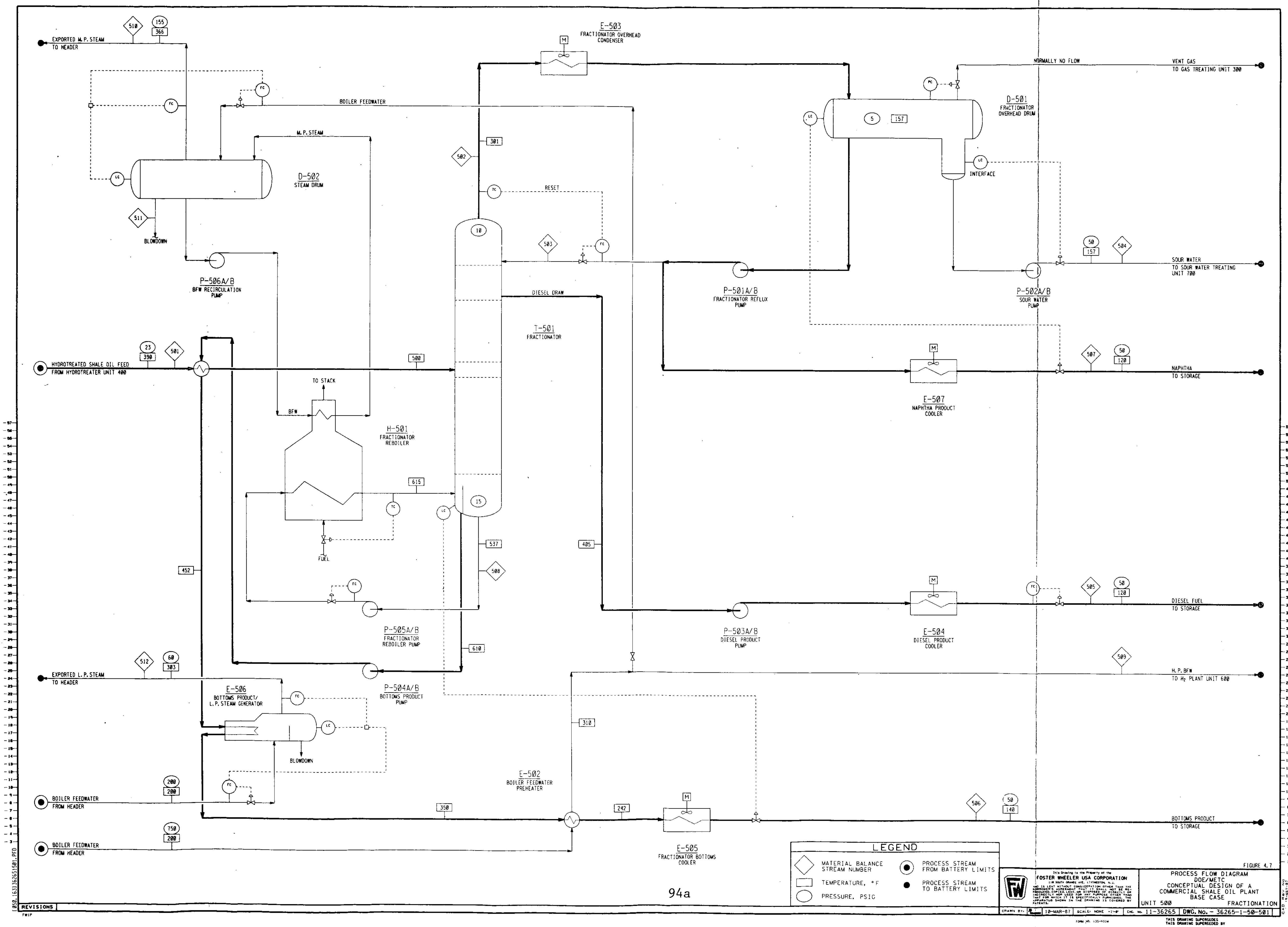
Item No.	Description	TEMA Type	Area Ft^2	Duty 10^6BTU/Hr	Material of Shell/Tube
E-501	Feed/Product Exchanger	AES	13,424	23.8	C.S./C.S.
E-502	Boiler Feedwater Preheater	AES	4,615	15.4	C.S./C.S.
E-503	Fractionator Overhead Condenser	Air Cooler (Forced Draft)	9,363	62.8	C.S. with Al Fins
E-504	Diesel Product Cooler	Air Cooler (Forced Draft)	1,175	7.6	C.S. with Al Fins
E-505	Fractionator Bottoms Cooler	Air Cooler (Forced Draft)	4,984	13.2	C.S. with Al Fins
E-506	Bottoms Product/ LP Steam Generator	AKT	1,151	16.1	C.S./C.S.
E-507	Naphtha Product Cooler	Air Cooler (Forced Draft)	310	0.6	C.S. with Al Fins

TABLE 4.18 (Cont'd)

UNIT 500 - HYDROTREATED OIL FRACTIONATION EQUIPMENT SPECIFICATIONS

Pumps

Item No.	Description	Type	Flow GPM	Discharge Pressure Psig	Material of Construction
P-501A/B	Fractionator Reflux Pump and Spare	Centrif.	1060	89	C.S
P-502A/B	Sour Water Pump and Spare	Centrif.	3.4	82	C.S.
P-503A/B	Diesel Product Pump and Spare	Centrif.	166	89	C.S.
P-504A/B	Bottoms Product Pump and Spare	Centrif.	970	1Z5	C.S.
P-505A/B	Fractionator Reboiler Pump and Spare	Centrif.	2230	83	C.S.
P-506A/B	BFW Circulation Pump and Spare	Centrif.	256	300	C.S.



EXPORTED M.P. STEAM TO HEADER
BOILER FEEDWATER
M.P. STEAM
D-502 STEAM DRUM
BLOWDOWN
P-506A/B BFW RECIRCULATION PUMP
E-503 FRACTIONATOR OVERHEAD CONDENSER
RESET
NORMALLY NO FLOW
VENT GAS TO GAS TREATING UNIT 300
D-501 FRACTIONATOR OVERHEAD DRUM
INTERFACE
SOUR WATER TO SOUR WATER TREATING UNIT 700
P-501A/B FRACTIONATOR REFLUX PUMP
P-502A/B SOUR WATER PUMP
DIESEL DRAW
T-501 FRACTIONATOR
HYDROTREATED SHALE OIL FEED FROM HYDROTREATER UNIT 400
TO STACK
BFW
H-501 FRACTIONATOR REBOILER
FUEL
NAPHTHA TO STORAGE
E-507 NAPHTHA PRODUCT COOLER
P-505A/B FRACTIONATOR REBOILER PUMP
P-503A/B DIESEL PRODUCT PUMP
E-504 DIESEL PRODUCT COOLER
DIESEL FUEL TO STORAGE
EXPORTED L.P. STEAM TO HEADER
E-506 BOTTOMS PRODUCT/ L.P. STEAM GENERATOR
P-504A/B BOTTOMS PRODUCT PUMP
H.P. BFW TO H2 PLANT UNIT 600
BOILER FEEDWATER FROM HEADER
E-502 BOILER FEEDWATER PREHEATER
E-505 FRACTIONATOR BOTTOMS COOLER
BOTTOMS PRODUCT TO STORAGE
BOILER FEEDWATER FROM HEADER
LEGEND
MATERIAL BALANCE STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM FROM BATTERY LIMITS
PROCESS STREAM TO BATTERY LIMITS
FIGURE 4.7
FOSTER WHEELER USA CORPORATION
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 500 FRACTIONATION
10-MAR-87
DWG. No. - 36265-1-50-501
REVISIONS

4.6 Hydrogen Plant - Unit 600

- **Basis of Design**

The hydrogen plant is designed as two parallel trains each capable of producing 35 MMSCFD of hydrogen, with a minimum hydrogen purity of 99.6% by volume. Natural gas is the design feedstock. The product hydrogen is delivered to battery limits at a minimum of 3000 psig and at 234°F.

The plant is capable of operation from 30 to 100% of rated capacity on a natural gas feedstock, having the following characteristics. The design is based on the Pressure Swing Adsorption (PSA) process using molecular sieves for hydrogen purification.

NATURAL GAS FEEDSTOCK

Composition	Typical, mol.%	Design, mol.%
H_2	0.01	-
CO	0.01	-
O_2	0.01	0.01
CH_4	94.93	94.00
C_2H_6	2.35	2.29
C_2H_4	0.01	1.00
C_3H_8	0.20	0.20
$i\text{-}C_4H_{10}$	0.01	-
$n\text{-}C_4H_{10}$	0.01	-
N_2	2.02	2.50
CO_2	0.49	-
		100.00

Conditions

Pressure, psig	550
Temperature, °F	Ambient
Higher Heating Value, BTU/lb	22,400

4.6 Hydrogen Plant - Unit 600 (Cont'd)

- Process Description

The process flow is shown schematically on the process flow diagrams, in Figures 4.8 and 4.9.

Natural gas is received at the battery limits at 60°F and 550 psig. The feedstock is flow controlled into the systems with a reset for pressure downstream at the Chloride Guard, R-603. Hydrogen is recycled from the first stage of the Make-up Compressor, C-601, to the feedstock to maintain about a 5 mol.% H_2 content in the feed.

The mixture of feedstock and recycle hydrogen flows to the Feed KO Drum, D-601, for removal of any entrained liquid before it flows through the convection section of the Reformer, H-601 where it is heated to 700°F.

The preheated feed gas passes through the Hydrogenator, R-601, which contains a bed of cobalt-moly catalyst. In this reactor, hydrogen present in the feed gas facilitates conversion of sulfur compounds into hydrogen sulfide as it passes over the cobalt-moly catalyst. The chlorides present in the feed gas are converted to hydrogen chloride. The feed gas next passes through two sulfur absorbers, R-602A/B, containing zinc oxide beds. These sulfur guard vessels are designed to operate in series with the piping arranged in such a way that either one of these vessels could be the lead one. The hydrogen sulfide is removed from the gas as it passes through the beds of zinc oxide. Provision is also made for by-passing either of these sulfur absorbers to change out the catalyst while the plant is in operation. From the sulfur absorbers, the gas passes through the Chloride Guard, R-603, where any hydrogen chloride present is absorbed by the chloride guard catalyst.

The desulfurized gas is split and mixed with 500 psig superheated steam. Sufficient steam is added to the hydrocarbon feed to give a steam to carbon ratio of 3.0. The hot mixture, 1000°F, passes through parallel nickel catalyst filled tubes in each cell of the reformer. Hydrocarbons are reformed to produce hydrogen, carbon monoxide, carbon dioxide and methane. Heat in the flue gas leaving the radiant section is removed by process steam preheat, high pressure steam superheat, steam generation, process gas preheat and boiler feed water preheat in the convection section. Finally the flue gas is used to preheat combustion air. The reformer effluent gas stream is routed through the Reformer Waste Heat Exchanger, E-602, where heat is recovered by the generation of 1600 psig steam in a natural circulation steam generator.

4.6 Hydrogen Plant - Unit 600 (Cont'd)

The gas stream exiting the Reformer Waste Heat Exchanger, E-602, enters the High Temperature Shift Converter, R-604, where the bulk of the carbon monoxide produced in the reformer is reacted with steam, producing CO_2 and H_2. The process stream leaving the HTS Converter, R-604, is cooled from 801°F to the Low Temperature Shift Converter, R-605,inlet temperature of 420°F by passing through the HTS BFW Preheater, E-603. The process gas leaving R-605 is cooled from 461 to 325°F, in the LTS BFW Preheater, E-604. The CO concentration in the gas after passing through the Low Temperature Shift Converter, R-605, is about 0.6 vol.% on a dry basis.

The hydrogen rich gas is further cooled in the Raw Gas Cooler, E-605, to 140°F. At this temperature most of the water is condensed and is separated from the hydrogen rich gas in the Hot Process Condensate Drum, D-606. The gas is cooled to 100°F by the Raw Gas Trim Cooler, E-606, before entering the Cold Process Condensate Drum, D-607, where entrained water is removed before the raw hydrogen flows to the Pressure Swing Adsorption Package. Process condensate from both D-606 and D-607 combine and flow to the Condensate Stripper, T-601.

The process condensate removed from the raw hydrogen contains some dissolved CO_2 and traces of methane and ammonia. To recover this condensate for use as make-up water for the boiler feed water system, the impurities are stripped in the Condensate Stripper, T-601. The process condensate is preheated in the Raw Condensate Feed Preheater, E-607, before entering the top section of the tower. Steam enters the bottom of the stripper and strips impurities from the condensate which flows downward through the tower.

The overhead vapors from the top of the stripper are condensed first in the Raw Condensate Free Preheater, E-607, and then in the Stripper Overhead Condenser, E-608. The non-condensed vapor which contains steam and most of the impurities is separated from the condensate in the Stripper Reflux Drum, D-608. The vapors are vented to the atmosphere and the condensate is pumped back to the stripper.

A PSA molecular sieve system is used for removal of CO, CO_2, CH_4 and most of the nitrogen from the process gas stream leaving the Cold Process Condensate Drum, D-607. The PSA Package is expected to give a hydrogen recovery of 87%. The impurities are released from the molecular sieves at about 5 psig and are used for fuel in the reformer. Product hydrogen with a minimum purity of 99.6% leaves the PSA Package and is compressed in a three stage reciprocating compressor, Make-up Compressor, C-601, to 3005 psig. A slip stream of hydrogen from the first stage of compression is recycled to the feedstock to maintain about a 5 mol% H_2 content in the feed. A small amount of the compressed gas from the third stage spills back to the first stage compressor inlet to maintain a constant suction pressure.

4.6 Hydrogen Plant - Unit 600 (Cont'd)

- Utilities Summary

The normal operating requirements for one train of the hydrogen plant are summarized below. The total plant contains two identical operating trains.

Utility	Normal Demand*
Natural Gas, MMSCFD	
H-601, Reformer Feed	13.76
Fuel Gas, MMBTU/HR (LHV)	
H-601 Total	291.9
PG-601 PSA Package	(192.9)
Net	99
Cooling Water, GPM	
E-606	270
E-608	191
E-609	19
E-601	244
E-613	28
E-614	55
E-615	55
	862
Electric Power, KW	
B-601	83
B-605	51
B-602	14
B-603	2
C-601	5290
E-610	9
E-611	18
E-612	2
	5469

* Parenthesis denotes production rather than consumption.

4.6 Hydrogen Plant - Unit 600 (Cont'd)

Utility	Normal Demand*
Steam (600 psig, 700°F), lb/hr	
H-601	(163,900)
H-601	82,574
B-602	12,028
P-601	6,003
	(63,295)
Steam (150 psig, 360°F), lb/hr	
B-602	(12,028)
P-601	(6,003)
D-604	(1,736)
	(19,767)
Boiler Feed Water, lb/hr	
D-603	168,971
BFW Blowdown, lb/hr	
D-604	(3,333)
Process Condensate, lb/hr	
T-601	(49,650)

Catalyst & Chemicals

Catalyst Service	Catalyst Volume, $Ft.^3$	Expected Life, Yrs.
Hydrogenation	469	3
Sulfur Guard	938	1
Chloride Guard	433	3
Reformer	510	2
HT Shift Converter	780	3
LT Shift Converter	1,093	2
PSA Molecular Sieves	24,500	3

* Parenthesis denotes production rather than consumption.

4.6 Hydrogen Plant - Unit 600 (Cont'd)

- Heat and Material Balance

A summary of process stream flows for the hydrogen plant, keyed to the process flow diagram by stream numbers, is given in Table 4.19. This material balance table represents one of two operating trains for the hydrogen plant.

- Process Equipment Summary

Major process equipment required per train of hydrogen production, as well as for the total plant, are listed in Table 4.20. The corresponding equipment specifications are provided in Table 4.21.

TABLE 4.19

UNIT: HYDROGEN PLANT — SECTION NO.: UNIT 600 — FOSTER WHEELER USA CORPORATION

CUSTOMER: DOE/METC — REF. DWG.: 36265-1-50-601 — PG. NO.: 1

LOCATION: — CONTRACT NO: 11-36265 — DATE: 3/13/87 — REV.: 0

STREAM NO. & UNITS	601	602	603	604	605 A/B	606
STREAM DESCRIPTION	NATURAL GAS FEED	PRODUCT HYDROGEN RECYCLE	NATURAL GAS & RECYCLE HYDROGEN	PROCESS STEAM	FEED/CELL REFORMER	REFORMER EFFLUENT
OPERATING CASE	BASECASE	BASECASE	BASECASE	BASECASE	BASECASE	BASECASE
FLUID STATE	VAPOR	VAPOR	VAPOR	VAPOR	VAPOR	VAPOR
TEMPERATURE (°F)	60	223	60	644	1000	1000
PRESSURE (PSIG)	550	648	525	475	410	410
LIQUID (#/HR)	-	-	-	-	-	-
VAPOR (#/HR)	25435	169	25604	82574	54089	108178
TOTAL (#/HR)	25435	169	25604	82574	54089	108178
MW OF VAPOR	16.84	2.12	16.10	18.02	17.52	12.84
COMPONENTS (#mols/HR)						
N2	37.8	0.3	38.1	-	19.05	38.1
O2	0.2	-	0.2	-	0.10	-
CH4	1419.4	-	1419.4	-	709.70	394.0
C2H6	34.7	-	34.7	-	17.35	-
C2H4	15.1	-	15.1	-	7.55	-
C3H8	3.0	-	3.0	-	1.50	-
H2	-	79.5	79.5	-	39.75	3868.4
CO	-	-	-	-	-	675.2
CO2	-	-	-	-	-	458.8
TOTAL, DRY	1510.2	79.8	1590.0	-	795.00	5434.5
H2O			-	4583.3	2291.65	2991.1
TOTAL, WET	1510.2	79.8	1590.0	4583.3	3086.65	8425.6

110 - 19 PFD TABULATION

TABLE 4.19 (Cont'd)

UNIT: HYDROGEN PLANT — SECTION NO.: UNIT 600 — FOSTER WHEELER USA CORPORATION

CUSTOMER: DOE/METC — REF. DWG.: 36265-1-50-601 — PG. NO.: 2

LOCATION: — CONTRACT NO: 11-36265 — DATE: 3/13/87 — REV.: 0

STREAM NO. & UNITS	607	608	609	610	611	612
STREAM DESCRIPTION	HTS REACTOR EFFLUENT	LTS REACTOR EFFLUENT	PSA PACKAGE UNIT FEED	PRODUCT HYDROGEN	TAIL GAS FROM PSA PACKAGE UNIT	PROCESS CONDENSATE
OPERATING CASE	BASECASE	BASECASE	BASECASE	BASECASE	BASECASE	BASECASE
FLUID STATE	VAPOR	VAPOR	VAPOR	VAPOR	VAPOR	LIQUID
TEMPERATURE (°F)	801	461	100	234	100	139
PRESSURE (PSIG)	356	348	325	3005	5	325
LIQUID (#/HR)	-	-	-	-	-	41416
VAPOR (#/HR)	108178	108178	66144	8352	57623	-
TOTAL (#/HR)	108178	108178	66144	8352	57623	41416
MW OF VAPOR	12.84	12.84	10.86	2.12	26.84	
COMPONENTS (#mols/HR)						
N2	38.1	38.1	38.1	15.8	22.3	-
O2	-	-	-	-	-	-
CH4	394.0	394.0	394.0	-	394.0	-
C2H6	-	-	-	-	-	-
C2H4	-	-	-	-	-	-
C3H8	-	-	-	-	-	-
H2	4321.0	4509.4	4509.4	3923.2	507.1	-
CO	222.5	34.1	34.1	-	34.1	-
CO2	911.5	1099.9	1099.9	-	1099.9	-
TOTAL, DRY	5887.1	6075.5	6075.5	3939.0	2136.5	-
H2O	2538.5	2350.1	16.9	-	16.9	2299.0
TOTAL, WET	8425.6	8425.6	6092.4	3939.0	2074.3	2299.0

110 - 18 PFD TABULATION

TABLE 4.19 (Cont'd)

UNIT: HYDROGEN PLANT — SECTION NO.: UNIT 600 — FOSTER WHEELER USA CORPORATION

CUSTOMER: DOE/METC — REF. DWG.: 36265-1-50-601 — PG. NO.: 3

LOCATION: — CONTRACT NO: 11-36265 — DATE: 3/13/87 — REV.: 0

STREAM NO. & UNITS	613	614	615	616		
STREAM DESCRIPTION	PROCESS CONDENSATE	TOTAL PROCESS CONDENSATE	STRIPPED CONDENSATE	VENT		
OPERATING CASE	BASECASE	BASECASE	BASECASE	BASECASE		
FLUID STATE	LIQUID	LIQUID	LIQUID	VAPOR		
TEMPERATURE (°F)	139	139	250	232		
PRESSURE (PSIG)	325	325	110	ATM.		
LIQUID (#/HR)	618	42034	49650	-		
VAPOR (#/HR)	-	-	-	621		
TOTAL (#/HR)	618	42034	49650	621		
MW OF VAPOR						
COMPONENTS (#mols/HR)						
N2	-	-	-	-		
O2	-	-	-	-		
CH4	-	-	-	-		
C2H6	-	-	-	-		
C2H4	-	-	-	-		
C3H8	-	-	-	-		
H2	-	-	-	-		
CO	-	-	-	-		
CO2		-	-	-		
TOTAL, DRY		-	-	-		
H2O	34.2	2333.2	2755.9	34.5		
TOTAL, WET	34.2	2333.2	2755.9	34.5		

TABLE 4.20

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION, PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: UNIT 600	EQUIPMENT LIST	NAME OF UNIT: HYDROGEN PLANT	PAGE 1 OF 3

CLIENT: DOE/METC

LOCATION:

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO PER TRAIN	TOTAL PLANT		REV.
TOWERS	T-601	CONDENSATE STRIPPER		1	2		
REACTORS	R-601	HYDROGENATOR		1	2		
	R-602A	SULFUR ABSORBER		1	2		
	R-602B	SULFUR ABSORBER		1	2		
	R-603	CHLORIDE GUARD		1	2		
	R-604	HIGH TEMPERATURE SHIFT CONVERTER		1	2		
	R-605	LOW TEMPERATURE SHIFT CONVERTER		1	2		
DRUMS	D-601	FEED KO DRUM		1	2		
	D-602	FUEL GAS KO DRUM		1	2		
	D-603	STEAM DRUM		1	2	PART OF H-601 REFORMER PACKAGE	
	D-604	CONTINUOUS BLOWDOWN DRUM		1	2		
	D-605	INTERMITTENT BLOWDOWN DRUM		1	2		
	D-606	HOT PROCESS CONDENSATE DRUM		1	2		
	D-607	COLD PROCESS CONDENSATE DRUM		1	2		
	D-608	STRIPPER REFLUX DRUM		1	2		

TABLE 4.20 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT 11-36265 SECTION: UNIT 600	EQUIPMENT LIST	NAME OF UNIT: HYDROGEN PLANT	PAGE 2 OF 3

CLIENT: DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION:	DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N NO PER TRAIN	TOTAL PLANT		REV.
EXCHANGERS	E-601	COMBUSTION AIR PREHEATER		1	2	PART OF H-601 REFORMER PACKAGE	
	E-602	REFORMER WASTE HEAT EXCHANGER		1	2	PART OF H-601 REFORMER PACKAGE	
	E-603	HTS BFW PREHEATER		1	2		
	E-604	LTS BFW PREHEATER		1	2		
	E-605	RAW GAS COOLER		1	2		
	E-606	RAW GAS TRIM COOLER		1	2		
	E-607	RAW CONDENSATE FEED PREHEATER		1	2		
	E-608	STRIPPER OVERHEAD CONDENSER		1	2		
	E-609	STRIPPED CONDENSATE AND BLOWDOWN COOLER		1	2		
	E-610	FIRST STAGE COOLER		1	2		
	E-611	SECOND STAGE COOLER		1	2		
	E-612	SPILL BACK COOLER		1	2		
	E-613	FISRT STAGE TRIM COOLER		1	2		
	E-614	SECOND STAGE TRIM COOLER		1	2		
	E-615	THIRD STAGE TRIM COOLER		1	2		
HEATERS	H-601	REFORMER		1	2		
PUMPS	P-601A	BFW CIRCULATION PUMP		1	2		
	P-601B	SPARE BFW CIRCULATION PUMP		1	2		
	P-602A	STRIPPED CONDENSATE PUMP		1	2		
	P-602B	SPARE STRIPPED CONDENSATE PUMP		1	2		
	P-603A	STRIPPER REFLUX PUMP		1	2		
	P-603B	SPARE STRIPPER RFLUX PUMP		1	2		
COMPRESSORS	C-601A	MAKE-UP COMPRESSOR		1	2		
	C-601B	SPARE MAKE-UP COMPRESSOR		1	2		

TABLE 4.20 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: UNIT 600	EQUIPMENT LIST	NAME OF UNIT HYDROGEN PLANT	PAGE 3 OF 3

CLIENT: DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION:	DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'D PER TRAIN	NO TOTAL PLANT		REV.
FANS	B-601	REFORMER F.D. FAN		1	2	PART OF H-601 REFORMER PACKAGE	
	B-602	REFORMER I.D. FAN		1	2	PART OF H-601 REFORMER PACKAGE	
FILTERS	F-601	HYDROGEN RECYCLE OIL FILTER		1	2		
MIXERS	M-601A	REFORMER FEED MIXER		1	2		
	M-601B	REFORMER FEED MIXER		1	2		
MISC.	ST-601	REFORMER STACK		1	2	PART OF H-601 REFORMER PACKAGE	
	PK-601	PSA PACKAGE		1	2		

TABLE 4.21
UNIT 600 - HYDROGEN PLANT EQUIPMENT SPECIFICATIONS

TOWERS

ITEM NO.	DESCRIPTION	DIA/HEIGHT	DESIGN PRESSURE	INTERNALS	MAT. OF CONSTR.
T-601	Condensate Stripper	3'-6"/61'-0"	40 PSIG + Max. Liq. Head + Full Vaccuum	Single Pass Valve Trays	5/64" 304L

REACTORS

ITEM NO.	DESCRIPTION	DIA/HEIGHT	DESIGN PRESSURE	INTERNALS	MAT. OF CONSTR.
R-601	Hydrogenator	7'-6"/13'-6"	520	Catalyst	C-1/2 MO
R-602A	Sulfur Absorber	7'-6"/13'-6"	520	Catalyst	C-1/2 MO
R-602B	Sulfur Absorber	7'-6"/13'-6"	520	Catalyst	C-1/2 MO
R-603	Chloride Guard	7'-6"/12'-6"	520	Catalyst	C-1/2 MO
R-604	HTS Converter	10'-9"/11'-6"	400	Catalyst	1 1/4 Cr-1/2 MO
R-605	LTS Converter	10'-9"/15'-0"	400	Catalyst	C.S.

DRUMS

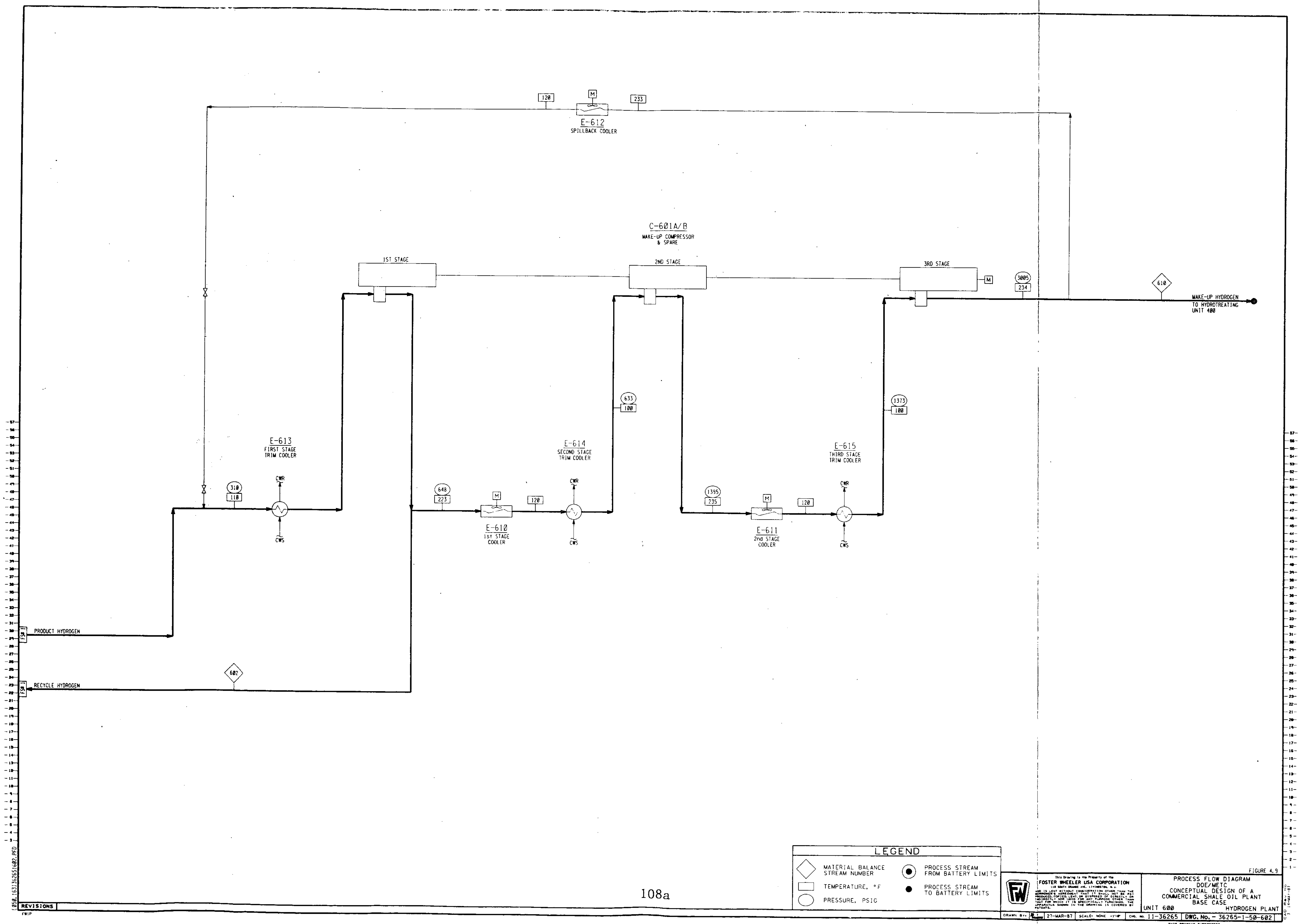
ITEM NO.	DESCRIPTION	POSITION	DIA/HEIGHT	DESIGN PRESSURE	CONSTRU.
D-601	Feed KO Drum	Vert.	2'-6"/7'-6"	550	C.S.
D-602	Fuel Gas KO Drum	Vert.	3'-0"/7'-0"	80	C.S.
D-603	Steam Drum	Horiz.	4'-9"/49'-6"	1850	5A-516-70
D-604	Cont. B.D. Drum	Vert.	2'-0"/5'-0"	275	C.S.
D-605	Intrmt. B.D. Drum	Vert.	5'-6"/6'-6"	30	C.S.
D-606	Hot Process Cond. Drum	Vert.	4'-9"/	365	C.S. 304L Clad
D-607	Cold Process Cond. Drum	Vert.		365	C.S.
D-608	Stripper Reflux Drum	Horiz.		40	C.S. 304L Clad

AIR COOLERS

ITEM NO.	DESCRIPTION	NO. OF BAYS	AREA, $FT.^2$	MAT. OF CONSTR.
E-605	Raw Gas Cooler	3	6615	304 S.S.
E-610	First Stage Coler	1	1650	C.S.
E-611	Second Stage Cooler	1	1650	C.S.
E-612	Spill Back Cooler	1	185	C.S.

HEATERS

ITEM NO.	DESCRIPTION	TYPE	DUTY, 10^6BTU/HR	COIL MAT.	OUTLET TEMP., ^oF
H-601	Reformer	Terrace Wall	146.14	25-35Nb	1560



E-612
SPILLBACK COOLER
C-601A/B
MAKE-UP COMPRESSOR & SPARE
1ST STAGE
2ND STAGE
3RD STAGE
MAKE-UP HYDROGEN TO HYDROTREATING UNIT 400
610
3005
234
E-613
FIRST STAGE TRIM COOLER
310
110
CWR
CWS
648
223
E-610
1st STAGE COOLER
120
E-614
SECOND STAGE TRIM COOLER
633
100
1395
235
E-611
2nd STAGE COOLER
E-615
THIRD STAGE TRIM COOLER
1373
PRODUCT HYDROGEN
RECYCLE HYDROGEN
602
233
LEGEND
MATERIAL BALANCE STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM FROM BATTERY LIMITS
PROCESS STREAM TO BATTERY LIMITS
FIGURE 4.9
This Drawing is the Property of the FOSTER WHEELER USA CORPORATION 110 SOUTH ORANGE AVE. LIVINGSTON, N.J.
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 600
HYDROGEN PLANT
DRAWN BY:
27-MAR-87
SCALE: NONE
CHG. No. 11-36265
DWG. No. - 36265-1-50-602
THIS DRAWING SUPERSEDES
THIS DRAWING SUPERSEDED BY
REVISIONS

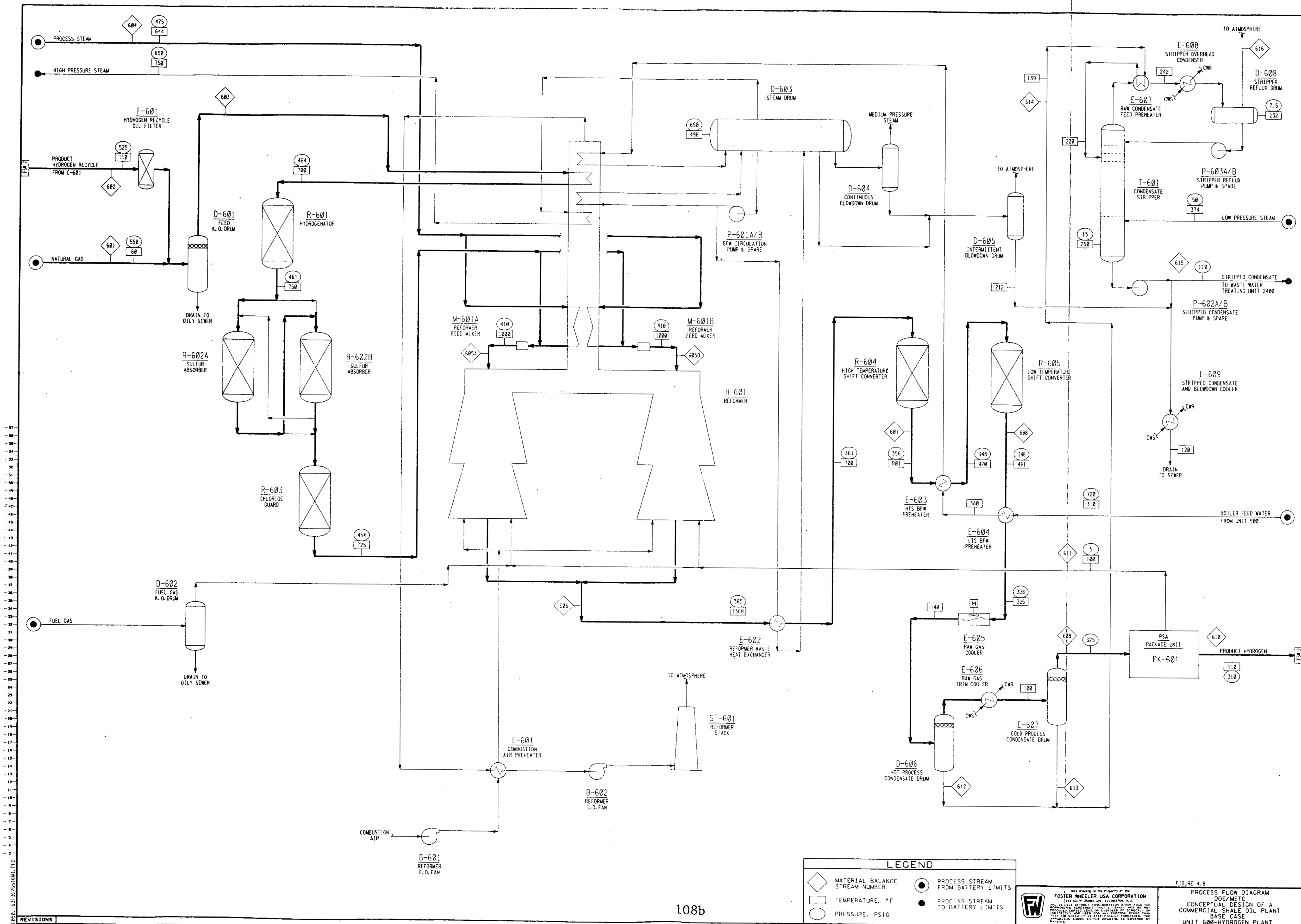

PROCESS STEAM
HIGH PRESSURE STEAM
PRODUCT HYDROGEN RECYCLE FROM C-601
NATURAL GAS
FUEL GAS
F-601 HYDROGEN RECYCLE OIL FILTER
D-601 FEED K.O. DRUM
DRAIN TO OILY SEWER
R-601 HYDROGENATOR
R-602A SULFUR ABSORBER
R-602B SULFUR ABSORBER
R-603 CHLORIDE GUARD
D-602 FUEL GAS K.O. DRUM
DRAIN TO OILY SEWER
M-601A REFORMER FEED MIXER
M-601B REFORMER FEED MIXER
H-601 REFORMER
D-603 STEAM DRUM
MEDIUM PRESSURE STEAM
D-604 CONTINUOUS BLOWDOWN DRUM
P-601A/B BFW CIRCULATION PUMP & SPARE
TO ATMOSPHERE
D-605 INTERMITTENT BLOWDOWN DRUM
E-608 STRIPPER OVERHEAD CONDENSER
E-607 RAW CONDENSATE FEED PREHEATER
D-608 STRIPPER REFLUX DRUM
T-601 CONDENSATE STRIPPER
P-603A/B STRIPPER REFLUX PUMP & SPARE
LOW PRESSURE STEAM
STRIPPED CONDENSATE TO WASTE WATER TREATING UNIT 2400
P-602A/B STRIPPED CONDENSATE PUMP & SPARE
E-609 STRIPPED CONDENSATE AND BLOWDOWN COOLER
DRAIN TO SEWER
R-604 HIGH TEMPERATURE SHIFT CONVERTER
R-605 LOW TEMPERATURE SHIFT CONVERTER
E-603 HTS BFW PREHEATER
E-604 LTS BFW PREHEATER
BOILER FEED WATER FROM UNIT 500
E-602 REFORMER WASTE HEAT EXCHANGER
E-605 RAW GAS COOLER
E-606 RAW GAS TRIM COOLER
D-606 HOT PROCESS CONDENSATE DRUM
E-607 COLD PROCESS CONDENSATE DRUM
PSA PACKAGE UNIT PK-601
PRODUCT HYDROGEN
E-601 COMBUSTION AIR PREHEATER
B-602 REFORMER I.D. FAN
ST-601 REFORMER STACK
COMBUSTION AIR
B-601 REFORMER F.D. FAN
CWS
CWR
REVISIONS
LEGEND
MATERIAL BALANCE STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM FROM BATTERY LIMITS
PROCESS STREAM TO BATTERY LIMITS
FIGURE 4.8
This Drawing is the Property of the FOSTER WHEELER USA CORPORATION 110 SOUTH ORANGE AVE. LIVINGSTON, N.J.
AND IS LENT WITHOUT CONSIDERATION OTHER THAN THE BORROWER'S AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT, OR DISPOSED OF DIRECTLY OR INDIRECTLY NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED. THE APPARATUS SHOWN IN THE DRAWING IS COVERED BY PATENTS.
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 600-HYDROGEN PLANT
DRAWN BY:
12-FEB-87
SCALE: NONE
CHG. No. 11-36265
DWG. No. - 36265-1-50-601
FORM NO. 135-931M
THIS DRAWING SUPERSEDES
THIS DRAWING SUPERSEDED BY

TABLE 4.21 (Cont'd)
UNIT 600 - HYDROGEN PLANT EQUIPMENT SPECIFICATIONS

PUMPS

ITEM NO.	DESCRIPTION	TYPE	FLOW, GPM	DISCH. PRESSURE PSIG	MAT. OF CONSTR.
P-601A/B	BFW Circ. Pump & Spare	Centrif.	110	183	C.S.
P-602A/B	Stripper Cond. Pump & Spare	Centrif.	135	144	C.S.
P-603A/B	Stripper Reflux Pump & Spare	Centrif.	20	74	C.S.

COMPRESSORS

ITEM NO.	DESCRIPTION	TYPE	FLOW, ACFM	OUTLET PRESSURE, PSIG	MAT. OF CONSTR.
C-601A/B	Make-Up Compr.	Recip.	1690	3005	C.S.

MISCELLANEOUS

ITEM NO.	DESCRIPTION
B-601	Reformer F.D. Fan*
B-602	Reformer I.D. Fan*
M-601A/B	Reformer Feed Mixer*
ST-601	Reformer Stack*

*Included in H-601 Reformer Package

4.7 Sour Water Treating - Unit 700

- Basis of Design

The sour water treating unit is designed to remove the dissolved acid gas components and ammonia from the aqueous process streams produced in Raw Oil Recovery, Unit 200, Gas Treating, Unit 300, Raw Oil Hydrotreating, Unit 400, and Hydrotreated Oil Fractionation, Unit 500. The design for sour water treating contains two parallel process trains, each capable of processing 540 gpm of sour water having the following composition:

	Wt. %
Carbon Dioxide	0.7
Hydrogen Sulfide	0.9
Ammonia	3.4
Non-Condensibles	0.1
Water	94.9
	100.0

The sour water treating process consists of the following steps:

- Steam stripping of acid gases
- Steam stripping of ammonia, after pH adjustment
- Selective absorption of ammonia from stripped acid gas
- Recovery and purification of ammonia

The design employs the USS Phosam-W process for selective removal and recovery of ammonia from acid gas streams. Specifications in the product streams from sour water treating are:

Anhydrous Ammonia	5 ppmw H_2S (Max)
Stripped Water	100 ppmw NH_3 (Max)
	100 ppmw H_2S (Max)

- Process Description

The process flow for sour water treating is shown in Figure 4.10.

Sour water from Raw Oil Recovery, Gas Treating, Hydrotreating and Fractionation are combined and preheated in the Sour Water Feed Preheater, E-702, so that the stream is at its bubble point. During start-up, and in the event of outages of E-702, the Sour Water Feed Heater, E-703, can provide the required stream heat-up by indirect low pressure steam. The preheated aqueous feed enters the top of the Sour Water Stripper, T-702, where both acid gases and free ammonia are stripped from the water. The water, stripped of its free ammonia, is then pumped to the Ammonia Stripper, T-701, where after pH adjustment the fixed ammonia content is removed. The bottoms from the stripper pass through the Sour Water Feed Preheater, E-702, and the Effluent Cooler, E-713, to be cooled before leaving battery limits. The stripped water, having an ammonia content of less than 100 ppmw, is recycled for use as wash water in the hydrotreater and make-up water for spent shale moisturizing.

4.7 Sour Water Treating - Unit 700 (Cont'd)

The combined overhead gas streams from the Ammonia Stripper and Sour Water Stripper, T-701 and T-702 respectively, containing stripped ammonia and acid gases are fed to the Absorber, T-704. There the gas stream is contacted with recirculating ammonium phosphate solution. About one half of the water entering the Absorber, T-704, is condensed in the first spray removing approximately 80% of the ammonia. The remaining vapor then passes upward through the tower where final scrubbing of ammonia occurs by counter current contact with cooled lean ammonium phosphate solution.

Vapor leaving the top of the Absorber, T-704, contains approximately 2,000 ppmv of ammonia. These vapors are cooled in the After Condenser, E-707, condensing a portion of the gas and reducing the ammonia content in the gas to less than 100 ppmw. The gas exits battery limits at 150°F and 5 psig and flows to Sulfur Recovery, Unit 800.

The rich ammonium phosphate solution from the bottoms of the Absorber, T-704, is heated in the Solution Exchanger, E-709, by hot lean solution from the bottom of the Stripper, T-705. The hot solution is sparged into the Contactor, D-703, where it is flashed. Flashing the rich solution releases small amounts of acid gas which were absorbed during contact with the vapor in the Absorber, T-704. The released acid gas returns to the Absorber, T-704, for reabsorption.

The rich solution, free of acid gas content, is pumped through the top section of the Stripper Condenser, E-712A, to the Stripper, T-705. The stripper removes the absorbed ammonia and generates lean ammonium phosphate solution for recycle to the Absorber, T-704.

The aqueous ammonia vapor, containing from 10 to 20 wt. % ammonia, from the top of the Stripper, T-705, is condensed in the Stripper Condenser, E-712A/B. The aqueous ammonia condensate flows by gravity to the Fractionator Feed Drum, D-704. To prevent trace amounts of CO_2 and H_2S gas from collecting in this drum, a small stream of sodium hydroxide, NaOH, is continuously fed into the drum by the Caustic Metering Pump, P-707. The NaOH reacts with the acid gases forming salts which are purged from the Fractionator, T-703, with the bottoms.

The aqueous ammonia condensate is pumped to the Fractionator, T-703, where it is distilled at elevated pressure to an anhydrous ammonia product, 99.5% NH_3 by volume. The overhead ammonia product is condensed and divided into a reflux and product stream. The rate of ammonia product leaving the battery limits is regulated to provide the continuous production of high quality product, which is pumped to storage.

The alkaline bottoms stream leaving the Fractionator, T-703, containing small amounts of ammonia, is flashed directly into the bottom of the Sour Water Stripper, T-702.

4.7 Sour Water Treating - Unit 700 (Cont'd)

- Utilities Summary

The normal operating requirements for one train of sour water treating are summarized below. The total plant contains two identical operating trains.

Utility	Normal Demand
Steam, 550 psig, 750°F	105,000 Lb/Hr
Steam, 45 psig, Sat.	46,550 Lb/hr
Cooling Water, 85°F	11,960 GPM
Electricity	550 KW
Phosphoric Acid (as 100% H_3PO_4)	44,700 Lb/Month
Caustic (as 100% NaOH)	63,900 Lb/Month

- Heat and Material Balance

A summary of process stream flows for the sour water treating unit, keyed to the process flow diagram by stream numbers, is given in Table 4.22. This material balance table represents one of two operating trains for sour water treating.

- Process Equipment Summary

Major process equipment required per train of sour water treating, as well as for the total plant, are listed in Table 4.23. The corresponding equipment specifications are provided in Table 4.24.

TABLE 4.22

UNIT: SOUR WATER TREATMENT — SECTION NO.: UNIT 700 — **FOSTER WHEELER USA CORPORATION**

CUSTOMER: DOE/METC SHALE OIL PLANT — REF. DWG.: 36265-1-50-701 — PG. NO.: 1

LOCATION: WESTERN COLORADO — CONTRACT NO: 11-36265 — DATE: May 12, 1987 — REV.:

STREAM NO. & UNITS	701	702	703	704		
STREAM DESCRIPTION	TOTAL SOUR WATER FEED	ACID GAS TO SULFUR RECOVERY	AMMONIA PRODUCT TO STORAGE	STRIPPED WATER		
OPERATING CASE	BASECASE	BASECASE	BASECASE	BASECASE		
FLUID STATE						
TEMPERATURE (°F)						
PRESSURE (PSIG)						
LIQUID (#/HR)	262,988	-	8824	248,721		
VAPOR (#/HR)	-	5443	-	-		
TOTAL (#/HR)	262,988	5443	8824	248,721		
MW OF VAPOR		31.66				
COMPONENTS (#mols/HR)						
CO2	41.9	41.9	--	-		
H2S	69.5	68.9	0.0012	0.6		
NH3	520.5	3.1	515.9	1.4		
NON-CONDENSIBLES	15.4	15.4	--	-		
TOTAL, DRY	647.3	129.3	515.9	5.8		
H2O	13,847.6	42.6	2.0	13,803.0		
TOTAL, WET	14,494.9	171.9	517.9	13,810.8		

110 - 18 PFD TABULATION

TABLE 4.23

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: UNIT 700	EQUIPMENT LIST	NAME OF UNIT: SOUR WATER TREATING	PAGE 1 OF 2

CLIENT: DOE/METC

LOCATION: Western Colorado

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO	DESCRIPTION	EFD	REQ'N. NO. PER TRAIN	TOTAL PLANT	REV.
TOWERS	T-701	AMMONIA STRIPPER		1	2	
	T-702	SOUR WATER STRIPPER		1	2	
	T-703	FRACTIONATOR		1	2	
	T-704	ABSORBER		1	2	
	T-705	STRIPPER		1	2	
DRUMS	D-701	REFLUX DRUM		1	2	
	D-702	CONDENSATE DRUM		1	2	
	D-703	CONTACTOR		1	2	
	D-704	FRACTIONATOR FEED DRUM		1	2	
TANKS	TK-701	PHOSPHORIC ACID STORAGE TANK		1	2	
	TK-702	CAUSTIC STORAGE TANK		1	2	
EXCHANGERS	E-701	AMMONIA STRIPPER REBOILER		1	2	
	E-702	SOUR WATER FEED PREHEATER		1	2	
	E-703	SOUR WATER FEED HEATER		1	2	
	E-704	SOUR WATER STRIPPER REBOILER		1	2	
	E-705	FRACTIONATOR REBOILER		1	2	
	E-706	FRACTIONATOR CONDENSER		1	2	
	E-707	AFTERCONDENSER		1	2	
	E-708	ABSORBER COOLER		1	2	
	E-709	SOLUTION EXCHANGER		1	2	
	E-710	LEAN SOLUTION COOLER		1	2	
	E-711	STRIPPER REBOILER		1	2	
	E-712A	STRIPPER CONDENSER (TOP)		1	2	
	E-712B	STRIPPER CONDENSER (BOTTOM)		1	2	
	E-713	EFFLUENT COOLER		1	2	

TABLE 4.23 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION, PROCESS PLANTS DIVISION	CONTRACT: 11-36265	EQUIPMENT LIST	NAME OF UNIT: SOUR WATER TREATING	PAGE 2 OF 2
	SECTION: UNIT 700			

CLIENT: DOE/METC

LOCATION: Western Colorado

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO. PER TRAIN	TOTAL PLANT		REV.
PUMPS	P-701A	AMMONIA STRIPPER BOTTOMS PUMP		1	2		
	P-701B	SPARE AMMONIA STRIPPER BTMS. PUMP		1	2		
	P-702A	FRACTIONATOR REFLUX PUMP		1	2		
	P-702B	SPARE FRACTIONATOR REFLUX PUMP		1	2		
	P-703A	CONDENSATE PUMP		1	2		
	P-703B	SPARE CONDENSATE PUMP		1	2		
	P-704A	ABSORBER CIRCULATION PUMP		1	2		
	P-704B	ABSORBER CIRCULATION PUMP		1	2		
	P-704C	SPARE ABSORBER CIRCULATION PUMP		1	2		
	P-705	PHOSPHORIC ACID ADDITION PUMP		1	2		
	P-706A	RICH SOLUTION PUMP		1	2		
	P-706B	SPARE RICH SOLUTION PUMP		1	2		
	P-707A	CAUSTIC METERING PUMP		1	2		
	P-707B	SPARE CAUSTIC METERING PUMP		1	2		
	P-708A	FRACTIONATOR FEED PUMP		1	2		
	P-708B	SPARE FRACTIONATOR FEED PUMP		1	2		
	P-709A	AMMONIA STRIPPER FEED PUMP		1	2		
	P-709B	SPARE AMMONIA STRIPPER FEED PUMP		1	2		

TABLE 4.24

UNIT 700 - SOUR WATER TREATING EQUIPMENT SPECIFICATIONS

TOWERS

ITEM NO.	DESCRIPTION	DIA/HEIGHT	DESIGN PRESSURE	INTERNALS	MAT. OF CONSTR.
T-701	Ammonia Stripper	7'-0"/110'-0"	25 PSIG	304 S.S. Trays	5A-516-70
T-702	Sour Water Stripper	8'-0"/168'-0"	50 PSIG	304 S.S. Trays	C.S.
T-703	Fractionator	3'-6"/194'-0"	300 PSIG	304 S.S. Trays	304 L. S.S.
T-704	Absorber	7'-0"/97'-0"	50 PSIG	304 S.S. Trays	304 L. S.S.
T-705	Stripper	6'-0"/122'-0"	300 PSIG	304 S.S. Trays	304 L. S.S.

DRUMS

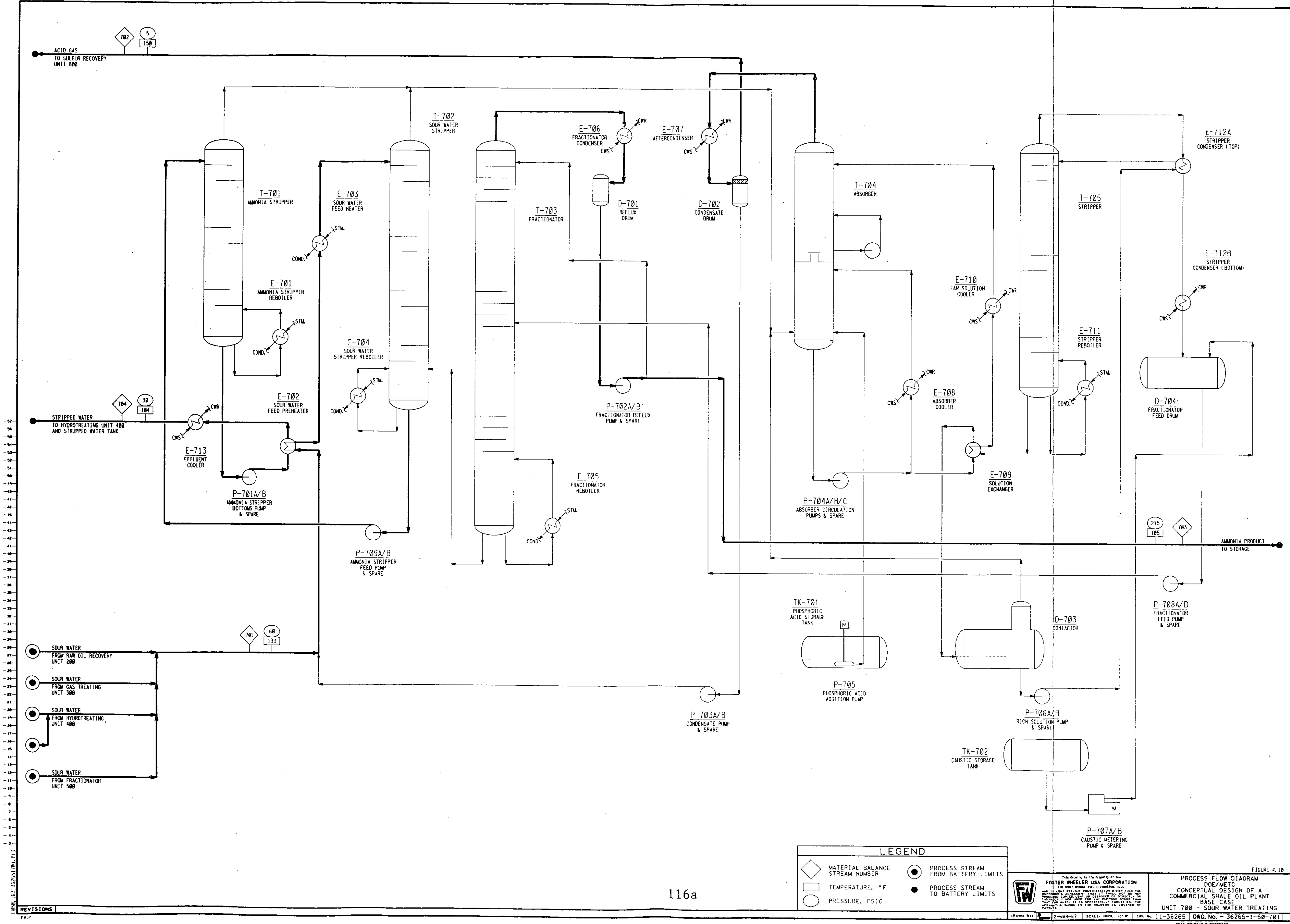
ITEM NO.	DESCRIPTION	POSITION	DIA/HEIGHT	DESIGN PRESSURE	MAT OF CONSTR.
D-701	Reflux Drum	Vert.	2'6"/4'-0"	300 PSIG	C.S.
D-702	Condensate Drum	Vert.	3'6"/20'-0"	20 PSIG	316 L. S.S.
D-703	Contractor	Horiz.	9'-0"/18'-6"	15 PISG	304 L. S.S.
D-704	Fractionator Feed Drum	Horiz.	10'-0"/26'-6"	300 PSIG	304 L. S.S.

TANKS

ITEM NO.	DESCRIPTION	POSITION	DIA/HEIGHT	DESIGN PRESSURE	MAT. OF CONSTR.
TK-701	Phosporic Acid Storage Tank	N.A.	6'-0"/12'-0"	ATM.	316 L. S.S.
TK-702	Caustic Storage Tank	N.A.	40'-0"/40'-0"	ATM.	C.S.

EXCHANGERS

ITEM NO.	DESCRIPTION	TEMA TYPE	AREA, $FT.^2$	MAT. OF CONSTR.
E-701	Ammonia Stripper Reboiler	AEL	5009	C.S. 430 S.S. Tubes
E-702	Sour Water Feed Preheater	Spiral Plate	6949	304 S.S. 304 S.S. Tubes
E-703	Sour Water Feed Heater	AEU	632	C.S. 304 S.S. Tubes
E-704	Sour Water Stripper Reboiler	AEL	3411	C.S. C.S. Tubes
E-705	Fractionator Reboiler	AES	1551	C.S. 430 S.S. Tubes
E-706	Fractionator Condenser	AJU	6752	C.S. C.S. Tubes
E-707	Aftercondenser	AEP	409	C.S. 304 L. S.S. Tubes
E-708	Absorber Cooler	AEU	3538	C.S. 304 L. S.S. Tubes
E-709	Solution Exchanger	AEU	1074	304 L. S.S. 304 L. S.S. Tubes



ACID GAS
TO SULFUR RECOVERY
UNIT 800
702
5
150
T-701
AMMONIA STRIPPER
T-702
SOUR WATER
STRIPPER
T-703
FRACTIONATOR
E-706
FRACTIONATOR
CONDENSER
E-707
AFTERCONDENSER
D-701
REFLUX
DRUM
D-702
CONDENSATE
DRUM
T-704
ABSORBER
T-705
STRIPPER
E-712A
STRIPPER
CONDENSER (TOP)
E-712B
STRIPPER
CONDENSER (BOTTOM)
E-703
SOUR WATER
FEED HEATER
E-701
AMMONIA STRIPPER
REBOILER
E-704
SOUR WATER
STRIPPER REBOILER
E-702
SOUR WATER
FEED PREHEATER
E-713
EFFLUENT
COOLER
STRIPPED WATER
TO HYDROTREATING UNIT 400
AND STRIPPED WATER TANK
704
30
104
P-701A/B
AMMONIA STRIPPER
BOTTOMS PUMP
& SPARE
P-709A/B
AMMONIA STRIPPER
FEED PUMP
& SPARE
E-705
FRACTIONATOR
REBOILER
P-702A/B
FRACTIONATOR REFLUX
PUMP & SPARE
E-710
LEAN SOLUTION
COOLER
E-711
STRIPPER
REBOILER
E-708
ABSORBER
COOLER
D-704
FRACTIONATOR
FEED DRUM
E-709
SOLUTION
EXCHANGER
P-704A/B/C
ABSORBER CIRCULATION
PUMPS & SPARE
275
105
703
AMMONIA PRODUCT
TO STORAGE
TK-701
PHOSPHORIC
ACID STORAGE
TANK
D-703
CONTACTOR
P-708A/B
FRACTIONATOR
FEED PUMP
& SPARE
P-705
PHOSPHORIC ACID
ADDITION PUMP
P-703A/B
CONDENSATE PUMP
& SPARE
P-706A/B
RICH SOLUTION PUMP
& SPARE
TK-702
CAUSTIC STORAGE
TANK
P-707A/B
CAUSTIC METERING
PUMP & SPARE
701
60
133
SOUR WATER
FROM RAW OIL RECOVERY
UNIT 200
SOUR WATER
FROM GAS TREATING
UNIT 300
SOUR WATER
FROM HYDROTREATING
UNIT 400
SOUR WATER
FROM FRACTIONATOR
UNIT 500
STM.
COND.
CWR
CWS
M
LEGEND
MATERIAL BALANCE
STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM
FROM BATTERY LIMITS
PROCESS STREAM
TO BATTERY LIMITS
FIGURE 4.10
This Drawing is the Property of the
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110 SOUTH ORANGE AVE, LIVINGSTON, N.J.
AND IS LENT WITHOUT CONSIDERATION OTHER THAN THE BORROWER'S AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT, OR DISPOSED OF DIRECTLY OR INDIRECTLY NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED. THE APPARATUS SHOWN IN THE DRAWING IS COVERED BY PATENTS.
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 700 - SOUR WATER TREATING
DRAWN BY:
12-MAR-87
SCALE: NONE
CHG. No. 11-36265
DWG. No. - 36265-1-50-701
REVISIONS
FORM NO. 135-931M
THIS DRAWING SUPERSEDES
THIS DRAWING SUPERSEDED BY

4.8 Sulfur Recovery - Unit 800

- **Basis of Design**

The sulfur recovery plant is designed to treat the effluent gases from Gas Treating, Unit 300, and Sour Water Treating, Unit 700, for removal of hydrogen sulfide via the LO-CAT(R) Process. Two identical process trains, with a design capacity of 35 TPD sulfur, are provided to treat the make gas produced in the entire plant.

The compositions, flowrates, and conditions at which the feed gases are delivered to each of the sulfur recovery trains are as follows:

Component	Mol%	
	Unit 300	Unit 700
H_2	44.95	-
CO	3.72	-
CO_2	14.86	24.38
H_2O	1.47	24.78
H_2S	0.89	40.08
NH_3	0.01	1.80
CH_4	16.01	-
C_2H_4	2.24	-
C_2H_6	5.71	-
C_3H_6	2.47	-
C_3H_8	2.87	-
C_4H_8	2.54	-
C_4H_{10}	0.50	-
N_2	1.65	8.96
C_5+	0.11	-
	100.00	100.00
Total Weight, Lbs/Hr	47,712	5,443
Molecular Wt.	18.6	31.7
Pressure, PSIG	100	5
Temperature, °F	120	150

4.8 Sulfur Recovery - Unit 800 (Cont'd)

The sulfur recovery unit is designed to remove 99+% of the H_2S contained in the raw gas feed, while producing a high purity molten sulfur by-product. The treated fuel gas contains a maximum of 10 ppmv H_2S and has the following expected composition:

Component	Mol%
H_2	45.32
CO	3.75
CO_2	14.99
H_2O	1.53
H_2S	(<10 ppmv)
NH_3	0.01
CH_4	16.15
C_2H_4	2.26
C_2H_6	5.75
C_3H_6	2.49
C_3H_8	2.90
C_4H_8	2.56
C_4H_{10}	0.51
N_2	1.67
C_5+	0.11
	100.00
Total Weight, Lbs/Hr	46,958
Molecular Wt.	18.50
LHV, BTU/SCF	626

- Process Description

The process flow diagram for the sulfur recovery unit is shown in Figure 4.11.

The sour gas from Gas Treating, Unit 300, at 100 psig and 120°F enters the sulfur recovery unit and is passed through the Sour Gas Scrubber to remove entrained liquids. The gas stream then enters at the bottom of Liquid Filled Absorber, through a specially designed Venturi Pre-contactor (prescrubber). The gas is distributed in the LO-CAT(R) solution by means of a non-plugging type distributor and bubbles upward through the solution where the H_2S is converted to elemental sulfur. The sweet fuel gas with less than 10 ppmv H_2S leaves the unit.

4.8 Sulfur Recovery - Unit 800 (Cont'd)

Regenerated LO-CAT(R) solution from the oxidizer enters the absorber slightly below the liquid level and flows downward, countercurrent to the gas flow. The spent solution leaves the vessel through an internal cone bottom. Partially reduced solution passes through the Solution Cooler and into the Oxidizer vessel, where it is regenerated by direct contact with compressed air.

The oxidizer is a cone bottom vessel which performs two functions: oxidation and settling. Oxidation of the iron based catalyst is performed in the portion of the vessel above the air sparger. The partially reduced catalyst solution enters the vessel just below the liquid level and flows downward through the oxidizer section where it is contacted with air and reoxidized. The liquid is distributed across the entire cross sectional area of the vessel via a standard slotted pipe distributor. The air is distributed via a non-plugging type distributor. The overall reaction for hydrogen sulfide removal is:

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

Air for re-oxidation of the catalyst solution is provided by an Air Compressor.

The off-gas from Sour Water Treating, Unit 800, at 5 psig and 150°F is passed through the Gas Cooler and cooled to 120°F. It is then treated in a small absorber located within the oxidizer vessel. The spent air, along with the treated off-gas from Sour Water Treating having H_2S removed to less than 10 ppmv, leaves the top of the Oxidizer vessel and discharges to the atmosphere.

Sulfur formed in the absorber vessel circulates with the solution and the particles grow to the 10-20 micrometer range. The larger particles settle out of the bulk solution in the bottom of the Oxidizer vessel and are flushed out of the cone-bottomed settling area as a slurry at 10 to 20 wt% sulfur.

The sulfur slurry is pumped at approximately 100 psig through a special non-plugging sulfur melter, where it is heated to 270°F by 50 psig steam. The solution and molten sulfur phase, formed in the melter, flow through steam jacketed piping to the Sulfur Separator, where a liquid-liquid interface is maintained. The molten sulfur product is withdrawn from the Sulfur Separator on level control and sent to molten sulfur storage.

4.8 Sulfur Recovery - Unit 800 (Cont'd)

The aqueous solution leaves the Sulfur Separator through a back pressure control valve and is returned to the Oxidizer.

In the oxidation of H_2S to sulfur, the following side reaction takes place:

$$4HS^- + 3O_2 \longrightarrow 2H_2S_2O_3$$

This reaction reduces the pH of the scrubbing solution, and therefore Na_2CO_3, KOH or other alkaline salt must be added to maintain the solution in the 8-8.5 pH range. This leads to a gradual buildup of $Na_2S_2O_3$ or similar water-soluble sulfur-containing salts in the solution. These have no deleterious effect at concentrations below about 30 wt%. The solution composition is maintained at a stable level by continuous addition of the following chemicals:

ARI-310 Concentrate is added to replace any solution which may be lost with the sulfur cake.

ARI-310M Chelate-Rich Makeup solution is added to replace Type A and Type B chelate compounds lost from the solution by slow oxidation reactions.

Na_2CO_3 Buffering Solution is added to replace losses with the sulfur cake and to neutralize thiosulfate ions formed in the process. Adjustments in the addition rate are based on daily measurements of the solution pH.

ARI-400 Biochem Biostat is added at about 10 ppm by weight per day. This prevents biological damage to the chelate system.

Wetting Agent and Anti-Foam Additives may be added continuously in small amounts if the gas stream contains oily materials which interfere with sulfur settling, or surface active materials which can otherwise cause foaming.

4.8 Sulfur Recovery - Unit 800 (Cont'd)

- Utilities and Chemical Summary

The normal operating utilities and chemicals requirement for one train of sulfur recovery are summarized below. The total plant contains two identical trains.

Utilities Consumption

Electric Power	Normal KW	Connected Load KW
Air Compressor	331	402
Air Compressor (Spare)	-	402
Pumps (Total)	720	796
Pumps (Spare Total)	-	796
Instruments and Lighting	10	10
Total	1061	

	Battery Limits Conditions	Normal Demand
Steam Consumption, lb/hr	60 psig/303°F	4,000
Condensate Production, lb/hr		4,000
Cooling Water, GPM @ 30°F ΔT	80 psig/80°F	1,039

Chemicals Consumption

ARI-310	40.6 Lbs/Hr
ARI-310M	207.3 Lbs/Hr
KOH	130.7 Lbs/Hr
Other Chemicals	72 $/Day

- Heat and Material Balance

A summary of process stream flows for the sulfur recovery unit, keyed to the process flow diagram by stream numbers, is given in Table 4.25. This material balance table represents one of two operating trains for sulfur recovery.

TABLE 4.25

UNIT: Sulfur Recovery	SECTION NO.: 800	FOSTER WHEELER USA CORPORATION
CUSTOMER: DOE/METC SHALE OIL PLANT	REF. DWG.:	PG. NO.: 1 of 2
LOCATION: Western Colorado	CONTRACT NO.: 11-36265 DATE 5/12/87	REV. NO.:

STREAM NO. & UNITS		801	802	803	804	805	
STREAM DESCRIPTION		Treated Gas From Gas Treating	Acid Gas From Sour Water Treating	Sweet Fuel Gas	Liquid Sulfur	Oxidizing Air	
FLUID STATE		Vapor	Vapor	Vapor	Liquid	Vapor	
TEMPERATURE (°F)		120	150	120	270	AMB	
PRESSURE (PSIG)		100	5	95		0	
LIQUID (LB/HR)					2,941		
VAPOR (LB/HR)		47,712	5,443	46,958		63,315	
SOLIDS (LB/HR)							
TOTAL (LB/HR)		47,712	5,443	46,958	2,941	63,315	
MOLECULAR WEIGHT (SOLIDS FREE)		18.6	31.66	18.50		28.6	
COMPONENTS (LB-MOL/HR)	MW						
HYDROGEN	2.016	1150.7		1150.7			
CARBON MONOXIDE	28.01	95.3		95.3			
CARBON DIOXIDE	44.01	380.6	41.9	380.6			
WATER	18.016	37.5	42.6	38.8		50.9	
HYDROGEN SULFIDE	34.086	22.8	68.9	<10 ppmv			
AMMONIA	17.034	0.2	3.1	0.2			
METHANE	16.042	409.9		409.9			
ETHYLENE	28.052	57.4		57.4			
ETHANE	30.068	146.1		146.1			
PROPYLENE	42.078	63.2		63.2			
PROPANE	44.094	73.5		73.5			
BUTENE	56.104	65.1		65.1			
BUTANE	58.12	12.9		12.9			
NITROGEN	28.02	42.3	15.4	42.3		1708.8	
HEAVY NAPHTHA		2.9		2.9			
SULFUR	32.07				91.7		
OXYGEN	32.00					453.7	
TOTAL (LB-MOL/HR)		2560.4	171.9	2538.9	91.7	2213.4	

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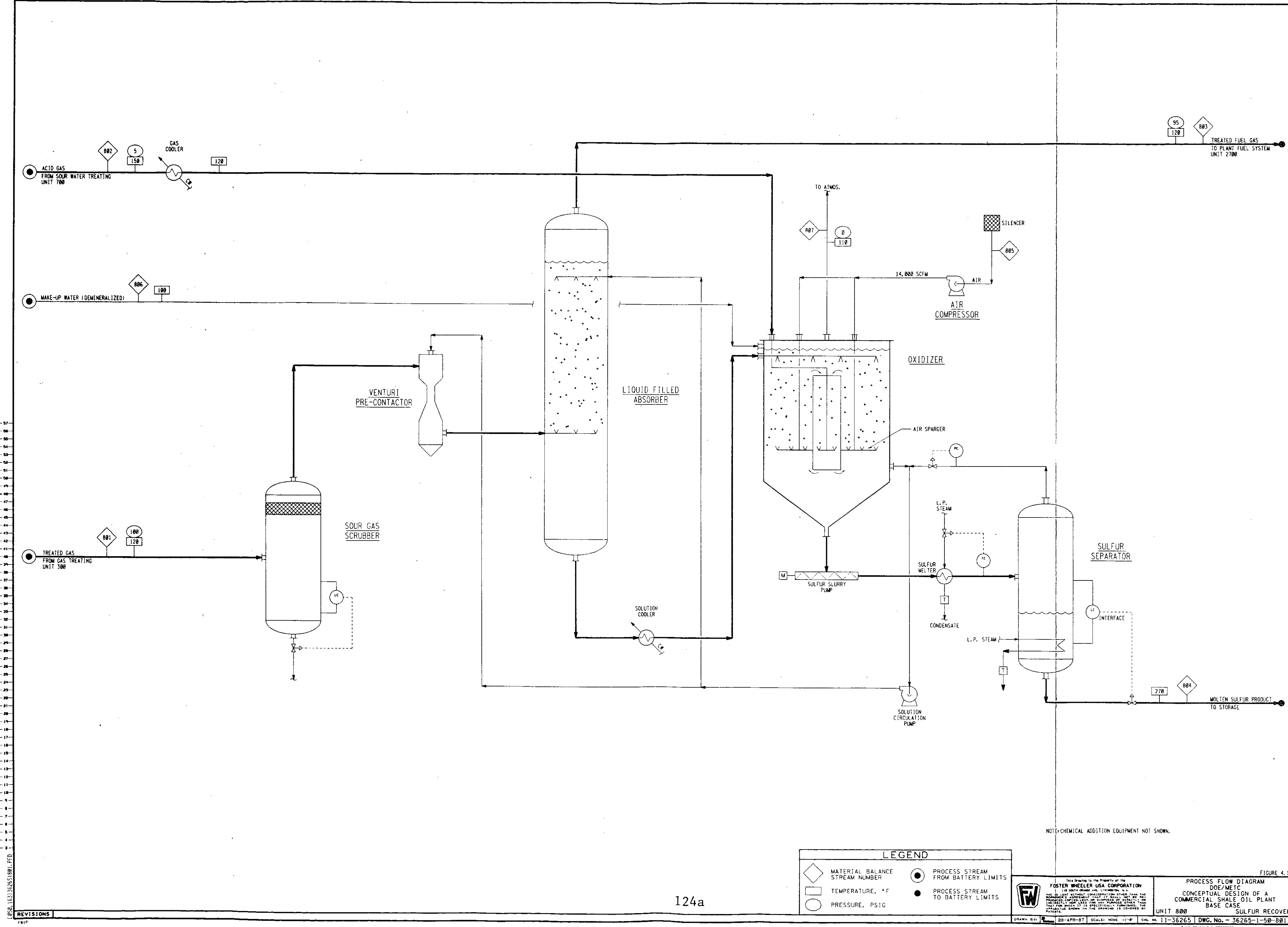
TABLE 4.25 (Cont'd)

UNIT: Sulfur Recovery
CUSTOMER: DOE/METC SHALE OIL PLANT
LOCATION: Western Colorado

SECTION NO.: 800
REF. DWG.:
CONTRACT NO.: 11-36265
DATE 5/12/87

FOSTER WHEELER USA CORPORATION
PG. NO.: 2 of 2
REV. NO.:

STREAM NO. & UNITS	MW	806	807
STREAM DESCRIPTION		Make-Up Water	Oxidizer Vent
FLUID STATE		Liquid	Vapor
TEMPERATURE (°F)			110
PRESSURE (PSIG)			0
LIQUID (LB/HR)		2,108	
VAPOR (LB/HR)			68,679
SOLIDS (LB/HR)			
TOTAL (LB/HR)		2,108	68,679
MOLECULAR WEIGHT (SOLIDS FREE)			27.72
COMPONENTS (LB-MOL/HR)	MW		
HYDROGEN	2.016		
CARBON MONOXIDE	28.01		
CARBON DIOXIDE	44.01		41.9
WATER	18.016	117.0	300.9
HYDROGEN SULFIDE	34.086		
AMMONIA	17.034		3.1
METHANE	16.042		
ETHYLENE	28.052		
ETHANE	30.068		
PROPYLENE	42.078		
PROPANE	44.094		
BUTENE	56.104		
BUTANE	58.12		
NITROGEN	28.02		1724.2
HEAVY NAPHTHA			
SULFUR	32.07		
OXYGEN	32.00		407.8
TOTAL (LB-MOL/HR)		117.0	2477.9


ACID GAS
FROM SOUR WATER TREATING
UNIT 700
802
5
150
GAS
COOLER
CW
120
95
120
803
TREATED FUEL GAS
TO PLANT FUEL SYSTEM
UNIT 2700
TO ATMOS.
807
0
110
SILENCER
805
14,000 SCFM
AIR
AIR
COMPRESSOR
MAKE-UP WATER (DEMINERALIZED)
806
100
VENTURI
PRE-CONTACTOR
LIQUID FILLED
ABSORBER
OXIDIZER
AIR SPARGER
PC
SOUR GAS
SCRUBBER
TREATED GAS
FROM GAS TREATING
UNIT 300
801
100
120
LC
L.P.
STEAM
TC
SULFUR
MELTER
SULFUR SLURRY
PUMP
M
T
CONDENSATE
SULFUR
SEPARATOR
LC
INTERFACE
L.P. STEAM
SOLUTION
COOLER
CW
SOLUTION
CIRCULATION
PUMP
270
804
MOLTEN SULFUR PRODUCT
TO STORAGE
NOTE: CHEMICAL ADDITION EQUIPMENT NOT SHOWN.
LEGEND
MATERIAL BALANCE
STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM
FROM BATTERY LIMITS
PROCESS STREAM
TO BATTERY LIMITS
FIGURE 4.11
This Drawing is the Property of the
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PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 800
SULFUR RECOVERY
DRAWN BY:
08-APR-87
SCALE: NONE
CHG. No. 11-36265
DWG. No. - 36265-1-50-801
FORM NO. 135-951M
THIS DRAWING SUPERSEDES
THIS DRAWING SUPERSEDED BY
REVISIONS

TABLE 4.24 (Cont'd)

UNIT 700 - SOUR WATER TREATING EQUIPMENT SPECIFICATIONS

EXCHANGERS (continued)

E-710	Lean Solution Cooler	AEU	3032	C.S. 304 L. S.S. Tubes
E-711	Stripper Reboiler	AES	3095	C.S. 304 L. S.S. Tubes
E-712A	Stripper Condenser (Top)	BEX	3095	304 L. S.S. 304L. S.S. Tubes
E-712B	Stripper Condenser (Bottom)	XEP	1390	C.S. 304 L. S.S. Tubes
E-713	Effluent Cooler	AEU	5903	C.S. C.S. Tubes

PUMPS

ITEM NO.	DESCRIPTION	TYPE	FLOW, GPM	DISCH. PRESS. PSIG	MAT. OF CONSTR.
P-701A/B	Ammonia Stripper Bottoms Pump & Spare	Centrif.	820	50	304 S.S.
P-702A/B	Fractionator Reflux Pump & Spare	Centrif.	140	40	C.S. Case S.S. Impel
P-703A/B	Condensate Pump & Spare	Centrif.	40	66	304 S.S.
P-704A/B/C	Absorber Circulation Pumps & Spare	Centrif.	1580	58	304 S.S.
P-705	Phosphoric Acid Addition Pump	Centrif.	65	29	316 S.S.
P-706A/B	Rich Solution Pump & Spare	Centrif.	475	241	304 S.S.
P-707A/B	Caustic Metering Pump & Spare	Recip.	2	260	316 S.S.
P-708A/B	Fractionator Feed Pump & Spare	Centrif.	185	77	304 S.S.
P-709A/B	Ammonia Stripper Feed Pump & Spare	Centrif.	915	30	304 S.S.

4.9 Spent Shale Moisturizing - Unit 900

- **Basis of Design**

Spent shale produced on the retorting system, Unit 100, is moisturized to 14%, based on the dry weight, in order to condition this material for disposal and compaction on a spent shale pile. The spent shale moisturizing system is designed as six parallel trains, each capable of processing 9200 TPD of dry feed. Each retorting train will have a dedicated train of spent shale moisturizing to avoid long distance handling of the powdery dry material.

Each moisturizing train receives the following feed streams of dry spent shale at 350°F, from the corresponding retorting module:

	Size	TPD
Coarse Retorted Shale	-6 mm	8,323
Fine Retorted Shale	-100 microns	867
Total		9,190

The outlet temperature for the moisturized spent shale is limited to 180°F to avoid particulate emissions resulting from surface water evaporation. Stripped sour water, from Unit 700, and other treated aqueous streams produced in the normal plant operation are used as make-up water for moisturizing the spent shale.

- **Process Description**

Dry spent shale is stored in the Spent Shale Surge Bin, BN-901. This bin, in addition to providing a surge between the retorting plant and the moisturizing unit, helps to blend the coarse shale with fines to assure a fairly homogenous particle size distribution in the feed.

Blended spent shale is continuously fed by the Screw Conveyor, CV-901, to the Pugg Mill, A-901 . Moisturizing water is sprayed in the pugg mill to cool and moisturize the shale.

Moisturized shale is discharged on the moisturized shale conveyors, CV-902, CV-903 and CV-904. These conveyors are hooded and ventilated to avoid particulate emissions. Moisturized shale is then discharged directly into a hauling truck for final disposal. At the CV-904 conveyor discharge, the Moisturized Shale Hopper, BN-902, allows for short time storage required for truck changing. There is no provision for longer period storage of moisturized spent shale, due to its tendency for hardening and compaction in bins.

4.9 Spent Shale Moisturizing - Unit 900 (Cont'd)

Spent shale dust and steam generated by the spent shale cooling is vented from the pugg mill and collected in Venturi Scrubber, A-902, where water scrubbing removes the dust and condenses the steam. Non-condensibles carried by the dry spent shale, and air leaking into the system, are separated in the Water Separator, D-901, and vented to the atmosphere.

Venturi scrubber water is supplied by the Recirculating Pump, P-901, after it is air cooled in E-901. Make-up water is sprayed into the Water Separator D-901, or fed directly to the venturi scrubber inlet.

Steam and spent shale dust generated on the conveyor, CV-902, are handled in the Conveyor Blower, B-902, and scrubbed in the water separator D-901. The entire plant is maintained under a slight vacuum to avoid dust emissions.

- Utilities Summary

The normal operating requirements for one train of spent shale moisturizing are summarized below. The total plant contains six identical operating trains.

Utility		Normal Demand
Raw Water, GPM		
Shale Moisturizing		220
Dust Surpression		40
Total		260
Electric Power, KW		
A-901	Pugg Mill	
B-901	Vent Blower	20
B-902	Conveyor Blower	20
CV-901	Screw Conveyor	80
CV-902	Moisturized Shale Conveyor	40
CV-903	Transfer Conveyor	40
CV-904	Cross Conveyor	75
E-901	Cooler	40
P-901	Pump	100
Total		415

4.9 Spent Shale Moisturizing - Unit 900 (Cont'd)

- **Heat and Material Balance**

A summary of process stream flows for the spent shale moisturizing unit, keyed to the process flow diagram by stream numbers, is given in Table 4.26. This material balance table represents one of six operating trains for spent shale moisturizing.

- **Process Equipment Summary**

Major process equipment required per train of spent shale moisturizing, as well as for the total plant, are listed in Table 4.27. The corresponding equipment specifications are provided in Table 4.28.

TABLE 4.26

UNIT: SPENT SHALE MOISTURIZING	SECTION NO.: 900	FOSTER WHEELER USA CORPORATION
CUSTOMER: DOE/METC	REF. DWG.:	PG. NO.: 1 of 3
LOCATION: WESTERN COLORADO	CONTRACT NO.: 11-36265 DATE 4/15/87	REV. NO.:

STREAM NO. & UNITS	901	902	903	904	905	906
STREAM DESCRIPTION	SPENT SHALE	BIN VENT	WATER	MOIST. WATER	WATER	WATER
Fluid State	SOLIDS	VAPOR	LIQUID	LIQUID	LIQUID	LIQUID
Temperature °F	350	350	140	140	140	140
Pressure PSIA	ATM	ATM	20	20	20	20
Liquid lbs/hr			215,388	150,771	64,616	805,764
Vapor lbs/hr	307	91,350	-	-	-	
Solids lbs/hr	765,680	50	6,700	4,710	1,890	24,236
Total lbs/hr	765,987	91,400	222,088	155,481	65,966	830,000
Components lbs/hr						
Spent Shale	765,680	50	6,700	4,710	1,890	24,236
H_2O	-		215,388	150,771	64,616	805,764
CO_2	150					
N_2	157					
Air		91,350				

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TABLE 4.26 (Cont'd)

UNIT: SPENT SHALE MOISTURIZING
SECTION NO.: 900
FOSTER WHEELER USA CORPORATION
CUSTOMER: DOE/METC
REF. DWG.:

LOCATION: WESTERN COLORADO
CONTRACT NO.: 11-36265
DATE 4/15/87
REV. NO.:

STREAM NO. & UNITS	907	908	909	910	911	912
STREAM DESCRIPTION	WATER	WATER	VENT LINE	VENTURI DISCH	CONV. BLOWER	DRUM VENT
Fluid State	LIQUID	LIQUID	VAPOR	LIQ/VAPOR	VAPOR	VAPOR
Temperature °F	140	175	195	175	AMB	170
Pressure PSIA	20	30	ATM	ATM	ATM	ATM
Liquid lbs/hr	1,021,152	1,021,152	-	836,388	-	
Vapor lbs/hr	-	-	26,731	607	91,378	95,835
Solids lbs/hr	30,736	30,736	6,500	30,736	200	-
Total lbs/hr	1,051,888	1,051,888	33,231	867,731	91,578	95,835
Components lbs/hr						
Spent Shale	30,736	30,736	6,500	30,736	200	-
H_2O	1,021,152	1,021,152	30,624	836,388		3,850
CO_2 / N_2			307	307		307
Air			300	300	91,378	91,678

UNIT: SPENT SHALE MOISTURIZING

CUSTOMER: DOE/METC

LOCATION: WESTERN COLORADO

SECTION NO.: 900

REF. DWG.:

CONTRACT NO.: 11-36265

FOSTER WHEELER USA CORPORATION

DATE 4/16/87

REV. NO.:

STREAM NO. & UNITS	913	914	915			
STREAM DESCRIPTION	MAKE UP WATER	VENT	MOISTURIZED SPENT SHALE			
Fluid State	LIQUID	VAPOR	SOLID			
Temperature °F	AMB	170	170			
Pressure PSI A	50	ATM	ATM			
Liquid lbs/hr						
Vapor lbs/hr		186,185	107,195			
Solids lbs/hr		50	765,630			
Total lbs/hr	110,045	186,235	872,825			
Components lbs/hr						
Spent Shale		50	765,630			
H_2O	110,045	2,850	107,195			
CO_2		307				
N_2						
Air		183,028				

TABLE 4.27

FORM NO 135-904

FOSTER WHEELER USA CORPORATION
PROCESS PLANTS DIVISION

CONTRACT 11-36265
SECTION 900

EQUIPMENT LIST

NAME OF UNIT: Spent Shale Moisturizing

CLIENT DOE/METC
LOCATION: Western Colorado

REVISION	ORIGINAL	1	2	3	4	5
DATE	1/30/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Per Train	Total Plant		REV.
	A-901	Pugg Mill		1	6		
	A-902	Venturi Scrubber		1	6		
	B-901	Vent Blower		1	6		
	B-902	Conveyor Blower		1	6		
	BN-901	Spent Shale Surge Bin		1	6		
	BN-902	Moisturized Shale Hopper		1	6		
	CV-901	Screw Conveyor		1	6		
	CV-902	Moisturized Shale Conveyor		1	6		
	D-901	Water Separator		1	6		
	E-901	Cooler		1	6		
	F-901	Bag Filter		1	6		
	P-901A	Recirculating Pump		1	6		
	P-901B	Recirculating Pump Spare		1	6		
	CV-903	Transfer Conveyor		1	6		
	CV-904A/B	Cross Conveyor		-	4		

TABLE 4.28

UNIT 900 - SPENT SHALE MOISTURIZING EQUIPMENT SPECIFICATIONS

Conveyors

Item No.	Description	Type	Width/Length ft.	Design Capacity TPH
CV-901	Screw Conveyor	Double Screw	2/70	420
CV-902	Moisturized Shale Conv.	Belt	2.5/200	480
CV-903	Transfer Conveyor	Belt	2.5/600	480
CV-904	Cross Conveyor	Belt	3.5/400	460

Exchangers

Item No.	Description	Type	Area ft^2
E-901	Cooler	Air Cooler	9200 (Bare surface)

Pumps

Item No.	Description	Type	Capacity GPM	Discharge Pressure PSIG
P-901A/B	Recirculating pump	Centif.	2300	40

Drums

Item No.	Description	Capacity Gal.	Diam/Length ft.
D-901	Water separator	9000	8/24

Bins

Item No.	Description	Capacity ft^3
BN-901	Spent shale Surge bin	86000
BN-902	Moisturized Shale Hopper	1300

Blowers

Item No.	Description	Type	Capacity ACFM	Dif. Pres. in Water
B-901	Vent Blower	Centif.	20,000	5
B-902	Conveyor Blower	Centif.	20,000	4

TABLE 4.28(Cont'd)

900 - SPENT SHALE MOISTURIZING EQUIPMENT SPECIFICATIONS

Miscellaneous Equip.

A-901	Pugg Mill	420 TPH Capacity 600 HP Motor
A-902	Venturi Scrubber	33,500 lb/hr Scrubbed gas 170 GPM Scrubbing Water
F-901	Bag filter	40,000 ACFM incoming air 50 lb/hr allowable emissions

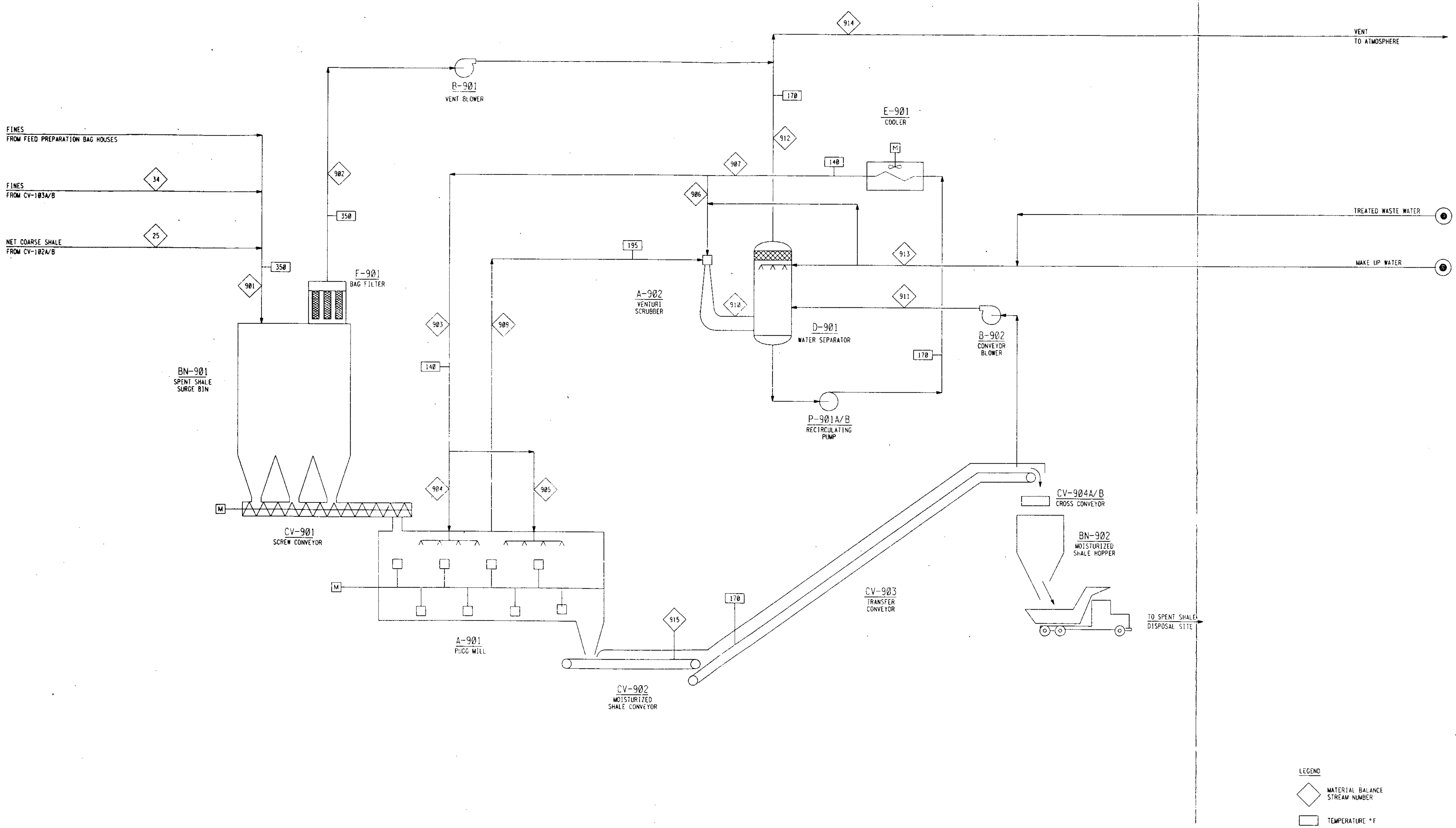

FIGURE 4.12

This Drawing is the Property of the
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PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 900 - SPENT SHALE MOISTURIZING

DRAWN BY:	VOV	02-17-87	SCALE: NONE	CHG. No. 11-36265	DWG. No. - 36265-2-50-901

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REVISIONS

4.10 Feed Preparation - Unit 1000

- **Basis of Design**

In the feed preparation unit, run-of-mine shale ore, delivered to the plant battery limits by mine trucks, is crushed to minus 6 mm particles which is suitable as feed to the retorting section, Unit 100. Crushing of the run-of-mine shale is accomplished in three stages:

	Feed	Product
Primary Crushing	ROM	- 6 inch
Secondary Crushing	-6 inch	- 1.5 inch
Tertiary Crushing	-1.5 inch	- 6 mm

The feed preparation unit is designed as two 60% parallel trains, each capable of supplying 36,000 TPD of shale feed to retorting for continuous seven days a week operation. Operation of the feed preparation system is predicated on three shifts, five days per week, allowing time for scheduled maintenance and equipment failure. Therefore, each train of feed preparation is designed to crush 60,500 tons per operating day.

The following storage capacities are provided for in the feed preparation unit:

Primary crushed shale @ 7 days
Retort feed shale @ 2 1/2 days

The feed preparation unit is designed to produce tertiary crushed shale with a particle size distribution as follows:

Fraction Size Microns	Fraction Wt. %	Cumulative Wt. %
6300 - 4700	5.8	100
4700 - 2370	40.9	94.2
2370 - 1200	22.9	53.3
1200 - 600	13.2	30.4
600 - 300	7.1	17.2
300 - 210	2.5	10.1
210 - 150	1.7	7.6
150 - 104	1.4	5.9
104 - 74	0.8	4.5
74 - 43	0.9	3.7
43 - 20	1.0	2.8
20 - 10	0.4	1.8
10 - 5	0.57	1.4
5 - 2	0.33	0.83
2 - 1	0.12	0.50
1 -	0.38	0.38

4.10 Feed Preparation - Unit 1000 (Cont'd)

- System Description

The flow diagram for the feed preparation system is shown schematically in Figure 4.13. The conceptual layout for this system is presented in Figure 4.14.

Mined shale is brought into the plant by 80 ton back dumping trucks. From the truck, mined shale is dumped into V-1001 receivers through the stationary 40" grizzlies, S-1001A/B/C . Big boulders remaining on the grizzly are split with a hydraulic rock buster, X-1006 . Capacity of the V-1001 receiver is limited to three truck loads as it is intended to facilitate the truck discharge only.

From V-1001, mined shale is continuously fed in three parallel trains, via apron feeders A-1001, over 6" grizzlies S-1002 to the primary crushers K-1001. These grizzlies allow -6" material to bypass the crusher in order to minimize the production of fines.

The primary crusher discharge is taken by conveyors CV-1001 to the transfer conveyor and the stacker conveyors CV-1002 and CV-1003, respectively. From the last conveyor, the traveling boom stacker, X-1001, discharges the crushed shale onto the stock pile.

The transfer conveyor CV-1002 is provided with a scale for controlling the in-plant flow and inventory. Primary crushed shale is also sampled using the PK-1001 sampling station. The sampling station along with further lab analysis provides information on crushed shale particle size distribution and grade. Shale grade information is further used for shale blending to obtain a uniform grade for the retort feed.

From the stock pile, the bucket wheel reclaimers, X-1002, reclaim the shale and feed it to the Coarse Shale Conveyor, CV-1004, via intermediate rail traveling hoppers V-1002. The equipment layout permits by-passing the stock pile and feeding shale directly to the secondary crusher using the by-pass chute to CV-1004A/B.

Conveyor CV-1004 feeds the secondary crushing feed bin V-1003. Ferrous materials are removed from the coarse shale by magnetic separators, X-1004. From V-1003, the processing streams follow three parallel trains through the tertiary crushing circuit.

Coarse shale from V-1003 is fed via apron feeders, A 1003, over 2" screen S-1003 to the secondary crusher, K-1002. Screen throughput bypasses the crusher to minimize fines formation. Crusher bypass and output is discharged on conveyor CV-1005 which feeds the conveyors V-1004 and then the V-1004 tertiary crushing feed bins.

4.10 Feed Preparation - Unit 1000 (Cont'd)

- System Description

From the V-1004 bins, using the A-1003 apron feeders, minus 2" the crusher shale is fed over 6mm screens, S-1004, to tertiary crushers, K-1003. The crusher output is screened on 6mm screens, S-1005, and the refuse is recycled to V-1004.

Minus 6mm shale is discharged onto tertiary crusher conveyors, CV-1006, to transfer conveyors, CV-1009, transversal conveyors CV-1010, and stored in the retort feed silos, V-1005. On CV-1007, tertiary crushed shale is weighed and sampled. The results of sample analysis confirms the feed particle size distribution and grade. Grade homogenization can be further achieved by uneven silo distribution.

The retort feed silo capacity assures the plant operation for 60 hours, to cover the lack of feed preparation over the weekends. For each feed preparation train, there are 12 retort feed silos feeding three retorting modules. Between the two silo blocks, each one containing 12 silo cells, there are two cross transfer conveyors, CV-1014. These conveyors permit feeding from one crushing train to the other train in the event of a partial shut down of equipment.

From the V-1005 silos, crushed shale is fed to the retorting modules via lower transfer conveyors CV-1011, retort feed conveyor CV-1012 and retort distribution conveyor CV-1013. In this operation, further adjustment of the feed grade can be made using the rotary feeders located at the bottom of the silo cells.

The entire feed preparation unit is located on an area adjacent to the retorting section, Unit 100. The two crushing trains are layed out in mirror image with the incoming truck ramp at the exterior. Each train has a separate enclosed structural steel building for primary crushing, secondary crushing, and tertiary crushing. These buildings, as well as any point of shale discharge or transfer, are ventilated and the fugitive dust is collected in bag houses. All conveyors are hooded and maintained under slight negative pressure to avoid particulate emissions. At open discharges, the dust emissions are controlled with water sprays.

4.10 Feed Preparation - Unit 1000 (Cont'd)

- **Utilities Summary**

The normal operating requirements for one train of feed preparation, based on five days per week operation, are summarized below. The total plant contains two parallel operating trains.

Utility	Normal Demand
Raw Water, GPM	
Dust Suppression	50
Electric Power, kw	
Conveyors	2200
Crushers	8850
Blowers	2800
Screens	500
Sampling Stations	300
Feeders	600
Total	15250

- **Heat and Material Balance**

A summary of process stream flows for the shale feed preparation unit, keyed to the process flow diagram by stream numbers, is given in Table 4.29. This material balance table represents one of two operating trains for feed preparation, and reflects the design capacity rather than the normal operation flow rates.

- **Process Equipment Summary**

Major process equipment required per train of shale feed preparation, as well as for the total plant, are listed in Table 4.30. The corresponding equipment specifications are provided in Table 4.31.

TABLE 4.29

UNIT: Feed Preparation | SECTION NO.: 1000 | FOSTER WHEELER USA CORPORATION

CUSTOMER: DOE/METC | REF. DWG.: 36265-1-50-1001 | PG. NO.: 1 of 2

LOCATION: Western Colorado | CONTRACT NO.: 11-36265 | DATE | REV. NO.:

STREAM NO. & UNITS	1	2	3	4	5	6
STREAM DESCRIPTION	PRIMARY CRUSHED SHALE	6" GRIZZLE SHALE THROUGH	PRIMARY CRUSHED SHALE	2" SCREEN SHALE THROUGH	SECONDARY CRUSHED SHALE	
Fluid State	SOLID	SOLID	SOLID	SOLID	SOLID	
Temperature °F	AMB	AMB	AMB	AMB	AMB	
Pressure PSI						
Liquid lbs/hr						
Vapor lbs/hr						
Solids TPH	850	120	2550	80	850	
Total TPH	850	120	2550	80	850	
Particle Size	-6"	-6"	-6"	-2"	-2"	

110 – 18 FOR TABULATION

TABLE 4.29 (Cont'd)

UNIT: Feed Preparation
SECTION NO.: 1000
FOSTER WHEELER USA CORPORATION
CUSTOMER: DOE/METC
REF. DWG.: 36265-1-50-1001
PG. NO.: 2 of 2
LOCATION: Western Colorado
CONTRACT NO.: 11-36265
DATE
REV. NO.:

STREAM NO. & UNITS		7	8	9	10	11	12
STREAM DESCRIPTION		6MM SCREEN SHALE THROUGH	TERTIARY CRUSHED SHALE	CRUSHER RECICLE	TERTIARY CRUSHED SHALE	CRUSHED SHALE	RETORT FEED
Fluid State		SOLID	SOLID	SOLID	SOLID	SOLID	SOLID
Temperature °F		AMB	AMB	AMB	AMB	AMB	AMB
Pressure PSI							
Liquid lbs/hr							
Vapor lbs/hr							
Solids	TPH	80	1350	515	835	2500	2500
Total	TPH	80	1350	515	835	2500	2500
Particle Size		-6mm	-1"	6mm ÷ 1"	-6mm	-6mm	-6mm

110 - 18 FSP TABULATION

TABLE 4.30

FORM NO 135-904

FOSTER WHEELER USA CORPORATION
PROCESS PLANTS DIVISION

CONTRACT: 11-36265
SECTION: 1000

EQUIPMENT LIST

NAME OF UNIT: Feed Preparation

PAGE 1 OF 2

CLIENT: DOE/METC

LOCATION: Western Colorado

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Per Train	Total Plant		REV.
FEEDERS	A-1001ABC	Appron Feeder		3	6		
	A-1002ABC	" "		3	6		
	A-1003ABC	" "		3	6		
BLOWERS	B-1001A/B	Primary Crushing Blower		2	4		
	B-1002A/B	Secondary " "		2	4		
	B-1003A/B	Tertiary " "		2	4		
	B-1004	Boom Stacker "		1	2		
	B-1005A/B	Silos Blower		2	4		
CONVEYORS	CV-1001ABC	Primary Crusher Conveyor		3	6		
	CV-1002	Transfer Conveyor		1	2		
	CV-1003	Stacker "		1	2		
	CV-1004AB	Coarse Shale Conveyor		2	4		
	CV-1005ABC	Secondary Crusher Conveyor		3	6		
	CV-1006ABC	Tertiary Crusher Conveyor		3	6		
	CV-1007AB	Tertiary Crusing Conveyor		2	4		
	CV-1008ABC	Recycle Conveyor		3	6		
	CV-1009AB	Transfer Conveyor		2	4		
	CV-1010AB	Transversal Conveyor		2	4		
	CV-1011AB	Lower Transversal Conveyor		2	4		
	CV-1012AB	Retort Feed Conveyor		2	4		
	CV-1013AB	Retort Distribution Conveyor		2	4		
	CV-1014AB	Cross Transfer — " —		-	2		
BAGHOUSE	F-1001	Primary Crushing Baghouse		1	2		
	F-1002	Secondary Crushing Baghouse		1	2		
	F-1003	Tertiary Crushing Baghouse		1	2		
	F-1004	Boom Stacker " "		1	2		
	F-1005	Silos Baghouse		1	2		

TABLE 4.30 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION
PROCESS PLANTS DIVISION

CONTRACT: 11-36265
SECTION: 1000

EQUIPMENT LIST

NAME OF UNIT: Feed Preparation

PAGE 2 OF 2

CLIENT: DOE/METC
LOCATION: Western Colorado

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Per Train	Total Plant	REV.
CRUSHERS	K-1001ABC	Primary Crusher		3	6	
	K-1002ABC	Secondary Crusher		3	6	
	K-1003ABC	Tertiary Crusher		3	6	
PACKAGE UNITS	PK-1001	Sampling Station		1	2	
	PK-1002	" "		1	2	
SCREENS	S-1001ABC	40" Stationary Grizzly		3	6	
	S-1002ABC	6" " "		3	6	
	S-1003ABC	2" Screen		3	6	
	S-1004ABC	6 MM Screen		3	6	
	S-1005ABC	6 MM Screen		3	6	
BINS	V-1001ABC	Receiver		3	6	
	V-1002	Traveling Hopper		20	40	
	V-1003ABC	Feed Bin		3	6	
	V-1004ABC	Feed Bin		3	6	
	V-1005	Retort Feed Silo		1	2	
MISC.	X-1001	Traveling Boom Stacker		1	2	
	X-1002AB	Bucket Wheel Reclaimer		2	4	
	X-1003	Scale		1	2	
	X-1004 A/B	Scale		1	2	
	X-1005 A/B	Magnetic Separator		1	2	
	X-1006	Hydraulic Rock Buster		1	2	

TABLE 4.31

UNIT 1000 - FEED PREPARATION EQUIPMENT SPECIFICATIONS

Feeders Item No.	Description	Type	Capacity TPH
A-1001	Apron Feeder	Apron	850
A-1002	" "	"	850
A-1003	" "	"	1400

Blowers Item No.	Description	Type	Capacity ACIM	Differential Pressure in Water
B-1001	Primary Crushing Blower	Centrif.	130000	5
B-1002	Secondary Crushing Blower	"	687000	5
B-1003	Tertiary Crushing Blower	"	766500	5
B-1004	Stacking Boom Blower	"	247000	5
B-1005	Silos Blower	"	130000	4

Conveyors

Item No.	Description	Type	Width/Length Ft	Design Capacity TPH
CV-1001ABC	Primary Crusher Conveyor	Belt	3/120	250
CV-1002	Transfer Conveyor	Belt	4/360	3000
CV-1003	Stacker Conveyor	Belt	4/1600	3000
CV-1004AB	Coarse Shale Conveyor	Belt	4/350	3000
CV-1005ABC	Secondary Crusher Conveyor	Belt	3/220	850
CV-1006ABC	Tertiary Crusher Conveyor	Belt	3/160	850
CV-1007AB	Tertiary Crushing Conveyor	Belt	4/280	2600
CV-1008ABC	Recycle Conveyor	Belt	2.5/100	520
CV-1009AB	Transfer Conveyor	Belt	4/60	2600
CV-1010AB	Transversal Conveyor	Belt	4/550	2600
CV-1011AB	Lower Transversal Conveyor	Belt	4/550	2600
CV-1012AB	Retort Feed Conveyor	Belt	4/750	2600
CV-1013AB	Retort Distribution Conveyor	Belt	4/540	2600
CV-1014AB	Cross Transfer Conveyor	Belt	4/260	2600

TABLE 4.31 (Cont'd)

UNIT 1000 - FEED PREPARATION EQUIPMENT SPECIFICATIONS

Baghouses Item No.	Description	Incoming Air ACFM	Allowable Emissions lbs/hr
F-1001	Primary Crushing Baghouse	121000	15
F-1002	Secondary Crushing Baghouse	682000	87
F-1003	Tertiary Crushing Baghouse	767000	98
F-1004	Boom Stacker Crushing Baghouse	25000	0.2
F-1005	Silos Baghouse	130000	17

Crushers Item No.	Description	Type	Capacity TPH	Motor HP
K-1001ABC	Primary Crusher	Impact	850	450
K-1002ABC	Secondary Crusher	Impact	850	1000
K-1003ABC	Tertiary Crusher	Impact	1350	1500

Grizzly-Screens Item No.	Description	Type	Width/Length Ft.	Capacity TPH
S-1001A/B/C	40" Grizzly	Stationary	20/40	1000
S-1002A/B/C	6" Grizzly	Stationary	8/10	900
S-1003A/B/C	2" Screen	Vibrating	9/12	850
S-1004A/B/C	6 mm Screen	Vibrating	9/12	1450
S-1005A/B/C	6 mm Screen	Vibrating	12/16	1350

Bins Item	Description	Capacity Ft^3
V-1001ABC	Receiver	10000
V-1002	Traveling Hopper	1750
V-1003ABC	Feed Bin	5000
V-1004ABC	Feed Bin	5000
V-1005	Retort Feed Silo	192000

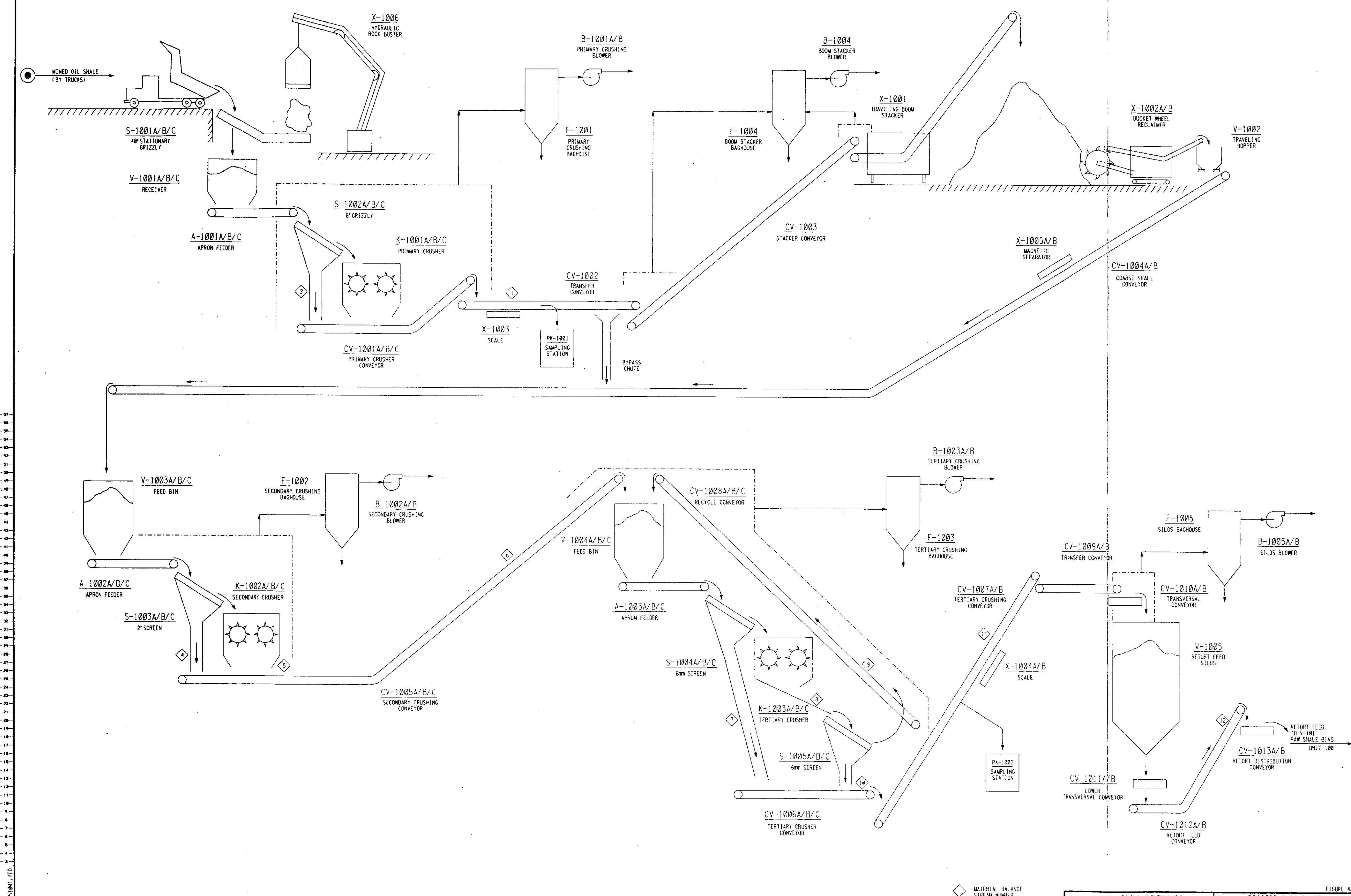

FIGURE 4.13

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PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 1000 – FEED PREPARATION

DRAWN BY: 18-FEB-87 SCALE: NONE CHG. No. 11-36265 DWG. No. – 36265-1-50-1001

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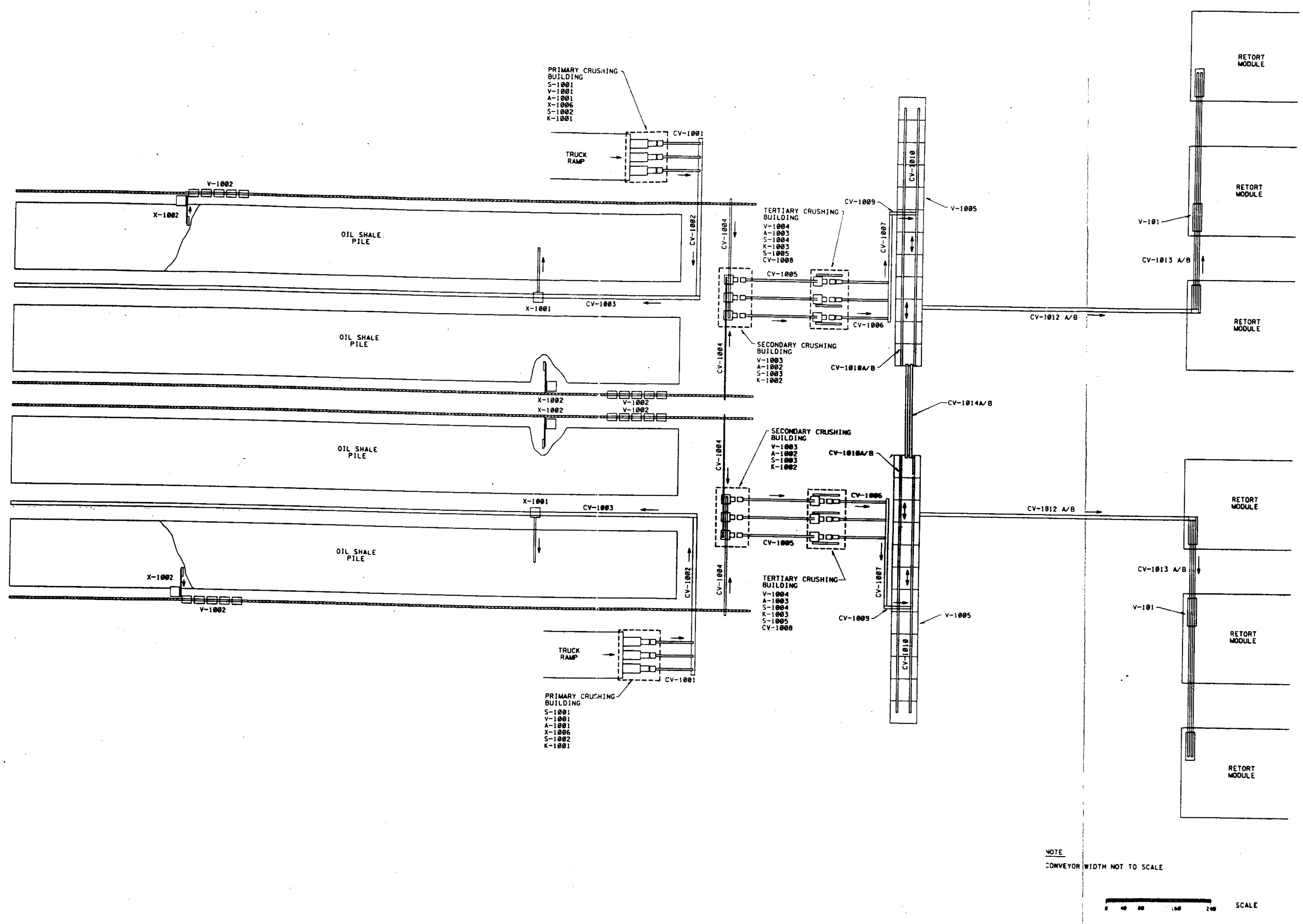


FIGURE 4.14

FOSTER WHEELER USA CORPORATION

PLOT PLAN
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 1000 FEED PREPARATION

18-FEB-87 | 11-36265 | DWG. NO.-36265-1-01-1002

REVISIONS

4.11 Spent Shale Disposal - Unit 1100

• Basis of Design

Disposal of moisturized spent shale, as produced in Section 900, is based on truck haulage to a suitable disposal site, located approximately two miles from the processing plant. The spent shale is deposited on a disposal pile, which is compacted, covered with overburden and top soil, and ultimately revegetated. In general, the approach to spent shale disposal is specific to the site and mining technique employed. The current design follows a concept proposed for a commercial oil shale facility, as described in the literature (12). For the purposes of this study, it is assumed that a disposal site, capable of storing 30 years production of processed shale, is available together with the required quantities of overburden and top soil for reclamation.

Design of the truck hauling system and disposal pile is based on the following quantities of moisturized spent shale, assuming 330 days/year operation of the processing plant:

	Weight Tons	Loose Volume Cu. Yd.	Compacted Volume Cu. Yd.
Daily Rate	62,847	77,758	54,700
30 Yr. Cumulation	622×10^6	769×10^6	542×10^6

The spent shale disposal operations are conducted on a three shift basis, seven days a week.

• System Description

Processed shale is transported to the disposal site in 100 CY bottom - dump trucks. A fleet of 18 operating trucks provides the haulage capacity for servicing the processed shale production rate of 2618 tons/hr from six retort modules. Each truck is capable of transporting 80 tons of material per haul and is scheduled for two round trips per hour to the disposal site.

During site preparation for the disposal pile, the top soil is removed and stockpiled for later use in reclamation. An access ramp for the processed shale pile is constructed of overburden from the mining operation as the pile progresses. The base layer of the pile consists of five feet of compacted spent shale, required to prevent ground water contamination. This layer is deposited by scrapers, ahead of the advancing disposal pile, and is compacted to about 90 lb/ft^3 via mechanical segmented rollers.

4.11 Spent Shale Disposal - Unit 1100 (Cont'd)

Moisturized spent shale is loaded into the haul trucks directly from the load-out hoppers in Section 900. The trucks deposit the processed shale on the disposal pile in windrows which are spread in approximately 24 inch lifts by a grader. The interior of the pile is compacted to an estimated 85 lb/ft^3 by the haulage trucks. The pile exterior is mechanically compacted to insure stability and to form an impervious layer which retards the penetration of moisture.

As the pile construction progresses, the side slopes will be dressed to a 4:1 slope by dozing and grading, in order to minimize erosion and facilitate revegetation of the finished pile. The pile is designed to conduct surface water away from that part of the pile which has not yet been rehabilitated. Runoff water, containing leached salts and suspended fines from the processed shale pile, is intercepted by a system of lined ditches. The contaminated water is delivered to a lined collection pond from which the excess water is returned to the disposal pile for dust control and compaction.

As the final exterior surfaces of the pile are contoured, rehabilitation of the land is accomplished via revegetation. In order to sustain plant growth, an artificial soil profile is constructed over the spent shale pile. The finished pile is covered by a 4 foot layer of overburden which is dressed with one foot of top soil. Seeding is done prior to the period of greatest precipitation, preferably in late fall. Irrigation via sprinkler systems is provided to supplement the natural rainfall during the critical periods of seed germination and establishment.

The disposal pile will be constructed to an average height of 400 feet. To accommodate an annual disposal rate of 20.7 million tons of processed shale, over a period of thirty years operation, the disposal pile will contain about 540 million CY of compacted shale. The land area required for such a pile is estimated at about 1500 acres.

- Equipment List

The major equipment required for spent shale disposal and land reclamation consists primarily of mobile equipment for hauling processed shale to the disposal site and contouring the disposal pile. Table 4.32 lists the number and type of vehicles required. In estimating these requirements, it was assumed that the haul trucks and earth moving equipment would have operating availabilities of 70% and 80%, respectively. Periodic replacement of worn-out equipment is assumed to be an operating expense over the plant life.

4.11 Spent Shale Disposal - Unit 1100 (Cont'd)

Miscellaneous equipment, as shown in Table 4.32, provides for water supply at the disposal site for dust control and irrigation and for control of water run-off from the disposal pile.

- Operating Requirements

The average operating requirements for the spent shale disposal facilities, including land reclamation, are estimated as follows:

Diesel Fuel:	3600 gallon/day
Electric Power:	400 KW
Raw Water:	350 gpm
Consumables	400 $/Day

In addition to the cost of the above items, the annual operating costs for spent shale disposal and land reclamation require allowances for mobile equipment maintenance and periodic replacement. The average useful life of the haul trucks and other vehicles is assumed to be 6 years.

TABLE 4.32

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 1100	EQUIPMENT LIST		NAME OF UNIT: SPENT SHALE DISPOSAL		PAGE 1 OF 1
CLIENT: DOE/METC		REVISION	ORIGINAL	1	2 3 4	5
LOCATION: Western Colorado		DATE	3/17/87			

CLASS	ITEM NO.	DESCRIPTION	NO. UNITS		SPECIFICATIONS	REV.
MOBILE EQUIPMENT	X-1101	Haul Trucks	25		Bottom dump, 100 cu. yd. capacity 1500 HP diesel engine	
	X-1102	Crawler Bulldozer	3		400 HP	
	X-1103	Pusher Dozer	3		400 HP	
	X-1104	Scraper	10		54 cu. yd. capacity	
	X-1105	Scraper	2		20 cu. yd. capacity	
	X-1106	Grader	2		140 HP	
	X-1107	Segmented Compactor	2		4000 lb.	
	X-1108	Tractor	2		100 HP rubber tired	
	X-1109	Water Tank Trucks	2		5000 Gal capacity	
MISC.	TK-1101	Water Storage Tank	1		60,000 bbl, cone roof	
	P-1101	Water Pump	2		500 GPM, 50 HP Motor	
		Irrigation System			Sprinkler System, 500 GPM	
		Collection Pond	1		750' x 750' x 3', Lined	
		Pile Drainage System			Lined ditches around 1500 acre pile	
		Lighting & Electrical Dist.				
		Haul Road			2 Miles, 80 ft. wide, compacted stone	
		Site Preparation				

5.0 SUPPORT FACILITIES DESIGN

The conceptual designs and specifications for the individual utilities and support systems, Units 2000-2900, are described in the following sections. In general, these facilities represent conventional systems, commonly employed in the design of grassroots process plants. Accordingly, the conceptual design of the supports systems reflect less detail than that developed for the plant processing units. As appropriate, the technical definition for the support units includes the design capacity, system description, estimated normal operating requirements, and a major equipment list with corresponding specifications.

5.1 Raw Water Treatment - Unit 2000

- Design Capacity

The raw water treatment system is designed to provide cooling tower make-up water, process and potable water, and demineralized make-up water for the plant's steam generation system. River water will be softened, clarified, filtered and, as required, demineralized to a boiler feed water quality required for generating 650 psig, 750°F superheated steam.

A total of two demineralizer trains, one operating train and one spare train, each sized for 520 gpm throughput rate are provided to service the entire plant. The design capacity is predicated on providing the normal boiler feed water make-up requirement of 440 gpm. Each train will consist of the following equipment:

Carbon Filter
Cation Exchanger
Degasser
Anion Exchanger
Mixed Bed Ion Exchanger

The carbon filters in each train, however, are sized for 720 gpm to provide 200 gpm of potable water.

The following equipment, common to both trains, are also provided:

Demineralized Water Storage Tank
Acid Storage Drum and Feeding Equipment
Caustic Storage Drum and Feeding Equipment
Neutralization Tanks

5.1 Raw Water Treatment - Unit 2000 (Cont'd)

- System Description

The schematic diagrams given in Figures 5.1 and 5.2 present the flow scheme for the Raw Water Treatment System.

River water, pumped from a water storage facility, is fed to a clarifier where lime and alum are added to soften and reduce the suspended solids. The clarifier underflow is sent to Waste Water Treatment, Unit 2500, or Spent Shale Moisturizing, Unit 900, and the overflow is sent to sand filters. Part of the treated raw water is pumped to the Cooling Water System, Unit 2200 and process water users and the balance is purified through an activated carbon filter. The activated carbon serves as a protection for the demineralizer by absorbing traces of oxidants which can damage the cation resin and organics which foul anion resins. In the demineralizer, the mineral salts present in the water are removed by ion exchange. The process employs a three step demineralization consisting of an acidic cation exchanger followed by a degasser, designed to produce an effluent containing less than 10 ppm carbon dioxide, a basic anion exchange unit and finally by a mixed bed ion exchanger. The cation exchangers remove cations such as calcium, magnesium and sodium, while the anion exchangers remove anions such as chlorides, sulfates and silica. The demineralized water flows to the demineralized water storage tank. The demineralized water is then pumped to Steam and Power Generation, Unit 2100, as boiler feed water make-up.

Sulfuric acid from the acid storage tank is used to regenerate the cation exchangers. Caustic from the caustic storage tank is used to regenerate the anion exchanger. Both acid and caustic are used in the mixed bed ion exchangers for regeneration.

Regeneration waste water is collected in a neutralization tank and neutralized with caustic or acid. Neutralized waste water is pumped to the spent shale moisturizing make-up water tank. Activated carbon and demineralizer long rinses are recycled upstream of the clarifier.

The potable water is drawn downstream of the activated carbon filter and, after chlorination, is supplied to the users by a 200 gpm capacity Potable Water Pump.

5.1 Raw Water Treatment - Unit 2000 (Cont'd)

- Utilities and Chemicals Summary

The estimated utility and chemical requirements for the Raw Water Treatment System are presented below. These requirements are based on treated raw water and boiler feed water requirements for the entire plant.

Electric Power	Normal Demand KW	Connected KW
Total Consumption	331	680

Chemicals Consumption

Granular Activated Carbon	290 FT^3/yr
Cation Resin	470 Ft^3/yr
Anion Resin	470 Ft^3/yr
Mixed Bed Exchanger	470 Ft^3/yr
H_2SO_4 (66°Be)	4430 Lbs/day
NaOH (50%)	7150 Lbs/day
Lime	15120 Lbs/day
Alum	1440 Lbs/day
Sand (sand filter)	500 Ft^3/yr
Gravel (sand filter)	500 Ft^3/yr
Anthracite (sand filter)	1000 Ft^3/yr

- Equipment Summary

Major equipment required for the raw water treating system are listed in Table 5.1, together with the corresponding equipment specifications.

TABLE 5.1

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 2000	EQUIPMENT LIST	NAME OF UNIT: Raw Water Treatment	PAGE 1 OF 3

CLIENT: DOE/METC Shale Oil Plant	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: Western Colorado	DATE	4/29/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
CLARIFIERS	CL-2001 A/B	Clarifier Softener		1	2	75 ft. diameter, 10 ft. st. side, cone bottom, C.S. 1½ MHP rake arm	
FILTERS	F-2001 A-H	Clarified Water Sandfilter		4	8	12'-0" diameter, 4' ht of bed, 8 ft. T to T, C.S., Vertical Gravity Filter 25 psig design pressure	
TANKS	TK-2001 A/B	Head Tank		1	2	15'-0" diameter x 32 ft. ht., open top, C.S.	
	TK-2002	Treated Raw Water Storage Tank		-	1	80 ft. diameter x 48 ft. ht, API type cone roof tank. C.S.	
MISC.	X-2001	Chemical Feed System		-	1	Lime and alum slurry tanks w/agitators and metering pumps Two pumps each (4 total) warehouse spares. Tanks (2) - each 2'-6" dia. x 3'-0" st. side, flat bottom, C.S. each with 1 MPH agitator; metering pumps (6 - each 0-100 gph, 15 psi Δ P, 0.2 BHP, 1 MHP	
PUMPS	P-2001 A-D	Clarifier Underflow Pump		2	4	95 GPM, 25 psi (58 ft) TDH, 52% Eff., 2.7 BHP, 5 MHP	
	P-2002 A-D	Sandfilter Discharge Pump		2	4	1905 GPM, 30 psi (69ft), TDH, 85% eff, 39.2 BHP, 50 MHP, Centrif.	
	P-2003 A/B/C	Carbon Filter Feed Pump		-	3	1905 GPM, 75 psi (173 ft.) TDH, 81% eff., 103 BHP, 125 MHP, centrif.	

TABLE 5.1 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION, PROCESS PLANTS DIVISION	CONTRACT: 11-36265	EQUIPMENT LIST	NAME OF UNIT: Boiler Feed Water Treatment	PAGE 2 OF 3
CLIENT: DOE/METC Shale Oil Plant	SECTION: 2000	REVISION: ORIGINAL	1 2 3 4 5	
LOCATION: Western Colorado		DATE: 4/29/87		

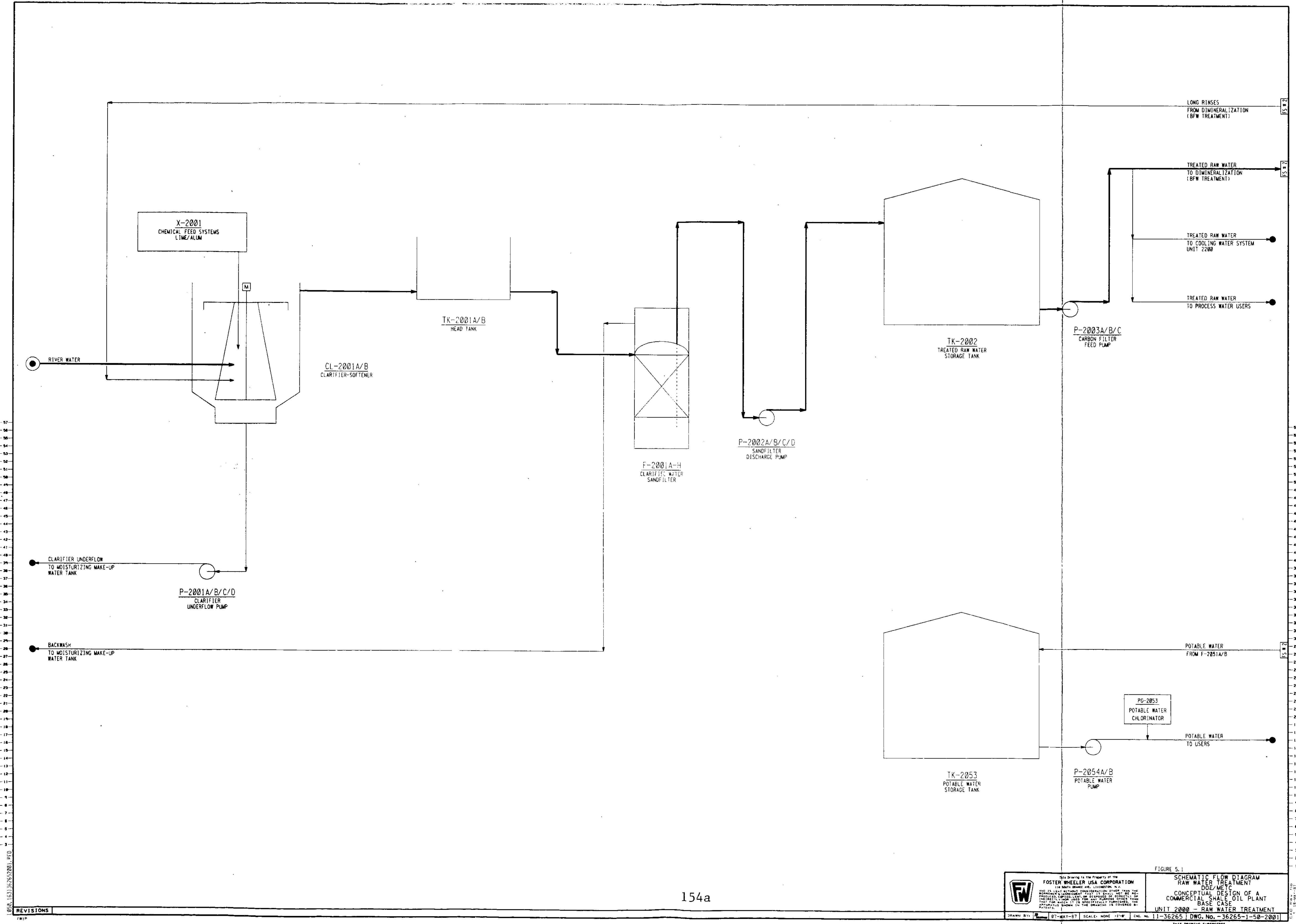
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
DRUMS (Resin Beds)	D-2051 A/B	Cation Exchanger		2	2	520 gpm, 12'-0" diameter, C.S./Lined (Epoxy) Ht of bed = 8'-0", st. side = 12'-0", 125 psig design pressure	
	D-2052 A/B	Anion Exchanger		2	2	520 gpm, 12'-0" diameter, C.S./Lined (Epoxy) Ht of bed = 8'-0", st. side = 12'-0" 125 psig design pressure	
	D-2053 A/B	Mixed Bed Exchanger		2	2	520 gpm, 12'-0" diameter, C.S./Lined (Epoxy) Ht of bed = 8'-0", st. side = 12'-0", 125 psig design pressure	
	D-2054	Acid Storage Drum		-	1	6 ft. diameter x 16 ft. long, C.S., Horizontal, 25 psig design	
	D-2055	Caustic Storage Drum		-	1	6 ft. diameter x 16 ft. long, C.S., Horizontal, 25 psig design pressure	
FILTERS	F-2051 A/B	Activated Carbon Filter		2	2	720 gpm, 12'-6" diameter, C.S. Ht of bed = 8'-0", st. side = 14'-0' 125 psig design pressure	
TOWERS	T-2051	Degasser		1	1	520 gpm, 5'-0" dia stripper mounted on 9'-0" dia. drum (horizontal drum), C.S. ht of stripper - 12'-0" length of drum - 10'-0" design pressure - 25 psig and full vacuum Degasser fan - 300 SCFM, 30 in H_2O press drop, 3.7 BHP, 5 MHP	

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 2000	EQUIPMENT LIST	NAME OF UNIT: Boiler Feed Water Treatment	PAGE 3 OF 3

CLIENT: DOE/METC Shale Oil Plant	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: Western Colorado	DATE	4/29/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
TANKS	TK-2051 A/B	Neutralization Tank		-	2	10 ft. diameter x 18 ft. Ht./C.S./Lined (Epoxy) vertical, atmospheric pressure operation/design	
	TK-2052	Demineralized Water Storage Tank		-	1	40 ft. diameter x 32 ft. ht., API type cone roof tank, C.S. (Epoxy-Lined)	
	TK-2053	Potable Water Storage Tank				50 ft. diameter x 42 ft. ht., API type cone roof tank. C.S. (Epoxy-Lined)	
PUMPS	P-2051 A/B	Neutralized Water Pump		-	2	130 gpm, 30 psi (69 ft) TDH, 58% eff.	
	P-2502 A/B	Demineralized Water Pump		-	2	520 pgm, 55 psi (127 ft) TDH, 77% eff., 21.7 BHP, 30 MHP, C.S.	
	P-2503 A/B	Degasifier Discharge Pump		-	2	600 gpm, 75 psi, (173 ft) TDH, 78% eff., 33.6 BHP, 40 MHP, C.S.	
	P-2504 A/B	Potable Water Pump				200 gpm, 80 psi, (185 ft) TDH, 66% eff., 14.1 BHP, 20 MHP, C.S.	
MISC.	PG-2051	Acid Injection Package		-	2	Dilution tank and 2 pumps (1 gpm each) by demineralization vendor (Permutit, Belco, Graver, etc.,), 316SS	
	PG-2052	Caustic Injection Package		-	2	Caustic heater and 2 pumps (1 GPM each) by demineralization vendor, C.S.	
	PG-2053	Potable Water Chlorinator		-	2	Chlorinator to treat 200 gpm of potable water.	



LONG RINSES
FROM DIMINERALIZATION (BFW TREATMENT)
TREATED RAW WATER
TO DIMINERALIZATION (BFW TREATMENT)
TREATED RAW WATER
TO COOLING WATER SYSTEM UNIT 2200
TREATED RAW WATER
TO PROCESS WATER USERS
X-2001
CHEMICAL FEED SYSTEMS LIME/ALUM
M
RIVER WATER
CL-2001A/B
CLARIFIER-SOFTENER
TK-2001A/B
HEAD TANK
F-2001A-H
CLARIFIED WATER SANDFILTER
P-2002A/B/C/D
SANDFILTER DISCHARGE PUMP
TK-2002
TREATED RAW WATER STORAGE TANK
P-2003A/B/C
CARBON FILTER FEED PUMP
CLARIFIER UNDERFLOW
TO MOISTURIZING MAKE-UP WATER TANK
P-2001A/B/C/D
CLARIFIER UNDERFLOW PUMP
BACKWASH
TO MOISTURIZING MAKE-UP WATER TANK
POTABLE WATER
FROM F-2051A/B
PG-2053
POTABLE WATER CHLORINATOR
POTABLE WATER
TO USERS
TK-2053
POTABLE WATER STORAGE TANK
P-2054A/B
POTABLE WATER PUMP
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SCHEMATIC FLOW DIAGRAM
RAW WATER TREATMENT
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 2000 - RAW WATER TREATMENT
DRAWN BY:
07-MAY-87
SCALE: NONE
CHG. No. 11-36265
DWG. No. -36265-1-50-2001
FORM NO. 135-931M
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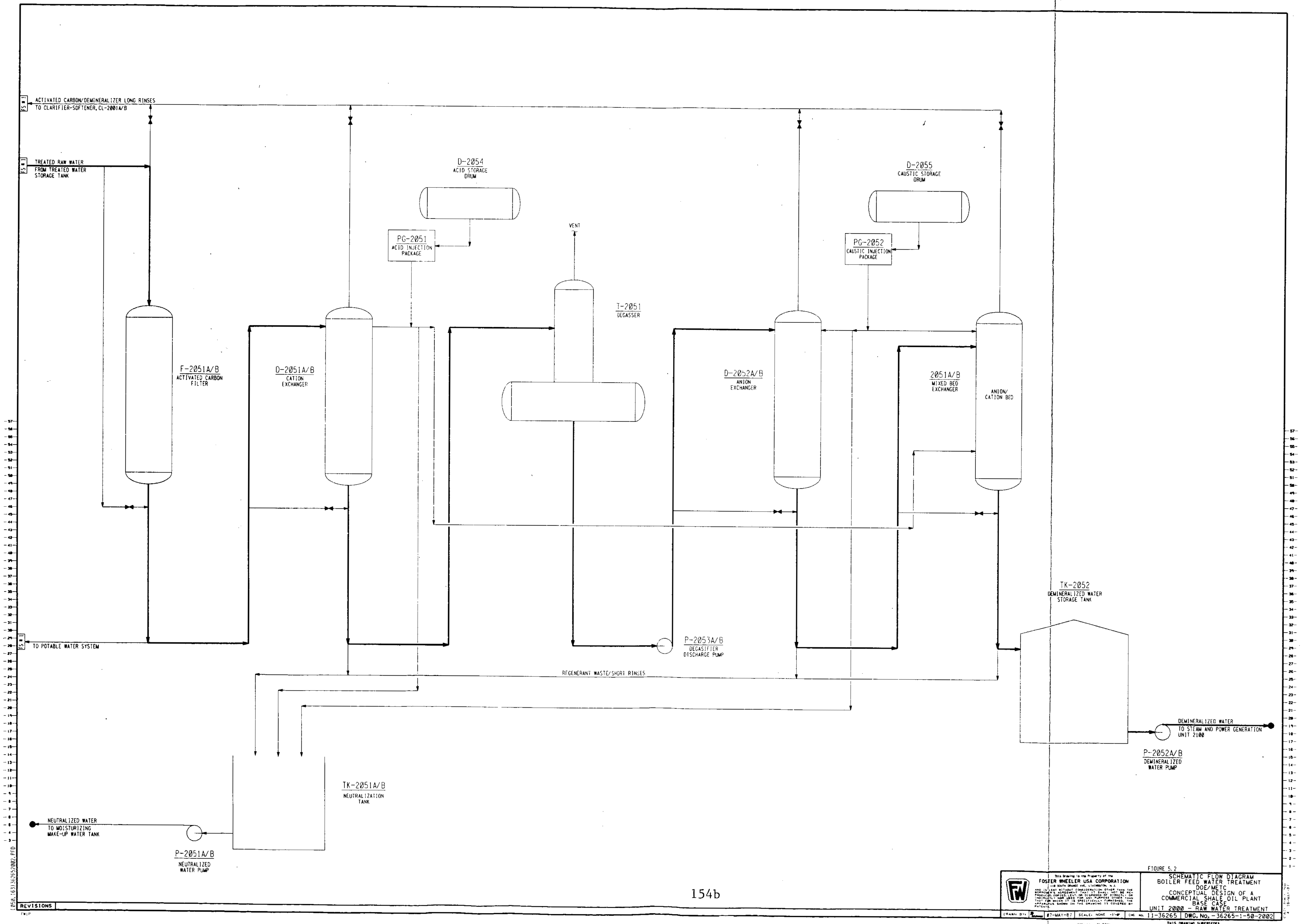
FIGURE 5.1


ACTIVATED CARBON/DEMINERALIZER LONG RINSES
TO CLARIFIER-SOFTENER, CL-2001A/B
TREATED RAW WATER
FROM TREATED WATER
STORAGE TANK
TO POTABLE WATER SYSTEM
F-2051A/B
ACTIVATED CARBON
FILTER
D-2051A/B
CATION
EXCHANGER
D-2054
ACID STORAGE
DRUM
PG-2051
ACID INJECTION
PACKAGE
VENT
T-2051
DEGASSER
P-2053A/B
DEGASIFIER
DISCHARGE PUMP
D-2055
CAUSTIC STORAGE
DRUM
PG-2052
CAUSTIC INJECTION
PACKAGE
D-2052A/B
ANION
EXCHANGER
2051A/B
MIXED BED
EXCHANGER
ANION/
CATION BED
TK-2052
DEMINERALIZED WATER
STORAGE TANK
DEMINERALIZED WATER
TO STEAM AND POWER GENERATION
UNIT 2100
P-2052A/B
DEMINERALIZED
WATER PUMP
REGENERANT WASTE/SHORT RINSES
TK-2051A/B
NEUTRALIZATION
TANK
NEUTRALIZED WATER
TO MOISTURIZING
MAKE-UP WATER TANK
P-2051A/B
NEUTRALIZED
WATER PUMP
REVISIONS
FIGURE 5.2
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SCHEMATIC FLOW DIAGRAM
BOILER FEED WATER TREATMENT
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 2000 - RAW WATER TREATMENT
DRAWN BY:
07-MAY-87
SCALE: NONE
CHG. NO. 11-36265
DWG. No. -36265-1-50-2002
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5.2 Steam and Power Generation - Unit 2100

- **Basis of Design**

This unit includes a piping system to collect the various qualities of steam produced by the different processing units, distribute it to the various consumers and use the excess steam to generate electric power.

The qualities of steam produced are defined as follows:

	Pressure Psig	Temperature °F
High Pressure Steam	650	700
Medium Pressure Steam	150	Sat
Low Pressure Steam	60	Sat
Exhaust Steam	50	Sat

- **System Description**

The main steam producer in the plant is the CO incinerator and waste heat boiler in Unit 100, Retorting. There are six CO incinerators in the plant, one for each retorting module. These incinerators have provisions for natural gas firing required for CO incineration. During the start-up of the plant this provision allows for using CO incinerators as start-up boilers. For this reason, there is no start-up boiler specified for the plant. After the start-up period, other processing units contribute steam generation for the overall system balance.

An overall schematic of the plant steam distribution system is shown in Figure 5.3. Unit 2100 includes the following:

- Boiler feed water pumps
- Boiler feed water deaerators
- Condensate collection system
- Electric power generators

The entire unit is designed as two parallel trains which offer easy start-up and high operating reliability. Furthermore, each train contains a high pressure system and a medium pressure system. Low pressure steam and exhaust steam is used for BFW deaeration. BFW pumps are turbine driven and the spares have electrical motors drive. Electrical motors are to be used for start-up.

5.2 Steam and Power Generation - Unit 2100 (Cont'd)

Electric power generators use high and medium pressure steam for a total generation capacity of approximately 80 MW. During normal operation conditions with Unit 1000, feed preparation, in operation the wet requirement of power import is approximately 18.5 MW. During the weekend operation when Unit 1000 is down, a wet export of approximately 12 MW will be fed back into the public utility system.

The power generation turbines are condensation turbines working at 2" Hg condensation pressure. The heat of condensation is removed by a dedicated cooling water system as described on Section 5.3.

- Utilities and Chemicals Summary

Estimated operating requirements for the steam and power generation system are summarized below. These requirements correspond to the total plant operation.

Utility	Normal Demand*
Electric Power, KW	
HP Turbogenerator	(55,122)
MP Turbogenerator	(25,093)
HP BFW Pumps	1,004
MP/LP BFW Pumps	88
Condensate Pumps	205
Vacuum Pumps	200
TOTAL	(78,718)
Steam, lb/hr	
HP Turbogenerator	693,500
MP Turbogenerator	498,700
LP BFW Deaerator	182,500
Steam Condensate, lb/hr	
HP Turbogenerator	(693,500)
MP Turbogenerator	(498,700)
TOTAL	1,192,200
BFW Make-up, lb/hr	220,000
Cooling Water, GPM	
Turbogenerator Jackets (30°FΔT)	2,844
Turbogenerator Condensers (10°FΔT)	170,010
TOTAL	172,854

*Parenthesis denotes production rather than consumption.

5.2 Steam and Power Generation - Unit 2100 (Cont'd)

- Equipment Summary

Major equipment required for the steam and power generation system are listed in Table 5.2. The corresponding equipment specifications are given in Table 5.3.

TABLE 5.2

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: UNIT 2100	EQUIPMENT LIST		NAME OF UNIT: STEAM & POWER GENERATION			PAGE 1 OF 2
CLIENT: DOE/METC		REVISION	ORIGINAL	1	2	3	4	5
LOCATION:		DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N NO. PER TRAIN	TOTAL PLANT		REV.
DRUMS	D-2101A	CONDENSATE DRUM		1	2		
	D-2101B	CONDENSATE DRUM		1	2		
DEAERATORS	DH-2101A	H.P. BFW DEAERATOR		1	2		
	DH-2101B	H.P. BFW DEAERATOR		1	2		
	DH-2102A	M.P./L.P. BFW DEAERATOR		1	2		
	DH-2102B	M.P./L.P. BFW DEAERATOR		1	2		
EXCHANGERS	E-2101A	STEAM CONDENSER		1	2		
	E-2101B	STEAM CONDENSER		1	2		
PUMPS	P-2101A	H.P. BFW PUMP		1	2	TURBINE DRIVE	
	P-2101B	H.P. BFW PUMP		1	2	TURBINE DRIVE	
	P-2101C	H.P. BFW PUMP		1	2		
	P-2101D	H.P. BFW PUMP		1	2		
	P-2101E	SPARE H.P. BFW PUMP		1	2		
	P-2101F	SPARE H.P. BFW PUMP		1	2		
	P-2102A	M.P./L.P. BFW PUMP		1	2	TURBINE DRIVE	
	P-2102B	M.P./L.P. BFW PUMP		1	2		
	P-2102C	SPARE M.P./L.P. BFW PUMP		1	2		
	P-2103A	CONDENSATE PUMP		1	2		
	P-2103B	CONDENSATE PUMP		1	2		
	P-2103C	CONDENSATE PUMP		1	2		
	P-2103D	CONDENSATE PUMP		1	2		
	P-2103E	SPARE CONDENSATE PUMP		1	2		
	P-2103F	SPARE CONDENSATE PUMP		1	2		
	P-2103G	SPARE CONDENSATE PUMP		1	2		
	P-2103H	SPARE CONDENSATE PUMP		1	2		

TABLE 5.2 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT 11-36265 SECTION UNIT 2100	EQUIPMENT LIST	NAME OF UNIT STEAM & POWER GENERATION	PAGE 2 OF 2

CLIENT: DOE/METC

LOCATION:

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO. PER TRAIN	TOTAL PLANT		REV.
COMPRESSORS	C-2101A	VACUUM PUMP		1	2		
	C-2101B	VACUUM PUMP		1	2		
	C-2101C	SPARE VACUUM PUMP		1	2		
	C-2101D	SPARE VACUUM PUMP		1	2		
TURBO-GENERATORS	TG-2101	H.P. TURBOGENERATOR		1	2		
	TG-2102	M.P. TURBOGENERATOR		1	2		

TABLE 5.3

UNIT 2100 - STEAM & POWER GENERATION - EQUIPMENT SPECIFICATIONS

DRUMS

ITEM NO.	DESCRIPTION	POSITION	DIA/HEIGHT	DESIGN PRESSURE	MAT OF CONSTR.
D-2101A/B	Condensate Drums	Vert.	7'-6"/15'-0"	Full Vacuum + 15 PSIG	C.S.

DEHERATORS

ITEM NO.	DESCRIPTION	DIA/HEIGHT	DESIGN PRESSURE	MAT. OF CONSTR.
DH-2101A/B	HP BFW Deaerators	10'-0"/39'-0"	50	C.S.
DH-2102A/B	MP/LP BFW Deaerators	7'-0"/22'-0"	50	C.S.

EXCHANGERS

ITEM NO.	DESCRIPTION	TYPE	AREA, $FT.^2$	DUTY 10^6BTU/HR	MAT. OF CONSTR.
E-2101A/B	Steam Condensers	Surface Condenser	33300	617.0	C.S.

PUMPS

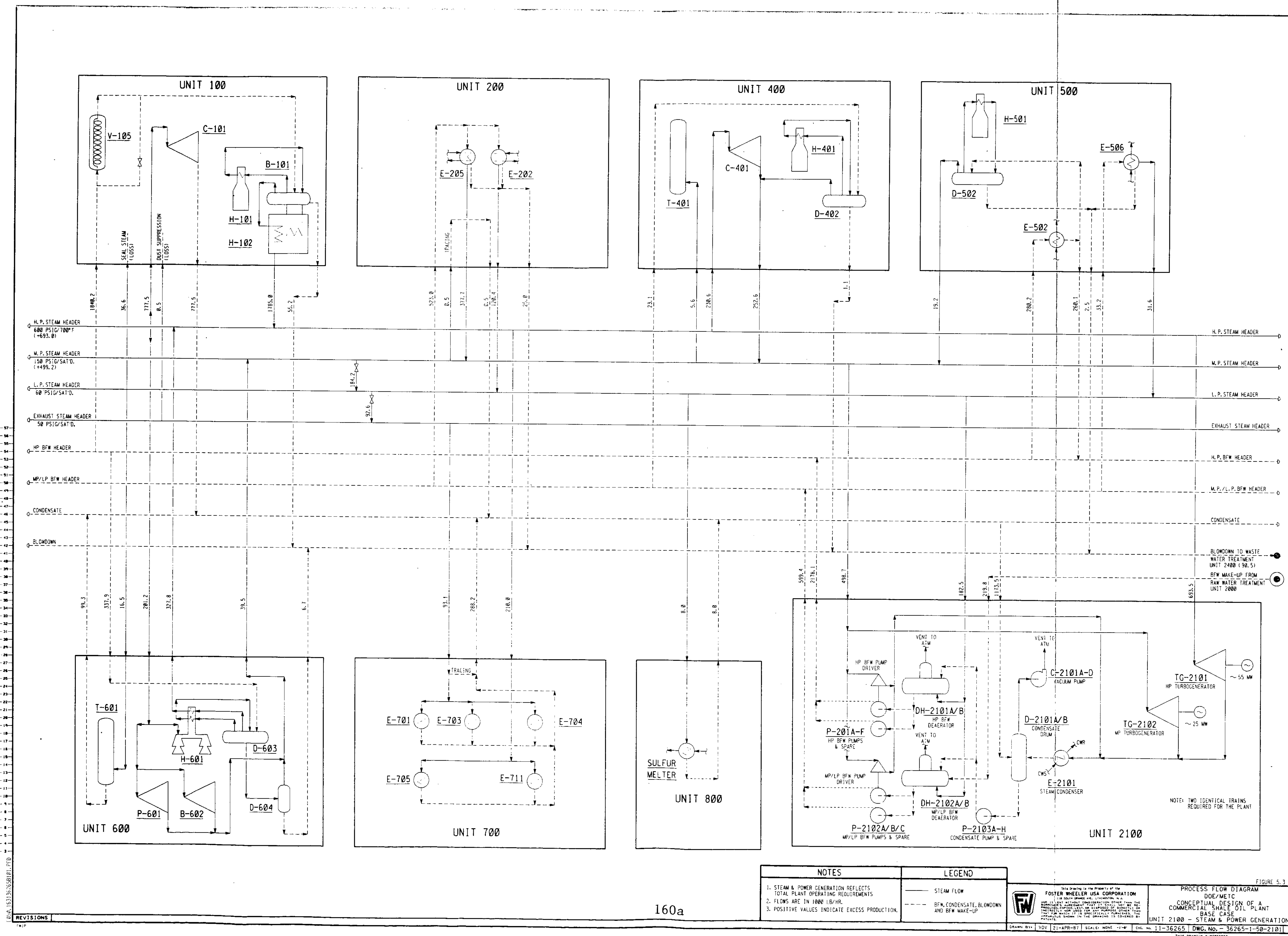
ITEM NO.	DESCRIPTION	TYPE	FLOW, GPM	DISCH. PRESS. PSIG	MAT. OF CONSTR.
P-2101A-F	HP BFW Pumps & Spares	Centrif.	625	675	C.S.
P-2102A/B/C	MP/LP BFW Pumps & Spares	Centrif.	350	185	C.S.
P-2103A-H	Condensate Pumps & Spares	Centrif.	700	65	C.S.

COMPRESSORS

ITEM NO.	DESCRIPTION	TYPE	FLOW, GPM	DISCH. PRESS. PSIG	MAT. OF CONSTR.
C-2101A-D	Vacuum Pump	Centrif.	800	2" Hg abs.	C.S.

TURBOGENERATORS

ITEM NO.	DESCRIPTION	STM PRESS.,PSIG	STM FLOW, LB/HR	POWER OUTPUT, KW
TG-2101	H. P. Turbogenerator	600	346,515	27.56
TG-2102	M. P. Turbogenerator	150	240,012	12.55


UNIT 100
V-105
C-101
B-101
H-101
H-102
SEAL STEAM (LOSS)
DUST SUPPRESSION (LOSS)
UNIT 200
E-205
E-202
UNIT 400
T-401
C-401
H-401
D-402
UNIT 500
H-501
E-506
D-502
E-502
H.P. STEAM HEADER 600 PSIG/700°F (+693.0)
M.P. STEAM HEADER 150 PSIG/SAT'D. (+499.2)
L.P. STEAM HEADER 60 PSIG/SAT'D.
EXHAUST STEAM HEADER 50 PSIG/SAT'D.
HP BFW HEADER
MP/LP BFW HEADER
CONDENSATE
BLOWDOWN
BLOWDOWN TO WASTE WATER TREATMENT UNIT 2400 (90.5)
BFW MAKE-UP FROM RAW WATER TREATMENT UNIT 2000
UNIT 600
T-601
H-601
D-603
P-601
B-602
D-604
UNIT 700
E-701
E-703
E-704
E-705
E-711
SULFUR MELTER
UNIT 800
UNIT 2100
HP BFW PUMP DRIVER
DH-2101A/B HP BFW DEAERATOR
P-2101A-F HP BFW PUMPS & SPARE
MP/LP BFW PUMP DRIVER
DH-2102A/B MP/LP BFW DEAERATOR
P-2102A/B/C MP/LP BFW PUMPS & SPARE
P-2103A-H CONDENSATE PUMP & SPARE
C-2101A-D VACUUM PUMP
D-2101A/B CONDENSATE DRUM
E-2101 STEAM CONDENSER
TG-2101 HP TURBOGENERATOR ~55 MW
TG-2102 MP TURBOGENERATOR ~25 MW
NOTE: TWO IDENTICAL TRAINS REQUIRED FOR THE PLANT
NOTES
1. STEAM & POWER GENERATION REFLECTS TOTAL PLANT OPERATING REQUIREMENTS
2. FLOWS ARE IN 1000 LB/HR.
3. POSITIVE VALUES INDICATE EXCESS PRODUCTION.
LEGEND
STEAM FLOW
BFW, CONDENSATE, BLOWDOWN AND BFW MAKE-UP
FIGURE 5.3
FOSTER WHEELER USA CORPORATION
PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 2100 - STEAM & POWER GENERATION
DRAWN BY: VOV 21-APR-87 SCALE: NONE
CHG. No. 11-36265
DWG. No. - 36265-1-50-2101
REVISIONS

5.3 Cooling Water System - Unit 2200

- Design Capacity

The cooling water unit consists of two separate systems: one dedicated to Steam and Power Generation, Unit 2100, and the other system for servicing the balance of the plant.

The cooling water requirement for Unit 2100 is 172,854 gpm with a 10°F temperature rise. A dedicated cooling water system, consisting of two cooling tower modules, each having a design capacity of 86,500 gpm is provided for this service.

The cooling water requirement for the balance of the plant is 79,124 gpm with a 30°F temperature rise. The cooling water system for this service is designed as a single module having a design capacity of 80,000 gpm.

- System Description

The schematic flow diagram for the cooling water system is shown in Figure 5.4.

Heated cooling water from the various process and support systems is fed to the corresponding spray header of a mechanical induced draft cooling tower. Counter current contact of the cooling water with ambient air cools the water by both evaporation and sensible heat exchange. The evaporation losses, windage losses, and blowdown rates for each cooling water system is given below:

	CT-2201A/B	CT-2202
Evaporation Losses, GPM	1780	2374
Windage Losses, GPM	86	40
Blowdown, GPM	432	561
Total	2298	2975

The blowdown streams are provided to prevent scaling and are sent to Spent Shale Moisturizing, Unit 900. These streams contain suspended solids, dissolved solids, dispersant and inhibitors. A chemical addition package for each cooling tower is also provided that includes:

Scale inhibitor/dispersant - to prevent carbonate scaling

Corrosion inhibitor - to prevent oxygen attack

Acid - to reduce circulating water alkalinity to reduce scaling

Chlorine gas - to kill pathogens

Biocide - to prevent biological fouling

5.3 <u>Cooling Water System - Unit 2200</u> (Cont'd)

The cooling water circulation pumps take the cooled water from corresponding tower basin and pump it to the process and utility areas for heat removal completing the cooling cycle. These pumps also send the system blowdown to Spent Shale Moisturizing, Unit 900.

The total cooling water usage for each plant unit is as follows:

Unit	Consumption GPM	$\Delta T°F$
100	47,700	30
200	252	30
300	200	30
400	80	30
500	48	30
600	1,724	30
700	23,920	30
800	2,078	30
2100	172,854	10.3
2200	200	30
2300	290	30
2400	34	30
2500	2,640	29
2800	100	30
TOTAL	252,120	

5.3 Cooling Water System - Unit 2200 (Cont'd)

- Utilities and Chemicals Summary

The normal operating requirements for the entire cooling water system is summarized below:

	GPM	
	CT-2201A/B	CT-2202
Treated Raw Water (Make-Up)	2298	2975
Blowdown Water (Produced)	432	561
Cooling Water	200	

Electric Power Consumption Service	Normal KW	Connected Load KW
P-2201A (Module 1)	2,174	2,360
P-2201B (Module 1)	2,174	2,360
P-2201C (Module 1)	-	2,360
P-2201A (Module 2)	2,174	2,360
P-2201B (Module 2)	2,174	2,360
P-2201C (Module 2)	-	2,360
P-2202A	2,016	2,360
P-2202B	2,016	2,360
P-2202C	-	2,360
CT-2201A Fans	364	408
CT-2201B Fans	364	408
CT-2202 Fans	852	970
Chemical Feed	4	6
Instruments and Lighting	10	10
TOTAL	14,322	

Chemical Consumption

Service	Quantity, Lbs/Hr CT-2201A/B	CT-2202
Corrosion Inhibitor	38	50
Scale Inhibitor/Dispersant	15	20
Chlorine Gas	4	6
Biological Fouling Inhibitor	12	15
Sulfuric Acid (100%)	58	75

- Equipment Summary

Major equipment required for the cooling water system are listed in Table 5.4, together with the corresponding equipment specifications.

TABLE 5.4

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 2200	EQUIPMENT LIST	NAME OF UNIT: Cooling Water System	PAGE 1 OF 2

CLIENT: DOE/METC Shale Oil Plant	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: Western Colorado	DATE	4/24/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
COOLING TOWERS	CT-2201 A/B	Cooling Tower(Package) for Unit 2100		1	2	Each Cooling Tower : 86,427 GPM, 4 Cell. 10.3°F ΔT, 63°F Wet bulb, 17°F approach; tower is ~60' Wide x 246' long	
						Cooling tower package to include the following chemical addition systems: Biocide, corrosion inhibitor, dispersant and acid	
						Cooling tower fans : one 125 MHP fan on each cell, four total	
	CT-2202	Cooling Tower (Package)		1	1	79,130 GPM, 6 Cell , 30°F ΔT, 63°F Wet bulb, 17°F approach; tower is ~ 54' Wide X 294' long	
						Cooling tower package to include the following chemical addition systems: Biocide, Corrosion inhibitor, dispersant and acid	
						Cooling tower fans: One 200 MHP fan on each cell, six total	

TABLE 5.4 (Cont'd)

FORM NO. 135-904

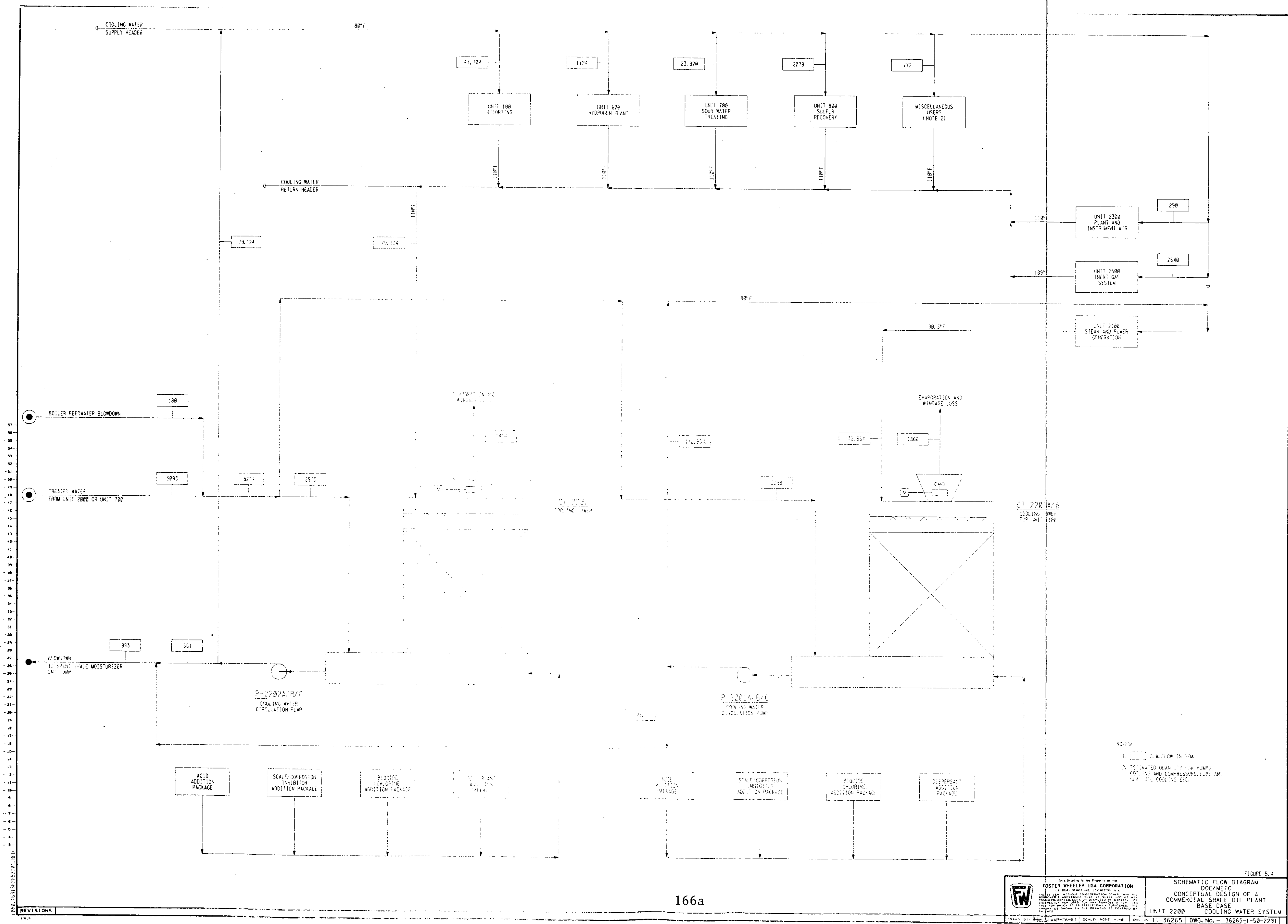
FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 2200	EQUIPMENT LIST	NAME OF UNIT: Cooling Water System	PAGE 2 OF 2

CLIENT: DOE/METC Shale Oil Plant

LOCATION: Western Colorado

REVISION	ORIGINAL	1	2	3	4	5
DATE	4/24/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
PUMPS	P-2201A	Cooling Water Circ. Pump for CT-2201		1	2	Each pump: 47,550 GPM, 85 psi (196 ft)	
	P-2201B	Cooling Water Circ. Pump for CT-2201		1	2	TDH, 85% eff., 2760 BHP, 3000 MHP,	
	P-2201C	Spare for P-2201A OR P-2201 B		1	2	C.S.	
	P-2202 A	Cooling Water Circ. Pump for CT-2202		1	1	Each pump: 43,520 GPM, 85 psi (196ft)	
	P-2202 B	Cooling Water Circ. Pump for CT-2202		1	1	TDH, 84% eff., 2556 BHP, 3000 MHP,	
	P-2202 C	Spare for P-2202 A Or P-2202 B		1	1	C.S.	


COOLING WATER SUPPLY HEADER
80°F
47,700
1724
23,970
2078
772
UNIT 100 RETORTING
UNIT 600 HYDROGEN PLANT
UNIT 700 SOUR WATER TREATING
UNIT 800 SULFUR RECOVERY
MISCELLANEOUS USERS (NOTE 2)
110°F
COOLING WATER RETURN HEADER
79,124
290
UNIT 2300 PLANT AND INSTRUMENT AIR
2640
105°F
UNIT 2500 INERT GAS SYSTEM
UNIT 2100 STEAM AND POWER GENERATION
90.3°F
EVAPORATION AND WINDAGE LOSS
1666
180
BOILER FEEDWATER BLOWDOWN
5093
5277
2975
TREATED WATER FROM UNIT 2000 OR UNIT 700
CT-2203A/B
COOLING TOWER FOR UNIT 2100
993
561
BLOWDOWN TO SPENT SHALE MOISTURIZER UNIT 300
P-2202A/B/C COOLING WATER CIRCULATION PUMP
P-2201A/B/C COOLING WATER CIRCULATION PUMP
ACID ADDITION PACKAGE
SCALE/CORROSION INHIBITOR ADDITION PACKAGE
BIOCIDE (CHLORINE) ADDITION PACKAGE
DISPERSANT ADDITION PACKAGE
NOTES:
2. ESTIMATED QUANTITY FOR PUMPS, COOLING AND COMPRESSORS, LUBE AND SEAL OIL COOLING ETC.
REVISIONS
FIGURE 5.4
This Drawing is the Property of the FOSTER WHEELER USA CORPORATION
110 SOUTH ORANGE AVE. LIVINGSTON, N.J.
AND IS LENT WITHOUT CONSIDERATION OTHER THAN THE BORROWER'S AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT, OR DISPOSED OF DIRECTLY OR INDIRECTLY NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED. THE APPARATUS SHOWN IN THE DRAWING IS COVERED BY PATENTS.
SCHEMATIC FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 2200 COOLING WATER SYSTEM
DRAWN BY: MAR-26-87
SCALE: NONE
CHG. No. 11-36265
DWG. No. - 36265-1-50-2201
THIS DRAWING SUPERSEDES
THIS DRAWING SUPERSEDED BY

5.4 Plant and Instrument Air - Unit 2300

- Design Capacity

The plant and instrument air system is required to supply compressed air at 125 psig for use in the plant processing and support facilities. The plant and instrument air system has a design capacity of 5800 SCFM, of which 1800 SCFM is available as instrument air and 4000 SCFM is available as plant air.

- System Description

The schematic flow diagram for the plant and instrument air system is shown in Figure 5.5.

The combined plant and instrument air system is supplied by three air compressors, two operating and one spare, each rated at 2900 SCFM at a discharge pressure of 125 psig. The compressors are motor driven, three stage machines, complete with intercoolers and aftercoolers to cool the compressed air to 115°F. Compressed air is distributed to the plant air and instrument air systems from the air receiver drums. An air drying package is provided for each compressor, to reduce the moisture content of the instrument air to a minus 40°F dew point.

- Utilities and Chemical Summary

The estimated normal operating requirements for the total plant and instrument air system are summarized below:

Electric Power	Normal KW	Connected Load KW
C-2301 A	760	991
C-2301 B	760	991
C-2301 C	-	991
	1520	

Cooling Water	GPM
Air Compressor Coolers (@ ΔT = 30°F)	290

Chemicals Consumption	
Silica Gel	2000 Lb/yr

- Equipment Summary

Major equipment required for the plant and instrument air system are listed in Table 5.5, together with the corresponding equipment specifications.

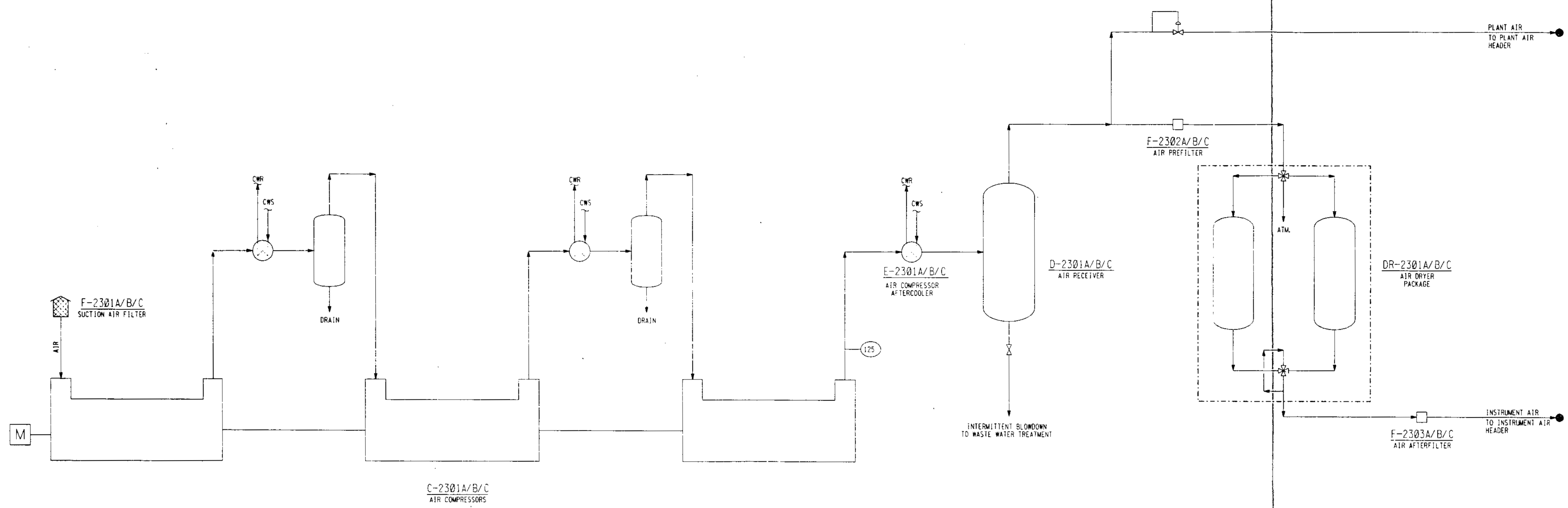
TABLE 5.5

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 2300	EQUIPMENT LIST	NAME OF UNIT: PLANT AND INSTRUMENT AIR	PAGE 1 OF 1

CLIENT: DOE/METC Shale Oil Plant	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: Western Colorado	DATE	4/2/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
AIR COMPRESSORS	C-2301 A/B/C	Air Compressors		1	3	2,900 SCFM each, 125 psig discharge pressure, 10.5 psia suction pressure 953 BHP, 1250 MHP, C.S. Centrifugal Type, 3 stage with water-cooled intercoolers	
DRUMS	D-2301 A/B/C	Air Receiver		1	3	5'-6" dia x 7'-0" ht., C.S. 150 psig design pressure	
EXCHANGERS	E-2301 A/B/C	Air Compressor Aftercooler		1	3	Cool 2,900 SCFM of air from 255°F to 100°F Duty = 516,000 Btu/hr Water Cooled, Area = 233 ft^2 C.S. Shell & Tube	
DRYERS	DR-2301 A/B/C	Air Dryer		1	3	Dry to -40°F dew point Dual dryer system Thru-put = 900 SCFM, C.S.	
FILTERS	F-2301 A/B/C	Suction Air Filter		1	3	Suction filter unit package with replaceable glass fiber filter sections, 2900 SCFM flow, C.S.	
	F-2302 A/B/C	Air Prefilter		1	3	Cartridge type, 900 SCFM flow 4126 lbs/hr, C.S. housing	
	F-2303 A/B/C	Air Afterfilter		1	3	Cartridge type, 900 SCFM flow 4126 lbs/hr, C.S. housing	
					NOTE:	BAROMETRIC PRESS = 10.5 PSIA	



NOTES:
1. THE AIR COMPRESSOR SYSTEM CONSISTING OF TWO OPERATING AND ONE SPARE TRAIN, PROVIDED TO SERVE THE ENTIRE RETORTING AND UPGRADING PLANT.

LEGEND
☐ OPERATING TEMPERATURE, °F
◯ OPERATING PRESSURE, PSIG
● PROCESS STREAM TO BATTERY LIMITS

FIGURE 5.5

This Drawing is the Property of the FOSTER WHEELER USA CORPORATION 110 SOUTH ORANGE AVE. LIVINGSTON, N.J. AND IS LENT WITHOUT CONSIDERATION OTHER THAN THE BORROWER'S AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT, OR DISPOSED OF DIRECTLY OR INDIRECTLY NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED. THE APPARATUS SHOWN IN THE DRAWING IS COVERED BY PATENTS.

SCHEMATIC FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 2300 PLANT AND INSTRUMENT AIR

DRAWN BY:	VOV	03-25-87	SCALE: NONE	CHG. No. 11-36265	DWG. No. -36265-1-50-2301

FORM NO. 135-931M

THIS DRAWING SUPERSEDES
THIS DRAWING SUPERSEDED BY

REVISIONS

5.5 Waste Water Treatment - Unit 2400

- **Design Capacity**

The waste water treatment system is designed to process waste water streams produced by the shale oil plant facility. The following three streams are the primary feeds to waste water treatment. The design capacities correspond to the total processing plant.

	Capacity, GPM
• Water containing inorganic salts - stormwater	1,080
• Water containing organic material - pad washing	650
• Sanitary wastes	200

The waste water treatment unit is designed as two 50% parallel trains, except for sanitary wastes which are handled independent of the other waste water streams and are processed by a single train system.

- **System Description**

The process flow for Waste Water Treatment, Unit 2400, is shown in Figures 5.6 and 5.7.

Storm water and wastes from the oily water sewer system enter the waste water treatment plant by flowing to the Stormwater Basin, BA-2401. Stripped water which may contain phenols enters the system by flowing to the Induced Air Flotation System, S-2402. Spent caustic flows directly to the API Separator, BA-2407 while blowdown from the cooling towers is sent directly to the Equalization Basin, BA-2403.

Effluent from the Stormwater Basin, BA-2401, is pumped by the Stormwater Basin Pump, P-2401, to the API Separator, BA-2407. The effluent from the API Separator is then pumped by the API Separator Pump, P-2402, to the Induced Air Flotation System, S-2402. Oil recovered by the Rotary Drum Oil Skimmer, L-2408, located in the API Separator, flows to the Recovered Oil Sumps, BA-2402. Oil is also recovered in the API Separator by the Slotted Skimmer Pipe which is located at the opposite end of the Rotary Drum Oil Skimmer in the API Separator. This oil also flows to the Recovered Oil Sump.

As the oil is pumped from the Recovered Oil Sump by the Recovered Oil Pump, P-2403, it passes through the Decantation Valve, S-2403, which separates water that is carried over from the API Separator. The recovered water is returned to the API Separator. The oil leaving the decantation valve flows to the oil slop system.

5.5 Waste Water Treatment - Unit 2400 (Cont'd)

Effluent from the Induced Air Flotation System flows to the Equalization Basin where it is neutralized with acid or caustic. Additionally, nutrients for subsequent biological growth are added. After being thoroughly mixed by the Equalization Basin Diffusion System, L-2402, the Equalization Basin Pumps, P-2407 A/B, pump the waste water to the Trickling Filter, BA-2408. The Trickling Filter acts as the preliminary biological removal step. Effluent from the filter flows by gravity to the Splitter, BA-2410. The Splitter allows operational flexibility by providing a means with which to recycle trickling filter effluent (in low flow situations), or bypassing the Aeration Basin, BA-2404, should operational problems preclude its operation. Waste water from the Splitter flows to the Aration BAsin where it undergoes biological assimilation prior to suspended solids removal in the Activated Sludge Clarifiers, L-2404 A/B. Sludge settled in the clarifiers is either recycled to the aeration basin or occasionally wasted.

Overflow from the clarifiers flow to the Filter Feed Sump, BA-2409, where it is pumped by the Filter Feed Pumps, P-2412 A/B to the Pressure Filters, L-2412 A/B. The effluent from the filters, now fully treated, flows to the Backwash Holding Truck, TK-2402. The tank stores enough treated effluent to be used when backwashing of the filters are required. Overflow from this tank is pumped to Raw Water Treatment via the Treated Effluent pump, P-2414.

- Utilities Summary

The estimated normal operating requirements for the waste water treating system are summarized below:

Utility	Demand
MP Steam, lb/hr	
D-2401	11
D-2402	23
D-2402	11
D-2404	11
	56 (Intermittent)
Cooling Water, GPM	
Pumps	34

5.5 Waste Water Treatment - Unit 2400 (Cont'd)

Electric Power, KW

	Continuous	Intermittent
P-2401A/B	-	4.5
P-2402A/B/C	10.2	5.1
P-2403A/B	2.6	2.6
P-2404A/B	0.4	0.4
P-2405A/B	0.4	0.4
P-2406A/B	0.4	0.4
P-2407A/B/C	19.8	9.9
P-2408A/B	0.9	0.9
P-2409A/B	8.7	8.7
P-2410A/B	0.4	0.4
P-2411A/B	1.1	1.1
P-2412A/B/C	34.4	17.2
P-2413A/B/C	18.2	18.2
P-2414A/B	34.4	-
P-2415A/B	-	9.0
S-2401A/B	0.3	0.3
S-2402A/B	5.7	5.7
TK-2401	0.6	-
L-2401	0.9	-
L-2402	10.4	-
L-2403	31.2	-
L-2404A/B	0.7	0.7
L-2408A/B	1.6	-
TOTAL	183.3	

Chemicals Consumption, lb/hr

Phosphoric Acid (75%) (Nutrient)	150
Caustic (45%)	150
Sulfuric Acid (98%)	150
Alum	80

- Equipment Summary

Major equipment required for the waste water treatment system are listed in Table 5.6, together with the corresponding equipment specifications.

TABLE 5.6

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION
PROCESS PLANTS DIVISION

CONTRACT: 11-36265
SECTION: UNIT 2400

EQUIPMENT LIST

NAME OF UNIT: WASTE WATER TREATMENT

PAGE 1 OF 4

CLIENT: DOE/METC
LOCATION:

REVISION	ORIGINAL	1	2	3	4	5
DATE	4/27/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO PER TRAIN	REQ'N. NO TOTAL PLANT		REV.
DRUMS	D-2401	NUTRIENT STORAGE DRUM		1	2	HORIZ., 2'-6" ∅ x 5'-6" T.T., C.S.	
	D-2402	CAUSTIC DAY DRUM		1	2	HORIZ., 2'-6" ∅ x 5'-6" T.T., C.S.	
	D-2403	ACID DAY DRUM		1	2	HORIZ., 2'-6" ∅ x 5'-6" T.T., C.S.	
	D-2404	ALUM STORAGE DRUM		1	2	HORIZ., 2'-6" ∅ x 5'-6" T.T., C.S.	
TANKS	TK-2401	SLUDGE HOLDING TANK		1	2	30'-0" ∅ x 8'-0" DEPTH	
	TK-2402	BACKWASH HOLDING TANK		1	2	11'-6" ∅ x 9'-6" HEIGHT	
PUMPS	P-2401A	STORM WATER BASIN PUMP		1	2	VERTICAL CENTRIF., 200 GPM, 25 PSIG, C.S.	
	P-2401B	SPARE STORM WATER BASIN PUMP		1	2		
	P-2402A	API SEPARATOR PUMP		1	2	VERTICAL CENTRIF., 210 GPM, 30 PSIG, C.S.	
	P-2402B	API SEPARATOR PUMP		1	2		
	P-2402C	SPARE API SEPARATOR PUMP		1	2		
	P-2403A	RECOVERED OIL PUMP		1	2	VERTICAL CENTRIF., 25 GPM, 70 PSIG, C.S.	
	P-2403B	SPARE RECOVERED OIL PUMP		1	2		
	P-2404A	NUTRIENT METERING PUMP		1	2	METERING, 2.0 GPH, 10 PSIG, S.S.	
	P-2404B	SPARE NUTRIENT METERING PUMP		1	2		
	P-2405A	CAUSTIC METERING PUMP		1	2	METERING, 1.6 GPM, 10 PSIG, S.S.	
	P-2405B	SPARE CAUSTIC METERING PUMP		1	2		
	P-2406A	ACID METERING PUMP		1	2	METERING, 1.6 GPM, 10 PSIG, S.S.	
	P-2406B	SPARE ACID METERING PUMP		1	2		
	P-2407A	EQUILIZATION BASIN PUMP		1	2	VERTICAL CENTRIF., 1200 GPM, 35 PSIG, C.S	
	P-2407B	EQUILIZATION BASIN PUMP		1	2		
	P-2407C	SPARE EQUILIZATION BASIN PUMP		1	2		
	P-2408A	PRIMARY SLUDGE PUMP		1	2	VERTICAL CENTRIF., 120 GPM, 25 PSIG, C.S.	
	P-2408B	SPARE PRIMARY SLUDGE PUMP		1	2		
	P-2409A	RETURN SLUDGE PUMP		1	2	VERTICAL CENTRIF., 1200 GPM, 35 PSIG, C.S	
	P-2409B	SPARE RETURN SLUDGE PUMP		1	2		
	P-2410A	ALUM METERING PUMP		1	2	METERING, 1.6 GPM, 10 PSIG, C.S.	
	P-2410B	SPARE ALUM METERING PUMP		1	2		
	P-2411A	SLUDGE PUMP		1	2	DIAPHRAM, 50 GPM, 15 PSIG, C.S.	
	P-2411B	SPARE SLUDGE PUMP		1	2		

TABLE 5.6 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT 11-36265 SECTION: UNIT 2400	EQUIPMENT LIST	NAME OF UNIT WASTE WATER TREATMENT	PAGE 2 OF 4

CLIENT: DOE/METC

LOCATION:

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO. PER TRAIN	TOTAL PLANT		REV.
PUMPS (CONT.)	P-2412A	FILTER FEED PUMP		1	2	VERTICAL CENTRIF., 1200 GPM, 15 PSIG, C.S	
	P-2412B	FILTER FEED PUMP		1	2		
	P-2412C	SPARE FILTER FEED PUMP		1	2		
	P-2413A	BACKWASH PUMP		1	2	CENTRIF., 1450 GPM, 60 PSIG, C.S.	
	P-2413B	BACKWASH PUMP		1	2		
	P-2413C	SPARE BACKWASH PUMP		1	2		
	P-2414A	TREATED EFFLUENT PUMP		1	2	CENTRIF., 1200 GPM, 50 PSIG, C.S.	
	P-2414B	SPARE TREATED EFFLUENT PUMP		1	2		
	P-2415A	CLEAN STORMWATER PUMP		1	2	VERTICAL CENTRIF., 200 GPM, 50 PSIG, C.S.	
	P-2415B	SPARE CLEAN STORMWATER PUMP		1	2		
SEPARATORS	S-2401A	API SEPARATOR MECHANISM		1	2		
	S-2401B	API SEPARATOR MECHANISM		1	2		
	S-2402A	INDUCED AIR FLOTATION SYSTEM		1	2		
	S-2402B	INDUCED AIR FLOTATION SYSTEM		1	2		
	S-2403	DECANTATION VALVE		1	2		
STRUCTUAL	BA-2401	STORMWATER BASIN		1	2		
	BA-2402	RECOVERED OIL SUMP		1	2		
	BA-2403	EQUALIZATION BASIN		1	2		
	BA-2404	AEARATION BASIN		1	2		
	BA-2405	RETURN SLUDGE SUMP		1	2		
	BA-2406	PRIMARY SLUDGE SUMP		1	2		
	BA-2407A	API SEPARATOR		1	2		
	BA-2407B	API SEPARATOR		1	2		
	BA-2408	TRICKLING FILTER		1	2		
	BA-2409	FILTER FEED SUMP		1	2		
	BA-2410	SPLITTER		1	2		

TABLE 5.6 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: UNIT 2400	EQUIPMENT LIST	NAME OF UNIT: WASTE WATER TREATMENT	PAGE 3 OF 4

CLIENT: DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION:	DATE	4/27/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO. PER TRAIN	TOTAL PLANT		REV.
SPECIAL EQUIPMENT	L-2401	IAF POLYMER FEED SYSTEM		1	2		
	L-2402	EQUALIZATION BASIN DIFFUSION SYSTEM		1	2		
	L-2403	AERATION BASIN DIFFUSION SYSTEM		1	2		
	L-2404A	ACTIVATED SLUDGE CLARIFIER		1	2		
	L-2404B	ACTIVATED SLUDGE CLARIFIER		1	2		

TABLE 5.6 (Cont'd)

FORM NO. 135-904

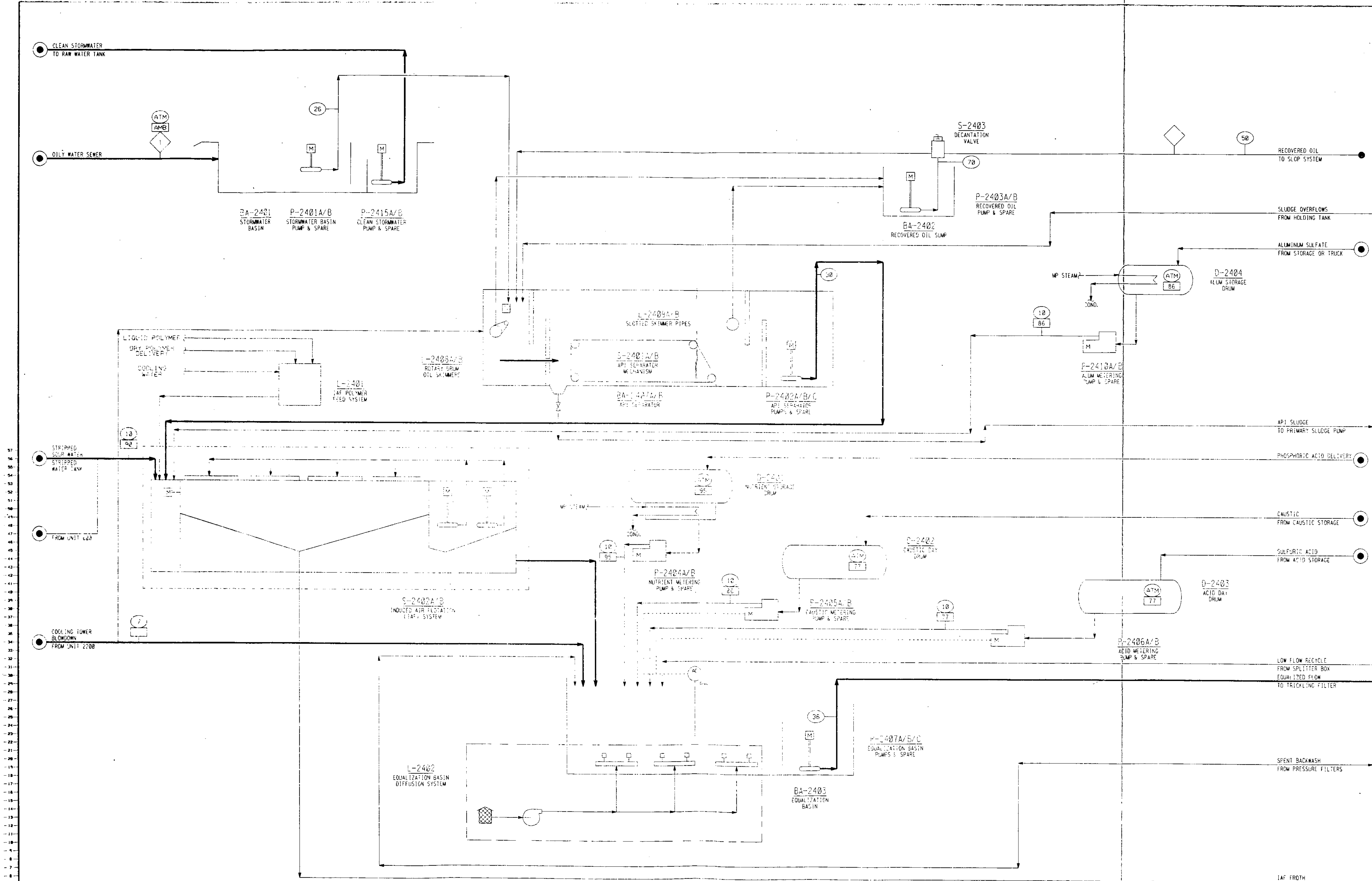
FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: UNIT 2400	EQUIPMENT LIST	NAME OF UNIT: WASTE WATER TREATMENT	PAGE 4 OF 4

CLIENT: DOE/METC

LOCATION:

REVISION	ORIGINAL	1	2	3	4	5
DATE	4/21/81					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO. PER TRAIN	TOTAL PLANT		REV.
SPECIAL EQUIPMENT							
	L-2408A	ROTARY DRUM OIL SKIMMER		1	2		
	L-2408B	ROTARY DRUM OIL SKIMMER		1	2		
	L-2409A	SLOTTED SKIMMER PIPE		1	2		
	L-2409B	SLOTTED SKIMMER PIPE		1	2		
	L-2410	ROTARY DISTRIBUTOR		1	2		
	L-2411	TRICKLING FILTER MEDIA		1	2		
	L-2412A	PRESSURE FILTER		1	2		
	L-2412B	PRESSURE FILTER		1	2		
PACKAGE UNITS	PK-2401	SANITARY WASTEWATER TREATMENT SYSTEM		-	1		



LEGEND

MATERIAL BALANCE STREAM NUMBER	PROCESS STREAM FROM BATTERY LIMITS
TEMPERATURE, °F	PROCESS STREAM TO BATTERY LIMITS
PRESSURE, PSIG	

FIGURE 5.6

PROCESS FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 2400-WASTEWATER TREATMENT

DRAWN BY: | SCALE: NONE | CHG. No. 11-36265 | DWG. No. -36265-1-50-2401

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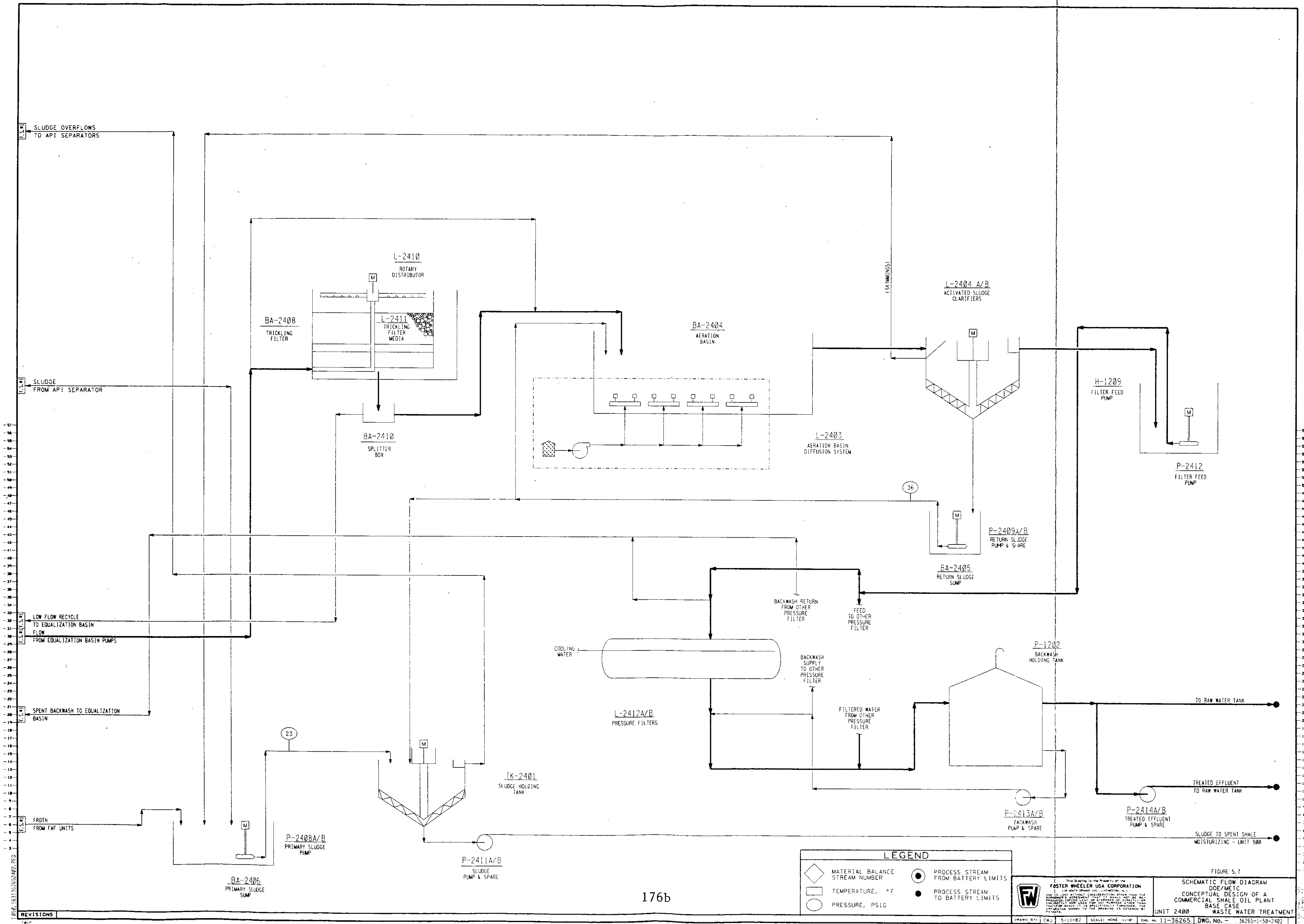
SLUDGE OVERFLOWS TO API SEPARATORS
SLUDGE FROM API SEPARATOR
LOW FLOW RECYCLE TO EQUALIZATION BASIN
FLOW FROM EQUALIZATION BASIN PUMPS
SPENT BACKWASH TO EQUALIZATION BASIN
FROTH FROM FAF UNITS
L-2410
ROTARY DISTRIBUTOR
BA-2408
TRICKLING FILTER
L-2411
TRICKLING FILTER MEDIA
BA-2410
SPLITTER BOX
BA-2404
AERATION BASIN
L-2403
AERATION BASIN DIFFUSION SYSTEM
(SKIMMINGS)
L-2404 A/B
ACTIVATED SLUDGE CLARIFIERS
H-1209
FILTER FEED PUMP
P-2412
FILTER FEED PUMP
36
P-2409A/B
RETURN SLUDGE PUMP & SPARE
BA-2405
RETURN SLUDGE SUMP
BACKWASH RETURN FROM OTHER PRESSURE FILTER
FEED TO OTHER PRESSURE FILTER
COOLING WATER
BACKWASH SUPPLY TO OTHER PRESSURE FILTER
P-1202
BACKWASH HOLDING TANK
L-2412A/B
PRESSURE FILTERS
FILTERED WATER FROM OTHER PRESSURE FILTER
TO RAW WATER TANK
TREATED EFFLUENT TO RAW WATER TANK
P-2413A/B
BACKWASH PUMP & SPARE
P-2414A/B
TREATED EFFLUENT PUMP & SPARE
SLUDGE TO SPENT SHALE MOISTURIZING - UNIT 900
23
TK-2401
SLUDGE HOLDING TANK
P-2408A/B
PRIMARY SLUDGE PUMP
BA-2406
PRIMARY SLUDGE SUMP
P-2411A/B
SLUDGE PUMP & SPARE
LEGEND
MATERIAL BALANCE STREAM NUMBER
TEMPERATURE, °F
PRESSURE, PSIG
PROCESS STREAM FROM BATTERY LIMITS
PROCESS STREAM TO BATTERY LIMITS
FIGURE 5.7
This Drawing is the Property of the FOSTER WHEELER USA CORPORATION
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SCHEMATIC FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 2400 WASTE WATER TREATMENT
DRAWN BY: CWJ 5-11-87 SCALE: NONE
CHG. No. 11-36265
DWG. No. - 36265-1-50-2402
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REVISIONS

5.6 Inert Gas System - Unit 2500

- **Design Capacity**

The inert gas system contains two identical operating trains to supply inert gas for use in the plant processing and support facilities. Each train is designed to supply 153,300 SCFH of inert gas at 50 psig and 100°F. The composition of the inert gas is as follows:

Component	Mol%
CO_2	11.4
N_2, Ar	88.0
H_2	0.1 to 0.5
CO	0.1 to 0.5
O_2	500 ppm (Max.)
H_2O	Saturated at 50 psig and 100°F

- **System Description**

The schematic flow diagram for the inert gas system is shown in Figure 5.8. Natural gas is combusted in the Inert Gas Generator to produce the inert gas at a pressure of 12 inches of H_2O (gauge). The inert gas product is then compressed to 55 psig, cooled to 100°F and distributed to the plant inert gas system from the Inert Gas Surge Drum.

- **Utilities Summary**

Presented below are the estimated operating requirements for the inert gas system. The summary corresponds to one of two identical operating trains required to service the overall plant needs.

Electric Power	Normal KW	Connected Load KW
PG-2501	30	33
C-2501A	439	480
C-2501B	-	480
TOTAL	469	

Cooling Water (80 psig/80°F)	Consumption, GPM
PG-2501 (@ 30°F ΔT)	1200
E-2501 (@ 20°F ΔT)	120
TOTAL	1320

Natural Gas Consumption (100 psig/AMB Temp.)	18,000 SCF/HR
Sour Water Produced (From D-2501)	320 lb/hr (Normal) 415 lb/hr (Design)

- **Equipment Summary**

Major equipment required for the inert gas system are listed in Table 5.7, together with the corresponding equipment specifications.

TABLE 5.7

FORM NO. 135-904

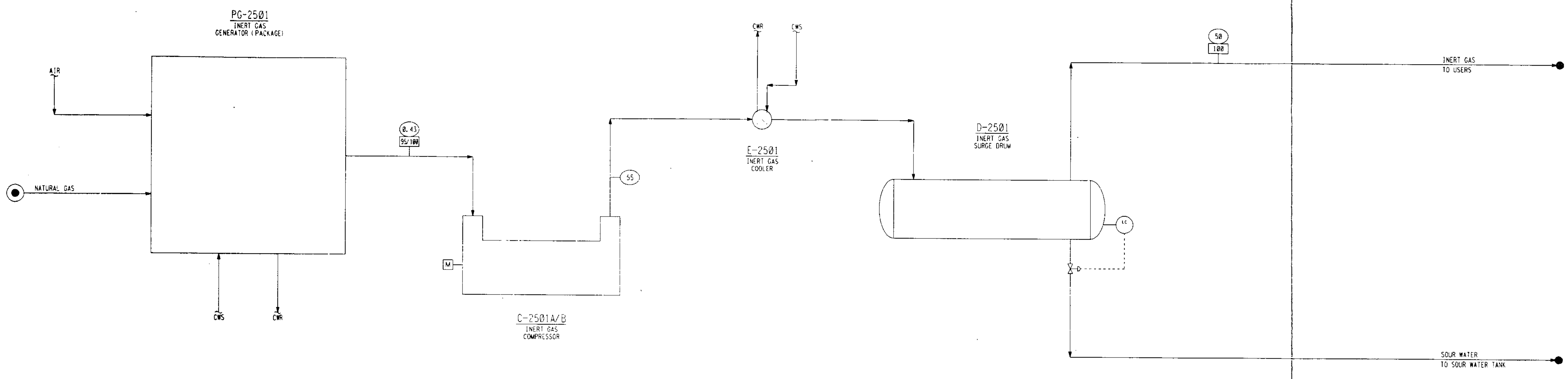
FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 2500	EQUIPMENT LIST	NAME OF UNIT: Inert Gas System	PAGE 1 OF 1

CLIENT: DOE/METC . Shale Oil Plant

LOCATION: Western Colorado

REVISION	ORIGINAL	1	2	3	4	5
DATE	4/24/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
INERT GAS GENERATORS	PG-2501	Inert Gas Generator (Package)		1	2	153,300 SCF/HR each, Natural Gas Feed, Inert Gas Produced at P=12" H_2O & T=100°F	
COMPRESSORS	C-2501 A/B	Inert Gas Compressor		2	4	3856 ACFM each, 55 PSIG discharge pressure, 10.5 PSIA suction pressure, 536 BHP, 600 MHP C. S.	
EXCHANGERS	E-2501	Inert Gas Cooler		1	2	To cool 12,078 lb/hr of inert gas from 360°F to 100°F. Duty = 1,180,000 Btu/hr Water Cooled, Area =503 ft2, AES, C.S. Shell & Tube	
DRUMS	D-2501	Inert Gas Surge Drum				Horizontal Drum 9'- 6" ID x 22'-0" To To T, C.S. 80 PSIG Design Pressure	
					NOTE:	Barometric Press. = 10.5 PSIA	



NOTE: THE INERT GAS SYSTEM CONSISTING OF TWO OPERATING TRAINS, PROVIDE TO SERVE THE ENTIRE PLANT.

LEGEND

▭	TEMPERATURE, °F	◉	PROCESS STREAM FROM BATTERY LIMITS
◯	PRESSURE, PSIG	●	PROCESS STREAM TO BATTERY LIMITS

FIGURE 5.8

SCHEMATIC FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 2500 - INERT GAS SYSTEM

DRAWN BY: | 08-MAY-87 | SCALE: NONE | CHG. No. 11-36265 | DWG. No. -36265-1-50-2501

REVISIONS

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5.7 Flare System - Unit 2600

- Design Capacity

A total of five flare systems are provided to service the overall process plant. Three identical flare systems serve the six retorting trains and two identical flare systems serve the balance of the processing units.

The function of the flare system is to provide safe burning of combustible vapors produced during programmed start-up and shutdown, normal operation or upset conditions. Plant upsets include emergencies such as: power failure, cooling water failure, unit depressuring, steam failure, instrument air failure, fire or blocked outlets.

The elevated flare design is based on the relieving load for local power failure or blocked outlet. The design load for each flare serving the retorting trains is 636,400 lb/hr of vapor of 31.0 molecular weight at 250°F. The design load for each flare serving the upgrading trains is 390,000 lb/hr of vapor of 26.6 molecular weight at 250°F. The selection of flare stack location is based on minimizing the length of the main flare header, minimizing the flare stack height, keeping the radiation level and maximum sulfur dioxide concentration at ground level below allowable limits.

- System Description

The schematic flow diagram for a typical flare system serving the retorting and upgrading units is shown in Figure 5.9.

Knock-out drums are provided for each identifiable battery limit process area in the plant. These drums receive and disengage liquids from the vapors discharged from the individual process areas to the flare system. Liquid hydrocarbons collected in the K.O. drums are sent to Raw Oil Recovery, Unit 200, by automatic start-up pumps provided at the drums. Water settled in the K.O. drums is pumped to Sour Water Treating, Unit 700, by separate automatic start-up pumps.

Vapors from the process unit K.O. Drums flow to the Flare K.O. Drums and are burned in the elevated flare. All drums are provided with a steam coil to vaporize light ends, to prevent water freezing in cold weather, and to reduce viscosity of heavy hydrocarbons for pumping purposes. The elevated flare includes the following features:

- Facilities for smokeless burning of hydrocarbons up to 25% of its design capacity

- A molecular seal, located underneath the flare tip, to prevent oxygen back-diffusion inside the system

5.7 Flare System - Unit 2600 (Cont'd)

- A flame front generator to start pilots

- Pilot flame detectors

Facilities are supplied for automatic inert gas injection inside all flare K.O. Drums, to compensate for the system "contraction" after a hot blow. A continuous supply of purge gas is used, in conjunction with a molecular seal, for flashback protection from the flare into the pressure relief system. Medium pressure steam is provided to the flare tip for smokeless burning. Smokeless flaring is based on the principle of increasing the burning rate by the injection of steam into a flame, by the creation of turbulence in the reacting gases and the aspiration of air, thereby reducing the formation of soot.

- Utilities Summary

Normal utilities requirement for the total flare system are summarized below. These correspond to five flare systems servicing the entire processing plant.

	Normal Demand	Connected Load
Electric Power, KW (Intermittent)	--	625
Inert Gas, SCFH	7,820	-
M.P. Steam, Lb/Hr (150 psig/364°F)	242,600 (Intermittent)	
Fuel Gas, MMBTU/HR (LHV) (100 psig/AMB Temp.)	2.2	-

- Equipment Summary

Major equipment required for the plant flare system are listed in Table 5.8. The corresponding equipment specifications are given in Table 5.9.

TABLE 5.8

FORM NO 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 2600	EQUIPMENT LIST	NAME OF UNIT: Flare System	PAGE 1 OF 2

CLIENT: U.S. DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: Western Colorado	DATE	4/15/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total	REV.
FLARE STACKS	FL-2601 A/B/C	Flare for Retorting Modules		1	3	
	FL-2602 A/B	Flare for Upgrading Modules		1	2	
DRUMS	D-2601 A-F	K.O. Drum for Unit 100		1	6	
	D-2602A/B	K.O. Drum for Unit 300		1	2	
	D-2603A/B	K.O. Drum for Units 400/500		1	2	
	D-2604A/B	K.O. Drum for Unit 600		1	2	
	D-2605A/B	K.O. Drum for Unit 700		1	2	
	D-2606A/B	K.O. Drum for Unit 800		1	2	
	D-2607 A/B/C	Flare K.O. Drum for FL-2601 A/B/C		1	3	
	D-2608A/B	Flare K.O. Drum for FL-2602 A/B		1	2	
PUMPS	P-2601 A-F	Unit 100 K.O. Drum Pump		1	6	
	P-2602 A-F	Unit 100 K.O. Drum Water Boot Pump		1	6	
	P-2603A/B	Unit 300 K.O. Drum Pump		1	2	
	P-2604A/B	Unit 300 K.O. Drum Water Boot Pump		1	2	
	P-2605A/B	Units 400/500 K.O. Drum Pump		1	2	
	P-2606A/B	Units 400/500 K.O. Drum Water Boot Pump		1	2	
	P-2607A/B	Unit 600 K.O. Drum Pump		1	2	
	P-2608A/B	Unit 700 K.O. Drum Pump		1	2	
	P-2609A/B	Unit 800 K.O. Drum Pump		1	2	
	P-2610 A-F	Flare K.O. Drum Pump for D-2607 A/B/C		2	6	
	P-2611 A/B/C	Flare K.O. Drum Water Boot Pump for D-2607 A/B/C		1	3	

TABLE 5.8 (Cont'd)

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION, PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 2600	EQUIPMENT LIST	NAME OF UNIT: Flare System	PAGE 2 OF 2

CLIENT: U.S. DOE/METC	REVISION	ORIGINAL	1	2	3	4	5
LOCATION: Western Colorado	DATE	4/15/87					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
PUMPS (Cont'd.)	P-2612 A-D	Flare K.O. Drum Pump for D-2608 A/B		2	4		
	P-2613A/B	Flare K.O. Drum Water Boot Pump for D-2608 A/B		1	2		

TABLE 5.9

UNIT 2600 - FLARE SYSTEM EQUIPMENT SPECIFICATIONS

FLARE STACKS

ITEM NO.	DESCRIPTION(*)	TYPE	TIP ELEVA. FEET	TIP DIA. INCHES	TEMP. °F	MAT. OF CONSTR.
FL-2601A/B/C	Flare for Retorting Modules	Guy Supported	270	36	0-400	C.S.
FL-2602A/B	Flare for Upgrading Modules	Guy Supported	190	30	0-400	C.S.

* (Includes mol seal, flame front generator, automatic smokeless steam injection, pilots and all equipment associated with the items mentioned above).

DRUMS

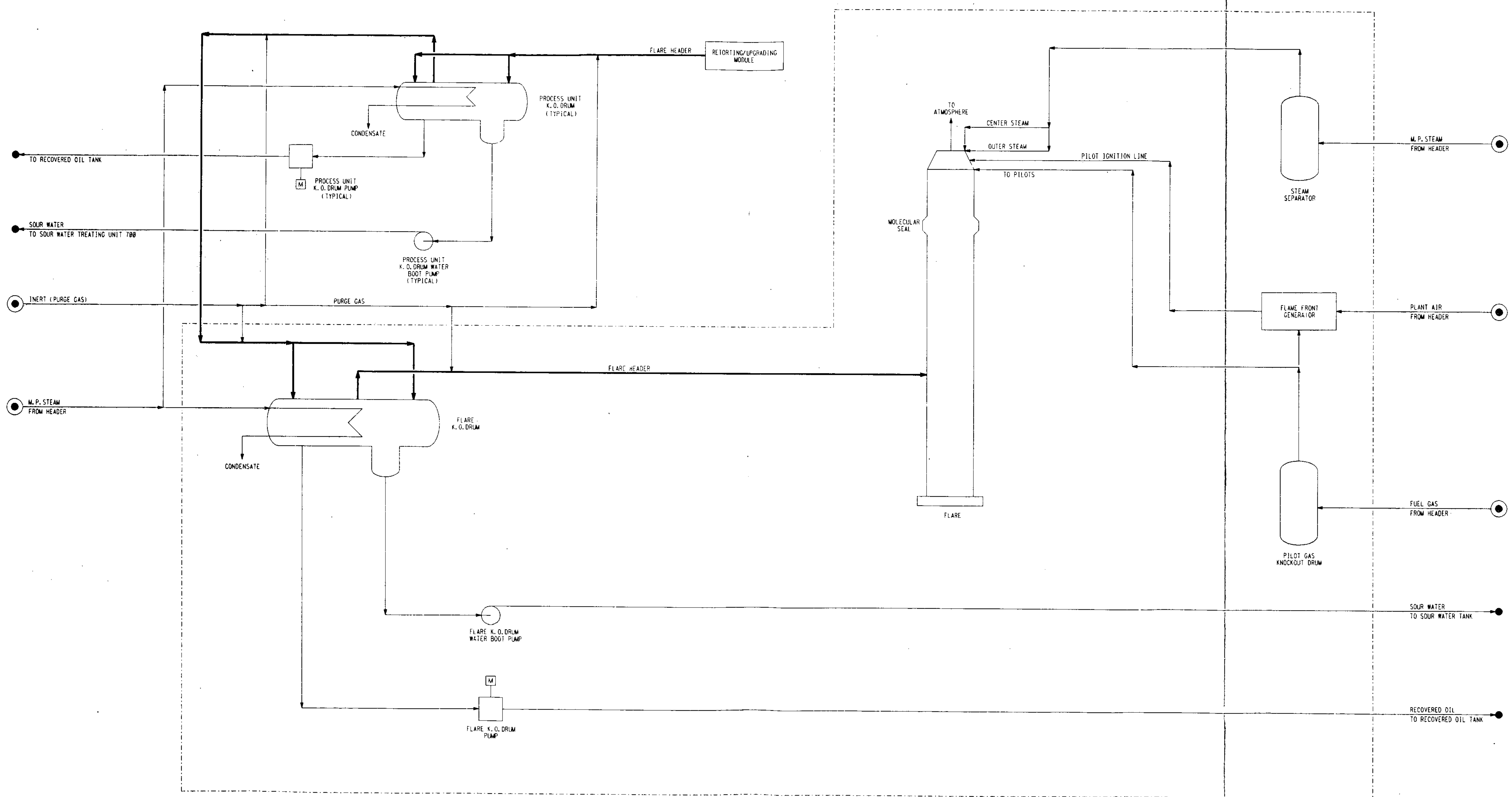
ITEM NO.	DESCRIPTION	POSITION	DIA/HGT. OR LENGTH	DESIGN PRESS, PSIG	MAT. OF CONSTR.
D-2601A-F	K.O. Drum for Unit 100	Horiz.	14'-0"/42'-0" (3'-0" x 2'-0" Boot)	50	C.S.
D-2602A/B	K.O. Drum for Unit 300	Horiz.	12'-6"/37'-6" (3'-0" x 2'-0" Boot)	50	C.S.
D-2603A/B	K.O. Drum for Unit 400/500	Horiz.	10'-0"/30'-0" (3'-0" x 2'-0" Boot)	50	C.S.
D-2604A/B	K.O. Drum for Unit 600	Horiz.	8'-6"/26'-0"	50	C.S.
D-2605A/B	K.O. Drum for Unit 700	Horiz.	8'-6"/25'-6"	50	C.S.
D-2606A/B	K.O. Drum for Unit 800	Horiz.	10'-0"/30'-0"	50	C.S.
D-2607A/B/C	Flare K.O. Drum for FL-2601A/B/C	Horiz.	16'-0"/48'-0" (3'-0" x 2'-0" Boot)	50	C.S.
D-2608A/B	Flare K.O. Drum for FL-2602A/B		19'-0"/57'-0" (3'-0" x 2'-0" Boot)	50	C.S.

TABLE 5.9

UNIT 2600 - FLARE SYSTEM EQUIPMENT SPECIFICATIONS (Cont'd)

PUMPS

ITEM NO.	DESCRIPTION	TYPE	DIA/HGT FLOW GPM	DESIGN PRESS, PSIG	MAT. OF CONSTR.
P-2601A-F	Unit 100 K.O. Drum Pump	Recip.	230	150	C.S. Casing
P-2602A-F	Unit 100 K.O. Drum Water Boot Pump	Centrif.	25	70	C.S. Casing
P-2603A/B	Unit 300 K.O. Drum Pump	Recip.	65	100	C.S. Casing
P-2604A/B	Unit 300 K.O. Drum Water Boot Pump	Centrif.	15	50	C.S. Casing
P-2605A/B	Units 400/500 K.O. Drum Pump	Recip.	82	100	C.S. Casing
P-2606A/B	Units 400/500 K.O. Drum Water Boot Pump	Centrif.	25	70	C.S. Casing
P-2607A/B	Unit 600 K.O. Drum Pump	Centrif.	25	50	C.S. Casing
P-2608A/B	Unit 700 K.O. Drum Pump	Centrif.	50	150	C.S. Casing
P-2609A/B	Unit 800 K.O. Drum Pump	Recip.	50	150	C.S. Casing
P-2610A-F	Flare K.O. Drum Pump for D-2607A/B/C	Recip.	200	150	C.S. Casing
P-2611A/B/C	Flare K.O. Drum Water Boot Pump for D-2607A/B/C	Centrif.	35	70	C.S. Casing
P-2612A-D	Flare K.O. Drum Pump for D-2608A/B	Recip.	300	150	C.S. Casing
P-2613A/B	Flare K.O. Drum Water Boot Pump for D-2608A/B	Centrif.	45	70	C.S. Casing



NOTE:

1. DOTTED AREA REPRESENTS FIVE (5) FLARE SYSTEMS (THREE IDENTICAL FLARE SYSTEMS SERVING SIX RETORTING TRAINS AND TWO IDENTICAL FLARE SYSTEMS SERVING TWO UPGRADING TRAINS).

FIGURE 5.9

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SCHEMATIC FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE

UNIT 2600 FLARE SYSTEM

DRAWN BY: | APR-20-87 | SCALE: NONE | CHG. NO. 11-36265 | DWG. No. - 36265-1-50-2601

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5.8 Plant Fuel System - Unit 2700

- System Description

Fuel requirements for operation of the retorting and upgrading plants will be supplied from the following sources:

- Treated fuel gas produced in the processing plants.
- Natural gas available at plant battery limits.

Fuel gas is produced in the retorting and upgrading units and is treated in Unit 800, Sulfur Recovery. The composition and flow rate of the treated fuel gas delivered to the plant fuel gas header are:

Component	Mol%
H_2	45.32
CO	3.75
CO_2	14.99
H_2O	1.53
H_2S	(10 ppmv)
NH_3	0.01
CH_4	16.15
C_2H_4	2.26
C_2H_6	5.75
C_3H_6	2.49
C_3H_8	2.90
C_4H_8	2.56
C_4H_{10}	0.51
N_2	1.67
C_5+	0.11
	100.00
Total Weight, Lbs/Hr	93,916
Molecular Wt.	18.50
LHV, BTU/SCF	626

5.8 Plant Fuel System - Unit 2700 (Cont'd)

Natural gas, at the following flow rate and composition, is used to supplement the in-plant fuel gas production in order to satisfy the overall plant fuel requirements.

Component	Mol.%
CH_4	94.0
C_2H_4	1.0
C_2H_6	2.3
C_3H_8	0.2
N_2	2.5
	100.0
Total Weight, Lbs/Hr	40,361
Molecular Wt.	16.84
LHV, BTU/SCF	911.3
Sulfur GR/100CF Max.	20.0

A schematic diagram of the plant fuel gas distribution system is shown in Figure 5.10.

The total amount of treated fuel gas produced in Unit 800, Sulfur Recovery, is combined with natural gas to supply the fuel gas requirement for Retorting Unit 100, via fuel gas mixing drum. The fuel gas for all other plant requirements is supplied from the natural gas supply header.

- Equipment Summary

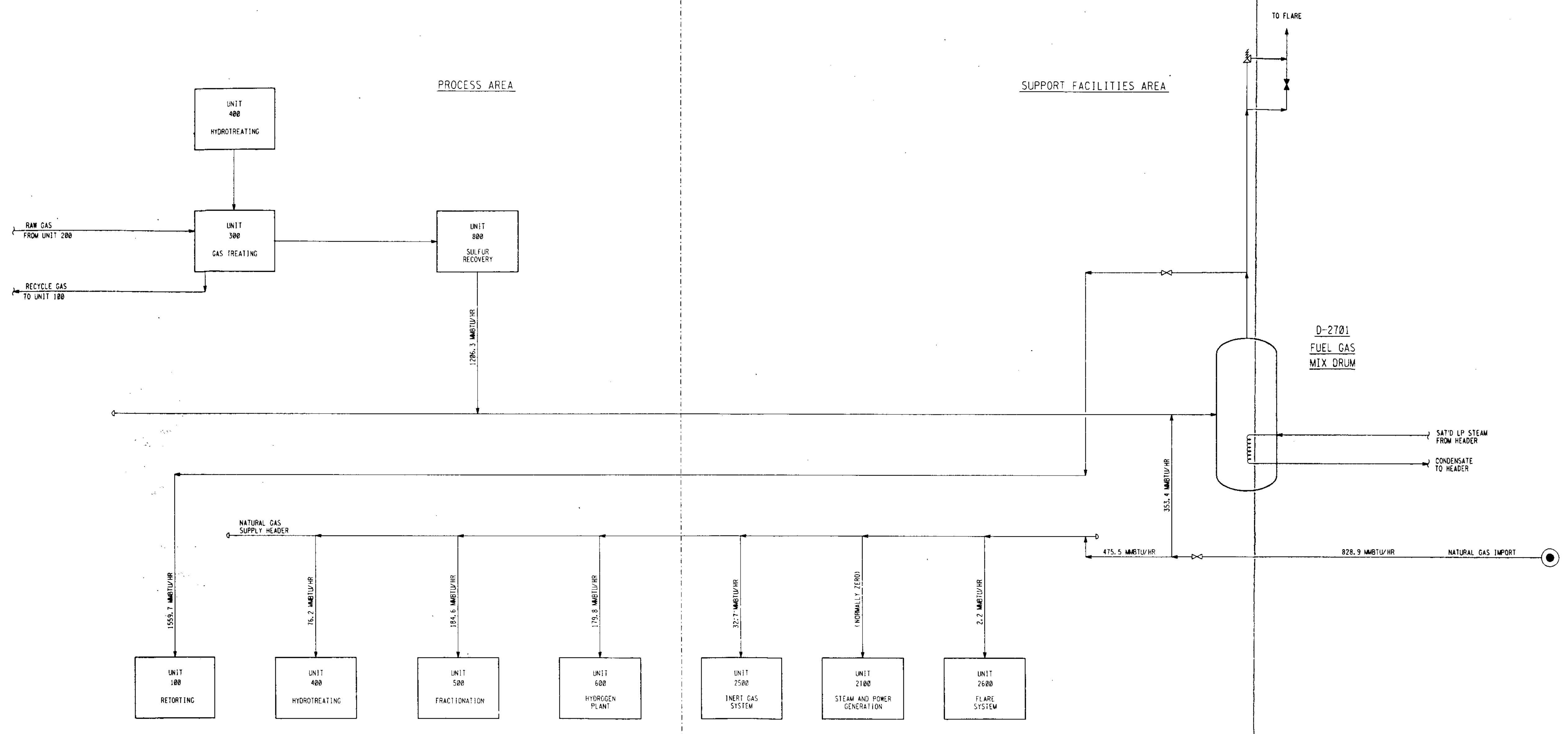
Major equipment required for the plant fuel system are listed in Table 5.10, together with the corresponding equipment specifications.

TABLE 5.10

FORM NO 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: 11-36265 SECTION: 2700	EQUIPMENT LIST		NAME OF UNIT: PLANT FUEL SYSTEM	PAGE 1 OF 1
CLIENT: DOE/METC Shale Oil Plant		REVISION	ORIGINAL	1 2 3 4 5	
LOCATION: Western Colorado		DATE	5/12/87		

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO Train	Total		REV.
DRUMS	D-2701	Fuel Gas Mix Drum		1	1	Vertical Drum	
						10'-0" I.D. x 17'-0" T to T, C.S.	
						150 Psig Design Pressure	



NOTE:

FUEL CONSUMPTION (LHV) DUTIES SHOWN ARE TOTAL FOR ALL OPERATING UNITS.

FIGURE 5.10

LEGEND

◉ PROCESS STREAM FROM BATTERY LIMITS

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SCHEMATIC FLOW DIAGRAM
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE
UNIT 2700 PLANT FUEL SYSTEM

DRAWN BY:	CWJ	3-13-87	SCALE: NONE	CHG. NO. 11-36265	DWG. No. -36265-1-50-2701

REVISIONS

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5.9 Storage Facilities - Unit 2800

- Design Capacity

Storage facilities for products, intermediates, chemicals and additives is provided as follows:

Material Stored	Capacity, Days
Raw Oil	10
Naphtha Product	10
Diesel Oil Product	10
Bottom Product (Heavy Oil)	10
Ammonia Product	30
Sulfur Product	30
Sour and Stripped Water	10
Raw Water	1
Oil Additive	10

For the various chemicals required for the plant operation, the storage capacity is either 10 days or one truck load.

Volatile products are stored in floating roof tanks to minimize product loss and air emissions.

- System Description

Storage facilities consist in a tank farm and two pumping stations.

Each product is stored in one or more dedicated tanks. Piping interconnecting system allows for transferring the stored liquids to and from various processing units or loading/unloading stations.

Syncrude oil can be shipped out of the plant via pipeline either as separate fractions (heavy oil, diesel, naphtha), or as a blend. In either case the pour point of the heavy oil is too high to permit ambient temperature pumping. In order to use existing unheated pipeline systems, a pour point depressant additive is added and in line blended before shipping. The oil additive is brought into the plant by truck, stored and proportionally fed to the syncrude stream before shipping.

5.9 Storage Facilities - Unit 2800 (Cont'd)

The following tanks have floating roof construction to minimize hydrocarbon/chemical emissions:

- Raw Oil Tanks
- Product Naphtha Tank
- Diesel Oil Tank
- Sour Water Tank
- Sponge Oil Tank

Sulfur product is stored in molten state and kept heated during storage and shipping. Liquid ammonia is stored in ambient temperature high pressure spheric tanks and shipped at ambient temperature. For both sulfur and ammonia shipping trucks loading stations are provided.

- **Utility Summary**

The normal operating requirements for the total plant are summarized below:

Exhaust Steam	1000 lb/hr
Electric Power	600 kW
Cooling Water	100 GPM

- **Equipment Summary**

The major equipment required for the plant storage facilities are listed in Table 5.11, together with the corresponding equipment specifications.

TABLE 5.11

FORM NO. 135-904

FOSTER WHEELER USA CORPORATION PROCESS PLANTS DIVISION	CONTRACT: SECTION: 2800	EQUIPMENT LIST	NAME OF UNIT: Storage Facilities	PAGE 01
CLIENT: DOE/METC		REVISION: ORIGINAL, 1, 2, 3, 4, 5		
LOCATION: Western Colorado		DATE: 4/14/87		

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO		Specification		REV.
	T-2801A/B	Raw Oil Intermediate Storage Tank		2		260,000 BBL	FR	
	T-2802A/B	Naphtha Storage Tank		2		30,000 BBL	FR	
	T-2803A/B	Diesel Oil Storage Tank		2		40,000 BBL	FR	
	T-2804A/B	Bottom Product Tank		2		200,000 BBL	CR	
	T-2805A/B	Sulfur Tank		2		5000 BBL	CR Heated	
	T-2806A/B	Ammonia Storage Spheres		2		3000 Tons	(26000 BBL)	
	T-2807	Raw Water Tank		2		100,000 BBL	CR or Open	
	T-2808	Filtered Water Tank		2		50,000 BBL	CR	
	T-2809	Sour Water Tank		2		180,000 BBL	FR	
	T-2810	Stripped Water Tank		2		180,000 BBL	FR	
	T-2811	Gasoline Tank		1		1000 BBL	UG	
	T-2812	Potable Water		1		5000 BBL	CR	
	T-2813	Caustic Soda Tank		1		2000 BBL	CR	
	T-2814	Slop Oil Tank		1		10,000 BBL	CR	
	T-2815	Sponge Oil Tank		1		5000 BBL	FR	
	T-2816	Oil Additive Tank		1		10,000 BBL	CR	
	P-2801-8A/B	Transfer Pumps		16		800 GPM 50 PSIG		
	P-2809A/B	Sulfur Pumps		2		50 GPM 50 PSIG	Steam Traced	
	P-2810A/B	Ammonia Pumps		2		50 GPM 50 PSI ΔP		
	P-2811-13A/B	Transfer Pumps		6		200 GPM 50 PSIG		
	P-2814A/B	Additive Metering Pumps		2		50-80 GPM 100 PSIG		

-191-

5.10 General Plant Facilities - Unit 2900

General facilities required for support of the plant operation include the following systems:

- Inter-connecting piping. A system of main pipe racks to connect all units including the storage facilities and pumping stations is provided as shown on the plot plan Figure 6.1. Further to this system, minor pipe racks will connect the various units as required.

- Fire water system. Through the plant the fire water will be distributed by a piping grid, essentially surrounding each unit, to assure a double feed supply. The piping grid is provided with curb hydrants. Each unit has its own internal hydrants and/or sprinkler system as required by fire codes and minimum two feeders. The entire system includes fire waste storage tanks, fire water pumps with spares (motor and engine drive), jockey pump, valves and instumentations.

  Further to the fire water system, two fire trucks and one foam trailer are provided.

- Electric Power System. Electric power is assumed to be available at the plant battery limit at 13.8 kV. Minimum two feeders are supplying the main substation located at the north center of the plant. Three secondary substations are provided for the plant: Two for the feed preparation, Unit 1000, and one for the rest of the plant, An underground distribution system at 13.8, 5.5 and 0.4 kV is provided too. General lighting of the roads and open areas are provided from the plant illumination system. Local lighting is included in each unit electrical system.

  In-plant electric power generating system is provided to use th plant excess steam and, on the same time, supply the emergency power. The in-plant power generation system consists of two steamdriven generators with a total capacity of approximately 80 MS at normal operation conditions.

- Sewers. The plant includes the following systems:

  - Oily water sewer to collect any process water as well as rain water from the processing plant paved and curbed areas.

  - Rain water sewer to collect rain water run-off from curbed non-process areas (roads, storage platforms, etc.) and not plaved areas.

  - Sanitary sewer.

5.10 General Plant Facilities - Unit 2900 (Cont'd)

All sewers are collected and processed in Unit 2400, waste water treatment.

- Communication and Alarm System. The plant is provided with internal telephone system, fire alarm and general emergency alarm systems.

- Roads and Fences. The plant shall have roads as shown in the plot plan figure 6.1. The entire plant perimeter shall be fenced. Also hazardous areas such as flare area, waste water treatment, truck unloading areas, etc., shall be separately fenced to prevent the access of unauthorized persons.

- Buildings. The following main buildings, required for the plant operation and maintenance, shall be provided:

Buildings	Area ft^2
- Administration	15,000
- Central Control/Laboratory	5,000
- Change House/Cafeteria	3,200
- Warehouse	40,000
- Maintenance Shop	10,000
- Guard House	1,500
- Fire House	5,000

The normal operating requirements for the general plant facilities are summarized below:

Potable Water	200 GPM
Electric Power	700 KW

6.0 PLANT LAYOUT

6.1 Key Plot Plan

The entire plant layout is conceived as an integrated plant built on a "table top" site as shown on Figure 6.1. The oil shale mine and the spent shale disposal sites are assumed to be located on the west side of the plant, consequently the mine trucks enter the plant from the west. These are heavy off-the-road vehicles and are purposely confined in a separate area. In the west side of the plot, the feed preparation unit is located together with the raw shale stock piles and silos.

In the center of the plant are located the retorting modules; each module consisting of Retorting, Unit 100, Raw Oil Recovery, Unit 200, Spent Shale Moisturizing, Unit 900,. These units are located in close proximity to avoid long distance conveying of solids and piping of retort products. Each retorting module has a 300' x 425' plot area with a 200' x 300' paved and curbed process area. Control rooms, laboratory facilities and electric substations are located in the immediate proximity.

The center part of the plot is also occupied by the raw oil upgrading facilities, Units 300 through 800. The parallel trains of these units are located on the same block with road access all around. In the east side of the plant the storage facilities and waste water treatment facilities are located. At the extreme north of the plant, in a remote location, are the flares.

The administration and plant maintenance buildings are located in the south-east section of the plot with access from the south. This location is intended to house the non-operating personnel in a relatively non-hazardous area.

The entire plant requires an area of approximately 275 acres not including the spent shale disposal site. Spent shale disposal requires a separate plot area of about 1500 acres to accommodate 30 years storage.

6.2 Retorting Plant Elevation

Figure 6.2 shows an elevation sketch of the major process vessels in a 12,000 TPOD oil shale retorting train. Vessel elevations were estimated on the basis of the following criteria, whichever was limiting:

6.2 Retorting Plant Elevation (Cont'd)

- A minimum angle of 70^{o} from the horizontal for all solids standpipes.
- A pressure drop of at least 4.0 psi available for solids control valves.
- Separation between vessels of at least 5 feet.
- Length of riser combustor of about 200 feet.

The primary purpose of the elevation sketch was to provide a guide for capital cost estimating. The position of individual process vessels and the overall arrangement were not optimized.

The bottom of the engager section of Combustor V-103 was positioned at an elevation of 20 feet above grade to allow headroom for access to and service of the combustor. The bottom of the retort vessel was located at an elevation of 65 feet to allow for a 70^{o} angle on the standpipe leading to the engager vessel. The bottom of the raw shale accumulator was located at an elevation of 215 feet to allow for a 70^{o} angle on the standpipes leading to the furthest two quadrants of the top of the retort vessel. The bottom of the combusted shale separator was located at an elevation of 215 feet to allow for a 70^{o} angle on the standpipe leading to the top stage of the combusted shale cooler. The retorted shale separator was located at the same elevation as the retort vapor outlet in order to minimize the length of the transfer line between these two vessels.

In this arrangement, the length of the riser section of the combustor between the top of the engager vessel and its termination inside the combusted shale separator is 185 feet. This is a minimum length required to provide 5 seconds solids residence time based on an assumed solids slip factor of 2.0. A lower slip factor would require a longer riser section and, consequently, a higher elevation for the combusted shale separator.

Pressure drop calculations indicate that the process vessel elevations shown in Figure 6.2 provide at least 4 psi pressure drop for control valves in solids standpipes. Since the solids may not be completely fluidized in all standpipes, the calculations were based upon 50 percent of the pressure head developed in a fully fluidized standpipe.

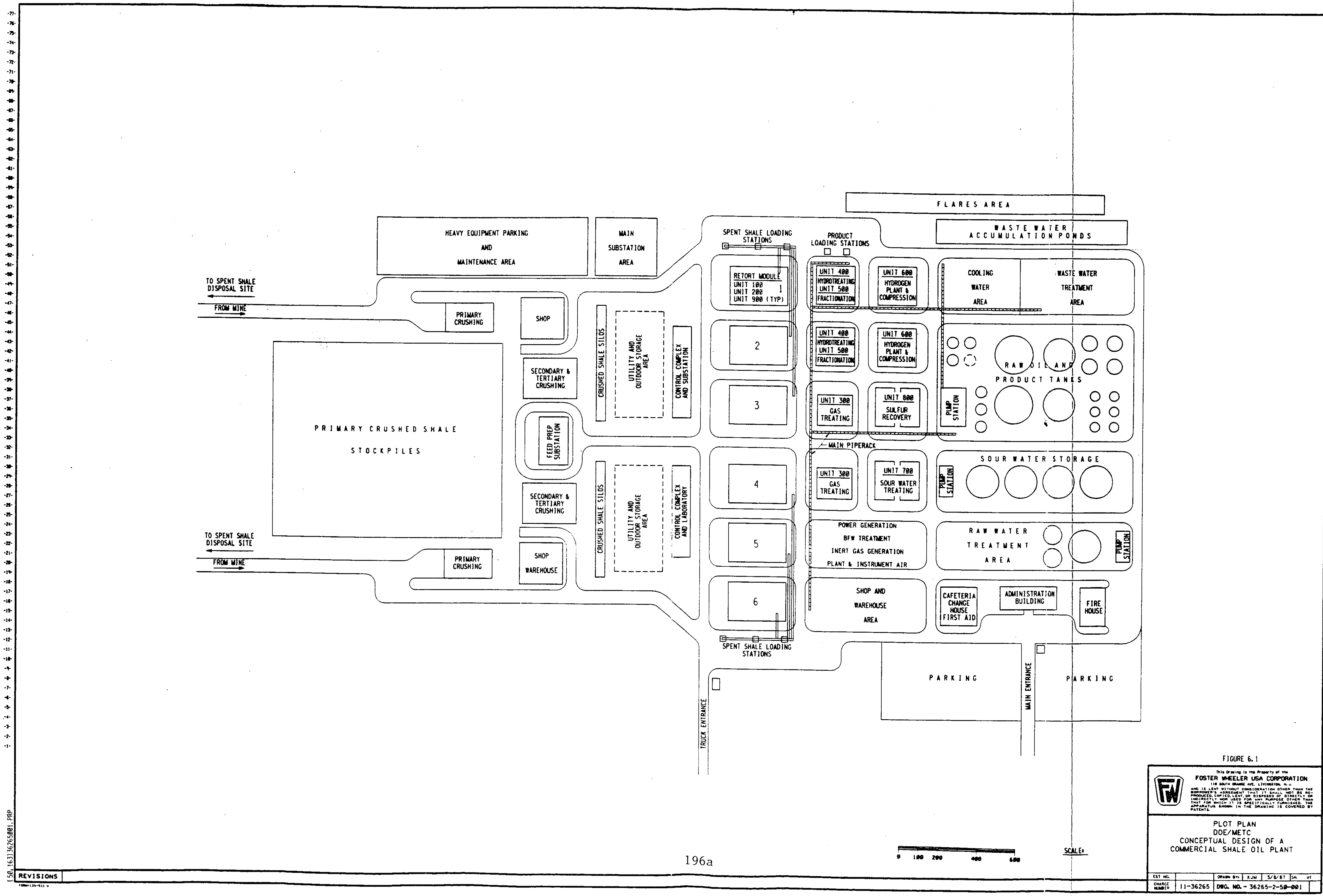
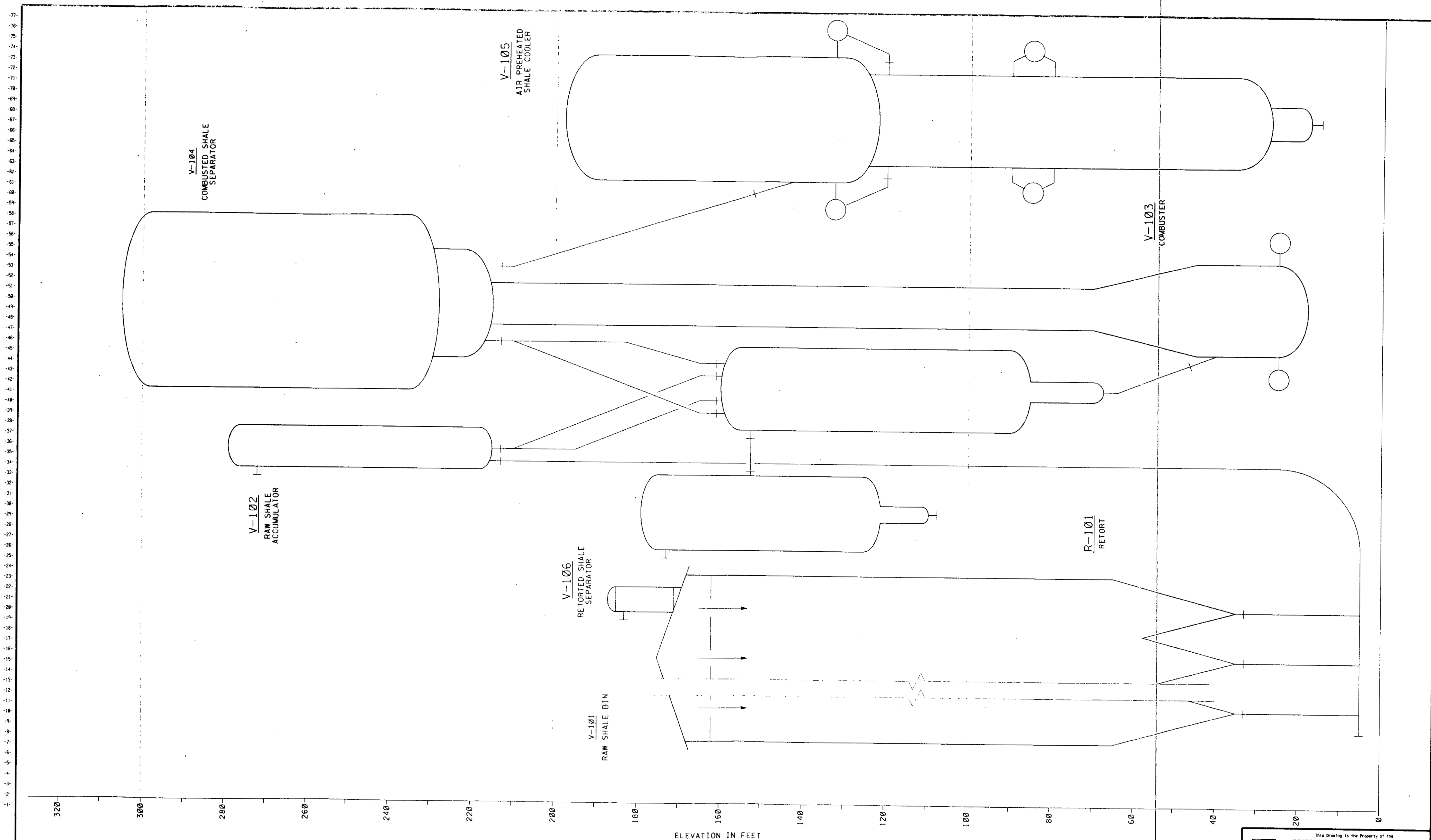

FLARES AREA
WASTE WATER ACCUMULATION PONDS
HEAVY EQUIPMENT PARKING AND MAINTENANCE AREA
MAIN SUBSTATION AREA
SPENT SHALE LOADING STATIONS
PRODUCT LOADING STATIONS
TO SPENT SHALE DISPOSAL SITE
FROM MINE
PRIMARY CRUSHING
SHOP
CRUSHED SHALE SILOS
UTILITY AND OUTDOOR STORAGE AREA
CONTROL COMPLEX AND SUBSTATION
RETORT MODULE
UNIT 100
UNIT 200
UNIT 900 (TYP)
1
UNIT 400 HYDROTREATING
UNIT 500 FRACTIONATION
UNIT 600 HYDROGEN PLANT & COMPRESSION
COOLING WATER AREA
WASTE WATER TREATMENT AREA
PRIMARY CRUSHED SHALE STOCKPILES
SECONDARY & TERTIARY CRUSHING
2
3
UNIT 300 GAS TREATING
UNIT 800 SULFUR RECOVERY
PUMP STATION
RAW OIL AND PRODUCT TANKS
FEED PREP SUBSTATION
MAIN PIPERACK
4
UNIT 700 SOUR WATER TREATING
SOUR WATER STORAGE
SECONDARY & TERTIARY CRUSHING
CONTROL COMPLEX AND LABORATORY
5
POWER GENERATION
BFW TREATMENT
INERT GAS GENERATION
PLANT & INSTRUMENT AIR
RAW WATER TREATMENT AREA
SHOP WAREHOUSE
6
SHOP AND WAREHOUSE AREA
CAFETERIA CHANGE HOUSE FIRST AID
ADMINISTRATION BUILDING
FIRE HOUSE
PARKING
MAIN ENTRANCE
PARKING
TRUCK ENTRANCE
SCALE:
0 100 200 400 600
FOSTER WHEELER USA CORPORATION
PLOT PLAN
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
11-36265
DWG. NO. - 36265-2-50-001
REVISIONS

FIGURE 6.1



SCALE : 1" = 10'-0"

FIGURE 6.2

VESSEL ELEVATION
DOE/METC
CONCEPTUAL DESIGN OF A
COMMERCIAL SHALE OIL PLANT
BASE CASE

UNIT 100 — RETORTING MODULE ELEVATION SKETCH

EST. NO.		DRAWN BY: KJM	5/13/87	SH.	OF
CHARGE NUMBER	11-36265	DWG. NO. - 36265-2-50-002			

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7.0 PLANT OPERATING REQUIREMENTS

The estimated normal operating requirements for the overall oil shale processing plant are summarized in the following sections.

7.1 Feed and Product Summary

The plant is designed to process oil shale feed into one primary product, syncrude oil, and reject the spent shale solids. Syncrude product oil is produced and stored as three fractions, naphtha, diesel oil, and heavy oil. These fractions may be shipped separately or blended and transported as a whole syncrude oil.

In addition to spent shale, the plant produces anhydrous liquid ammonia and molten elemental sulfur as by-products. Plant operations are supported by use of raw water, natural gas, and electric power available at the plant battery limits. All aqueous effluent streams generated in normal operations, are treated and used to moisturize the spent shale.

- Feed Summary

Oil Shale Feed @ 30 GPT, TPD (as received)	72,720
Natural Gas @ 911 BTU/SCF (LHV), MMSCFD	
Process	27.5
Fuel	16.2
Total	43.7
Raw Water, GPM	6,225

- Product Summary

Syncrude Oil, BPD	
Naphtha @ 58.8°API	6,158
Diesel Oil @ 36.9°API	8,207
Heavy Oil @ 32.4°API	40,195
Total @ 36.1°API	54,560
Anhydrous Ammonia, TPD	211.8
Elemental Sulfur, TPD	70.6
Moisturized Spent Shale, TPD	62,847

7.2 Overall Mass and Energy Balances

The overall plant mass and energy balances are shown on Tables 7.1 and 7.2. In developing these balances, the following assumptions and simplifications have been made.

- Fuel gas and combustion air for all process heaters in the plant were not considered in the mass balances, since they are not contributors of the process mass balance.

- Rain water collected on the plant paved areas, treated and used for spent shale moisturizing was not considered, in order to obtain a mass balance reflecting maximum raw water usage.

- Heat efficiency for gas fired heaters was assumed at 85% of the heat input.

- Energy balance is based on estimated higher heats of combustion at 77°F, ideal gas heat capacities, and heat capacity of shale as reported in the literature (13).

- Mineral carbonate CO_2 in raw shale was assigned a negative "heat of combustion" of 1400 Btu/lb of CO_2 evolved.

- Water of hydration in raw shale was assigned a negative "heat of combustion" of 1100 Btu/lb of water vaporized.

TABLE 7.1

Overall Plant Mass Balance

Unit	Description	Mass In Lbs/Hr	Mass Out Lbs/Hr
100	Natural Gas to Incinerator	34,800	-
	Air	3,431,249	-
	Flue Gas	-	3,809,203
500	Syncrude Product	-	671,066
600	Process Natural Gas to Reformer	50,870	-
	Vent Gas	-	1,242
	Flue Gas	-	115,184
700	Ammonia Product	-	17,648
800	Sulfur Product	-	5,882
	Vent Gas	-	7,744
900	Moisturized Spent Shale	-	5,237,250
	Vent Gas	-	25,542
	Dust Control Water (Unit 900 + 1100)	-	295,000
1000	Raw Shale Feed	6,120,000	-
	Dust Control Water	-	50,000
	Fines Loss	-	60,000
2000	Raw Water	3,112,500	-
2100	Deaerator Steam Loss	-	130,000
2200	Cooling Tower Evaporation	-	2,140,000
2500	Process Natural Gas - Inert Gas Generation	1,601	-
	Miscellaneous Loss	-	185,259
	Plant Total	12,841,020	12,841,020

TABLE 7.2

Overall Plant Energy Balance

Unit	Description	Heat In MM Btu/Hr	Heat Out MM Btu/Hr
100	Raw Shale	15,200.0	
	CO Incinerator Flue Gas		263.6
	H-101 Flue Gas		9.0
400	H-401 Flue Gas		10.0
500	Syncrude Product		12858.0
	H-501 Flue Gas		24.0
600	Natural Gas	1,161.3	
	Vent Gas		0.1
	Flue Gas		15.0
700	Ammonia Product		0.4
800	Sulfur Product		0.7
	Vent Gas		0.1
900	Spent Shale		156.2
	Vent Gas		4.8
2200	Cooling Towers Evaporated Water		2,354.0
2100	Steam		130.0
2700	Make-up Natural Gas	681.1	-
	Total Plant Air Cooling Loss		1045.0
	Total Plant Miscellaneous Losses		171.5
	Plant Total	17,042.4	17,042.4

7.3 Sulfur and Nitrogen Balances

The sulfur and nitrogen balances correspond to the total plant normal operating case. Sulfur and nitrogen enter the plant as components of the raw shale. During the retorting process, part of the sulfur is transformed into H_2S and part of the nitrogen in NH_3. During hydrotreating, most of the sulfur and nitrogen contained in the raw oil are transformed to H_2S and NH_3. In Unit 700, ammonia is separated, condensed and shipped out of the plant as liquid ammonia by-product. In Unit 800, H_2S is absorbed and oxidized to elemental sulfur which is shipped out of the plant as molten sulfur by-product.

- Sulfur Balance

Sulfur In	Lb/Hr
Raw Shale	10,216
Natural Gas	-
Total In	10,216
Sulfur Out	
Sulfur Product	5,882
Hydrotreated Syncrude	10
Flue Gas - CO inciner	420
Moisturized Shale	3,902
Flue Gas (Heater Stacks)	2
Total Out	10,216

- Nitrogen Balance*

Nitrogen In	Lb/Hr
Raw Shale	23,817
Combustion Air	-
Total In	23,817
Nitrogen Out	
Ammonia	14,533
Spent Shale	8,780
Hydrotreated Syncrude	328
CO Incinerator Stack	176
Total Out	23,817

*The nitrogen carried into the process by combustion air and inert gas purges were excluded from this balance.

7.4 Steam Balance

The steam required for normal plant operation is entirely generated in the process units via waste heat recovery. Table 7.3 summarizes the overall steam balance according to the individual plant sections. The distribution system and detailed steam and boiler feed water balance are given in Figure 5.3 in Section 5.2 of this report.

During normal operation, the excess steam generated in the processing units, about 1,190,000 lb/hr, is used to generate electric power in Unit 2100, Steam and Power Generation.

7.5 Plant Water Balance

In addition to raw water, supplied at the plant battery limits, water enters the plant circuit as moisture on the shale feed and that produced via chemical reactions such as retorting, oil hydrotreating, and fuel combustion. Water leaves the plant as moisturized spent shale, evaporation and drift loss from cooling towers, and stack flue gases. All aqueous blowdown and effluent streams are treated and re-used within the plant so that there are zero aqueous discharges from the plant.

The following summarizes the overall plant water balance, reflecting normal operating conditions. The net raw water requirement of 6,225 gpm represents the maximum expected consumption. In practice, this consumption can be reduced through utilization of collected rain water run-off from the plant areas. However, this is highly dependent on the plant location and season.

The following is the overall plant water balance reflecting normal operation conditions:

		GPM	
Unit	Description	Produced	Consumed
200	Raw Oil Recovery	365	
300	Gas Treating		67
400	Hydrotreating	496	423
900	Spent Shale Moisturizing		1560
2200	Cooling Water System		4280
2100	Steam Generation		440
1000	Feed Preparation		100
1100	Spent Shale Disposal		350
	Total	928	7153
	Total raw water requirements		6225 GPM

TABLE 7.3

Steam Consumption and Production

Plant Unit		Steam, 1000 lb/hr* HP	MP	LP	Exhaust
100	Retorting	(1007.5)		36.6	0.5
200	Raw Oil Recovery		(377.2)	(120.4)	
400	Raw Oil Hydrotreating	230.6	(247.0)		
500	Oil Fractionation		(19.2)	(31.6)	
600	Hydrogen Plant	(126.6)	(39.5)	16.5	
700	Sourwater Treat	210			92.1
800	Sulfur Recovery			8.0	
	Let Down Steam		184.2	(184.2)	
	Let Down Steam			92.6	(92.6)
2100	Power Generation	693.5	498.7	182.5	
	Total	0	0	0	0

*Parenthesis denotes production rather than consumption.

7.6 Plant Fuel Balance

The following are the production and consumption of fuel gas excluding the natural gas used for hydrogen production:

Unit		MMBTU/HR (LHV)
100	Retorting	1326.0
400	Hydrotreating	76.4
500	Fractionation	184.6
600	Hydrogen Plant	198.0
800	Sulfur Recovery	(1206.3)*
2500	Inert Gas System	32.7
2600	Flare System	2.2
	Natural Gas Import	(613.6)
	Total	0

*Represents retorting/hydrotreating fuel gas production.

The natural gas import represents the fuel system make-up only. The total natural gas import for the plant consists of:

Fuel make-up	16.17	MMSCFD
Hydrogen plant feed	27.54	MMSCFD
Total	43.71	MMSCFD

7.7 Electric Power Summary

Estimated electric power requirements for the total plant are summarized in Table 7.4. Electric power is generated in Unit 2100, Steam and Power Generation, at a normal rate of 80,215 KW. This satisfies over 80% of plant needs, so that the net purchased power requirement is only 18,465 KW.

TABLE 7.4

Plant Electric Power Summary

Unit	Normal* Consumption, KW
100 Retorting	2,800
200 Raw Oil Recovery	7,044
300 Gas Treating	16,994
400 Raw Oil Hydrotreating	3,418
500 Hydrotreated Oil Fractionation	782
600 Hydrogen Plant	10,938
700 Sour Water Treating	1,100
800 Sulfur Recovery	2,122
900 Spent Shale Moisturizing	2,490
1000 Feed Preparation	30,500**
1100 Spent Shale Disposal	400
2000 Raw Water Treatment	331
2100 Steam and Power Generation	1,497
2200 Cooling Water System	14,322
2300 Plant and Instrument Air	1,520
2400 Waste Water Treatment	184
2500 Inert Gas System	938
2600 Flare System	-
2700 Plant Fuel System	-
2800 Storage Facilities	600
2900 General Plant Facilities	700
Plant Total	98,680
2100 Power Generation	(80,215)
Net Requirement	18,465

* Parenthesis denotes production rather than consumption.
**Normal requirement for 5 day per week operation.

7.8 Catalyst and Chemicals Consumption

Operation of the plant processing units and support facilities requires a variety of catalysts and chemicals. Catalyst consumption occurs periodically when the useful life is exhausted and replacement of the catalyst charge is required. With some exceptions, such as intermittent chemical injection for operation of the boiler feed water and cooling water systems, the chemical usage represents a normal continuous operating requirement. However, for the purpose of estimating the annual cost for catalyst and chemicals consumption, the intermittent usage requirements are averaged over their life cycle and estimated as normal continuous consumption.

The estimated annual consumption and costs for catalysts and chemicals used in the processing units and plant support systems are summarized in Tables 7.5 and 7.6, respectively. These estimates are based on plant operation for 330 days per year and current 1987 prices. Furthermore, it is assumed that the costs also include transportation to the plant.

The estimated annual cost for catalyst and chemicals is $21.4 million:

	$ Million
Processing Units	7.6
Support Systems	13.8
	21.4

The major cost item, which represents 53% of the total, is the chemical additive for pour point adjustment of the product oil.

Table 7.5

Plant Catalyst and Chemicals Consumption

Processing Units

Basis: 330 Operating Days/Year

Unit	Item		Annual Consumption	Unit Cost	Annual Cost $1000
200	Corrosion Inhibitor		55 ST	1,000 $/ST	55
400	Guard Catalyst		6,800 CF	270 $/CF	1836
	Hydrotreating Catalyst		-	-	1047
600	Hydrogenation catalyst		313 CF	115 $/CF	36
	Sulfur Guard Catalyst		1,880 CF	130 $/CF	244
	Chloride Guard Catalyst		290 CF	110 $/CF	32
	Reforming Catalyst		510 CF	275 $/CF	140
	H.T. Shift Catalyst		520 CF	120 $/CF	62
	L.T. Shift Catalyst		1,095 CF	225 $/CF	246
	Molecular Sieves		16,330 CF	80 $/CF	1,306
700	Phosphoric Acid (75%)		715 ST	600 $/ST	429
	Caustic Soda (50% NaOH)		1,534 ST	200 $/ST	307
800	Locat Chemicals:	ARI-310	322 ST	1,000 $/ST	322
		ARI-310M	1,642 ST	600 $/ST	985
		KOH	1,035 ST	400 $/ST	414
		Other	8 ST	6,000 $/ST	48
1100	Miscellaneous Consumables		-	-	132
	Total Processing Usage				7,641

Table 7.6

Plant Catalyst and Chemicals Consumption

Plant Support Systems

Basis: 330 Operating Days/Year

Unit	Item	Annual Consumption	Unit Cost	Annual Cost $1000
2000	Activated Carbon	290 CF	30 $/CF	9
	Ion Exchange Resin	1,410 CF	40 $/CF	56
	Anthracite	1,000 CF	20 $/CF	20
	Sand & Gravel	1,000 CF	20 $/CF	20
	Sulfuric Acid (66°Be)	731 ST	80 $/ST	59
	Caustic Soda (50% NaOH)	1,180 ST	200 $/ST	236
	Lime	2,495 ST	50 $/ST	125
	Alum	238 ST	700 $/ST	167
2100	BFW Additives	9 ST	1,000 $/ST	9
2200	Corrosion Inhibitor	349 ST	1,500 $/ST	524
	Dispersant	139 ST	2,000 $/ST	278
	Chlorine	40 ST	200 $/ST	8
	Biocide	107 ST	1,200 $/ST	128
	Sulfuric Acid (66°Be)	527 ST	80 $/ST	42
2300	Silica Gel	1 ST	1,000 $/ST	1
2400	Phosphoric Acid (75%)	594 ST	600 $/ST	356
	Caustic Soda (50% NaOH)	594 ST	200 $/ST	119
	Sulfuric Acid (66°Be)	594 ST	80 $/ST	48
	Alum	317 ST	700 $/ST	222
2800	Pour Point Additive	1,134,300 Gal.	10 $/gal.	11,343
	Total Support Systems Usage			13,770

7.9 Plant Staffing Requirements

The estimated plant staffing requirments, as detailed in Tables 7.7 and 7.8, totals to about 600 full time employees. The overall breakdown according to general categories is as follows:

Plant Management	6
Technical Staff	27
Administrative Staff	42
Shift Supervisors	40
Shift Operators	475
	590

This estimate excludes the plant maintenance labor. In developing the plant operating costs, the annual maintenance costs, including materials and labor, are estimated as a percentage of the installed plant cost.

Table 7.7

Plant Operating Staff

Plant Unit	Number Per Shift: Operators	Number Per Shift: Supervisors
100 - Retorting	12	1
200 - Raw Oil Recovery	3	1
300 - Gas Treating	2	
400 - Oil Hydrotreating	2	1
500 - Oil Fractionation	1	
600 - Hydrogen Plant	3	1
700 - Sour Water Treating	2	1
800 - Sulfur Recovery	2	
900 - Spent Shale Moisturizing	12	1
1000 - Feed Preparation	18	1
1100 - Spent Shale Disposal	45	1
2000 - Raw Water Treatment	2	
2100 - Steam & Power Generation	1	1
2200 To 2900 - Other Support Systems	3	
Total Per Shift	108	9
Plant Total	475	40

Table 7.8

Plant Administrative and Technical Staff

Position	Number	Position	Number
Plant Manager	1	Receptionist	1
Operations Manager	1	Secretaries	6
Business Manager	1	Clerk/Typist	6
Purchasing Controller	1	Accountant	2
Medical Advisor	1	Computer Operator	1
Human Resources Manager	1	Labor Relations	2
Total Management Staff	6	Paymaster	1
		Warehouse Supt.	1
		Purchasing Agent	1
Chief Plant Engineer	1	Records Clerk	1
Chief Field Engineer	1	Parts Foreman	4
Staff Engineers	7	Receiving Agent	1
Draftsmen	2	Warehouse-men	4
Chief Chemist	1	Nurse/First Aid	4
Chemists	2	Security Chief	1
Laboratory Technicians	9	Security Guards	4
Utility Men	4	Custodians	2
Total Technical Staff	27	Total Administrative Staff	42

8.0 ENVIRONMENTAL EMISSIONS

The present conceptual design is for a 50,000 BPD shale oil plant assumed to be located in western Colorado. The plant is designed to comply with all State of Colorado and Federal regulations on pollution control. Environmental aspects of the plant are presented in this section. For an actual commercial plant, a detailed environmental assessment report must be prepared prior to construction, once a specific site has been selected.

The overall concept for the plant design is based on gaseous emissions meeting pollution control regulations and all waste liquids and solids contained within the plant boundary limits, except for spent shale disposal.

Air Pollution Regulations

The Clean Air Act is designed to achieve and maintain air quality to protect public health and welfare. The Act directs the Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS), "primary" standards to protect public health, and "secondary" standards to protect public welfare.

Under the Act, each state is required to develop a State Implementation Plan, outlining the state's strategy for attaining and maintaining the national ambient standards. Primary responsibility for implementing the Act lies with the state, however, EPA has a major influence on the State Implementation Plan. The pollutants regulated under the plan, known as criteria pollutants, are SO_2, NO_x, CO, hydrocarbons, ozone, lead, and particulates. State air pollution control regulations cannot be less stringent than the Federal regulations. This conceptual plant design complies with the State of Colorado regulations.

This design study was conducted on the basis that the plant is located in an attainment area for all criteria pollutants. An area is designated as attainment if the NAAQS standard for that pollutant is met, and non-attainment if the NAAQS is not met.

Pollution in attainment areas is regulated by Prevention of Significant Deterioration (PSD) regulations. Pollution in non-attainment areas is regulated by non-attainment regulations, which require achievement of Lowest Achievable Emission Rate Control technology. An offset of that pollutant emission must also be obtained in a non-attainment area.

8.0 ENVIRONMENTAL EMISSIONS (Cont'd)

PSD regulations are followed for air pollution control in this plant design. PSD regulations require use of Best Available Control Technology (BACT) for the control of air pollutants. BACT is the most economical, energy efficient and environmentally sound means of control as defined by the Clean Air Act.

In addition, the plant design meets all the Federal New Source Performance Standards (NSPS) for SO_2, NO_x, and particulates. NSPS limit the emission of SO_2, NO_x, and particulates. These standards apply to new plants and are specific to the type of plant regulated.

Plant Air Emissions

The greatest uncertainty with regard to the magnitude of emissions is the fugitive particulate emissions generated by shale handling in Feed Preparation, Unit 1000. The shale loading/unloading, conveying, and crushing operations are all potential sources of fugitive dust. However, systems are provided to minimize dust emissions and satisfy PSD requirements. A wet suppression system for dust control is provided in the primary crushed storage area. All raised and ground level conveyors are covered, and all transfer points and unloading points are equipped with dust suppression systems. Baghouse dust filters are installed on all atmospheric vents. The emissions from these filters are shown on Table 8.4.

A similar uncertainty exists relative to handling and disposing of the spent shale in Unit 1100. Provisions are included in the current design to control fugitive dust emissions from this area via wet dust suppression techniques.

Sulfur dioxide emissions are primarily controlled by removing sulfur compounds, mainly H_2S, from the process gas streams prior to venting or combustion as fuel gas. All sulfur containing gases are processed through the Lo-Cat$^{(R)}$ system in Unit 800 to recover elemental sulfur. Key assumptions in the current design, relative to sulfur dioxide emissions, were that:

- Raw gas generated in retorting contained no significant quantities of sulfur compounds other than H_2S.

- During combustion of the retorted shale, 90% of the potential SO_2 was adsorbed in the mineral CaO in the shale and removed as $CaSO_4$.

In addition, SO_2 emissions were minimized by using low sulfur natural gas as supplemental plant fuel.

8.0 ENVIRONMENTAL EMISSIONS (Cont'd)

Control of NO_x emissions centered on removing nitrogen compounds, particularly ammonia, from the process gas stream prior to venting or combustion. This was accomplished via water scrubbing of the gases followed by recovery of ammonia in Sour Water Treating, Unit 700. Where appropriate, such as for the CO incinerator in the retorting unit, NO_x formation was minimized by employing staged combustion. Residual hydrocarbons and carbon monoxide emissions were minimized by excess air combustion in the process fired heaters and, in the case of the shale lift pipe combustor, by subsequent incineration of the off-gas.

Table 8.1 shows the federal new source performance standards for power for steam generation, together with the State of Colorado regulations for shale oil processing plants.

A summary of the combustion sources in the conceptual plant design is given in Table 8.2. This table reflects normal operation and does not include intermittent sources which exist during startup, shutdown, or operating upsets. The normal emissions of SO_2, NO_x, and particulates are within the Federal standards.

Fugitive vapor emissions from storage tanks are summarized in Table 8.3. Facilities are provided to minimize fugitive emissions from plant tankage; naphtha is stored in a floating roof tank to minimize hydrocarbon losses and by-product ammonia is stored in a pressurized sphere with a relief valve venting to the CO incinerator.

Fugitive emissions of hydrocarbons heavier than methane from relief valves are minimized by venting all relief systems to the flare. All vents from lines containing hydrocarbons, sulfur compounds, or particulates are vented to the flare.

Water and Solid Effluents

No aqueous waste streams are discharged from the plant. Water is reused to the maximum extent possible to reduce raw water makeup, which is desirable in the water scarce area of western Colorado.

Water makeup to the plant is necessitated due to water being consumed in reactions, lost by evaporation or disposed of with spent shale. The overall plant water balance is discussed in Section 7.5 and the details of waste water treatment systems are covered in Section 5.5.

All aqueous effluent streams are treated internally in Sour Water Treating, Section 700, or Waste Water Treatment, Section 2400, and then either recycled to process or utilized to moisturize the shale.

The primary solid discharge from the plant is moisturized spent shale. Periodically, catalysts and ion exchange resins must be replaced and the spent material is disposed of along with the spent shale. Provisions are included to control and collect water run-off from the spent shale pile.

TABLE 8.1

NEW SOURCE PERFORMANCE STANDARDS

	Federal Power Generation 40 CFR 60.42a		Federal Steam Generation 40 CFR 60.42	Colorado Air Quality Title 25
Pollutant	LB/MMBTU*	% Reduction	LB/MMBTU*	LB/MMBTU*
SO_2				
Solid Fuel	1.2	90	1.2	
Solid Fuel	0.6	70		
Liquid & Gaseous Fuel	0.8	90	0.8	0.2***
Liquid Fuel & Gas Fuel	0.2	0		
NO_x				
Subbituminous Coal	0.5	60	0.7	
Other Solids and Fuel	0.6	60	0.7	
Liq & Fuel	0.3	30	0.3	
Gaseous Fuel	0.2	25	0.2	
Particulates				
Solid Fuel	0.03	99	0.1	**
Other Fuels	0.03	-	-	-
Flue Gas Opacity	20%	-	20%	20%

* Million BTU (HHV) of fuel fired
** LB/MMBTU = 0.5 (MMBTU/HR Fired Duty)$^{0.26}$
*** Assumed equal to federal standard.

TABLE 8.2

ESTIMATED STACK EMISSION DATA

Stack Description	Unit 100 Retorting		Unit 400 Hydro-treater	Unit 500 Fraction-ation	Unit 600 Hydrogen Plant
Equipment Item	PK-101	H-101	H-401	H-501	H-601
No. of Stacks	6	6	2	2	2
Fuel Type *	PG	NG	NG	NG	NG
Total Fired Duty MMBTU/Hr (HHV)	1353	120	76.5	186.5	343.5
Stack Emission					
SO_2, lb/hr	839	7	4	11	20
lb/MMBTU	0.62	0.06	0.058	0.058	0.058
NO_x, lb/hr	580	24	15	37	68
lb/MMBTU	0.43	0.2	0.2	0.2	0.2
Hydrocarbon, lb/hr	28	3.4	2	5	10
lb/MMBTU	0.02	0.03	0.03	0.03	0.03
Particulates, lb/hr	434	2.6	1.5	3.8	6.8
lb/MMBTU	0.32	0.02	0.02	0.02	0.02
Carbon Monoxide, lb/Hr	265	-	-	-	-
lb/MMBTU	0.20	-	-	-	-

*PG = High BTU Process Gas
NG = Natural Gas

TABLE 8.3

ESTIMATED TANK VAPOR LOSSES

Tank Description	Raw Shale Oil Storage	Product Naphtha Storage	Product Diesel Storage	Bottoms Product Storage	Gasoline Storage	S[illegible] Oil Storage	Slop Oil Tank
Tank Service	Raw Shale Oil	Naphtha	Diesel Oil	Gas Oil	Gasoline	Lean Sponge Oil	Slop Oil
Tank Data							
Number	2	2	2	2	1	1	1
Dimensions, Ft	2000 x 48	700 x 45	780 x 48	1800 x 45	200 x 18	350 x 30	042.5 x 40
Capacity, BBL	260,000	30,000	40,000	200,000	1,000	5,000	10,000
*Type	FR	FR	FR	CR	UG	FR	CR
Storage Temp°F	100	100	100	100	55	100	100
Avg. Outage, %	50	50	50	50	50	50	50
Annual Turnovers	33	33	34	33	12	12	40
Vapor Pressure of Contents, PSI	0.01	2.2	0.02	0.01	2.5	0.02	0.01
Tank Vapor Losses, BBL/Yr							
Each	4.6	48.0	2	4	8	4.6	0.2
Total	9.2	96.0	4	8	8	4.6	0.2
Storage Capacity, Days	10	10	10	10	30	30	-

* FR = Floating Roof
CR = Cone Roof
UG = Underground

TABLE 8.4

ESTIMATED BAGHOUSE EMISSIONS

	Primary Crushing Baghouse	Secondary Crushing Baghouse	Tertiery Crushing Baghouse	Stacking Boom Baghouse	Silos Baghouse
Equipment Item	F-1001	F-1002	F-1003	F-1004	F-1005
Air Flow, ACFM	121,000	680,000	766,000	25,000	130,000
Particulate Emissions, lb/hr	15.5	87.5	98.5	0.1	16.7

9.0 ASSESSMENT OF THE CONCEPTUAL PLANT DESIGN

9.1 Process Design Assumptions and Uncertainties

This design assessment considers overall and specific aspects of the conceptual plant design, with emphasis on the process design assumptions and areas of risk or uncertainties reflected by this design. The main part of this assessment refers to the retorting unit, which is a new scale-up design rather than on the upgrading units which represent adaptations of commercially proven technology.

- Retorting - Unit 100

The retorting design developed in this study is based on yields and oil shale composition provided by DOE, and design parameters of retorting and combustion reported in the technical literature for this type of retorting process. Since the available published information usually involved ranges of values and was not specific to any particular oil shale deposit, the design developed therefrom is very conceptual. The parameter values used, however, are generally near the center of the reported ranges and are considered practical.

The design includes all of the major functions of fluidized bed retorting as well as incineration of combustor flue gas. In the absence of specific experimental data to the contrary, incineration is considered necessary as a means of achieving emission regulations which might be applicable at a commercial plant site. The design would be conservative if a CO content of less than about 100 ppmv could be achieved directly in the combustor flue gas without any major adverse change in other operating parameters.

The selection of a retorting module size of 12,000 tons per operating day (TPOD) of oil shale is considered a "middle of the road" tradeoff between the number of modules required for a 50,000 barrels per day (BPOD) shale facility and the size of major process vessels. Six modules are required for the commercial plant of 50,000 BPOD production. The retort vessel diameter of 19 feet is considered moderately large for fluidized bed operation, but within the size range of commercial experience. The diameter of the riser section of the combustor, about 9 feet, is considered large for a dilute phase riser and is probably about the largest that would be attempted in an actual commercial design within the present state-of-the-art. As a result, although a retorting module with a capacity larger than 12,000 TPOD might employ a single retort, multiple riser combustors would be required, involving complications in piping and control. The remaining process vessels, having diameters ranging from 10 to 42 feet, are primarily separators and are not of particular technical concern.

9.1 Process Design Assumptions and Uncertainties (Cont'd)

A module size appreciably smaller than 12,000 TPOD capacity, 3,000 to 6,000 TPOD for example, would require smaller diameter process vessels but would involve two to four times as many modules in the commercial plant with adverse impact on capital and operating costs.

The generally accepted standard for oil yield from western Colorado oil shale is 100% of Fisher Assay, although specific retorting processes and operating conditions provide yields of about 105 percent down to about 75 percent. Numerous studies of oil shale technology have shown that the yield of oil, adjusted for any fuel consumed in the plant beyond the gas produced in retorting and upgrading, is the single most important factor affecting the cost of oil produced from shale. Consequently, the following areas of risk in the conceptual retorting design are considered mainly from the aspect of potential impact on oil yield and energy usage.

Solids Mixing - Achievement of high oil yields in the retort vessel requires rapid and uniform mixing of raw shale with combusted shale. Since radial mixing of solids is poor in fluidized beds, particularly those using large particle size solids, compared to axial mixing, the retort vessel in this design was provided with four feed pipes for raw shale and four pipes for combusted shale, all entering through the top head of the vessel. In addition, a solids mixing zone of one minute nominal solids residence time was included. Non-uniform mixing of raw shale and combusted solids will cause overheating of part of the raw shale and underheating of the remainder, both of which adversely affect oil yield. If the four feed pipe system does not provide solids mixing adequate for high oil yield, additional feeder pipes and larger mixing zone could be added. Beyond some additional piping and control costs, this change is not considered major.

Particle Residence Time - Achievement of high oil yields in the retort vessel also requires counter current plug flow of both the solids mixture and the produced vapors. Plug flow maximizes conversion of solids and minimizes cracking and coking of oil vapors. Single stage fluidized beds are characteristically backmixed to a high degree in the axial direction in both the solids and gas phases, in the absence of any installed internals. This situation is favorable for maintaining isothermal conditions in the retorting zone, but is unfavorable with regard to oil yield because of the wide variation in particle residence time. In a completely backmixed single stage fluidized bed with an average particle residence time of four minutes as in the present design, about 22 percent of the particles would have a residence time of one minute or less and about 40 percent of the particles would have a residence time of two minutes or less. Data published by Chevron (4,5)

9.1 Process Design Assumptions and Uncertainties (Cont'd)

indicates that an oil yield loss of about 20 percent would be expected at one minute residence time and an oil yield loss about 5 percent would be expected at two minutes residence time.

The particle residence time distribution can be narrowed significantly by the use of multiple stages, as indicated by the following calculated values for a total residence time of four minutes:

No. of Theoretical Stages	Residence Time Per Stage Min.	% of Particles With Residence Time 1 Min. or Less	2 Min. or Less
1	4	24	43
2	2	12	32
4	1	5	19
8	0.5	1	10

On this basis, at least eight theoretical stages are required to restrict the proportion of shale particles having insufficient residence time to a reasonably low value. An alternate approach would be to use a longer residence time, eight minutes for example, and a lesser number of stages. This situation is illustrated by the following table:

No. of Theoretical Stages	Residence Time Per Stage Min.	% of Particles With Residence Time 1 Min. or Less	2 Min. or Less
1	8	12	25
2	4	5	20

The alternate approach reduces the number of stages required for a comparable reduction in the proportion of low residence time particles at the expense of additional total residence time.

The design developed in this study assumes that staging devices are installed in the fluidized-bed retort to provide sufficient number of stages to achieve the yields used in the process design basis for retorting. Staging devices are not detailed, however, since these were not described in the literature. An allowance was included in the cost of the retort vessel for the cost of staging. This allowance is equivalent to 8% of the vessel total cost.

9.1 Process Design Assumptions and Uncertainties (Cont'd)

Solids Attrition - Attrition of oil shale particles can occur in a fluidized bed retorting process as a result of the chemical processes of retorting and combustion as well as the physical processes of impact and abrasion of particles on other particles and on vessel walls. During retorting, an oil shale particle loses 15 to 30 percent of its weight due to kerogen, mineral hydrate, and mineral carbonate decompositions. Further weight loss occurs in the combustor due to combustion of char and additional carbonate decomposition. Since these components are distributed throughout the shale particle and removed as vapors, particles can be broken by rapid heating and vapor generation. The weight loss also renders the particles more susceptible to breakage by impact and abrasion.

Circulation of solids through the retort and combustor vessels, as well as through cyclones in the retort and solids separation vessels, results in attrition of particles. This is particularly the case in high velocity regions such as cyclones and lift pipes. The combination of all these factors produces a significant reduction in the size of particles in the retort process system. This affects both the yield of oil from retorting and the recovery of raw oil. Oil yield is adversely affected if significant attrition of raw shale occurs in the mixing zone located at the top of the fluid bed in the retort and the fines produced escape from the top of the retort vessel into the retorted shale collector before being fully retorted. In this circumstance, oil potentially available from the partially retorted shale is degraded to waste heat since solids collected in the retorted shale collector are incinerated. The present design is based on the assumption that the solids lost from the top of the retort are a mixture of combusted and fully retorted shale.

Solids attrition affects oil recovery in that any fines produced having diameters less than about 30 microns are not collected by the two stages of conventional cyclones used in the present design and are carried over to the Raw Oil Recovery Tower. The present design is based on a net solids flow from the top of the retort equivalent to about 10 percent of the retorted shale made and a solids flow to the Raw Oil Recovery of about 2.5 percent of the retorted shale produced. These latter solids are trapped in the condensed oil in the bottom of the tower and are removed from the oil with continuous flow centrifuges. If solids are carried over to the tower at an appreciably higher rate, higher than anticipated, additional centrifuges would be required. Since the centrifuged solids are recycled to the retort as a slurry in heavy oil, increased solids carryover to the tower could decrease oil yield through cracking or coking of the recycled oil. In an extreme case of high solids carryover from the retort, a different type of dry solids collection system with higher efficiency than conventional cyclones would be required.

9.1 Process Design Assumptions and Uncertainties (Cont'd)

Solids Flow - Operation of the fluid bed retorting process depends to a large extent upon the flow of solids in both the retorting combustion and collection vessels as well as in the standpipes between vessels. In the present design, superficial velocities in the vessels are at least 15 percent above the calculated minimum fluidization velocity of about 3 feet per second for the size range of particles considered. Reasonably good fluidization is expected under these conditions. The critical areas with respect to fluidization are the standpipes where defluidization might occur even though aeration taps are be provided. For this reason, the angle from the horizontal for all standpipes was maintained at 70 degrees as a minimum.

A second area of concern with regard to solids flow is that of solids flow control valves. Although design of control systems was outside the scope of the present design effort, it was assumed that slide valves or L-valves with seal pots would be used to control flow of raw, retorted, and combusted shale. Slide valves have a long history of use in commercial scale fluidized bed plants but require solids in the fluidized state for proper operation. L-valves do not require fluidized solids for operation, but do require that the solids flow readily in the settled condition. L-valves have been used on several fluidized bed pilot plants, but have never been applied in large scale commercial operations.

Combustion of Char - One of the key process design parameters of the combustion section of the fluidized bed retorting process is the extent of combustion of char contained in the retorted shale. This affects the recovery of heat energy from the retorted shale and the overall thermal efficiency of the process. In the present design, it was assumed that 95 percent combustion of char could be achieved with 5 percent excess air and about 5 seconds solids residence time in the riser section of the combustor at a temperature of about 1240 degrees Fahrenheit. Chevron (4,5) reported a value of 90 percent char combustion with the expectation that higher values could be achieved. Failure to achieve these levels would result in an increase in the amount of supplemental fuel required to maintain the overall heat balance of the retort-combustor system.

Carbonate Decomposition - The extent of mineral carbonate decomposition occurring in the combustor also affects process thermal efficiency because of the high endothermic heat of this reaction. It was assumed in the present design that 25 percent of the carbonate in the retorted shale was decomposed in the combustor. This value that is about 60 percent of that reported by Exxon (3) for dense phase fluidized bed combustion of retorted shale. The lower value was considered appropriate for the riser type combustion system. Calculation of the extent of decomposition, using kinetics measured in non-reacting laboratory systems, indicates that a temperature of about 1500°F would be required to achieve 25 percent decomposition. It is conceivable that localized temperatures in shale particles could reach this level during the char combustion process.

9.1 Process Design Assumptions and Uncertainties (Cont'd)

Carbon Monoxide Formation - Formation of carbon monoxide in the combustor adversely affects the retorting process thermal efficiency because of the lower heat generated by combustion of fuel to carbon monoxide as compared to combustion to carbon dioxide. A more significant impact of this situation, however, is that incineration of the flue gas from the combustor may be required to minimize atmospheric emissions. For the present design, a CO_2 to CO mole ratio of 12.3 in the combustor flue gas was assumed, based on test data published by Lawrence Livermore Laboratories (8). Use of this ratio resulted in a flue gas from the combustor containing about one mole percent carbon monoxide. Although atmospheric emissions modeling was beyond the scope of this study, it was assumed that, for a commercial oil shale plant, the carbon monoxide concentration should be limited to about 100 ppmv. On this basis, an incinerator was included in the design to heat the combustor flue gas to a temperature of 1700°F, a temperature considered necessary to reduce carbon monoxide concentration to this level.

Incineration of flue gas adds significant capital and fuel cost to the retorting unit, although energy in the form of high pressure steam is recovered from the hot incinerator gas. If low carbon monoxide concentration could be obtained directly from the combustor, these costs could be avoided.

Nitrogen Oxides Formation - A related environmental concern in the combustor design is that of NO_x formation. Char contained in retorted shale has a nitrogen content of 4.5 percent so that a high NO_x concentration in the combustor flue gas would be expected. However Lawrence Livermore Laboratories reported that only 3 percent or less of the nitrogen in raw shale was emitted as NO_x in tests on a cascading bed combustor. On this basis, it was assumed that 10 percent of the nitrogen in the retorted shale was converted to NO_x in the riser type combustor as used in the present design. Staged combustion, applied to fluidized-beds, has been found to reduce the NO_x emission. The possible reaction which suppresses the emission of NO_x is considered to be the reduction of NO_x by carbonaceous materials.(5) In the case of the present CO incinerator, most of the NO_x enters with the hot spent shale combustor gases. By staging the air supply to the incinerator, it is expected that the required NO_x reduction can be accomplished due to the carbonaceous materials brought in by the oil shale fines. Ammonia injection into the flue gas passages of the incinerator waste heat boiler was provided as an alternate method to reduce NO_x emissions.

9.1 Process Design Assumptions and Uncertainties (Cont'd)

Scale of Operation - Fluidized bed retorting processes have been tested intermittently during the past forty years, by Exxon in the 1950's, by Tosco in the 1970's, and mostly recently by Chevron and Lawrence Livermore Laboratories in the 1980's. Most of the experience is limited, however, to short periods of operation in relatively small scale equipment such as laboratory units or pilot plants having capacities up to about one ton of raw shale per day. The largest operation has been that carried out by Chevron in a 350 ton per day semi-works plant during 1984. The commercial scale plant design in the present study, having retorting modules of 12000 TPOD capacity, represents a scale-up of about 35 over Chevron's semi works scale. This extent of scale-up represents a significant area of risk for fluidized bed systems where performance is usually strongly dependent on vessel diameter.

Experience with related fluidized bed systems which have been demonstrated on a large scale indicates, however, that fluidized bed oil shale retorting processes should, in principle, be operable on a large scale. Fluidized bed catalytic cracking and fluidized bed coking processes represent relevant experience in that both chemical conversion and combustion are carried out in vessels having diameters up to about 50 feet and dilute phase risers having diameters up to about 7 feet. These processes, however, use relatively small diameter solids, about 100 microns in the case of catalytic cracking and about 1000 microns in the case of fluid coking. In contrast, the shale oil retorting design uses solids having diameters up to about 6000 microns. Particle diameter affects several aspects of fluidized bed performance such as gas and solids contacting and mixing and quality of fluidization. Fluidized bed boilers utilize large diameter solids but experience with circulating fluidized bed boilers on a large scale is only beginning to develop at the present time.

In light of the above discussion of specific areas of risk, the retorting plant design, developed for this study, is considered technically feasible and within the present state-of-the-art of design of fluidized bed systems. This conclusion must necessarily be qualified by the circumstance that the process design parameters used were based upon information published in the technical literature rather than upon specific experimental data. Several areas are evident where further research and development is needed, such as solids mixing and flow, solids attrition, staging in fluidized beds, and combustion of retorted shale, particularly with respect to CO, NO_x, and other emissions of environmental concern.

9.1 Process Design Assumptions and Uncertainties (Cont'd)

- Raw Oil Recovery - Unit 200

  In the design of this unit the following assumption have been made:

  - Retorting gas pressure is sufficient to assure a positive pressure in the tower overhead.
  - All solids entrained by the retort product stream will stay in the bottom section of the tower and end-up in the heavy oil fraction.
  - No water will condense in the upper section of the tower to avoid any framing problems. Should this occur an antifoaming agent can be injected along with the corrosion inhibitor.
  - Centrifugation of the quench tower bottoms oil will provide a centrate oil containing 0.5 wt. % of solids as a maximum.
  - The oily solids residue from centrifugation can be recycled to the retort for ultimate disposal.

  The first three assumptions are quite realistic and present little risk in this design. Hot centrifugation for solids removal has not been demonstrated. If this concept proves inoperable or results in inadequate solids removal, alternative methods such as solvent extractions, electrostatic precipitation, or coking need to be investigated. Although not demonstrated, recycle of the oily sludge to the retort is considered practical as the preferred route for disposing of this stream without penalty. The most likely alternative is to burn the sludge to recover its energy value for steam generation.

- Gas Treating Plant - Unit 300

  This design incorporates conventional compression and absorption which involves no special assumptions and minimal design risk.

- Raw Oil Hydrotreating - Unit 400

  The hydrotreater design reflects conventional refinery technology for hydroprocessing of heavy oils. Yields and operating conditions were projected by Unocal, based on their general experience with oils derived from Colorado shale. Differences in raw shale oil inspections and lack of direct hydrotreating data for the oil derived from fluid bed retorting, represent some risk which may require a modification in the design operating conditions, e.g. temperature, pressure, and hydrogen usage. As a conservative approach, the present design uses an operating pressure somewhat higher than the values reported in the open literature.

9.1 Process Design Assumptions and Uncertainties (Cont'd)

A more significant uncertainty relates to the solids and heavy metals content in the raw shale oil. While a catalyst guard bed is included in this design, there is no assurance that this will be adequate to protect the main hydrotreating catalyst against fouling and poisoning. This design assumes that the solids will be always suspended in oil, will not deposit on, poison or plug the catalyst or the process lines, and will end up in the heavy oil at the bottom of the fractionator.

- Hydrotreated Oil Fractionation - Unit 500

  This design represents a conventional fractionation unit with minimal risk or uncertainty.

- Hydrogen Plant - Unit 600

  Hydrogen production via steam reforming of natural gas, using molecular sieves for hydrogen purification, is a commercially proven process, having essentially no design risk or uncertainty.

- Sour Water Treating - Unit 700

  The design for sour water treating combines conventional steam stripping with the USS Phosam-W Process for ammonia recovery, both of which are commercially demonstrated technologies. The major uncertainty lies with other unidentified components which may be present in sour water streams derived from oil shale processing. The effects of such contaminants on operability, stripping efficiency, and stripped water quality can only be determined experimentally.

- Sulfur Recovery - Unit 800

  The Lo-Cat(R) process used in this design is commercially employed for sulfur recovery from gas streams containing H_2S. Of primary concern, is the likely presence of other sulfur compounds, such as COS, CS_2, and mercaptans, which are not accounted for in the present design. These could result in higher than expected sulfur emissions from the plant unless the raw gas is first hydrotreated to correct all sulfur compounds to H_2S.

- Spent Shale Moisturizing - Unit 900

  The design of this unit assumes that the spent shale subject to moisturizing, is either combusted retorted shale or raw shale fines.

9.1 Process Design Assumptions and Uncertainties (Cont'd)

Both these materials are expected to be easily moisturized with water sprays in a pugg mill. Uncombusted retorted shale, however, has characteristics similar to an oily powder with the tendency to float on water and therefore difficult to moisturize. For this situation, the risk is that the pugg mill discharge can be a mixture of overly wet shale and unmoisturized dry powder difficult to handle. The only way to avoid such a situation is to make provision to recycle uncombusted shale into the combustor or store it in a separate bin for gradual blending with the combusted shale. The present design assumes that all shale is suitable for moisturizing.

Pugg mills are reliable pieces of equipment, proven commercially, and do not present any risk. Venturi scrubbers have no moving parts and are widely used for dust collection.

- Feed Preparation - Unit 1000

This unit is a conventional design using rotary impact crushers and screens. The main assumption on this unit design is that the crushed shale particle size distribution will meet the retort feed specification. For the commercial plant design, field tests are required to determine the optimum equipment and operating parameters to minimize the fines formation and power consumption.

The present design assumes the primary crushing and primary crushed shale storage are on the plant site. An alternate design approach having the primary crushing and storage at the mine, is preferable since it minimizes material handling and makes better use of the hauling trucks.

- Spent Shale Disposal - Unit 1100

Spent shale disposal, on the large scale required for commercial plant operation, has not been demonstrated. The conceptual design is based on a proposed approach for commercial development on a Colorado tract. Obviously, spent shale disposal is a major environmental issue and is inherently tied to the plant site specifics. Containment of the spent shale pile, leachability, control of pipe run-off, and long term impact on ground water contamination are uncertainties which must eventually be addressed in the field.

9.2 Retorting Plant Process Design Alternatives

The following areas represent process design alternatives for the fluidized-bed retorting design which could potentially:

- Improve the yield and/or quality of shale oil.
- Improve plant operability and/or reliability.
- Reduce cost of shale oil product.
- Reduce environmental impacts.
- Improve plant related health and safety.

- CO Content of Combustor Flue Gas

The presence of more than trace quantities of carbon monoxide in the Retort Combustor flue gas, presently estimated at about one volume percent, imposes a severe energy and cost penalty on the design because of the need to reduce emissions from the plant. The present design uses a thermal oxidizer fired with natural gas to reduce the carbon monoxide concentration to about 100 ppmv. Achieving this reduction in carbon monoxide content requires heating the flue gas to a temperature of about 1800°F at a residence time of about one second. Approximately 35,000 pounds of fuel per hour is consumed, resulting in a significant energy and cost penalty.

It is proposed that a catalytic oxidizer be used in place of the thermal oxidizer. Systems of this type are currently used industrially on engine exhaust gases to oxidize CO and reduce NO_x although they probably cannot be directly applied to the present design because of the presence of solids in the flue gas. The principle could be applied, however, by positioning catalyst on the inside surface of open passageways such as tubes. The use of a catalytic oxidizer would minimize the extent to which the temperature of the flue gas must be raised to reduce the CO concentration to low levels and could also reduce NO_x concentration. This would greatly reduce or eliminate the need for added fuel and reducing agent such as ammonia, thereby saving energy and cost.

- CO Content of Combustor Flue Gas (Cont'd)

A second suggestion related to reduction of carbon monoxide in the combustor flue gas is to reduce the excess air in the combustor to near stoichiometric in regions where shale solids are present. Injection of the excess air in the dilute phase of the combustion may lower the carbon monoxide content without heating most of the shale solids appreciably above the nominal combustor temperature, which would increase carbonate decomposition. This technique is probably not sufficient in itself, however, to reduce carbon monoxide concentrations to the desired level of 100 ppmv.

- Combusted Shale Cooling

In the retorting unit design, combusted shale at a temperature of about 1240°F is cooled to a temperature of 350°F, suitable for moisturization, by preheating combustion air and boiler feed water. The selection of preheating essentially all of the combustion air (to 1000°F) is based on the judgement that air at that temperature is required to insure initiation of combustion of retorted shale in the engager vessel. This is considered a conservative judgement and it is likely that only a portion of the combustion air requires preheating. In that case, it is suggested that hot combusted shale be cooled by preheating raw shale. This would reduce the heat requirement of the retorting step, thereby reducing the heat input to the combustor and improving the thermal efficiency of the overall process to the extent that heat otherwise rejected to boiler feed water is retained within the retorting system. Combustion air could be preheated to the extent necessary by inline combustion of fuel.

It is proposed that the heat exchange between combusted and raw shale be carried out in a fluidized bed vessel containing vertical tubes. Combusted shale would enter the bottom of the vessel and flow upward inside the vertical tubes. Raw shale would enter the middle section of the vessel and flow downward through a staged fluidized bed and leave the bottom of the vessel directly into the retort. In this arrangement, any oil or gas generated during preheating would flow into the retort and thence into the recovery system. Cooled combusted shale would flow from the top of the vessel to the moisturization system.

9.2 Retorting Plant Process Design Alternatives (Cont'd)

- **Raw Shale Preheating**

  A further suggestion for improving process thermal efficiency is to preheat raw shale with partially cooled incinerator flue gas. This would utilize some of the energy in the flue gas to reduce the heat requirement of the retort rather than to recover energy as steam. The extent of shale preheating that can be accomplished in this manner, however, is limited to the temperature at which retorting of the shale begins. For Colorado shale, this temperature can be as low as 350°F. Since small particles in the raw shale will rapidly approach the flue gas temperature, it is necessary to limit the temperature of the flue gas to a maximum of 500°F to prevent any appreciable amounts of hydrocarbons from appearing in the flue gas. If that occurred, it would be necessary to incinerate the flue gas after separation from preheated shale before release to the atmosphere.

- **Stacked Vessel Arrangement**

  The retort plant design presented in this report requires an elevation of major equipment of about 300 feet measured from grade to the top of the combusted shale separator. The structure required to support the large vessels in this arrangement is a significant cost element in the capital cost of the overall retorting plant. To provide a more compact arrangement of process vessels, thereby reducing the maximum elevation, it is suggested that a "stacked" arrangement, as illustrated in Figure 9.1, be used in which the combusted shale separator, the raw shale accumulator, and the retort are positioned in a vertical line. The combusted shale accumulator would be located at the top of this arrangement and would function as a dense phase fluidized bed combustor. The raw shale accumulator would be located below the combusted shale accumulator and above the retort. A dilute phase, vertical transfer line located internal to the above three vessels, would provide a means of conveying the mixture of retorted and combusted shale with combustion air from the bottom of the retort to the shale combustor.

  If the following changes were made in the present design, it is estimated that the stacked arrangement could be accomplished within a maximum elevation of about 200 feet in place of the present 300 feet:

  - Replace the riser type combustion of retorted shale with dense phase combustion in the combusted shale separator.

  - Eliminate the first stage cyclones inside the retort in favor of external first stage cyclones located in a separate vessel.

  - Eliminate the first stage cyclones inside the combusted shale cooler.

  - Replace the present Raw Shale Accumulator with a larger diameter, shorter vessel.

9.2 Retorting Plant Process Design Alternatives (Cont'd)

The last three items above would decrease the height of the Raw Shale Accumulator, Retort, and Combusted Shale Cooler, and allow the vessel elevations to be set primarily by standpipe height necessary to overcome pressure differences rather than by the geometry of minimum standpipe angle and vessel diameter. It should be noted, however, that additional vessels and possibly larger diameter vessels may be required for the stacked arrangement than for the present arrangement. A design and cost study would be required to determine the relative cost effectiveness of the two arrangements.

- FCC Vessel Arrangement

Another possibility of fluidized bed retorting with medium plant height is a "catalytical cracking" side-by-side process. This process, as shown, in figure 9.2 will use fluidized bed reactor for both retorting and spent shale combusting processes. Raw shale feed into the retort, the spent shale feed into the combustor, and the recycled hot shale feed to the retort are dilute phase pneumatic transport systems. The system has the advantage of reducing the overall plant height, but requires handling larger amounts of gas for shale transfer and further gas-solid separation. The technical aspects as well as the economic considerations of such a design can be revealed by a conceptual design alternate of the base case design.

- Quenching of Retort Vapors

Vapors containing products of retorting leave the top of the retort at a temperature of 930°F and flow through a solids separation vessel and transfer line to the Raw Oil Recovery Quench Tower. The vapors are subject to thermal cracking and coking reactions for residence times up to 15 seconds before being quenched to lower temperatures in the tower. In order to avoid a potential loss of oil yield due to cracking and coking, it is proposed that the vapors leaving the retort be quenched to a temperature of about 850°F with cold (130°F) gas recycled from the raw oil recovery unit. This would decrease the extent of cracking and coking, but would increase the gas flow to the raw oil recovery tower, thereby increasing the cost of that operation. A further consideration is whether the reduced temperature would cause some of the heavy oil fraction to condense on the entrained shale solids, creating wet solids which could plug cyclones and transfer lines.

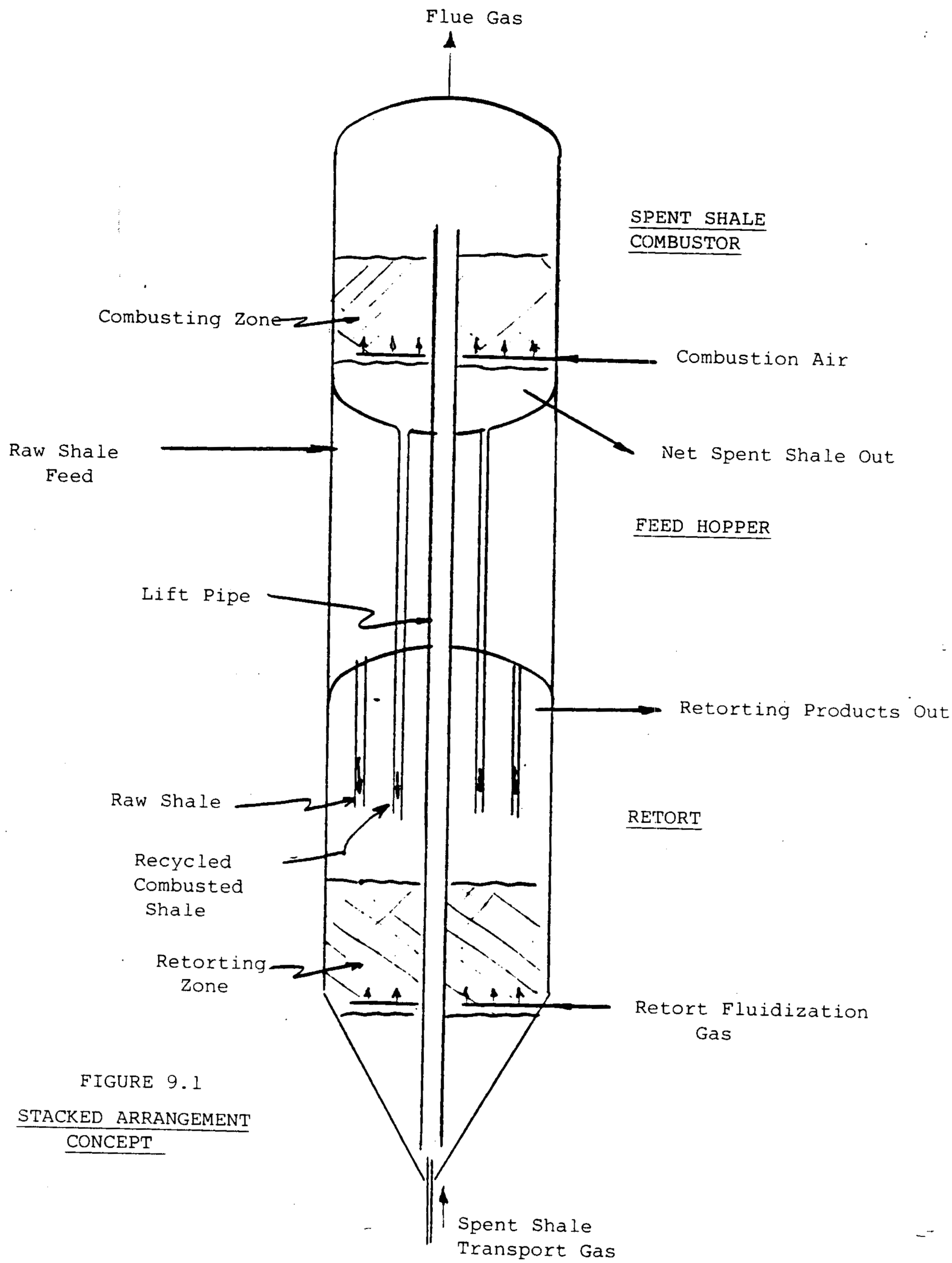

FIGURE 9.1

STACKED ARRANGEMENT CONCEPT

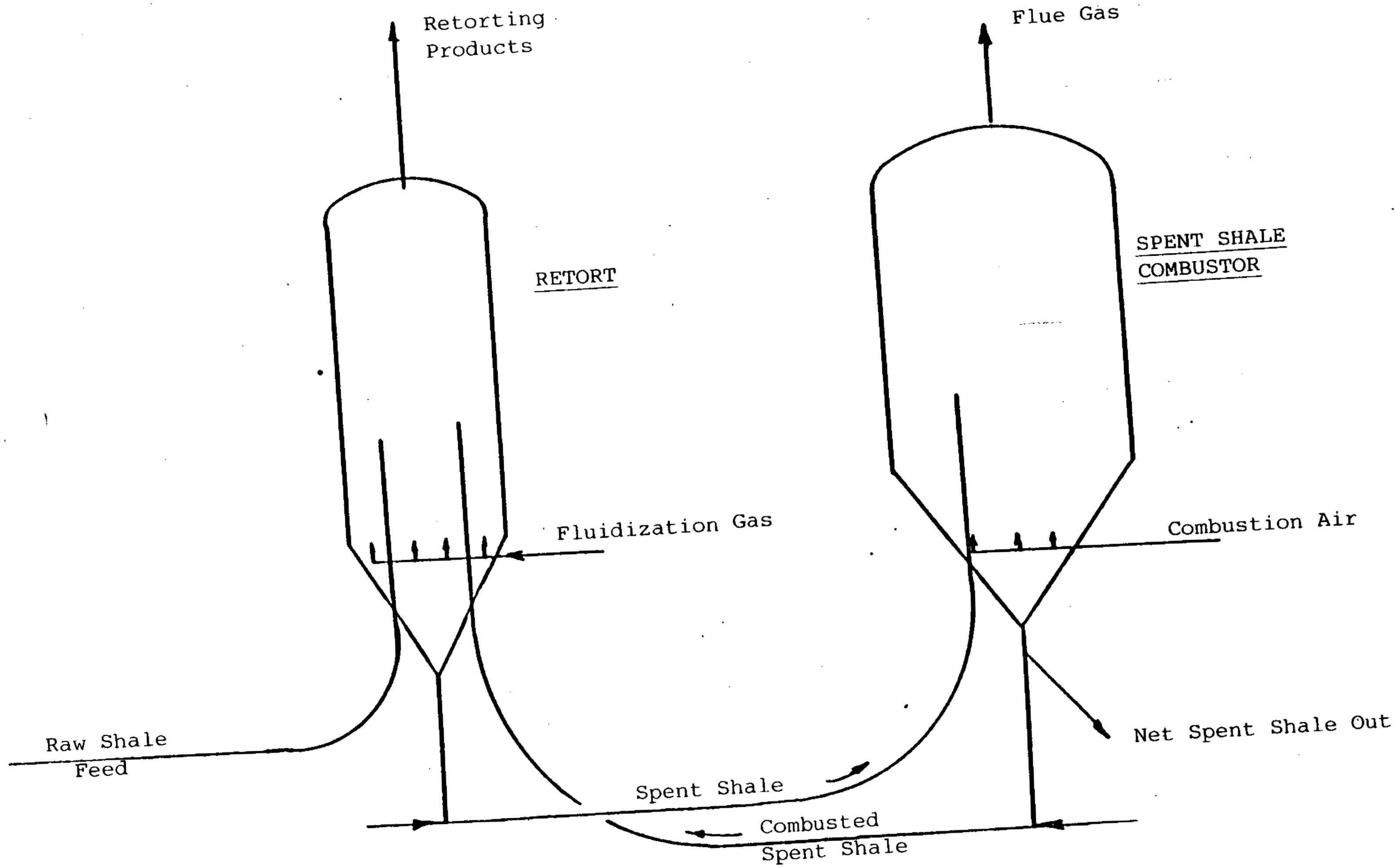

FIGURE 9.2

FCC ARRANGEMENT CONCEPT

10.0 CAPITAL COST ESTIMATE

10.1 Basis of Estimate

Capital costs for the 50,000 BPD shale oil plant were estimated for an unspecified Western Colorado site based on current day 1987 costs.

The technical definition of the plant, as given in Sections 4.0 - 6.0 of this report, formed the basis for estimating the installed plant cost. This cost was developed from battery limits cost estimates for the individual plant sections. All sections, except for Sulfur Recovery, Unit 800, were estimated by Foster Wheeler. A budgetary cost for the sulfur recovery unit was provided by ARI Technologies Incorporated and this was adjusted for winterization by Foster Wheeler.

For the majority of the plant sections, the process equipment specifications, developed as part of the plant design definition, were used as the cost estimating basis. Factors were applied to the estimated equipment costs to arrive at costs for bulk materials and installation labor. These factors were derived from previous detailed cost estimates, prepared by Foster Wheeler for conceptual oil shale plants located in Western Colorado. Using this factored estimating technique, installed costs were developed for all plant sections, with the exception of Sulfur Recovery, Unit 800, and General Plant Facilities, Unit 2900.

While the fire water system in Unit 2900 was factored from equipment definitions, the balance of the general facilities was estimated by in-house cost ratios or unit prices. Costs for interconnecting piping, pipe racks, and electrical distribution were developed from ratios on the total process unit costs. Unit prices were used for estimating buildings, in-plant roads, fences, sewers, and site preparation, based on the plot plan definition. The estimate for Unit 1100 also includes costs for site preparation of the spent shale disposal area.

Based on previous estimates, the indirect construction costs were developed as a ratio on installation labor requirements. Similarly, engineering costs were estimated as a percentage of the total equipment, bulk materials, direct and indirect labor costs for each plant section.

10.1 Basis of Estimate (Cont'd)

The estimated total plant investment costs specifically excludes the following items:

- Process royalties and license fees.
- Cost of land.
- Supply of electric power and raw water to the plant site.
- Infrastructure costs for access roads to the plant, housing for personnel, and construction labor camps.
- Building furnishings, laboratory equipment, and general plant vehicles.
- Costs for oil shale mining and product oil transportation.
- Project owner costs.

The last item of exclusion reflects costs such as project management, construction permits, baseline and environmental monitoring, and environmental impact statements.

The basis for the current cost estimate assumes a relatively clear and level site. Therefore, the allowed costs for site preparation do not include terracing or leveling of mountainous terrain.

10.2 Installed Plant Cost

The estimate summary for the installed plant cost is given in Table 10.1. This summary provides a breakdown of the total cost, estimated at $1.92 billion, according to the individual processing units and support systems.

With the exception of the sulfur recovery plant, Unit 800, the installed cost of each plant section is divided according to equipment, bulk materials, installation labor, indirect labor and construction management, and engineering costs.

The scope of these estimating categories is as follows:

- Equipment includes the cost of all equipment on equipment lists, including internals, freight, and subcontract items but excluding installation costs.

- Bulk materials includes all materials which become a permanent part of the plant, including concrete, steel, buildings, piping, instruments, electrical and protective cover.

- Installation labor includes all labor to install equipment and bulk materials. The labor estimate is based on non-union construction and includes bare wages plus benefits and payroll taxes.

Table 10.1

Summary of Installed Plant Cost

Basis: Mid-1987, Colorado

Unit	Description	Cost, $1000
100	Retorting	890,991
200	Raw Oil Recovery	78,131
300	Gas Treating	35,482
400	Raw Oil Hydrotreating	79,699
500	Hydrotreated Oil Fractionation	13,459
600	Hydrogen Plant	116,100
700	Sour Water Treating	25,165
800	Sulfur Recovery	15,700
900	Spent Shale Moisturizing	37,937
1000	Feed Preparation	169,219
1100	Spent Shale Disposal	60,829
Sub-Total Processing		1,522,712
2000	Raw Water Treatment	7,918
2100	Steam & Power Generation	33,493
2200	Cooling Water System	22,088
2300	Plant & Instrument Air	2,885
2400	Waste Water Treatment	16,216
2500	Inert Gas System	1,704
2600	Flare System	47,149
2700	Plant Fuel System	111
2800	Storage Facilities	26,686
2900	General Plant Facilities	235,506
Sub-Total Support Systems		393,756
Total Installed Plant Cost		1,916,468

10.2 Installed Plant Cost (Cont'd)

- Indirect labor and construction management includes all facilities, supplies, construction equipment, construction supervision, remote handling, and insurance to support the construction effort.

- Engineering includes all basic engineering, detail engineering, project management, and engineering fee for the facility.

Tables 10.2 and 10.3 provide the cost breakdown, according to the above categories, for the plant processing sections, Units 100 - 1100, and the plant support systems, Units 2000 - 2900, respectively. A further breakdown of the general plant facilities, Unit 2900, is given in Table 10.4. Details of the estimated process equipment costs for each plant section are included in Appendix-B of this report.

Based on the estimating techniques employed, the accuracy of the overall installed plant cost is expected to be ± 25%.

10.3 Total Plant Investment

In addition to the installed plant cost, allowances for project contingency, initial inventory of catalyst and chemicals, spare parts, start-up costs, and working capital are included as capital cost items. A summary of the total plant investment cost, estimated at $2.39 billion, is given in Table 10.5.

A project contingency equal to 15% of the installed plant cost was included. This provides for omissions and uncertainties in the technical definition of the plant due to the non-specific plant site and the lack of detailed engineering.

Cost for the initial charge of catalyst and chemicals was estimated from the requirements for individual plant sections, as shown in Table 10.6. An allowance for the spare parts inventory was estimated at 3.0% of the total plant equipment cost. Start-up costs and working capital requirements were estimated at 3 months and 2 months of the annual operating costs, respectively. The annual operating costs, as developed in Section 11.0 of this report, was about $370 million.

Table 10.2

Breakdown of Processing Units Cost

Basis: Mid-1987, Colorado

Unit	Cost Element, $1000					
	Equipment	Bulk Material	Direct Labor	Construction Indirects	Engineering	Total
100	204,380	194,160	198,248	251,775	42,428	890,991
200	28,446	12,232	13,370	16,980	7,103	78,131
300	12,919	5,555	6,072	7,711	3,225	35,482
400	39,063	12,110	9,375	11,906	7,245	79,699
500	6,596	2,045	1,583	2,011	1,224	13,459
600	39,660	15,468	22,210	28,207	10,555	116,100
700	5,678	4,088	5,338	6,779	3,282	25,165
900	10,933	5,685	7,872	9,997	3,450	37,937
1000	71,323	12,125	34,235	43,478	8,058	169,219
1100	53,472	3,225	1,295	1,645	1,192	60,829
Total	472,470	266,693	299,598	380,489	87,762	1,507,012
800	*	*	*	*	*	15,700
Total	-	-	-	-	-	1,522,712

* Included in Process Licensor Estimate

Table 10.3

Breakdown of Support Systems Cost

Basis: Mid-1987, Colorado

Unit	Cost Element, $1000					
	Equipment	Bulk Material	Direct Labor	Construction Indirects	Engineering	Total
2000	1,645	1,299	1,874	2,380	720	7,918
2100	12,570	4,776	6,411	8,141	1,595	33,493
2200	5,538	3,101	5,040	6,401	2,008	22,088
2300	735	419	647	822	262	2,885
2400	3,586	2,044	4,196	5,329	1,061	16,216
2500	599	120	366	464	155	1,704
2600	3,520	8,060	15,064	19,132	1,373	47,149
2700	25	13	26	33	14	111
2800	11,516	2,418	4,952	6,289	1,511	26,686
2900	768	60,351	72,664	92,284	9,439	235,506
Total	40,502	82,601	111,240	141,275	18,138	393,756

Table 10.4

Breakdown of General Plant Facilities Cost

Unit 2900

Basis: Mid-1987, Colorado

Unit	Cost Element, $1000					
	Equipment	Bulk Material	Direct Labor	Construction Indirects	Engineering	Total
Interconnecting Piping	0	21,814	34,279	43,534	3,985	103,612
Firewater System	768	1,254	1,415	1,797	209	5,443
Electrical Distribution	0	23,892	24,930	31,662	3,219	83,703
Sewers	0	7,271	8,310	10,554	1,045	27,180
Site Development	0	2,170	1,100	1,397	187	4,854
Plant Buildings	0	3,950	2,630	3,340	794	10,714
Total	768	60,351	72,664	92,284	9,439	235,506

Table 10.5

Total Plant Investment Summary

Basis: Mid-1987, Colorado

	Cost $1000
Installed Plant Cost:	
Processing Units	1,522,712
Support Systems	393,756
	1,916,468
Project Contingency @ 15%	287,470
Total Plant Cost	2,203,938
Initial Catalyst & Chemical Inventory	11,531
Spare Parts	15,390
Start-Up Costs	92,743
Working Capital	61,829
Total Plant Investment	2,385,431

Table 10.6

Initial Catalyst and Chemical Inventory

Unit	Item	Quantity	Cost, $1000
400	Guard Catalyst	3,400 CF	920
	Hydrotreating Catalyst	-	4,600
600	Hydrogenation Catalyst	940 CF	108
	Sulfur Guard Catalyst	1,880 CF	244
	Chloride Guard Catalyst	870 CF	96
	Reforming Catalyst	1,020 CF	281
	H.T. Shift Catalyst	1,560 CF	190
	L.T. Shift Catalyst	2,190 CF	493
	PSA Molecular Sieves	49,000 CF	3,920
700	Phosphoric Acid (75%)	25 ST	15
	Caustic Soda (50% NaOH)	30 ST	6
800	Locat Chemicals	-	300
2000	Activated Carbon	1,450 CF	43
	Cation Resin	940 CF	38
	Anion Resin	940 CF	38
	Mixed Bed Resin	940 CF	38
	Anthracite	5,000 CF	100
	Sand & Gravel	5,000 CF	100
2300	Silica Gel	2,000 lbs	1
	Total		11,531

10.4 Capital Expenditure Schedule

Table 10.7 provides an estimate of the annual capital outlay during the period required for plant construction and commissioning. These capital expenditures are based on a five year schedule for plant design and construction with start-up at the beginning of the sixth year. While phased construction and commissioning of the plant could be employed, the current estimates are based on simultaneous installation of the six retorting modules and multiple downstream processing trains.

The capital expenditure for plant design and construction was estimated on the following level.

Year	1	2	3	4	5
%	5	15	32	28	20

The capital outlay for spare parts inventory was assumed to follow the construction activity in years 2-5. Considering that plant staffing, training, and build-up of shale feed inventory would occur in the latter part of the fifth year, 25% of the working capital was apportioned to this period.

Table 10.7

Schedule of Capital Expenditure

Year	Investment Cost $ Million					
	Plant Construction	Initial Inventory	Spare Parts	Start-Up Cost	Working Capital	Total
1	110.2					110.2
2	330.6		2.4			333.0
3	705.2		5.2			710.4
4	617.1		4.5			621.6
5	440.8	11.5	3.3		15.5	471.1
6*				92.8	46.3	139.1
	2,203.9	11.5	15.4	92.8	61.8	2,385.4

* Plant start-up

11.0 OPERATING COST ESTIMATE

11.1 Basis of Estimate

The estimate of annual operating costs for the plant is based on a 0.9 operating factor, equivalent to 330 operating days per year. The following unit costs were assumed for the raw materials, utilities, and by-products delivered to the plant battery limits:

Oil Shale Ore	:	6.00 $/Ton
Natural Gas	:	3.50 $/1000 SCF
Diesel Oil	:	23.00 $/BBL
Electric Power	:	0.06 $/kWH
Raw Water	:	1.00 $/1000 Gallons
Elemental Sulfur	:	90.00 $/Ton
Anhydrous Ammonia	:	150.00 $/Ton

The oil shale feed cost represents an estimate for run-of-mine ore, based on private communication. This cost reflects an underground mine operation for providing high grade ore, 30 GPT, from a Colorado shale deposit.

Direct labor costs, excluding maintenance labor, were based on the plant staffing requirements estimated in Section 7.9 of this report. The annual wages assumed for the various labor categories are summarized in Table 11.1. Wages for the plant shift operators were based on $12.00 per hour for a 40 hour work week.

Indirect labor costs were based on 65% of the direct labor cost, and includes the following items:

Fringe Benefits @ 25%
General and Administrative Overhead @ 30%
Plant Supplies @ 10%

Annual costs for plant maintenance, including supplies and total maintenance labor costs, were estimated at 4.5% of the installed plant cost. This percentage was derived from consideration of the maintenance level assigned to individual plant units, as shown in Table 11.2. Maintenance costs are divided equally between maintenance labor and materials.

Annual costs for plant insurance and local taxes were estimated at 1.0% of the installed plant cost.

Periodic replacement of mobile equipment used for the spent shale disposal operation was included as an operating expense, averaged over an assumed plant life of 30 years. For this purpose, the average life of mobile equipment was taken as six years, so that, over the plant operating life, the cost of four total replacements is required.

Table 11.1

Estimated Direct Labor Cost *

Labor Category	Number	Annual Wage, $	Total Annual Wages $ 1000
Plant Managers	6	76,700	460
Chief Engineers	2	60,000	120
Staff Engineers	7	45,000	315
Chemists	3	40,000	120
Draftsmen	2	25,000	50
Technicians	13	22,000	286
Secretary/Clerical	13	17,300	225
Accounting/Payroll	6	28,300	170
Purchasing/Receiving	3	22,000	66
Warehouse	9	22,900	206
First Aid	4	25,000	100
Security/Custodians	7	21,000	147
Shift Supervisors	40	45,000	1,800
Shift Operators	475	25,000	11,875
	590		15,940

* Excluding Maintenance Labor

Table 11.2

Estimated Plant Maintenance Cost

Unit	Description	Installed Plant Cost, $1000	Annual Maintenance %	Annual Maintenance Cost, $1000
100	Retorting	890,991	5	44,550
200	Raw Oil Recovery	78,131	5	3,906
300	Gas Treating	35,482	3	1,604
400	Oil hydrotreating	79,699	4	3,188
500	Oil Fractionation	13,459	3	404
600	Hydrogen Plant	116,100	4	4,644
700	Sour Water Treating	25,165	3	755
800	Sulfur Recovery	15,700	4	628
900	Spent Shale Moisturizing	37,937	6	2,276
1000	Feed Preparation	169,219	6	10,153
1100	Spent Shale Disposal	60,829	7	4,258
2000	Raw Water Treatment	7,918	4	317
2100	Steam & Power Generation	33,493	4	1,340
2200	Cooling Water System	22,088	3	663
2300	Plant & Instrument Air	2,885	2	58
2400	Waste Water Treatment	16,216	4	649
2500	Inert Gas System	1,704	2	34
2600	Flare System	47,149	2	943
2700	Plant Fuel System	111	2	2
2800	Storage Facilities	26,686	2	534
2900	General Plant Facilities	235,506	2	4,710
	Total	1,916,468	4.5	85,616

11.2 Overall Operating Requirements

Annual operating requirements, in terms of the battery limits raw materials, utilities, by-products, catalyst and chemical usage, and plant labor, were based on the overall plant operations as summarized in Section 7.0. The following annual requirements were derived from the hourly and daily operating rates, based on continuous 24 hour a day operation for 330 days per year. The annual electric power usage, however, reflects only 260 operating days per year for the feed preparation system, Unit 1000.

Annual Usage		Operating Requirement
Oil Shale Ore	72,720 Tons/Day	23,997,600 Tons
Natural Gas	50.3 MMSCF/Day	16,599 MMSCF
Diesel Oil	3,600 Gal/Day	28,290 BBL
Electric Power	18,465 KW	95,003,000 KWH
Raw Water	6,225 GPM	2,958,120 MGAL
Catalyst & Chemicals	64,882 $/Day	21,411,000 $

Direct labor, excluding maintenance, was based on a full-time plant staff of 590. Plant operations produce the following quantities of salable sulfur and ammonia as by-products:

	Daily Rate	Annual Rate
Elemental Sulfur	70.6 Tons/Day	23,300 Tons
Anhydrous Ammonia	211.8 Tons/Day	69,886 Tons

11.3 Annual Operating Cost

The annual plant operating costs and by-product credits, corresponding to a 90% stream factor, are detailed in Table 11.3. The total estimated cost is summarized according to the major cost elements as follows:

	Annual Cost $1000	%
Raw Materials & Consumables	232,803	62.8
Operating & Maintenance Labor	69,109	18.6
Maintenance Materials	42,808	11.5
Other	26,251	7.1
	370,971	100.0
By-Product Credit	(12,580)	
Net Cost	358,391	

The oil shale ore represents the largest single cost item, which accounts for 62% of the raw materials and consumables cost. The annual cost for replacement of mobile equipment was estimated at $7.1 million, which is equivalent to four complete turnovers at a cost of $53.1 million per cycle over a 30 year period.

Based on the syncrude production rate of 54,560 BPD, the net operating cost per barrel of product oil is $19.91.

Table 11.3

Annual Plant Operating Cost

Basis: 330 Operating Days/Year

Cost Element	Annual Cost $1000
Raw Materials & Consumables	
Oil Shale Ore	143,986
Natural Gas	50,474
Diesel Oil	651
Electric Power	5,700
Raw Water	2,958
Catalyst & Chemicals	21,411
	225,180
Plant Labor	
Direct Labor (Excluding Maintenance)	15,940
Indirect Labor	10,361
Maintenance Labor	42,808
	69,109
Maintenance Materials	42,808
Insurance & Local Taxes	19,164
Mobile Equipment Replacement	7,087
Total Operating Cost	363,348
By-Product Credit	
Sulfur	2,097
Ammonia	10,483
Net Operating Cost	350,768

12.0 LITERATURE REFERENCES

1. Matzick, A. et al., "Experiments in Crushing Oil Shale," Bureau of Mines Report No. 5563 (1960)

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3. Nicolai, L. A., and Malstedt, B. V., "Fluid-Type Retorting of Oil Shale," U.S. Patent 2,634,233 (April 7, 1953)

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5. Bertelsen, G. M. et al., "The Chevron STB Oil Shale Retort," American Petroleum Institute, 46th Midyear Refining Meeting, Chicago, Illinois (May 13, 1981)

6. Anonymous, "Chevron Finds Its Retort More Economic," Synfuels Week (May 18, 1981)

7. Lewis, A. E. et al., "Oil Shale Retorting Processes: A Technical Overview," UCRL-90156 Preprint, Proceedings of the 17th Oil Shale Symposium, Golden, Colorado (April 16-18, 1984)

8. Cena, R. J. and Mallon, R. G., "Results and Interpretation of Rapid Pyrolysis Experiments Using the LLNL Solid-Recycle Oil Shale Retort," UCRL-94493 Preprint, 19th Oil Shale Symposium, Golden, Colorado (April 21-23, 1986)

9. Horio, H. et al., "Research and Development of NO_x Abatement in Fluidized Bed Combustors," International Conference on Fluidized Bed Combustion, Atlanta, Georgia (April 1980)

10. Anonymous, "A Way to Lower NO_x in Utility Boilers," Environmental and Science Technology, Vol, II, No. 3 (March 1977)

11. Abdulally, I. F., and Kersey, B. R., "Application of Foster Wheeler Fluidized Bed Combustion Technology in Waste Heat Recovery," American Petroleum Institute, Midyear Refining Meeting, San Diego, California (May 1986)

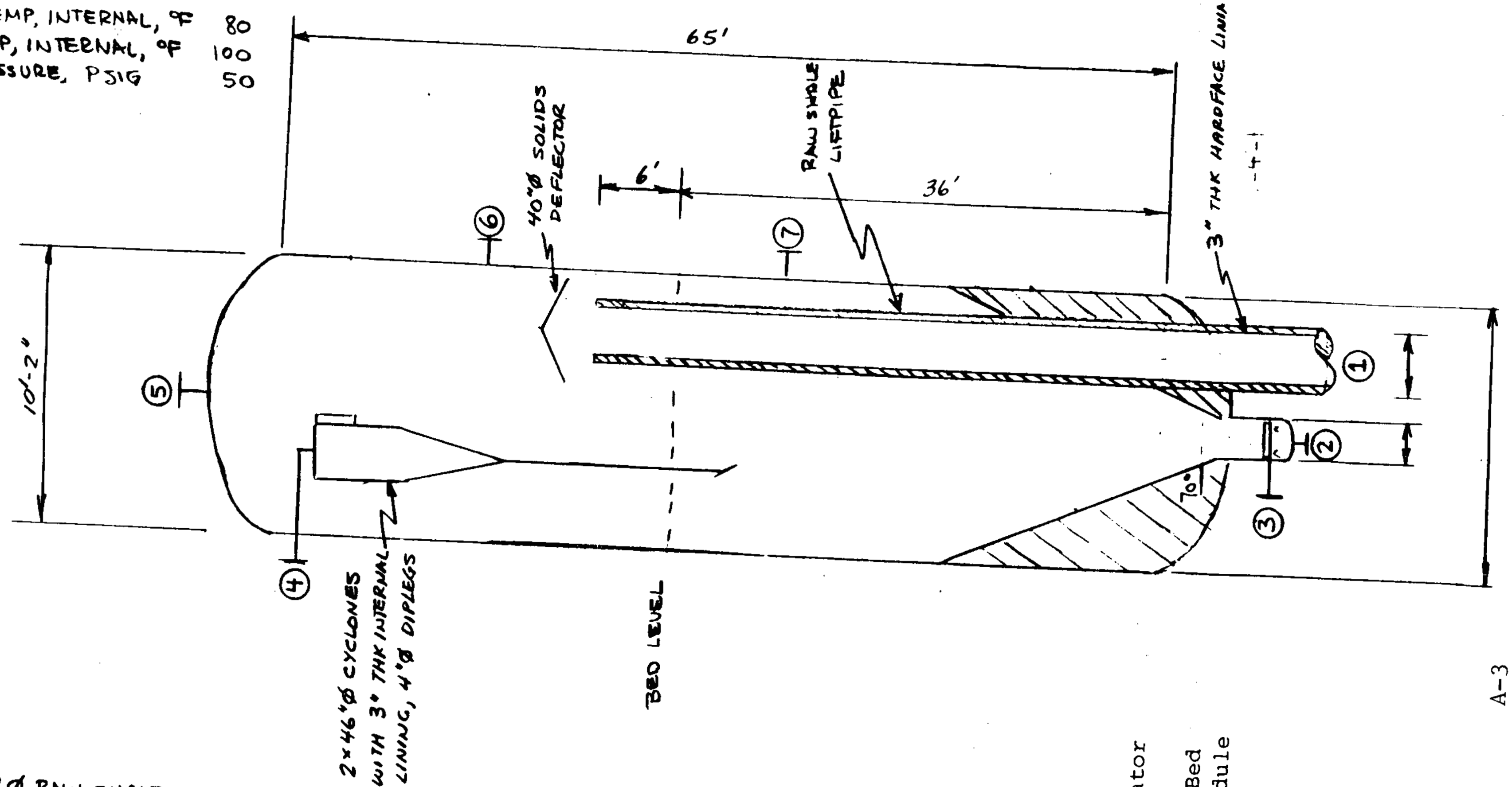
12. Rio Blanco Oil Shale Project, Detailed Development Plan Tract C-a (March 1976)

13. Shaw, R. J., "Specific Heat of Colorado Oil Shale, U.S. Bureau of Mines RI 4151 (1947)

APPENDIX - A

RETORT VESSEL SKETCHES

OPERATING TEMP, INTERNAL, °F	80
DESIGN TEMP, INTERNAL, °F	100
DESIGN PRESSURE, PSIG	50

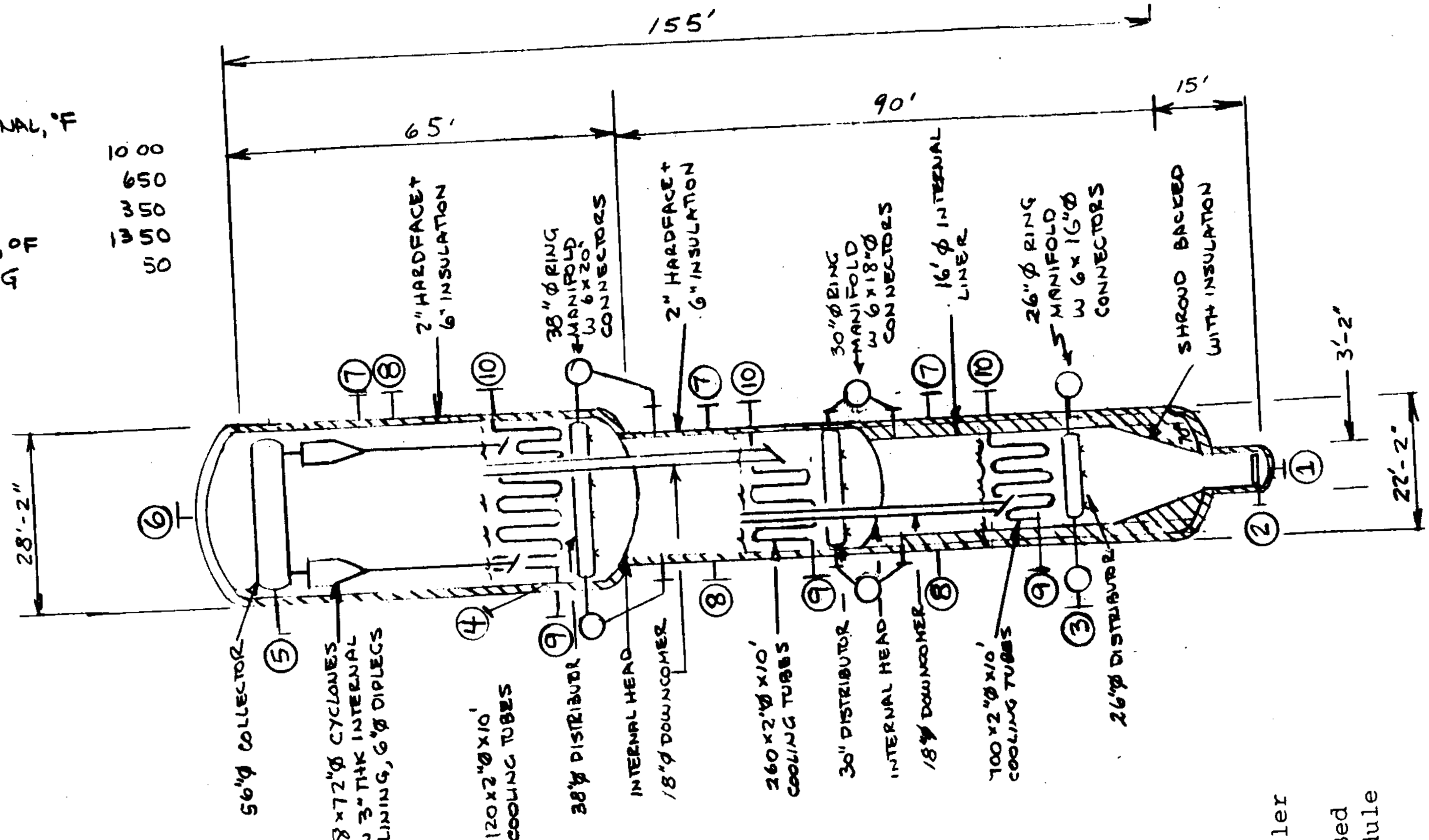


① 1 × 30"Ø RAW SHALE INLET
② 1 × 18"Ø RAW SHALE OUTLET
③ 1 × 6"Ø STRIPPING GAS INLET
④ 1 × 28"Ø CONVEYING AIR OUTLET
⑤ 1 × 72"Ø MANWAY
⑥ 6 × 2"Ø TEMPERATURE TAPS
⑦ 6 × 2"Ø PRESSURE TAPS

Raw Shale Feed Accumulator
V-102

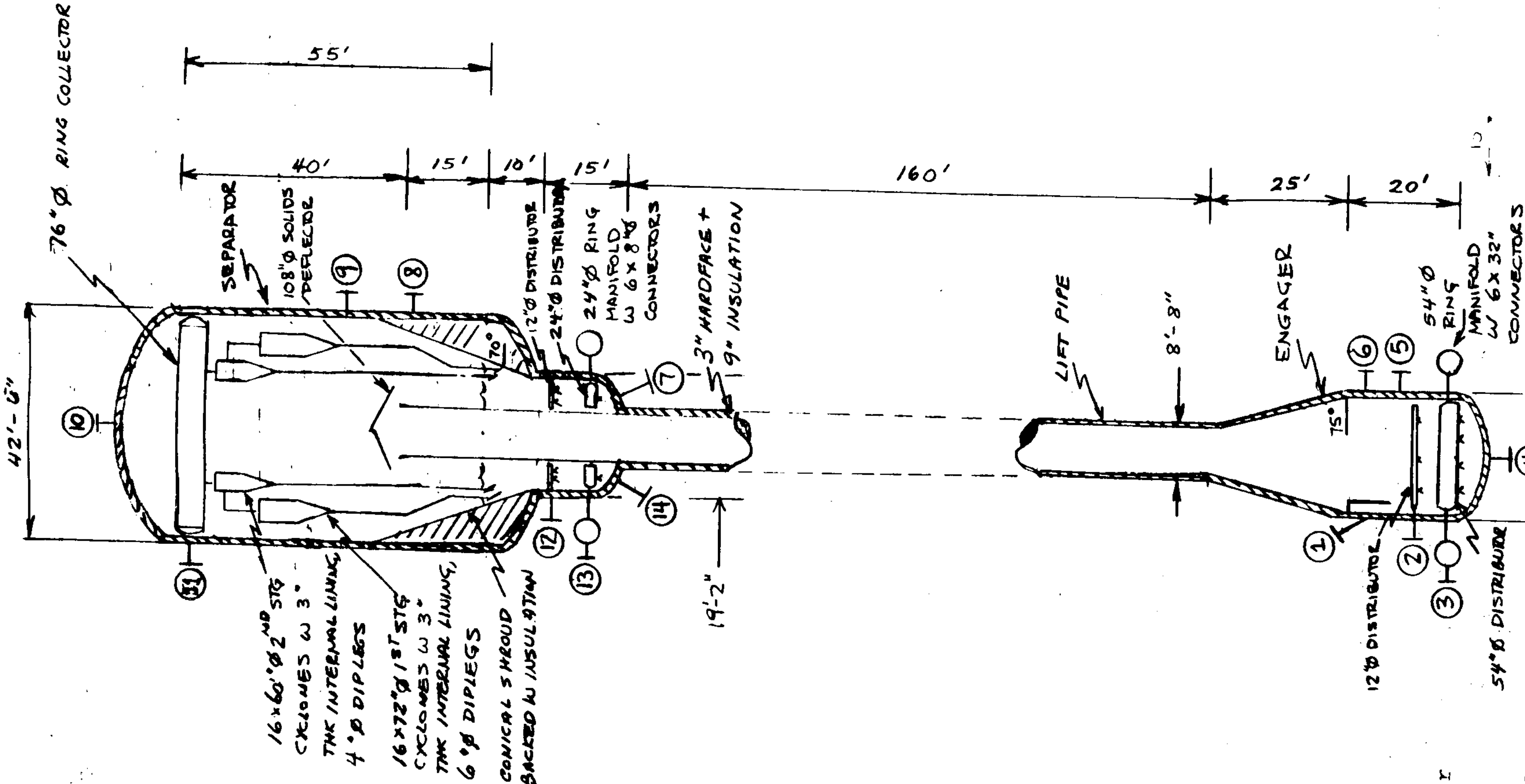
12,000 TPD Fluidized Bed
Oil Shale Retorting Module

OPERATING TEMP, INTERNAL, °F	
TOP STAGE, °F	1000
MID STAGE, °F	650
BTM STAGE, °F	350
DESIGN TEMP, INTERNAL, °F	1350
DESIGN PRESSURE, PSIG	50



1. 1 x 18" Ø NET COMBUSTED SHALE OUTLET
2. 1 x 8" Ø STRIPPING AIR INLET
3. 1 x 36" Ø COMBUSTION AIR INLET
4. 1 x 18" Ø NET COMBUSTED SHALE INLET
5. 1 x 76" Ø COMBUSTION AIR OUTLET
6. 1 x 84" Ø MANWAY
7. 15 x 2" Ø TEMPERATURE TAPS
8. 15 x 2" Ø PRESSURE TAPS
9. 12 x 6" Ø BOILER FEED WATER INLETS
10. 12 x 6" Ø BOILER FEED WATER OUTLETS

Air Preheater/Shale Cooler
V-105
12,000 TPD Fluidized Bed
Oil Shale Retorting Module

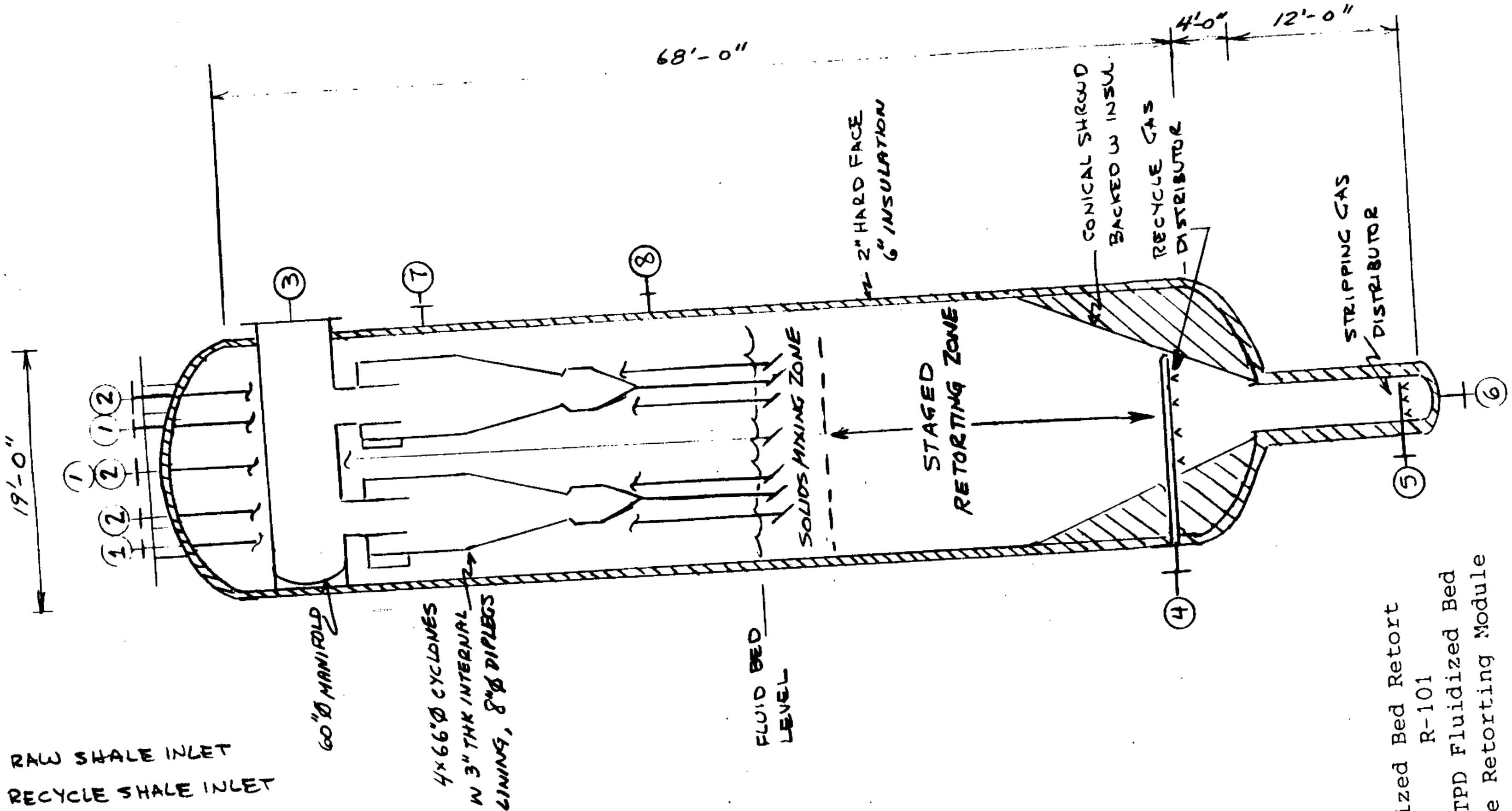


OPERATING TEMP, INTERNAL, °F 1250
DESIGN TEMP, INTERNAL, °F 1350
DESIGN PRESSURE, PSIG 50

1. 1 x 42"Ø RETORTED SHALE INLET
2. 1 x 12"Ø FUEL GAS INLET
3. 1 x 76"Ø COMBUSTION AIR INLET
4. 1 x 12"Ø SOLIDS DRAIN
5. 10 x 2"Ø TEMPERATURE TAPS
6. 10 x 2"Ø PRESSURE TAPS
7. 1 x 18"Ø NET COMBUSTED SHALE OUTLET
8. 10 x 2"Ø TEMPERATURE TAPS
9. 10 x 2"Ø PRESSURE TAPS
10. 1 x 96"Ø MANWAY
11. 1 x 104"Ø FLUE GAS OUTLET
12. 1 x 12"Ø FUEL GAS INLET
13. 1 x 36"Ø COMBUSTION AIR INLET
14. 1 x 36"Ø RECYCLE COMBUSTED SHALE OUTLET

Retorted Shale Combustor
V-103/V-104
12,000 TPD Fluidized Bed
Oil Shale Retorting Module

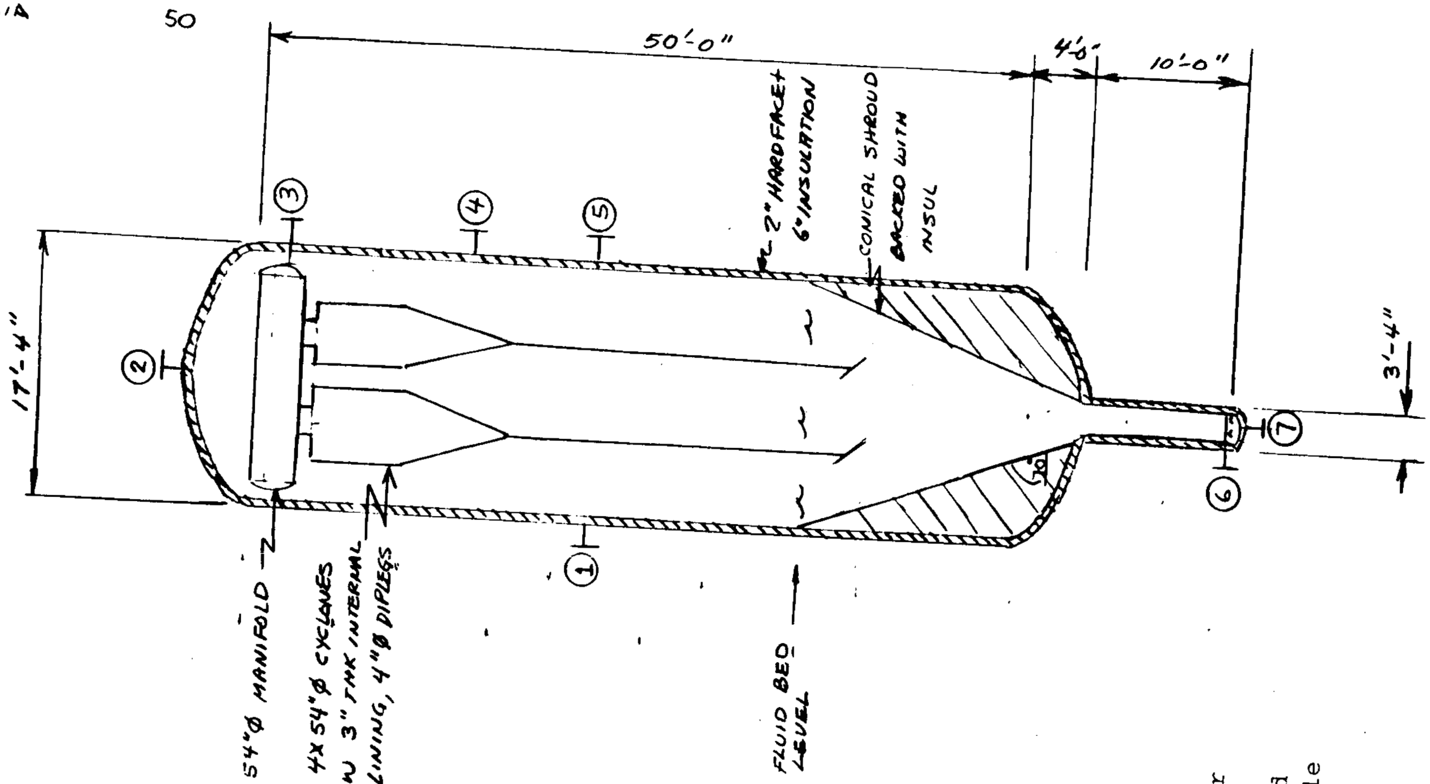
OPERATING TEMP, °F, INTERNAL	930
DESIGN TEMP, °F, INTERNAL	1000
DESIGN PRESSURE, PSIG	50



Fluidized Bed Retort
R-101
12,000 TPD Fluidized Bed
Oil Shale Retorting Module

(1) 4×8"Ø RAW SHALE INLET
(2) 4×14"Ø RECYCLE SHALE INLET
(3) 1× 60"Ø RETORT OVHD VAPOR OUTLET
(4) 1×20"Ø RECYCLE GAS INLET
(5) 1×8"Ø STRIPPING STEAM INLET
(6) 1×42"Ø RETORTED SHALE OUTLET
(7) 10×2"Ø TEMPERATURE TAPS
(8) 10×2"Ø PRESSURE TAPS

OPERATING TEMP, INTERNAL, °F	930
DESIGN TEMP, INTERNAL, °F	1000
DESIGN PRESSURE, PSIA	50



① 1 × 60"Ø RETORT VAPOR INLET
② 1 × 84"Ø MANWAY
③ 1 × 60"Ø RETORT VAPOR OUTLET
④ 10 × 2"Ø TEMPERATURE TAPS
⑤ 10 × 2"Ø PRESSURE TAPS
⑥ 1 × 4"Ø STRIPPING STEAM INLET
⑦ 1 × 8"Ø RETORTED SHALE OUTLET

Retorted Shale Separator
V-106
12,000 TPD Fluidized Bed
Oil Shale Retorting Module

APPENDIX B-1

EQUIPMENT COST DATA

RETORTING - UNIT 100

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	55,578,000	55,578,000	0	27.2%
130	DRUMS	999,000	1,103,100	2,102,100	0	1.0%
140	STORAGE TANKS	0	6,978,000	6,978,000	0	3.4%
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	541,400	0	541,400	0	0.3%
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	7,576,700	0	7,576,700	0	3.7%
240	FIRED PROCESS EQUIPMENT	3,388,700	0	3,388,700	0	1.7%
270	VACUUM EQUIPMENT	46,400	0	46,400	0	0.0%
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	144,300	0	144,300	0	0.1%
320	COMPRESSORS	17,211,300	0	17,211,300	0	8.4%
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	9,477,700	0	9,477,700	0	4.6%
360	MATERIALS TRANSPORT	1,334,900	0	1,334,900	0	0.7%
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	100,000,000	100,000,000	0	48.9%
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	40,720,400	163,659,100	204,379,500	0	100%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED B : TH

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
120	R-101	FLUID BED RETORT 19' DIA X 68' T/T W/ 304 SS INTERNALS	6	0		5,251,200	
		VERT. OR HORIZ.: V SUPPORT: LUGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 1/2" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/600 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	6	0	0	5,251,200	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	0	5,251,200	0
120	V-103	RETORTED SHALE COMBUSTOR 23'2"/8'8" DIA X 20' T/T W/ 310 SS INTERNALS	6			3,202,800	
		VERT. OR HORIZ.: V SUPPORT: LUGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 5/8" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/600 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	6	0	0	3,202,800	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	0	3,202,800	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
120	V-104	COMBUSTED SHALE SEPARATOR 42'6"/19'2" DIA X 55' T/T W/ 310 SS INTERNALS VERT. OR HORIZ.: V SUPPORT: LUGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 1" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/600 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1	6			24,460,800	
		SUBTOTAL :	6	0	0	24,460,800	
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	0	24,460,800	0
120	V-105	AIR PREHEATER/SHALE COOLER 28'2"/22'2" DIA X 155' T/T W 304 SS INTERNALS VERT. OR HORIZ.: V SUPPORT: LUGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/4" & 5/8" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/600 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1	6			18,565,800	
		SUBTOTAL :	6	0	0	18,565,800	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	0	18,565,800	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
120	V-106	RETORTED SHALE SEPARATOR 17'4" DIA X 50' T/T W/ 304 SS INTERNALS	6			4,097,400	
		VERT. OR HORIZ.: V SUPPORT: LUGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 1/2" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/600 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	6	0	0	4,097,400	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	0	4,097,400	0
		TOTAL CODE: 120	30	0	0	55,578,000	0

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	V-105A/C	CONDENSATE DRUM 25' DIA X 80' T/T	3	1,282,800	0	1,103,100	
		VERT. OR HORIZ.: H					
		SUPPORT: SDLS					
		MATERIAL: SA-516-60					
		STRESS RELIEVE: NO					
		X-RAY: SPOT					
		JOINT EFF.: 85%					
		WALL THICKNESS: 1 1/4"					
		CORR. ALLOW.: .125"					
		DESIGN - PSIG/TEMP: 75/150					
		ASME CODE: VIII D1					
		NOZ/MW RATING: 150#					
		SOURCE: 1					
		SUBTOTAL	3	1,282,800	0	1,103,100	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	3	1,282,800	0	1,103,100	0
130	V-102	RAW SHALE FEED ACCUMULATOR 10'2" DIA X 65' T/T	6		794,400		
		VERT. OR HORIZ.: V					
		SUPPORT: LUGS					
		MATERIAL: SA-516-70					
		STRESS RELIEVE: NO					
		X-RAY: SPOT					
		JOINT EFF.: 85%					
		WALL THICKNESS: 3/8"					
		CORR. ALLOW.: .125"					
		DESIGN - PSIG/TEMP: 50/100					
		ASME CODE: VIII D1					
		NOZ/MW RATING: 150#					
		SOURCE: 1					
		SUBTOTAL	6	0	794,400	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	794,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	V-107	CONDENSATE DRUM 12' DIA X 40' T/T	6		204,600		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/8" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/175 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL	6	0	204,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	204,600	0	0
		TOTAL CODE: 130	15	1,282,800	999,000	1,103,100	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
140	V-101	RAW SHALE BIN 60' DIA X 175' H	6			6,978,000	

VERT. OR HORIZ.: V
SUPPORT:
MATERIAL: CONCRETE
STRESS RELIEVE:
X-RAY:
JOINT EFF.:
WALL THICKNESS:
CORR. ALLOW.:
DESIGN - PSIG/TEMP:
ASME CODE:
NOZ/MW RATING:
SOURCE: 1

	QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL	6	0	0	6,978,000	0
FREIGHT 0.0%			0		
DEVELOPMENT 0.0%			0		
TOTAL	6	0	0	6,978,000	0
TOTAL CODE: 140	6	0	0	6,978,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-102	TURBINE EXHAUST SURFACE CONDENSER	3		243,600		
		TYPE: AGS					
		SHELL ID IN.: 59"					
		TUBE LENGTH FT.: 20					
		NO. OF SHELLS: 1					
		SQ. FT. PER SHELL: 10000					
		TOTAL SQ FT.: 10000					
		SHELL - PSIG/TEMP: FV/150					
		TUBE - PSIG/TEMP: 75/150					
		MATL. - SHELL/TUBE: CS/CS					
		SOURCE: 1					
		SUBTOTAL :	3	0	243,600	0	0
		FREIGHT 3.0%			7,310		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	0	250,910	0	0
210	E-101	TURBINE EXHAUST SURFACE CONDENSER	6		282,000		
		TYPE: AGS					
		SHELL ID IN.: 43					
		TUBE LENGTH FT.: 20					
		NO. OF SHELLS: 1					
		SQ. FT. PER SHELL: 5000					
		TOTAL SQ FT.: 5000					
		SHELL - PSIG/TEMP: FV/150					
		TUBE - PSIG/TEMP: 75/150					
		MATL. - SHELL/TUBE: CS/CS					
		SOURCE: 1					
		SUBTOTAL :	6	0	282,000	0	0
		FREIGHT 3.0%			8,460		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	290,460	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TPF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 210	9	0	541,370	0	0

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-103A/C	COMPRESSOR INTERCOOLERS	3		2,562,000		
		TOTAL BARE SQ FT.: 27500					
		NO. OF BAYS: 6					
		TUBE MATERIAL: CS					
		TUBE LENGTH: 36'					
		PLOT SIZE: 108' X 36'					
		NO. OF FANS/BAY: 2					
		HP EACH:					
		PRESS/TEMP: 50/250					
		SOURCE: 1					
		SUBTOTAL :	3	0	2,562,000	0	0
		FREIGHT 3.0%			76,860		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	0	2,638,860	0	0
230	E-104A/C	COMPRESSOR AFTERCOOLERS	3		4,794,000		
		TOTAL BARE SQ FT.: 52000					
		NO. OF BAYS: 10					
		TUBE MATERIAL: CS					
		TUBE LENGTH: 36'					
		PLOT SIZE: 200' X 36'					
		NO. OF FANS/BAY: 2					
		HP EACH:					
		PRESS/TEMP: 50/300					
		SOURCE: 1					
		SUBTOTAL :	3	0	4,794,000	0	0
		FREIGHT 3.0%			143,820		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	0	4,937,820	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 230	6	0	7,576,680	0	0

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
240	H-101	RECYCLE GAS HEATER, VC TYPE INLET:46 PSIG/120 DEG F OUTLET:26 PSIG/800 DEG F HT. ABS. 10.0M BTU/HR FLOW: 8302.7 SCFM	6		690,000		
		SOURCE: 1					
		SUBTOTAL :	6	0	690,000	0	0
		FREIGHT 3.0%			20,700		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	710,700	0	0
240	H-102A/B	STARTUP AIR HEATER, VC TYPE INLET: 77 DEG F OUTLET: 1000 DEG F/ 10.5 PSIG HT. ABS. 80.8 MM BTU/HR FLOW:81544 SCFM AIR	2		2,600,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	2,600,000	0	0
		FREIGHT 3.0%			78,000		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	2,678,000	0	0

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED B :

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 240	8	0	3,388,700	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
270	J-101A/C	VACUUM EJECTORS FOR E-102A/C	3		15,000		
		SOURCE: 1					
		SUBTOTAL :	3	0	15,000	0	0
		FREIGHT 3.0%			450		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	0	15,450	0	0
270	J-102	VACUUM EJECTOR FOR E-101	6		30,000		
		SOURCE: 1					
		SUBTOTAL :	6	0	30,000	0	0
		FREIGHT 3.0%			900		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	30,900	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 270	9	0	46,350	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TRF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-101A/F	CONDENSATE PUMPS	6		65,400		
		GPM: 1200					
		HD. FT.: 175					
		PSI:					
		S.G.: 62.4#/FT3					
		PUMP TYPE: HC					
		PUMP MATERIAL: S-1					
		DRIVE TYPE: M					
		DRIVE HP: 100					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	6	0	65,400	0	0
		FREIGHT 3.0%			1,960		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	67,360	0	
310	P-102A/B	CONDENSATE PUMPS	12		74,700		
		GPM: 100					
		HD. FT.: 175					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: S-1					
		DRIVE TYPE: M					
		DRIVE HP: 10					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	12	0	74,700	0	0
		FREIGHT 3.0%			2,240		
		DEVELOPMENT 0.0%			0		
		TOTAL :	12	0	76,940	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY :

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 310	18	0	144,300	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	C-101	COMBUSTION AIR BLOWER, CS WITH DRIVER	6		5,250,000		
		COMP TYPE: CENTR					
		INLET CAP ACFM: 41263					
		INLET PSIG: 19.5					
		OUTLET PSIG: 37.5					
		GAS HANDLED: AIR					
		K VALVE (CP/CV): 1.40					
		MATERIAL: CS					
		DRIVER TYPE: STM TURB					
		DRIVER H.P. 3700					
		SOURCE: 3 ROOTS-DRESSER					
		SUBTOTAL :	6	0	5,250,000	0	0
		FREIGHT 3.0%			157,500		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	5,407,500	0	0
320	C-102A/C	PROCESS AIR COMPRESSOR WITH ST-102A/C DRIVER	3		11,460,000		
		COMP TYPE: AXIAL					
		INLET CAP ACFM: 287220					
		INLET PSIG: -0.22					
		OUTLET PSIG: 32					
		GAS HANDLED: AIR					
		K VALVE (CP/CV): 1.40					
		MATERIAL: CS					
		DRIVER TYPE: STM TURB					
		DRIVER H.P. 28500					
		SOURCE: 3 DRESSER RAND					
		SUBTOTAL :	3	0	11,460,000	0	0
		FREIGHT 3.0%			343,800		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	0	11,803,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TPT

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	320	9	0	17,211,300	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED B: TP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	F-101A/C	AIR FILTERS, 281200 ACFM EA AMERICAN AIR FILTER SOURCE: 3	3		1,101,600		
		SUBTOTAL :	3	0	1,101,600	0	0
		FREIGHT 3.0%			33,050		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	0	1,134,650	0	0
350	PK-102	FLUE GAS BAG HOUSE W/ INTEGRAL SOLIDS HOPPER [70 DEG ANGLE] & 2 ROTARY VALVES FLUE GAS: 276400 ACFM @ 350 DEG F & 11.1 PSIA MW 30.04 SOLIDS: 71182#/HR 100%< 100 MICRONS SOURCE: 3 CINO EQUIPMENT	6		8,100,000		
		SUBTOTAL :	6	0	8,100,000	0	0
		FREIGHT 3.0%			243,000		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	8,343,000	0	0

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED B : TS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 350	9	0	9,477,650	0	0

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC		JOB NO.	: 11-36265
LOCATION: WESTERN COLO		DATE	: 17-Apr-87
UNIT : RETORT UNIT SECT. 100		REV.	: 0
		PREPARED BY	: TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-101A/B	SPENT SHALE CONVEYOR, 680227 #/HR 350 DEG F 36" W X 150' L 20 HP COVERED UNIT W/ EXH. GAS CONN	12		777,600		
		SOURCE: 1					
		SUBTOTAL :	12	0	777,600	0	0
		FREIGHT 3.0%			23,330		
		DEVELOPMENT 0.0%			0		
		TOTAL :	12	0	800,930	0	0
360	CV-102A/B	FINES CONVEYOR, 71111 #/HR 24" W X 150' L 5HP COVERED UNIT W/ EXH GAS CONN	12		518,400		
		SOURCE: 1					
		SUBTOTAL :	12	0	518,400	0	0
		FREIGHT 3.0%			15,550		
		DEVELOPMENT 0.0%			0		
		TOTAL :	12	0	533,950	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : RETORT UNIT SECT. 100

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. :
PREPARED BY :

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
		TOTAL CODE: 360	24	0	1,334,880	0	0

FOSTER WHEELER USA CORP.

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. :
PREPARED BY : TAC

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RETORT UNIT SECT. 100

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
920	PK-101	INCINERATOR WASTE HEAT PKG. INCLUDING:	6			100,000,000	
		BOILER					
		ECONOMIZER					
		COMBUSTOR					
		FANS					
		DRIVES					
		FIELD CONSTRUCTION					
		SOURCE: 3 FWEC					
		SUBTOTAL :	6	0	0	100,000,000	0
		FREIGHT 0.0%					
		DEVELOPMENT 0.0%					
		TOTAL :	6	0	0	100,000,000	0
		TOTAL CODE: 920	6	0	0	100,000,000	0

Section 100 - RETORTING UNIT

BREAKDOWN OF SUBCONTRACT EQUIPMENT COSTS

Equipment Item	Number Required	Cost Per Vessel, $		
		Material	Labor	Total
R-101	6	421,000	454,200	875,200
V-103	6	227,800	306,000	533,800
V-104	6	2,187,400	1,889,400	4,076,800
V-105	6	1,510,000	1,584,200	3,094,300
V-106	6	322,700	360,200	682,900
V-108	6	220,600	147,100	367,700
V-101	6	232,600	930,400	1,163,000
PK-101	6	3,333,000	13,333,000	16,666,000

APPENDIX B-2

EQUIPMENT COST DATA

RAW OIL RECOVERY - UNIT 200

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY: MD/TAR/SS

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	1,660,200		1,660,200		5.8%
120	REACTORS, REGEN.,CONVER.					
130	DRUMS	273,000		273,000		1.0%
140	STORAGE TANKS					
150	TOWERS (FIELD FABRICATED)					
160	PROCESS DUCTS					
180	VESSEL TESTING					
190	SPECIAL VESSELS					
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	1,109,300		1,109,300		3.9%
220	DOUBLE PIPE EXCHANGERS					
230	AIR COOLED EXCHANGERS	7,484,000		7,484,000		26.3%
240	FIRED PROCESS EQUIPMENT					
270	VACUUM EQUIPMENT					
280	STM. TURBINE SURFACE COND.					
290	OTHER HEAT TRANSFER EQUIP.					
	MECHANICAL EQUIPMENT					
310	PUMPS	797,200		797,200		2.8%
320	COMPRESSORS					
330	ELECTRICAL GENERATORS					
340	MATERIALS HANDLING					
350	MATERIALS PROCESSING	16,483,200		16,483,200		57.9%
360	MATERIALS TRANSPORT	618,000		618,000		2.2%
370	THERMO/MECHANICAL					
380	DRIVERS					
390	OTHER MECHANICAL EQUIPMENT					
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST					
910	PACKAGE SYSTEMS	21,600		21,600		0.1%
920	UTILITY THERMAL SYSTEMS					
930	WATER TREATING					
940	WASTE TREATING					
950	BLDG. & MAINT. EQUIPMENT					
960	CATALYST & CHEMICALS					
	TOTAL EQUIPMENT	28,446,500		28,446,500		100.0%

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
110	T-201	FRACTIONATOR		6	871,800	1,276,200		
		TRAYS :15 SIEVE CS, 9 SHED 410SS				384,000		
		12'-6" X 71'-6"T/T						
		CLADDING 1/8" 410SS						
		VERT. OR HORIZ.:	VERT					
		SUPPORT:	SKIRT					
		MATERIAL:	SA387GR11					
		STRESS RELIEVE:	NO					
		X-RAY:	SPOT					
		JOINT EFF.:	85%					
		WALL THICKNESS:	7/8"					
		CORR. ALLOW.:	3/16"					
		DESIGN - PSIG/TEMP:	50/650;700;980					
		ASME CODE:	YES					
		NOZ/MW RATING:	150#					
		SOURCE:	IN-HOUSE					
			SUBTOTAL :	6	871,800	1,660,200		
		FREIGHT						
		DEVELOPMENT						
			TOTAL :	6	871,800	1,660,200		
		TOTAL CODE:	110	6	871,800	1,660,200		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-201	FRACTIONATOR OVERHEAD DRUM 10' X 12'-6"T/T	6	117,000	123,000		
		VERT. OR HORIZ.: VERT SUPPORT: SKIRT MATERIAL: A516GR70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 7/16" CORR. ALLOW.: 3/16" DESIGN - PSIG/TEMP: 50/170 ASME CODE: YES NOZ/MW RATING: 150# SOURCE: IN-HOUSE					
		SUBTOTAL :	6	117,000	123,000		
		FREIGHT DEVELOPMENT					
		TOTAL :	6	117,000	123,000		
130	D-202	CENTRATE ACCUMULATOR 7'-6" X 26'T/T CLADDING 1/8" 410SS	6	102,000	150,000		
		VERT. OR HORIZ.: HORIZ SUPPORT: SADDLES MATERIAL: A285GRC STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 1/4" CORR. ALLOW.: 0" DESIGN - PSIG/TEMP: 50/640 ASME CODE: YES NOZ/MW RATING: 150# SOURCE: IN-HOUSE					
		SUBTOTAL :	6	102,000	150,000		
		FREIGHT DEVELOPMENT					
		TOTAL :	6	102,000	150,000		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 130	12	219,000	273,000		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-202	MID PUMPAROUND COOLER	6		201,000		
		TYPE: BKU SHELL ID IN.: TUBE LENGTH FT.: 20 NO. OF SHELLS: 1 SQ. FT. PER SHELL: 2330 TOTAL SQ FT.: 2330 SHELL - PSIG/TEMP: 90/350 TUBE - PSIG/TEMP: 210/462 MATL. - SHELL/TUBE: CS/CS SOURCE: IN-HOUSE					
		SUBTOTAL :	6		201,000		
		FREIGHT 3.0% DEVELOPMENT			6,030		
		TOTAL :	6		207,030		
210	E-203	SPONGE OIL COOLER	6		50,400		
		TYPE: AES SHELL ID IN.: TUBE LENGTH FT.: 10 NO. OF SHELLS: 1 SQ. FT. PER SHELL: 254 TOTAL SQ FT.: 254 SHELL - PSIG/TEMP: 200/331 TUBE - PSIG/TEMP: 210/410 MATL. - SHELL/TUBE: CS/CS SOURCE: IN-HOUSE					
		SUBTOTAL :	6		50,400		
		FREIGHT 3.0% DEVELOPMENT			1,510		
		TOTAL :	6		51,910		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-205	BOTTOM PUMPAROUND COOLER	6		540,600		

TYPE: BKU
SHELL ID IN.:
TUBE LENGTH FT.: 20
NO. OF SHELLS: 1
SQ. FT. PER SHELL: 4705
TOTAL SQ FT.: 4705
SHELL - PSIG/TEMP: 175/416
TUBE - PSIG/TEMP: 220/640
MATL. - SHELL/TUBE: CS 410CLAD/5CR-1/2MO
SOURCE: IN-HOUSE

		SUBTOTAL :	6		540,600		
		FREIGHT 3.0%			16,220		
		DEVELOPMENT					
		TOTAL :	6		556,820		

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-206	BOTTOMS COOLER	6		285,000		

TYPE: AES
SHELL ID IN.:
TUBE LENGTH FT.: 12
NO. OF SHELLS: 3
SQ. FT. PER SHELL: 552
TOTAL SQ FT.: 1656
SHELL - PSIG/TEMP: 200/366
TUBE - PSIG/TEMP: 220/480
MATL. - SHELL/TUBE: CS/CS
SOURCE: IN-HOUSE

		SUBTOTAL :	6		285,000		
		FREIGHT 3.0%			8,550		
		DEVELOPMENT					
		TOTAL :	6		293,550		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	210	24		1,109,310		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-201	OVERHEAD CONDENSER		6		6,806,400		
		PLOT AREA SQ FT.:						
		NO. OF BAYS:	6					
		TOTAL SQ FT.:	20110					
		PSIG:	50					
		MATERIAL:	316SS					
		NO. OF FANS:	12					
		NO. OF MOTERS:	12					
		HP EACH:	30					
		SOURCE:	IN-HOUSE					
			SUBTOTAL :	6		6,806,400		
		FREIGHT DEVELOPMENT	3.0%			204,190		
			TOTAL :	6		7,010,590		
230	E-204	SPONGE OIL AFTERCOOLER		6		198,000		
		PLOT AREA SQ FT.:						
		NO. OF BAYS:	1					
		TOTAL SQ FT.:	312					
		PSIG:	210					
		MATERIAL:	CS					
		NO. OF FANS:	2					
		NO. OF MOTERS:	2					
		HP EACH:	5					
		SOURCE:	IN-HOUSE					
			SUBTOTAL :	6		198,000		
		FREIGHT DEVELOPMENT	3.0%			5,940		
			TOTAL :	6		203,940		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-207	BOTTOMS AFTERCOOLER	6		261,600		
		PLOT AREA SQ FT.:					
		NO. OF BAYS: 1					
		TOTAL SQ FT.: 690					
		PSIG: 220					
		MATERIAL: CS					
		NO. OF FANS: 2					
		NO. OF MOTERS: 2					
		HP EACH: 10					
		SOURCE: IN-HOUSE					
		SUBTOTAL	6		261,600		
		FREIGHT 3.0%			7,850		
		DEVELOPMENT					
		TOTAL	6		269,450		
		TOTAL CODE: 230	18		7,483,980		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-201	CENTRATE PUMP	12	36,000	255,600		
		GPM: 1780					
		HD. FT.: 410					
		PSI: 146					
		S.G.: 0.73					
		PUMP TYPE: API					
		PUMP MATERIAL: CS/12CR					
		DRIVE TYPE: MOTOR					
		DRIVE HP: 200					
		SHOP OR FIELD MT.: SHOP					
		SOURCE: IN-HOUSE					
		SUBTOTAL	12	36,000	255,600		
		FREIGHT 3.0%			7,670		
		DEVELOPMENT					
		TOTAL	12	36,000	263,270		
310	P-202	MID PUMPAROUND PUMP	12	36,000	219,600		
		GPM: 1895					
		HD. FT.: 353					
		PSI: 143					
		S.G.: .74					
		PUMP TYPE: API					
		PUMP MATERIAL: CS/CI					
		DRIVE TYPE: MOTOR					
		DRIVE HP: 200					
		SHOP OR FIELD MT.: SHOP					
		SOURCE: IN-HOUSE					
		SUBTOTAL	12	36,000	219,600		
		FREIGHT 3.0%			6,590		
		DEVELOPMENT					
		TOTAL	12	36,000	226,190		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-203	REFLUX PUMP	12	13,200	104,400		
		GPM: 176					
		HD. FT.: 320					
		PSI: 115					
		S.G.: .795					
		PUMP TYPE: API					
		PUMP MATERIAL: CS/NIRESIST					
		DRIVE TYPE: MOTOR					
		DRIVE HP: 30					
		SHOP OR FIELD MT.: SHOP					
		SOURCE: IN-HOUSE					
		SUBTOTAL :	12	13,200	104,400		
		FREIGHT 3.0%			3,130		
		DEVELOPMENT					
		TOTAL :	12	13,200	107,530		
310	P-204	SOUR WATER PUMP	12	10,800	94,800		
		GPM: 111					
		HD. FT.: 217					
		PSI: 99					
		S.G.: .989					
		PUMP TYPE: API					
		PUMP MATERIAL: CS/NI RESIST					
		DRIVE TYPE: MOTOR					
		DRIVE HP: 15					
		SHOP OR FIELD MT.: SHOP					
		SOURCE: IN-HOUSE					
		SUBTOTAL :	12	10,800	94,800		
		FREIGHT 3.0%			2,840		
		DEVELOPMENT					
		TOTAL :	12	10,800	97,640		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-205	SPONGE OIL BOOSTR PUMP	12	12,000	99,600		
		GPM: 50					
		HD. FT.: 370					
		PSI: 223					
		S.G.: .86					
		PUMP TYPE: API					
		PUMP MATERIAL: CS/CI					
		DRIVE TYPE: MOTOR					
		DRIVE HP: 20					
		SHOP OR FIELD MT.: SHOP					
		SOURCE: IN-HOUSE					
		SUBTOTAL	12	12,000	99,600		
		FREIGHT 3.0%			2,990		
		DEVELOPMENT					
		TOTAL	12	12,000	102,590		
		TOTAL CODE: 310	60	108,000	797,220		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	PG-201	CENTRIFUGE PACKAGE	24		16,320,000		
		GPM 510 LIQUID DENSITY 45.5#/CF SOLID DENSITY 138#/CF PERCENT SOLIDS 3.95WT% TEMP 590F PRESS 5PSIG 304LSS 200HP SHARPLES OR EQUAL					
		SUBTOTAL :	24		16,320,000		
		FREIGHT 1.0%			163,200		
		DEVELOPMENT					
		TOTAL :	24		16,483,200		
		TOTAL CODE: 350	24		16,483,200		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CR-201	SCREW FEEDER	24		360,000		
		CAPACITY 14GPM MOTOR DRIVE DRIVER HP 15 FLUID TEMP 590F MAT'L 304LSS DENSITY 85.8#S/FT3 PERCENT SOLIDS 70% TYPE SCREW CONVEYOR SIZE 9" DIA					
		SUBTOTAL	24		360,000		
		FREIGHT 3.0%			10,800		
		DEVELOPMENT					
		TOTAL	24		370,800		
360	IF-201	SOLID CAKE INJECTION FEEDER	24		240,000		
		CAPACITY 14GPM TYPE POS DIS SCREW FEEDER DRIVER TYPE MOTOR DRIVER HP 15 FLUID TEMP 590F INLET PSIG 0 OUTLET PSIG 50 DENSITY 85.8#/FT3 PERCENT SOLIDS 70% MATERIAL 304LSS					
		SUBTOTAL	24		240,000		
		FREIGHT 3.0%			7,200		
		DEVELOPMENT					
		TOTAL	24		247,200		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 360	48		618,000		

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : SECTION 200 - RAW OIL RECOVERY

JOB NO. : 11-36265
DATE : 23-Apr-87
REV. : 0
PREPARED BY : MKD/TAR/SS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
910	PG-202	CORROSION INHIBITOR PACKAGE	6		21,000		
		CAPACITY 0-30GPM POLYSULFIDE INJECTION VESSEL AND PUMP					
		SUBTOTAL	6		21,000		
		FREIGHT 3.0%			630		
		DEVELOPMENT					
		TOTAL	6		21,630		
		TOTAL CODE: 910	6		21,630		

APPENDIX B-3

EQUIPMENT COST DATA

GAS TREATING - UNIT 300

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. :
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	126,800	0	126,800	0	1.0%
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	277,800	0	277,800	0	2.2%
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	1,036,200	0	1,036,200	0	8.0%
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	86,100	0	86,100	0	0.7%
320	COMPRESSORS	11,391,800	0	11,391,800	0	88.2%
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	12,918,700	0	12,918,700	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
* REV. :
PREPARED B[illegible] :TA[illegible]

EQUIPMENT DETAIL

FW	ITEM	DESCRIPTION	QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
CODE					MATERIALS	SUBCONTRACT	DIRECT LABOR
NO.	NO.				COST	D&E	MANHOURS
110	T-301	SPONGE ABSORBER	2	58,600	85,200		
		4'6" DIA X 65' T/T					
		W/ 25 410SS VALVE TRAYS					
		VERT. OR HORIZ.: V					
		SUPPORT: SKIRT					
		MATERIAL: SA-516-70					
		STRESS RELIEVE: NO					
		X-RAY: SPOT					
		JOINT EFF.: 85%					
		WALL THICKNESS: 1/2"					
		CORR. ALLOW.: 3/16"					
		DESIGN - PSIG/TEMP: 140/210					
		ASME CODE: VIII D1					
		NOZ/MW RATING: 150#					
		SOURCE: 1					
		SUBTOTAL	2	58,600	85,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	58,600	85,200	0	0
110	T-302	AMMONIA SCRUBBER	2	18,200	41,600		
		3'6" DIA X 24' T/T					
		W/ 125 FT3 1" 410 SS					
		VERT. OR HORIZ.: V					
		SUPPORT: SKIRT					
		MATERIAL: SA-516-70					
		STRESS RELIEVE: NO					
		X-RAY: SPOT					
		JOINT EFF.: 85%					
		WALL THICKNESS: 7/16"					
		CORR. ALLOW.: 3/16"					
		DESIGN - PSIG/TEMP: 135/170					
		ASME CODE: VIII D1					
		NOZ/MW RATING: 150#					
		SOURCE: 1					
		SUBTOTAL	2	18,200	41,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	18,200	41,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
* REV. :
PREPARED B :TA?

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 110	4	76,800	126,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
* REV. :
PREPARED BY :TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-301	FEED KO DRUM 13'6" DIA X 12' T/T W/ 4" CWM PAD TP316 SS	2	82,800	108,200		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: YES X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 9/16" CORR. ALLOW.: .25" DESIGN - PSIG/TEMP: 30/170 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	82,800	108,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	82,800	108,200	0	0
130	D-302	FIRST STAGE KO DRUM 10'6" DIA X 11' T/T W/ 316 SS CWM PADS	2	48,800	67,800		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: YES X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 1/2" CORR. ALLOW.: .25" DESIGN - PSIG/TEMP: 45/170 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	48,800	67,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	48,800	67,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
* REV. :
PREPARED BY :TAK

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
130	D-303	SECOND STAGE KO DRUM 8' DIA X 12' T/T W/ 316 SS CWM PAD		2	29,300	46,200		
		VERT. OR HORIZ.:	V					
		SUPPORT:	LEGS					
		MATERIAL:	SA-516-70					
		STRESS RELIEVE:	YES					
		X-RAY:	SPOT					
		JOINT EFF.:	85%					
		WALL THICKNESS:	9/16"					
		CORR. ALLOW.:	.25"					
		DESIGN - PSIG/TEMP:	80/170					
		ASME CODE:	VIII D1					
		NOZ/MW RATING:	150#					
		SOURCE:	1					
			SUBTOTAL :	2	29,300	46,200	0	0
		FREIGHT	0.0%			0		
		DEVELOPMENT	0.0%			0		
			TOTAL :	2	29,300	46,200	0	0
130	D-304	THIRD STAGE KO DRUM 4'6" DIA X 11' T/T W/ 316 SS CWM PAD		2	13,700	24,600		
		VERT. OR HORIZ.:	V					
		SUPPORT:	LEGS					
		MATERIAL:	SA-516-70					
		STRESS RELIEVE:	YES					
		X-RAY:	SPOT					
		JOINT EFF.:	85%					
		WALL THICKNESS:	9/16"					
		CORR. ALLOW.:	.25"					
		DESIGN - PSIG/TEMP:	146/170					
		ASME CODE:	VIII D1					
		NOZ/MW RATING:	150#					
		SOURCE:	1					
			SUBTOTAL :	2	13,700	24,600	0	0
		FREIGHT	0.0%			0		
		DEVELOPMENT	0.0%			0		
			TOTAL :	2	13,700	24,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. : 11-36265
DATE : 09-Apr-87
* REV. :
PREPARED BY : TAE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-305	ABSORBER GAS SEPARATOR 4' DIA X 10' T/T	2	10,200	16,400		
		VERT. OR HORIZ.: V SUPPORT: LEGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 1/2" CORR. ALLOW.: .25" DESIGN - PSIG/TEMP: 135/170 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	10,200	16,400	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	10,200	16,400	0	0
130	D-306	SETTLING DRUM 4'6" DIA X 10'T/T W/ SEGM. BAFFLE	2	11,300	14,600		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/8" CORR. ALLOW.: .25" DESIGN - PSIG/TEMP: 50/170 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	11,300	14,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	11,300	14,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
REV. :
PREPARED BY :TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	130	12	196,100	277,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
* REV. :
PREPARED BY :TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-301	FIRST STAGE AFTERCOOLER	2		453,800		
		TOTAL BARE SQ FT.: 6203 NO. OF BAYS: 2 TUBE MATERIAL: CS TUBE LENGTH: 32' PLOT SIZE: 28' X 32' NO. OF FANS/BAY: 2 HP EACH: 20 PRESS/TEMP: 45/307 SOURCE: 1					
		SUBTOTAL :	2	0	453,800	0	0
		FREIGHT 3.0%			13,610		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	467,410	0	0
230	E-302	SECOND STAGE AFTERCOOLER	2		386,600		
		TOTAL BARE SQ FT.: 4622 NO. OF BAYS: 2 TUBE MATERIAL: CS TUBE LENGTH: 24' PLOT SIZE: 40' X 24' NO. OF FANS/BAY: 2 HP EACH: 30 PRESS/TEMP: 80/313 SOURCE: 1					
		SUBTOTAL :	2	0	386,600	0	0
		FREIGHT 3.0%			11,600		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	398,200	0	0

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
REV. :
PREPARED BY :TA[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-303	THIRD STAGE AFTERCOOLER	2		120,400		
		TOTAL BARE SQ FT.: 1176 NO. OF BAYS: 1 TUBE MATERIAL: CS TUBE LENGTH: 24' PLOT SIZE: 10' X 24' NO. OF FANS/BAY: 2 HP EACH: 20 PRESS/TEMP: 146/282 SOURCE: 1					
		SUBTOTAL :	2	0	120,400	0	0
		FREIGHT 3.0%			3,610		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	124,010	0	0
230	E-304	ABSORBER GAS COOLER	2		45,200		
		TOTAL BARE SQ FT.: 110 NO. OF BAYS: 1 TUBE MATERIAL: CS TUBE LENGTH: 6' PLOT SIZE: 6' X 6' NO. OF FANS/BAY: 1 HP EACH: 5 PRESS/TEMP: 135/181 SOURCE: 1					
		SUBTOTAL :	2	0	45,200	0	0
		FREIGHT 3.0%			1,360		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	46,560	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
* REV. :
PREPARED BY :TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 230	8	0	1,036,180	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
* REV. :
PREPARED B :TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-301A/B	FEED KO DRUM PUMP	4		38,400		
		GPM: 30					
		HD. FT.: 104					
		PSI:					
		S.G.: .80					
		PUMP TYPE: HC					
		PUMP MATERIAL: 316 SS					
		DRIVE TYPE: M					
		DRIVE HP: 3					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	38,400	0	0
		FREIGHT 3.0%			1,150		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	39,550	0	0
310	P-302A/B	SOUR WATER PUMP	4		38,800		
		GPM: 37					
		HD. FT.: 208					
		PSI:					
		S.G.: .989					
		PUMP TYPE: HC					
		PUMP MATERIAL: 316 SS					
		DRIVE TYPE: M					
		DRIVE HP: 7 1/2					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	38,800	0	0
		FREIGHT 3.0%			1,160		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	39,960	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
* REV. :
PREPARED BY :TAK

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-303A/B	SKIMMED OIL PUMP	4		6,400		
		GPM: 18					
		HD. FT.: 314					
		PSI:					
		S.G.: .795					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS/CI					
		DRIVE TYPE: M					
		DRIVE HP: 5					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	6,400	0	0
		FREIGHT 3.0%			190		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	6,590	0	0
		TOTAL CODE: 310	12	0	86,100	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
* REV. :
PREPARED BY :TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	C-301A/B	FIRST STAGE COMPRESSOR W/ DRIVER (INCL. COST OF C-302A/B & C-303A/B)	2		11,060,000		
		COMP TYPE: CENTRIF					
		INLET CAP ACFM: 70013					
		INLET PSIG: 0.3					
		OUTLET PSIG: 18.6					
		GAS HANDLED: HYDROCARB					
		K VALVE (CP/CV): 1.2					
		MATERIAL: CS/17-4PH					
		DRIVER TYPE: M					
		DRIVER H.P. 13500					
		SOURCE: 3					
		SUBTOTAL :	2	0	11,060,000	0	0
		FREIGHT 3.0%			331,800		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	11,391,800	0	0
320	C-302A/B	SECOND STAGE COMPRESSOR (COST W/ C-101A/B)	2		0		
		COMP TYPE: CENTRIF					
		INLET CAP ACFM: 28837					
		INLET PSIG: 13.6					
		OUTLET PSIG: 55					
		GAS HANDLED: HYDROCARB					
		K VALVE (CP/CV): 1.20					
		MATERIAL: CS/17-4PH					
		DRIVER TYPE: M					
		DRIVER H.P. W/C-301A/B					
		SOURCE: 3					
		SUBTOTAL :	2	0	0	0	0
		FREIGHT 3.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : GAS TREATING SECT. 300

JOB NO. :11-36265
DATE : 09-Apr-87
REV. :
PREPARED BY :TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	C-303A/B	THIRD STAGE COMPRESSOR (COST W/ C-101A/B)	2		0		
		COMP TYPE: CENTRIF INLET CAP ACFM: 4135 INLET PSIG: 50 OUTLET PSIG: 121 GAS HANDLED: HYDROCARB K VALVE (CP/CV): 1.20 MATERIAL: CS DRIVER TYPE: M DRIVER H.P. W/C-301A/B SOURCE: 3					
		SUBTOTAL :	2	0	0	0	0
		FREIGHT 3.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	0	0
		TOTAL CODE: 320	6	0	11,391,800	0	0

APPENDIX B-4

EQUIPMENT COST DATA

RAW OIL HYDROTREATING - UNIT 400

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	113,800	0	113,800	0	0.3%
120	REACTORS, REGEN.,CONVER.	17,143,200	0	17,143,200	0	43.9%
130	DRUMS	921,600	0	921,600	0	2.4%
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	2,119,500	0	2,119,500	0	5.4%
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	1,533,900	0	1,533,900	0	3.9%
240	FIRED PROCESS EQUIPMENT	3,502,000	0	3,502,000	0	9.0%
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	2,707,900	0	2,707,900	0	6.9%
320	COMPRESSORS	10,300,000	0	10,300,000	0	26.4%
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	721,000	0	721,000	0	1.8%
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	39,062,900	0	39,062,900	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
110	T-401	H2S STRIPPER 5.5' I.D. X 47' T.L. X 1/2 " TK	2	50,340	113,800		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: YES X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 1/2" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 150/440 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	50,340	113,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	50,340	113,800	0	0
		TOTAL CODE: 110	2	50,340	113,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
120	R-401A	REACTOR GUARD BED 10'6" DIA X 20' T/T X 9 9/16" TK W/ CLAD 1/4" TP347SS VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: 2 1/4CR - 1MO. SA-336F22 STRESS RELIEVE: YES X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 9 9/16" CORR. ALLOW.: W/ 347SS CLAD DESIGN - PSIG/TEMP: 3115/825 ASME CODE: VIII D2 NOZ/MW RATING: SOURCE: 1	2	889,320	2,067,600		
		SUBTOTAL :	2	889,320	2,067,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	889,320	2,067,600	0	0
120	R-401B	REACTOR GUARD BED DUPLICATE OF R-401A	2	889,320	2,067,600		
		SUBTOTAL :	2	889,320	2,067,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	889,320	2,067,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
120	R-402	FIRST STAGE REACTOR 10.5' DIA X 85' T.L. X 11" TK W/ CLAD 1/4" TP347SS	2	3,130,940	6,504,000		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: 2 1/4CR - 1/2MO STRESS RELIEVE: YES X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 11" TK CORR. ALLOW.: W/ 347SS CLAD DESIGN - PSIG/TEMP: 3115/875 ASME CODE: VIII D2 NOZ/MW RATING: SOURCE: 1					
		SUBTOTAL :	2	3,130,940	6,504,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	3,130,940	6,504,000	0	0
120	R-403	SECOND STAGE REACTOR DUPLICATE OF R-402	2	3,130,940	6,504,000		
		SUBTOTAL :	2	3,130,940	6,504,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	3,130,940	6,504,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 120	8	8,040,520	17,143,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-401	HIGH PRESSURE SEPARATOR 6.5' ID X 25' T.L. X 6 3/4" TK	2	430,660	516,800		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: YES X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 6 3/4" CORR. ALLOW.: .25" DESIGN - PSIG/TEMP: 2680/200 ASME CODE: VIII D2 NOZ/MW RATING: 2500# SOURCE: 1					
		SUBTOTAL :	2	430,660	516,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	430,660	516,800	0	0
130	D-402	STEAM DRUM 6.5' ID X 26' T.L. X 9/16" TK	2	38,100	42,000		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 9/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: 190/412 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	38,100	42,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	38,100	42,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-403	KNOCKOUT DRUM 6.5' ID X 10' T.L. X 6 3/4" TK	2	235,440	294,400		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: YES X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 6 3/4" CORR. ALLOW.: .25" DESIGN - PSIG/TEMP: 2680/200 ASME CODE: VIII D2 NOZ/MW RATING: 2500# SOURCE: 1					
		SUBTOTAL :	2	235,440	294,400	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	235,440	294,400	0	0
130	D-406	CONDENSATE DRUM 4.5' ID X 11.5' T.L. 5/16" TK	2	9,280	15,400		
		VERT. OR HORIZ.: V SUPPORT: LEGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 5/16" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 28/250 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	9,280	15,400	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	9,280	15,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-407	LOW PRESSURE SEPARATOR 5' ID X 25' T.L. X 1/2" TK	2	28,300	39,600		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 1/2" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 200/200 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL	2	28,300	39,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	28,300	39,600	0	0
130	D-408	STRIPPER REFLUX DRUM 4' ID X 10' T.L. X 3/8" TK	2	9,500	13,400		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/8" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 145/170 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL	2	9,500	13,400	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	9,500	13,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	130	12	751,280	921,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-401	FEED/EFFLUENT EXCHANGER	2		1,641,200		

TYPE: AES
SHELL ID IN.: 60"
TUBE LENGTH FT.: 20'
NO. OF SHELLS: 2
SQ. FT. PER SHELL:
TOTAL SQ FT.: 20640
SHELL - PSIG/TEMP: 2795/975
TUBE - PSIG/TEMP: 3290/775
MATL. - SHELL/TUBE: 2 1/4CR - 1MO W/347SS CLAD /321SS
SOURCE: 1

			QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
		SUBTOTAL	2	0	1,641,200	0	0
		FREIGHT 3.0%			49,240		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	1,690,440	0	0

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-402	REACTOR EFFLUENT/ STRIPPER FEED EXCHANGER	2		416,600		

TYPE: AES
SHELL ID IN.: 42"
TUBE LENGTH FT.: 20'
NO. OF SHELLS: 2
SQ. FT. PER SHELL:
TOTAL SQ FT.: 9230
SHELL - PSIG/TEMP: 210/235
TUBE - PSIG/TEMP: 2750/510
MATL. - SHELL/TUBE: CS W/ 1/8"CA - CHANNEL CS/ 1/4"CA /304SS
SOURCE: 1

			QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
		SUBTOTAL	2	0	416,600	0	0
		FREIGHT 3.0%			12,500		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	429,100	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	210	4	0	2,119,540	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-403	EFFLUENT COOLER	2		1,325,400		
		TOTAL BARE SQ FT.: 15750					
		NO. OF BAYS: 6					
		TUBE MATERIAL: 304SS					
		TUBE LENGTH: 32'					
		PLOT SIZE: 84' X 32'					
		NO. OF FANS/BAY: 2					
		HP EACH: 15					
		PRESS/TEMP: 2680/354					
		SOURCE: 1					
		SUBTOTAL	2	0	1,325,400	0	0
		FREIGHT 3.0%			39,760		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	1,365,160	0	0
230	E-404	STRIPPER CONDENSER	2		163,800		
		TOTAL BARE SQ FT.: 1926					
		NO. OF BAYS: 1					
		TUBE MATERIAL: CS					
		TUBE LENGTH: 24'					
		PLOT SIZE: 14' X 24'					
		NO. OF FANS/BAY: 2					
		HP EACH: 25					
		PRESS/TEMP: 150/442					
		SOURCE: 1					
		SUBTOTAL	2	0	163,800	0	0
		FREIGHT 3.0%			4,910		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	168,710	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	230	4	0	1,533,870	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 17-Apr-87
REV. : 0
PREPARED BY : TAL

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
240	H-401	REACTOR CHARGE HEATER	2		3,400,000		
		TYPE: VC TUBE MATERIAL: 321SS W/.1" CA INLET: 2933 PSIG/ 725 DEG F DISCHARGE: 2853 PSIG / 825 DEG F 21.1 MM BTU/HR - PROCESS 11.4 MM BTU/HR - STM. COIL SOURCE: 1					
		SUBTOTAL :	2	0	3,400,000	0	0
		FREIGHT 3.0%			102,000		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	3,502,000	0	0
		TOTAL CODE: 240	2	0	3,502,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-401 A/B/C	FEED PUMP	6		1,350,000		
		GPM: 435					
		HD. FT.: 7718					
		PSI: 2990					
		S.G.: .865					
		PUMP TYPE: CENTIF					
		PUMP MATERIAL: CS/CI					
		DRIVE TYPE: M & PRT					
		DRIVE HP: 1250					
		SHOP OR FIELD MT.: F					
		SOURCE: 3 WORTHINGTON					
		SUBTOTAL :	6	0	1,350,000	0	0
		FREIGHT 3.0%			40,500		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	1,390,500	0	0
310	P-404 A/B	INJ. WATER PUMP	4		1,100,000		
		GPM: 230					
		HD. FT.: 5900					
		PSI: 2510					
		S.G.: .989					
		PUMP TYPE: RECIP					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 500					
		SHOP OR FIELD MT.: F					
		SOURCE: 3 WORTHINGTON					
		SUBTOTAL :	4	0	1,100,000	0	0
		FREIGHT 3.0%			33,000		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	1,133,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY. : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-405 A/B	REFLUX PUMP	4		30,400		

GPM: 104
HD. FT.: 148
PSI: 161
S.G.: .6
PUMP TYPE: CENTIF
PUMP MATERIAL: CS
DRIVE TYPE: M
DRIVE HP: 7 1/2
SHOP OR FIELD MT.: F
SOURCE: 1

		QTY	WEIGHT	MATERIALS COST	SUBCONTRACT D&E	DIRECT LABOR MANHOURS
SUBTOTAL		4	0	30,400	0	0
FREIGHT	3.0%			910		
DEVELOPMENT	0.0%			0		
TOTAL		4	0	31,310	0	0

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-406 A/B	BFW PUMP	4		35,200		

GPM: 335
HD. FT.: 119
PSI: 277
S.G.: .881
PUMP TYPE: CENTIF
PUMP MATERIAL: CS
DRIVE TYPE: M
DRIVE HP: 20
SHOP OR FIELD MT.: F
SOURCE: 1

		QTY	WEIGHT	MATERIALS COST	SUBCONTRACT D&E	DIRECT LABOR MANHOURS
SUBTOTAL		4	0	35,200	0	0
FREIGHT	3.0%			1,060		
DEVELOPMENT	0.0%			0		
TOTAL		4	0	36,260	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	PG-401	POLYSULFIDE INJ. PACKAGE INCLUDING P-403 & D-405	2		22,200		
		GPM: 10 - 60 GPD					
		HD. FT.: 47					
		PSI: 20					
		S.G.: 1.33					
		PUMP TYPE: METER					
		PUMP MATERIAL: 316SS					
		DRIVE TYPE: M					
		DRIVE HP: 1					
		SHOP OR FIELD MT.: F					
		SOURCE: 1					
		SUBTOTAL	2	0	22,200	0	0
		FREIGHT 3.0%			670		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	22,870	0	
310	PG-402	SULFIDE INJ. PACKAGE INCLUDING P-402 & D-404	2		91,200		
		GPM: 3-15					
		HD. FT.: 7882					
		PSI: 2900					
		S.G.: .85					
		PUMP TYPE: METER					
		PUMP MATERIAL: 316SS					
		DRIVE TYPE: M					
		DRIVE HP: 40					
		SHOP OR FIELD MT.: F					
		SOURCE: 1					
		SUBTOTAL	2	0	91,200	0	0
		FREIGHT 3.0%			2,740		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	93,940	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 310	22	0	2,707,880	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	C-401 A/B	RECYCLE COMPRESSOR	4		10,000,000		
		COMP TYPE: CENTRI					
		INLET CAP ACFM: 2542					
		INLET PSIG: 2440					
		OUTLET PSIG: 2995					
		GAS HANDLED:					
		K VALVE (CP/CV): 1.39					
		MATERIAL: CS OR CI					
		DRIVER TYPE: STM TURBINE					
		DRIVER H.P. 5000					
		SOURCE: 1					
		SUBTOTAL	4	0	10,000,000	0	0
		FREIGHT 3.0%			300,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	10,300,000	0	0
		TOTAL CODE: 320	4	0	10,300,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROTREATING - SECTION 400

JOB NO. : 11-36265
DATE : 09-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
380	RT-401 A/B	POWER RECOVERY TURBINE	4		700,000		

GPM: (INLET) 457
HD. FT.:
PSI: 2440/185 (IN/OUT)
LIQUID DENSITY: 48#/FT3
PUMP TYPE:
PUMP MATERIAL: CS
DRIVE TYPE:
DRIVE HP: 360
SHOP OR FIELD MT.: F
SOURCE: 3
WORTHINGTON

		QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL		4	0	700,000	0	0
FREIGHT	3.0%			21,000		
DEVELOPMENT	0.0%			0		
TOTAL		4	0	721,000	0	0
TOTAL CODE: 380		4	0	721,000	0	0

APPENDIX B-5

EQUIPMENT COST DATA

HYDROTREATED OIL FRACTIONATION - UNIT 500

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 22-Apr-87
REV. : 0
PREPARED BY: T.A.R.

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	685,800	0	685,800	0	10.4%
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	70,200	0	70,200	0	1.1%
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	434,700	0	434,700	0	6.6%
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	1,253,900	0	1,253,900	0	19.0%
240	FIRED PROCESS EQUIPMENT	3,914,000	0	3,914,000	0	59.3%
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	237,900	0	237,900	0	3.6%
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	6,596,500	0	6,596,500	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
110	T-501	FRACTIONATOR 16.5' DIA. x 87' T/T x 7/16" THK. W/24 BUBBLE CAP TRAYS	2	243,000	685,800		
		VERT. OR HORIZ.: VERT. SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 7/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: 40/351/660 ASME CODE: VIII DI NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	243,000	685,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	243,000	685,800	0	0
		TOTAL CODE: 110	2	243,000	685,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-501	FRACTIONATOR OVERHEAD DRUM 9.5' x 20'T/T x 5/16"THK. WITH BOOT	2	34,420	31,000		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: CS STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 5/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: 30/203 ASME CODE: VIII DI NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	34,420	31,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	34,420	31,000	0	0
130	D-502	STEAM DRUM 6.5' x 26' x 11/16"THK.	2	45,080	39,200		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: CS STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 11/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: 190/420 ASME CODE: VIII DI NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	45,080	39,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	45,080	39,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 130	4	79,500	70,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-501	FEED/PRODUCT EXCHANGER	2		282,600		
		TYPE: AES SHELL ID IN.: 35" TUBE LENGTH FT.: 20 NO. OF SHELLS: 4 SQ. FT. PER SHELL: 3356 TOTAL SQ FT.: 13424 SHELL - PSIG/TEMP: 180/560 TUBE - PSIG/TEMP: 50/550 MATL. - SHELL/TUBE: CS SOURCE: 1					
		SUBTOTAL	2	0	282,600	0	0
		FREIGHT 3.0%			8,480		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	291,080	0	0
210	E-502	BOILER FEEDWATER PREHEATER	2		85,000		
		TYPE: AES SHELL ID IN.: 41 TUBE LENGTH FT.: 20 NO. OF SHELLS: 1 SQ. FT. PER SHELL: 4615 TOTAL SQ FT.: 4615 SHELL - PSIG/TEMP: /360 TUBE - PSIG/TEMP: 180/400 MATL. - SHELL/TUBE: CS SOURCE: 1					
		SUBTOTAL	2	0	85,000	0	0
		FREIGHT 3.0%			2,550		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	87,550	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-506	BOTTOMS PRODUCT/LP STEAM GENERATO	2		54,400		

TYPE: AKT
SHELL ID IN.: 21"
TUBE LENGTH FT.: 16'
NO. OF SHELLS: 1
SQ. FT. PER SHELL: 1151
TOTAL SQ FT.: 1151
SHELL - PSIG/TEMP: 85/355
TUBE - PSIG/TEMP: 180/500
MATL. - SHELL/TUBE: CS
SOURCE: 1

		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
SUBTOTAL		2	0	54,400	0	0
FREIGHT	3.0%			1,630		
DEVELOPMENT	0.0%			0		
TOTAL		2	0	56,030	0	0
TOTAL CODE: 210		6	0	434,660	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-503	FRACT. OVHD. COND.	2		644,800		
		TOTAL BARE SQ FT.: 9363					
		NO. OF BAYS: 3					
		TUBE MATERIAL: CS W/AL FINS					
		TUBE LENGTH: 32'					
		PLOT SIZE: 42 X 32					
		NO. OF FANS/BAY: 2					
		HP EACH: 25					
		PRESS/TEMP: 40/351					
		SOURCE: 1					
		SUBTOTAL :	2	0	644,800	0	0
		FREIGHT 3.0%			19,340		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	664,140	0	0
230	E-504	DIESEL PRODUCT COOLER	2		118,800		
		TOTAL BARE SQ FT.: 1175					
		NO. OF BAYS: 1					
		TUBE MATERIAL: CS W/AL FINS					
		TUBE LENGTH: 24'					
		PLOT SIZE: 10 X 24					
		NO. OF FANS/BAY: 2					
		HP EACH: 15					
		PRESS/TEMP: 140/455					
		SOURCE: 1					
		SUBTOTAL :	2	0	118,800	0	0
		FREIGHT 3.0%			3,560		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	122,360	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-505	FRACTIONATTOR BOTTOMS COOLER	2		394,600		
		TOTAL BARE SQ FT.: 4984 NO. OF BAYS: 2 TUBE MATERIAL: CS W/AL FINS TUBE LENGTH: 30 PLOT SIZE: 28 X 30 NO. OF FANS/BAY: 2 HP EACH: 15 PRESS/TEMP: 180/292 SOURCE: 1					
		SUBTOTAL :	2	0	394,600	0	0
		FREIGHT 3.0%			11,840		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	406,440	0	0
230	E-507	NAPHTHA PRODUCT COOLER	2		59,200		
		TOTAL BARE SQ FT.: 311 NO. OF BAYS: 1 TUBE MATERIAL: CS W/AL FINS TUBE LENGTH: 10 PLOT SIZE: 10 X 10 NO. OF FANS/BAY: 1 HP EACH: 15 PRESS/TEMP: 135/207 SOURCE: 1					
		SUBTOTAL :	2	0	59,200	0	0
		FREIGHT 3.0%			1,780		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	60,980	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 230	8	0	1,253,920	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
240	H-501	FRACTIONATOR REBOILER BOX HEATER	2		3,800,000		

CAPACITY 79.3 MM BTU/HR.
TUBE MAT. 1.25 CR.-.50 MO.,CS<800 DEG. F.
INLET TEMP. 537 DEG. F.
INLET PRESS. 110 PSIG
OUTLET TEMP. 610 DEG. F.
OUTLET PRESS. 15 PSIG
CORROSION ALLOWANCE .125"
FUEL REQ.(LHV)=92.3 MM BTU/HR.

SOURCE: 1

		QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL		2	0	3,800,000	0	0
FREIGHT	3.0%			114,000		
DEVELOPMENT	0.0%			0		
TOTAL		2	0	3,914,000	0	0
TOTAL CODE: 240		2	0	3,914,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-501A/B	FRACTIONATOR REFLUX PUMP AND SPARE	4		42,000		
		GPM: 1060					
		HD. FT.: 260					
		PSI: 89					
		S.G.: .7					
		PUMP TYPE: HC					
		PUMP MATERIAL: S1					
		DRIVE TYPE: M					
		DRIVE HP: 75					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	42,000	0	0
		FREIGHT 3.0%			1,260		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	43,260	0	0
310	P-502A/B	SOUR WATER PUMP AND SPARE	4		5,200		
		GPM: 3.4					
		HD. FT.: 170					
		PSI: 82					
		S.G.: .978					
		PUMP TYPE: HC					
		PUMP MATERIAL: S1					
		DRIVE TYPE: M					
		DRIVE HP: 1.5					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	5,200	0	0
		FREIGHT 3.0%			160		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	5,360	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-503A/B	DIESEL PRODUCTS PUMP AND SPARE	4		29,000		
		GPM: 166					
		HD. FT.: 207					
		PSI: 89					
		S.G.: .71					
		PUMP TYPE: HC					
		PUMP MATERIAL: S1					
		DRIVE TYPE: M					
		DRIVE HP: 15					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	29,000	0	0
		FREIGHT 3.0%			870		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	29,870	0	0
310	P-504A/B	BOTTOMS PRODUCT PUMP AND SPARE	4		49,600		
		GPM: 970					
		HD. FT.: 398					
		PSI: 125					
		S.G.: .61					
		PUMP TYPE: HC					
		PUMP MATERIAL: S1					
		DRIVE TYPE: M					
		DRIVE HP: 100					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	49,600	0	0
		FREIGHT 3.0%			1,490		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	51,090	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-505A/B	FRACTIONATOR REBOILER PUMP AND SPARE	4		76,000		
		GPM: 2230					
		HD. FT.: 211					
		PSI: 83					
		S.G.: .69					
		PUMP TYPE: CH					
		PUMP MATERIAL: S1					
		DRIVE TYPE: M					
		DRIVE HP: 125					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	76,000	0	0
		FREIGHT 3.0%			2,280		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	78,280	0	0
310	P-506A/B	BFW RECIRC PUMP	4		29,200		
		GPM: 256					
		HD. FT.: 118					
		PSI: 300					
		S.G.: .88					
		PUMP TYPE: HC					
		PUMP MATERIAL: S1					
		DRIVE TYPE: M					
		DRIVE HP: 15					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	29,200	0	0
		FREIGHT 3.0%			880		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	30,080	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : FRACTIONATION SECTION 500

JOB NO. : 11-36265
DATE : 24-Apr-87
REV. : 0
PREPARED BY : T.A.R.

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 310	24	0	237,940	0	0

APPENDIX B-6

EQUIPMENT COST DATA

HYDROGEN PLANT - UNIT 600

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 22-Apr-87
REV. : 0
PREPARED BY: TAR

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	78,600	0	78,600	0	0.2%
120	REACTORS, REGEN.,CONVER.	865,000	0	865,000	0	2.2%
130	DRUMS	141,400	0	141,400	0	0.4%
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	941,000	0	941,000	0	2.4%
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	649,300	0	649,300	0	1.6%
240	FIRED PROCESS EQUIPMENT	17,983,800	0	17,983,800	0	45.3%
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	159,000	0	159,000	0	0.4%
320	COMPRESSORS	5,356,000	0	5,356,000	0	13.5%
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	24,700	0	24,700	0	0.1%
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	13,462,100	0	13,462,100	0	33.9%
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	39,660,900	0	39,660,900	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
110	T-601	CONDENSATE STRIPPER 3'6" DIA X 61'T/T X 5/16" TK W/ 28 VALVE TRAYS & 304 SS LINING VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 5/16" CORR. ALLOW.: W/ CLAD DESIGN - PSIG/TEMP: 40 /340 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1	2	28,200	78,600		
		SUBTOTAL	2	28,200	78,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	28,200	78,600	0	0
		TOTAL CODE: 110	2	28,200	78,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
120	R-601	HYDROGENATOR 7'6" DIA X 13'6" T/T	2	81,000	121,600		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-204 STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 1 7/16" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 520/850 ASME CODE: VIII D1 NOZ/MW RATING: 900# SOURCE: 1					
		SUBTOTAL	2	81,000	121,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	81,000	121,600	0	0
120	R-602A/B	SULFUR ABSORBERS 7'6" DIA X 13'6" T/T	4	162,000	243,200		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-204 STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 1 7/16" CORR. ALLOW.: .125 DESIGN - PSIG/TEMP: 520/800 ASME CODE: VIII D1 NOZ/MW RATING: 900# SOURCE: 1					
		SUBTOTAL	4	162,000	243,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	162,000	243,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
120	R-603	CHLORIDE GUARD 7'6" DIA X 12'6" T/T	2	77,960	117,000		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-204 STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 1 7/16" CORR. ALLOW.: .125 DESIGN - PSIG/TEMP: 520/800 ASME CODE: VIII D1 NOZ/MW RATING: 900# SOURCE: 1					
		SUBTOTAL	2	77,960	117,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	77,960	117,000	0	0
120	R-604	HI-TEMP SHIFT CONVERTER 10'9" DIA X 11'6" T/T	2	137,220	220,800		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-387-11 STRESS RELIEVE: YES X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 1 13/16" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 400/875 ASME CODE: VIII D1 NOZ/MW RATING: 600# SOURCE: 1					
		SUBTOTAL	2	137,220	220,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	137,220	220,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
120	R-605	LOW-TEMP SHIFT CONVERTER 10'9" DIA X 15' T/T	2	141,200	162,400		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: YES X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 1 5/8" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 400/540 ASME CODE: VIII D1 NOZ/MW RATING: 400# SOURCE: 1					
		SUBTOTAL	2	141,200	162,400	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	141,200	162,400	0	0
		TOTAL CODE: 120	12	599,380	865,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-601	FEED KO DRUM		2	6,100	16,600		
		2'6" DIA X 7'6" T/T						
		W/ 304 SS DEMISTER						
		VERT. OR HORIZ.:	V					
		SUPPORT:	LEGS					
		MATERIAL:	SA-516-70					
		STRESS RELIEVE:	NO					
		X-RAY:	FULL					
		JOINT EFF.:	100%					
		WALL THICKNESS:	5/8"					
		CORR. ALLOW.:	.125"					
		DESIGN - PSIG/TEMP:	550/355					
		ASME CODE:	VIII D1					
		NOZ/MW RATING:	600#					
		SOURCE:	1					
			SUBTOTAL :	2	6,100	16,600	0	0
		FREIGHT	0.0%			0		
		DEVELOPMENT	0.0%			0		
			TOTAL :	2	6,100	16,600	0	0
130	D-602	FUEL GAS KO DRUM		2	4,440	12,200		
		3' DIA X 7' T/T						
		W/ 304 SS DEMISTER						
		VERT. OR HORIZ.:	V					
		SUPPORT:	LEGS					
		MATERIAL:	SA-285-C					
		STRESS RELIEVE:	NO					
		X-RAY:	SPOT					
		JOINT EFF.:	85%					
		WALL THICKNESS:	5/16"					
		CORR. ALLOW.:	.125"					
		DESIGN - PSIG/TEMP:	80/220					
		ASME CODE:	VIII D1					
		NOZ/MW RATING:	150#					
		SOURCE:	1					
			SUBTOTAL :	2	4,440	12,200	0	0
		FREIGHT	0.0%			0		
		DEVELOPMENT	0.0%			0		
			TOTAL :	2	4,440	12,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-604	CONTINUOUS BLOWDOWN DRUM 2' DIA X 5'T/T	2	2,120	8,200		
		VERT. OR HORIZ.: V SUPPORT: LEGS MATERIAL: SA-285-C STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 3/8" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 275/536 ASME CODE: VIII D1 NOZ/MW RATING: 300# SOURCE: 1					
		SUBTOTAL :	2	2,120	8,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	2,120	8,200	0	0
130	D-605	INTERMITTENT BLOWDOWN DRUM 5'6" DIA X 6'6" T/T	2	8,840	14,600		
		VERT. OR HORIZ.: V SUPPORT: LEGS MATERIAL: SA-285-C STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 5/16" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 30/265 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	8,840	14,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	8,840	14,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-606	HOT PROCESS CONDENSATE DRUM 4'9" DIA X 9'6" T/T W/ 304L SS CLAD & 304SS DEMISTER	2	18,580	43,600		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 5/8" CORR. ALLOW.: W/ CLAD DESIGN - PSIG/TEMP: 365/190 ASME CODE: VIII D1 NOZ/MW RATING: 300# SOURCE: 1					
		SUBTOTAL :	2	18,580	43,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	18,580	43,600	0	0
130	D-607	COLD PROCESS CONDENSATE DRUM 4'9" DIA X 7' T/T W/ 304SS DEMISTER	2	18,340	33,200		
		VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 3/4" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 365/150 ASME CODE: VIII D1 NOZ/MW RATING: 300# SOURCE: 1					
		SUBTOTAL :	2	18,340	33,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	18,340	33,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-608	STRIPPER REFLUX DRUM 3' DIA X 6' T/T W/ 304L SS CLAD VERT. OR HORIZ.: V SUPPORT: LEGS MATERIAL: SA-285-C STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/16" CORR. ALLOW.: W/ CLAD DESIGN - PSIG/TEMP: 40/282 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1	2	3,320	13,000		
		SUBTOTAL :	2	3,320	13,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	3,320	13,000	0	0
		TOTAL CODE: 130	14	61,740	141,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-603	HTS BFW PREHEATER	2		326,600		
		TYPE: AES					
		SHELL ID IN.: 24"					
		TUBE LENGTH FT.: 20'					
		NO. OF SHELLS: 3					
		SQ. FT. PER SHELL: 1538.3					
		TOTAL SQ FT.: 4615					
		SHELL - PSIG/TEMP: 400/875					
		TUBE - PSIG/TEMP: 2600/600					
		MATL. - SHELL/TUBE: 1 1/4 CR-1/2 MO/304SS					
		SOURCE: 1					
		SUBTOTAL	2	0	326,600	0	0
		FREIGHT 3.0%			9,800		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	336,400	0	0
210	E-604	LTS BFW PREHEATER	2		223,800		
		TYPE: AES					
		SHELL ID IN.: 16"					
		TUBE LENGTH FT.: 20'					
		NO. OF SHELLS: 3					
		SQ. FT. PER SHELL: 743.3					
		TOTAL SQ FT.: 2230					
		SHELL - PSIG/TEMP: 400/536					
		TUBE - PSIG/TEMP: 2600/450					
		MATL. - SHELL/TUBE: 304L CLAD/304SS					
		SOURCE: 1					
		SUBTOTAL	2	0	223,800	0	0
		FREIGHT 3.0%			6,710		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	230,510	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-606	RAW GAS TRIM COOLER	2		86,200		
		TYPE: AES SHELL ID IN.: 15" TUBE LENGTH FT.: 20' NO. OF SHELLS: 2 SQ. FT. PER SHELL: 520 TOTAL SQ FT.: 1040 SHELL - PSIG/TEMP: 365/190 TUBE - PSIG/TEMP: 95/150 MATL. - SHELL/TUBE: 304L CLAD/430 SS SOURCE: 1					
		SUBTOTAL	2	0	86,200	0	0
		FREIGHT 3.0%			2,590		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	88,790	0	0
210	E-607	RAW CONDENSATE FEED PREHEATER	2		57,000		
		TYPE: AES SHELL ID IN.: 18" TUBE LENGTH FT.: 20' NO. OF SHELLS: 1 SQ. FT. PER SHELL: 830 TOTAL SQ FT.: 830 SHELL - PSIG/TEMP: 40/300 TUBE - PSIG/TEMP: 365/275 MATL. - SHELL/TUBE: 304L CLAD/430 SS SOURCE: 1					
		SUBTOTAL	2	0	57,000	0	0
		FREIGHT 3.0%			1,710		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	58,710	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
210	E-608	STRIPPER OVERHEAD CONDENSER	2		20,400		
		TYPE: AES SHELL ID IN.: 12" TUBE LENGTH FT.: 20' NO. OF SHELLS: 1 SQ. FT. PER SHELL: 200 TOTAL SQ FT.: 200 SHELL - PSIG/TEMP: 40/300 TUBE - PSIG/TEMP: 95/160 MATL. - SHELL/TUBE: 304L CLAD/430 SS SOURCE: 1					
		SUBTOTAL :	2	0	20,400	0	0
		FREIGHT 3.0%			610		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	21,010	0	0
210	E-609	STRIPPED CONDENSATE & BLOWDOWN CO	2		51,400		
		TYPE: AES SHELL ID IN.: 14" TUBE LENGTH FT.: 20' NO. OF SHELLS: 2 SQ. FT. PER SHELL: 445 TOTAL SQ FT.: 890 SHELL - PSIG/TEMP: 30/290 TUBE - PSIG/TEMP: 95/160 MATL. - SHELL/TUBE: CS/CS SOURCE: 1					
		SUBTOTAL :	2	0	51,400	0	0
		FREIGHT 3.0%			1,540		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	52,940	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-613	FIRST STAGE TRIM COOLER	2		43,800		
		TYPE: AES SHELL ID IN.: 22" TUBE LENGTH FT.: 20' NO. OF SHELLS: 1 SQ. FT. PER SHELL: 1350 TOTAL SQ FT.: 1350 SHELL - PSIG/TEMP: 140/155 TUBE - PSIG/TEMP: 335/160 MATL. - SHELL/TUBE: CS/CS SOURCE: 1					
		SUBTOTAL :	2	0	43,800	0	0
		FREIGHT 3.0%			1,310		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	45,110	0	0
210	E-614	SECOND STAGE TRIM COOLER	2		48,000		
		TYPE: AES SHELL ID IN.: 22" TUBE LENGTH FT.: 20' NO. OF SHELLS: 1 SQ. FT. PER SHELL: 1350 TOTAL SQ FT.: 1350 SHELL - PSIG/TEMP: 140/165 TUBE - PSIG/TEMP: 665/170 MATL. - SHELL/TUBE: CS/CS SOURCE: 1					
		SUBTOTAL :	2	0	48,000	0	0
		FREIGHT 3.0%			1,440		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	49,440	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-615	THIRD STAGE TRIM COOLER	2		56,400		
		TYPE: AES SHELL ID IN.: 22" TUBE LENGTH FT.: 20' NO. OF SHELLS: 1 SQ. FT. PER SHELL: 1350 TOTAL SQ FT.: 1350 SHELL - PSIG/TEMP: 140/165 TUBE - PSIG/TEMP: 1410/170 MATL. - SHELL/TUBE: CS/CS SOURCE: 1					
		SUBTOTAL	2	0	56,400	0	0
		FREIGHT 3.0%			1,690		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	58,090	0	0
		TOTAL CODE: 210	18	0	941,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-605	RAW GAS COOLER	2		364,400		
		TOTAL BARE SQ FT.: 6615					
		NO. OF BAYS: 3					
		TUBE MATERIAL: 304 SS					
		TUBE LENGTH: 30'					
		PLOT SIZE: 48 X30					
		NO. OF FANS/BAY: 2					
		HP EACH: 30					
		PRESS/TEMP: 400/					
		SOURCE: 1					
		SUBTOTAL	2	0	364,400	0	0
		FREIGHT 3.0%			10,930		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	375,330	0	0
230	E-610	FIRST STAGE COOLER	2		106,400		
		TOTAL BARE SQ FT.: 1650					
		NO. OF BAYS: 1					
		TUBE MATERIAL: CS					
		TUBE LENGTH: 32'					
		PLOT SIZE: 12 X32					
		NO. OF FANS/BAY: 1					
		HP EACH: 40					
		PRESS/TEMP: 675/					
		SOURCE: 1					
		SUBTOTAL	2	0	106,400	0	0
		FREIGHT 3.0%			3,190		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	109,590	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-611	SECOND STAGE COOLER	2		110,400		
		TOTAL BARE SQ FT.: 1650					
		NO. OF BAYS: 1					
		TUBE MATERIAL: CS					
		TUBE LENGTH: 32'					
		PLOT SIZE: 12 X32					
		NO. OF FANS/BAY: 1					
		HP EACH: 40					
		PRESS/TEMP: 1420/					
		SOURCE: 1					
		SUBTOTAL	2	0	110,400	0	0
		FREIGHT 3.0%			3,310		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	113,710	0	0
230	E-612	SPILL BACK COOLER	2		49,200		
		TOTAL BARE SQ FT.: 185					
		NO. OF BAYS: 1					
		TUBE MATERIAL: CS					
		TUBE LENGTH: 8'					
		PLOT SIZE: 6 X 8					
		NO. OF FANS/BAY: 1					
		HP EACH: 7 1/2					
		PRESS/TEMP: 3030/					
		SOURCE: 1					
		SUBTOTAL	2	0	49,200	0	0
		FREIGHT 3.0%			1,480		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	50,680	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 230	8	0	649,310	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
240		REFORMER PACKAGE INCLUDING:	2		17,460,000		
		H-601 REFORMER					
		D-603 STEAM DRUM					
		E-601 COMBUSTION AIR PREHEATER					
		E-602 REF. WASTE HEAT EXCH.					
		B-601 REFORMER F.D. FAN					
		B-602 REFORMER I.D. FAN					
		ST-601 REFORMER STACK					
		M-601A/B REFORMER FEED MIXERS					
		SOURCE: 1					
		SUBTOTAL :	2	0	17,460,000	0	0
		FREIGHT 3.0%			523,800		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	17,983,800	0	0
		TOTAL CODE: 240	2	0	17,983,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-601A/B	BFW CIRC. PUMP & SPARE	4		97,200		
		GPM: 1810					
		HD. FT.: 287					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: S-1					
		DRIVE TYPE: 1M/1T					
		DRIVE HP: 200					
		SHOP OR FIELD MT.: F					
		SOURCE: 1					
		SUBTOTAL :	4	0	97,200	0	0
		FREIGHT 3.0%			2,920		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	100,120	0	0
310	P-602A/B	STRIPPED CONDENSATE PUMP & SPARE	4		30,200		
		GPM: 135					
		HD. FT.: 307					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: S-1					
		DRIVE TYPE: M					
		DRIVE HP: 25					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	30,200	0	0
		FREIGHT 3.0%			910		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	31,110	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-603A/B	STRIPPER REFLUX PUMP & SPARE	4		27,000		
		GPM: 20					
		HD. FT.: 154					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: S-1					
		DRIVE TYPE: M					
		DRIVE HP: 5					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	27,000	0	0
		FREIGHT 3.0%			810		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	27,810	0	0
		TOTAL CODE: 310	12	0	159,040	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	C-601A/B	MAKE-UP COMPRESSOR	4		5,200,000		
		COMP TYPE: RECIP					
		INLET CAP ACFM: 1690					
		INLET PSIG: 301					
		OUTLET PSIG: 3005					
		GAS HANDLED:					
		K VALVE (CP/CV):					
		MATERIAL: CS					
		DRIVER TYPE: M					
		DRIVER H.P. 7100					
		SOURCE: 1					
		SUBTOTAL	4	0	5,200,000	0	0
		FREIGHT 3.0%			156,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	5,356,000	0	0
		TOTAL CODE: 320	4	0	5,356,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	F-601	HYDROGEN RECYCLE OIL FILTER	2		24,000		

SOURCE: 1

	SUBTOTAL :	2	0	24,000	0	0
FREIGHT	3.0%			720		
DEVELOPMENT	0.0%			0		
	TOTAL :	2	0	24,720	0	0
TOTAL CODE:	350	2	0	24,720	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLORADO
UNIT : HYDROGEN PLANT SECTION 600

JOB NO. : 11-36265
DATE : 08-Apr-87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
910		PSA PACKAGE 35MM+/SCFD INCLUDING:	2		13,070,000		
		D-609A/B TAIL GAS SURGE DRUM					
		D-610 ABSORBER DRUM					
		D-611 ABSORBER DRUM					
		D-612 ABSORBER DRUM					
		D-613 ABSORBER DRUM					
		D-614 ABSORBER DRUM					
		D-615 ABSORBER DRUM					
		D-616 ABSORBER DRUM					
		D-617 ABSORBER DRUM					
		D-618 ABSORBER DRUM					
		D-619 ABSORBER DRUM					
		D-620 MIXING DRUM					
		SOURCE: 1					
		SUBTOTAL	2	0	13,070,000	0	0
		FREIGHT 3.0%			392,100		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	13,462,100	0	0
		TOTAL CODE: 910	2	0	13,462,100	0	0

APPENDIX B-7

EQUIPMENT COST DATA

SOUR WATER TREATING - UNIT 700

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	2,202,800	0	2,202,800	0	38.8%
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	805,800	0	805,800	0	14.2%
140	STORAGE TANKS	56,800	204,000	260,800	0	4.6%
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	1,415,000	0	1,415,000	0	24.9%
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	430,500	0	430,500	0	7.6%
	MECHANICAL EQUIPMENT					
310	PUMPS	563,200	0	563,200	0	9.9%
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	5,474,100	204,000	5,678,100	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TRL

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
110	T-701	AMMONIA STRIPPER 7' DIA. X 110' T/T W/ 18 304SS VALVE TRAYS VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 7/16" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 25/235 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1	2	128,000	149,600		
		SUBTOTAL	2	128,000	149,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	128,000	149,600	0	0
110	T-702	SOUR WATER STRIPPER 8' DIA X 168' T/T W/ 36 304SS VALVE TRAYS VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-285C STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 13/16" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/300 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1	2	352,000	543,200		
		SUBTOTAL	2	352,000	543,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	352,000	543,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
110	T-703	FRACTIONATOR	2	172,300	535,600		
		3'6" DIA X 194' T/T					
		W/ 60 304SS VALVE TRAYS					
		VERT. OR HORIZ.: V					
		SUPPORT: SKIRT					
		MATERIAL: SA-240 304L					
		STRESS RELIEVE: NO					
		X-RAY: SPOT					
		JOINT EFF.: 85%					
		WALL THICKNESS: 3/4"					
		CORR. ALLOW.: 1/16"					
		DESIGN - PSIG/TEMP: 50/425					
		ASME CODE: VIII D1					
		NOZ/MW RATING: 150#					
		SOURCE: 1					
		SUBTOTAL :	2	172,300	535,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	172,300	535,600	0	0
110	T-704	ABSORBER	2	96,600	325,600		
		7' DIA X 97' T/T					
		W/ 4 304SS VALVE TRAYS					
		VERT. OR HORIZ.: V					
		SUPPORT: SKIRT					
		MATERIAL: SA-240 304L					
		STRESS RELIEVE: NO					
		X-RAY: SPOT					
		JOINT EFF.: 85%					
		WALL THICKNESS: 3/8"					
		CORR. ALLOW.: 1/16"					
		DESIGN - PSIG/TEMP: 50/300					
		ASME CODE: VIII D1					
		NOZ/MW RATING: 150#					
		SOURCE: 1					
		SUBTOTAL :	2	96,600	325,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	96,600	325,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
110	T-705	STRIPPER 6' DIA X 122' T/T W/ 30 304SS VALVE TRAYS VERT. OR HORIZ.: V SUPPORT: SKIRT MATERIAL: SA-240 304L STRESS RELIEVE: NO X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 13/16" CORR. ALLOW.: 1/16" DESIGN - PSIG/TEMP: 300/425 ASME CODE: VIII D1 NOZ/MW RATING: 300# SOURCE: 1	2	201,600	648,800		
		SUBTOTAL :	2	201,600	648,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	201,600	648,800	0	0
		TOTAL CODE: 110	10	950,500	2,202,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-701	REFLUX DRUM 2'6" DIA X 4' T/T VERT. OR HORIZ.: V SUPPORT: LEGS MATERIAL: CS STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 7/16" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 300/425 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1	2	4,800	10,800		
		SUBTOTAL	2	4,800	10,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	4,800	10,800	0	0
130	D-702	CONDENSATE DRUM 3'6" DIA X 20' T/T VERT. OR HORIZ.: V SUPPORT: LEGS MATERIAL: SA-240 316L STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 1/4" CORR. ALLOW.: 1/16" DESIGN - PSIG/TEMP: 20/300 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1	2	8,300	54,400		
		SUBTOTAL	2	8,300	54,400	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	8,300	54,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-703	CONTACTOR 9' DIA X 18'6" T/T	2	29,300	84,000		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-240 304L STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 5/16" CORR. ALLOW.: 1/16" DESIGN - PSIG/TEMP: 15/300 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	29,300	84,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	29,300	84,000	0	0
130	D-704	FRACTIONATOR FEED DRUM 10' DIA X 26'6" T/T	2	271,400	656,600		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-240 304L STRESS RELIEVE: YES X-RAY: FULL JOINT EFF.: 100% WALL THICKNESS: 2 5/8" CORR. ALLOW.: 1/16" DESIGN - PSIG/TEMP: 300/425 ASME CODE: VIII D1 NOZ/MW RATING: 300# SOURCE: 1					
		SUBTOTAL :	2	271,400	656,600	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	271,400	656,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED B. : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
		TOTAL CODE: 130	8	313,800	805,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TA[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
140	TK-701	PHOSPHORIC ACID STORAGE TANK 6' DIA X 12' T/T	2	9,000	56,800		
		VERT. OR HORIZ.: V SUPPORT: FLT BTM MATERIAL: SA-240 316L STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/16" CORR. ALLOW.: 1/16" DESIGN - PSIG/TEMP: ATM/AMB ASME CODE: Y NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	9,000	56,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	9,000	56,800	0	0
140	TK-702	CAUSTIC STORAGE TANK, API 40' DIA X 40' H W/ CONE ROOF	2			204,000	
		VERT. OR HORIZ.: V SUPPORT: MATERIAL: CS STRESS RELIEVE: X-RAY: JOINT EFF.: WALL THICKNESS: CORR. ALLOW.: DESIGN - PSIG/TEMP: ATM/AMB ASME CODE: N NOZ/MW RATING: SOURCE: 1					
		SUBTOTAL :	2	0	0	204,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	204,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	140	4	9,000	56,800	204,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-701	AMMONIA STRIPPER REBOILER	2		172,000		
		TYPE: AEL SHELL ID IN.: 25" TUBE LENGTH FT.: 20' NO. OF SHELLS: 3 SQ. FT. PER SHELL: 1670 TOTAL SQ FT.: 5009 SHELL - PSIG/TEMP: 65/390 TUBE - PSIG/TEMP: 75/300 MATL. - SHELL/TUBE: CS/430SS SOURCE: 1					
		SUBTOTAL	2	0	172,000	0	0
		FREIGHT 3.0%			5,160		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	177,160	0	0
210	E-703	SOUR WATER FEED HEATER	2		33,200		
		TYPE: AEU SHELL ID IN.: 15" TUBE LENGTH FT.: 20' NO. OF SHELLS: 1 SQ. FT. PER SHELL: TOTAL SQ FT.: 632 SHELL - PSIG/TEMP: 100/300 TUBE - PSIG/TEMP: 150/300 MATL. - SHELL/TUBE: CS/304SS SOURCE: 1					
		SUBTOTAL	2	0	33,200	0	0
		FREIGHT 3.0%			1,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	34,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
210	E-704	SOUR WATER STRIPPER REBOILER		2		83,600		
		TYPE:	AEL					
		SHELL ID IN.:	25"					
		TUBE LENGTH FT.:	20'					
		NO. OF SHELLS:	2					
		SQ. FT. PER SHELL:	1705					
		TOTAL SQ FT.:	3411					
		SHELL - PSIG/TEMP:	300/425					
		TUBE - PSIG/TEMP:	100/150					
		MATL. - SHELL/TUBE:	CS/CS					
		SOURCE:	1					
			SUBTOTAL	2	0	83,600	0	0
		FREIGHT	3.0%			2,510		
		DEVELOPMENT	0.0%			0		
			TOTAL	2	0	86,110	0	0
210	E-705	FRACTIONATOR REBOILER		2		83,600		
		TYPE:	AES					
		SHELL ID IN.:	24"					
		TUBE LENGTH FT.:	20'					
		NO. OF SHELLS:	1					
		SQ. FT. PER SHELL:						
		TOTAL SQ FT.:	1551					
		SHELL - PSIG/TEMP:	600/800					
		TUBE - PSIG/TEMP:	300/425					
		MATL. - SHELL/TUBE:	CS/430SS					
		SOURCE:	1					
			SUBTOTAL	2	0	83,600	0	0
		FREIGHT	3.0%			2,510		
		DEVELOPMENT	0.0%			0		
			TOTAL	2	0	86,110	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-706	FRACTIONATOR CONDENSER	2		179,400		
		TYPE: AJU SHELL ID IN.: 25" TUBE LENGTH FT.: 20' NO. OF SHELLS: 4 SQ. FT. PER SHELL: 1688 TOTAL SQ FT.: 6752 SHELL - PSIG/TEMP: 300/425 TUBE - PSIG/TEMP: 100/150 MATL. - SHELL/TUBE: CS/CS SOURCE: 1					
		SUBTOTAL :	2	0	179,400	0	0
		FREIGHT 3.0%			5,380		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	184,780	0	0
210	E-707	AFTERCONDENSER	2		28,200		
		TYPE: AEP SHELL ID IN.: 14" TUBE LENGTH FT.: 20' NO. OF SHELLS: 1 SQ. FT. PER SHELL: TOTAL SQ FT.: 409 SHELL - PSIG/TEMP: 100/150 TUBE - PSIG/TEMP: 30/300 MATL. - SHELL/TUBE: CS/304L SS SOURCE: 1					
		SUBTOTAL :	2	0	28,200	0	0
		FREIGHT 3.0%			850		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	29,050	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-708	ABSORBER COOLER	2		104,000		
		TYPE: AEU SHELL ID IN.: 26" TUBE LENGTH FT.: 20 NO. OF SHELLS: 2 SQ. FT. PER SHELL: 1769 TOTAL SQ FT.: 3538 SHELL - PSIG/TEMP: 100/150 TUBE - PSIG/TEMP: 150/300 MATL. - SHELL/TUBE: CS/304L SS SOURCE: 1					
		SUBTOTAL	2	0	104,000	0	0
		FREIGHT 3.0%			3,120		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	107,120	0	0
210	E-709	SOLUTION EXCHANGER	2		66,000		
		TYPE: AEU SHELL ID IN.: 20 TUBE LENGTH FT.: 20 NO. OF SHELLS: 1 SQ. FT. PER SHELL: TOTAL SQ FT.: 1074 SHELL - PSIG/TEMP: 75/300 TUBE - PSIG/TEMP: 300/425 MATL. - SHELL/TUBE: 304L/304L SOURCE: 1					
		SUBTOTAL	2	0	66,000	0	0
		FREIGHT 3.0%			1,980		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	67,980	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-710	LEAN SOLUTION COOLER	2		96,000		
		TYPE: AEU					
		SHELL ID IN.: 24					
		TUBE LENGTH FT.: 20					
		NO. OF SHELLS: 2					
		SQ. FT. PER SHELL: 1516					
		TOTAL SQ FT.: 3032					
		SHELL - PSIG/TEMP: 100/150					
		TUBE - PSIG/TEMP: 300/425					
		MATL. - SHELL/TUBE: CS/304L SS					
		SOURCE: 1					
		SUBTOTAL :	2	0	96,000	0	0
		FREIGHT 3.0%			2,880		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	98,880	0	0
210	E-711	STRIPPER REBOILER	2		140,800		
		TYPE: AES					
		SHELL ID IN.: 24					
		TUBE LENGTH FT.: 20					
		NO. OF SHELLS: 2					
		SQ. FT. PER SHELL: 1548					
		TOTAL SQ FT.: 3095					
		SHELL - PSIG/TEMP: 600/800					
		TUBE - PSIG/TEMP: 300/425					
		MATL. - SHELL/TUBE: CS/304L SS					
		SOURCE: 1					
		SUBTOTAL :	2	0	140,800	0	0
		FREIGHT 3.0%			4,220		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	145,020	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED B: : TA[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-712A	STRIPPER CONDENSER (TOP)	2		198,800		

TYPE: BEX
SHELL ID IN.: 24
TUBE LENGTH FT.: 20
NO. OF SHELLS: 2
SQ. FT. PER SHELL: 1548
TOTAL SQ FT.: 3095
SHELL - PSIG/TEMP: 300/425
TUBE - PSIG/TEMP: 300/425
MATL. - SHELL/TUBE: 304L/304L
SOURCE: 1

		QTY	WEIGHT	MATERIALS COST	SUBCONTRACT D&E	MANHOURS
SUBTOTAL		2	0	198,800	0	0
FREIGHT	3.0%			5,960		
DEVELOPMENT	0.0%			0		
TOTAL		2	0	204,760	0	0

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-712B	STRIPPER CONDENSER (BOTTOM)	2		58,600		

TYPE: XEP
SHELL ID IN.: 24
TUBE LENGTH FT.: 20
NO. OF SHELLS: 1
SQ. FT. PER SHELL:
TOTAL SQ FT.: 1390
SHELL - PSIG/TEMP: 100/150
TUBE - PSIG/TEMP: 300/425
MATL. - SHELL/TUBE: CS/304L SS
SOURCE: 1

		QTY	WEIGHT	MATERIALS COST	SUBCONTRACT D&E	MANHOURS
SUBTOTAL		2	0	58,600	0	0
FREIGHT	3.0%			1,760		
DEVELOPMENT	0.0%			0		
TOTAL		2	0	60,360	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-713	EFFLUENT COOLER	2		129,600		

TYPE: AEU
SHELL ID IN.: 28
TUBE LENGTH FT.: 20
NO. OF SHELLS: 3
SQ. FT. PER SHELL: 1967
TOTAL SQ FT.: 5903
SHELL - PSIG/TEMP: 100/200
TUBE - PSIG/TEMP: 100/200
MATL. - SHELL/TUBE: CS/CS
SOURCE: 1

		QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL		2	0	129,600	0	0
FREIGHT	3.0%			3,890		
DEVELOPMENT	0.0%			0		
TOTAL		2	0	133,490	0	0
TOTAL CODE:	210	26	0	1,415,020	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
290	E-702	SOUR WATER FEED PREHEATER	2		418,000		
		SPIRAL PLATE EXCHANGER, 6949 FT2 TYPE 304 SS, 150 PSIG @ 300 DEG F DESIGN					
		SOURCE: 1					
		SUBTOTAL :	2	0	418,000	0	0
		FREIGHT 3.0%			12,540		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	430,540	0	0
		TOTAL CODE: 290	2	0	430,540	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-701A/B	AMMONIA STRIPPER BOTTOMS PUMP & SPARE	4		48,800		
		GPM: 820					
		HD. FT.: 122					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: 304 SS					
		DRIVE TYPE: M					
		DRIVE HP: 40					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	48,800	0	0
		FREIGHT 3.0%			1,460		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	50,260	0	0
310	P-702A/B	FRACTIONATOR REFLUX PUMP & SPARE	4		30,400		
		GPM: 140					
		HD. FT.: 215					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS/SS					
		DRIVE TYPE: M					
		DRIVE HP: 20					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	30,400	0	0
		FREIGHT 3.0%			910		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	31,310	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
310	P-703A/B	CONDENSATE PUMP & SPARE	4		43,200		
		GPM: 40					
		HD. FT.: 359					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: 304 SS					
		DRIVE TYPE: M					
		DRIVE HP: 10					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	43,200	0	0
		FREIGHT 3.0%			1,300		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	44,500	0	0
310	P-704A/C	ABSORBER CIRCULATION PUMP & SPARE	6		129,000		
		GPM: 790					
		HD. FT.: 304					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: 304 SS					
		DRIVE TYPE: M					
		DRIVE HP: 200					
		SHOP OR FIELD MT.: F					
		SOURCE: 1					
		SUBTOTAL :	6	0	129,000	0	0
		FREIGHT 3.0%			3,870		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	132,870	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED B TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-705	PHOSPHORIC ACID ADDITION PUMP	2		13,400		
		GPM: 65 HD. FT.: 71 PSI: S.G.: PUMP TYPE: HC PUMP MATERIAL: 316 SS DRIVE TYPE: M DRIVE HP: 5 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL	2	0	13,400	0	0
		FREIGHT 3.0%			400		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	13,800	0	0
310	P-706A/B	RICH SOLUTION PUMP & SPARE	4		150,800		
		GPM: 475 HD. FT.: 1192 PSI: S.G.: PUMP TYPE: HC PUMP MATERIAL: 304 SS DRIVE TYPE: M DRIVE HP: 300 SHOP OR FIELD MT.: F SOURCE: 1					
		SUBTOTAL	4	0	150,800	0	0
		FREIGHT 3.0%			4,520		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	155,320	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-707A/B	CAUSTIC METERING PUMP & SPARE	4		9,200		
		GPM: 2					
		HD. FT.: 632					
		PSI:					
		S.G.:					
		PUMP TYPE: RECIP					
		PUMP MATERIAL: 316 SS					
		DRIVE TYPE: M					
		DRIVE HP: 1					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	9,200	0	0
		FREIGHT 3.0%			280		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	9,480	0	0
310	P-708A/B	FRACTIONATOR FEED PUMP & SPARE	4		47,600		
		GPM: 185					
		HD. FT.: 404					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: 304 SS					
		DRIVE TYPE: M					
		DRIVE HP: 40					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	47,600	0	0
		FREIGHT 3.0%			1,430		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	49,030	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SOUR WATER TREATING SECT. 700

JOB NO. : 11-36265
DATE : 04/10/87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-709A/B	AMMONIA STRIPPER FEED PUMP & SPARE		4		74,400		
		GPM:	915					
		HD. FT.:	382					
		PSI:						
		S.G.:						
		PUMP TYPE:	HC					
		PUMP MATERIAL:	304 SS					
		DRIVE TYPE:	M					
		DRIVE HP:	125					
		SHOP OR FIELD MT.:	S					
		SOURCE:	1					
			SUBTOTAL :	4	0	74,400	0	0
		FREIGHT	3.0%			2,230		
		DEVELOPMENT	0.0%			0		
			TOTAL :	4	0	76,630	0	0
		TOTAL CODE:	310	36	0	563,200	0	0

APPENDIX B-8

EQUIPMENT COST DATA

SPENT SHALE MOISTURIZING - UNIT 900

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	213,000	0	213,000	0	1.9%
140	STORAGE TANKS	2,038,200	0	2,038,200	0	18.6%
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	1,711,900	0	1,711,900	0	15.7%
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	208,300	0	208,300	0	1.9%
320	COMPRESSORS	293,600	0	293,600	0	2.7%
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	587,100	0	587,100	0	5.4%
360	MATERIALS TRANSPORT	2,049,500	0	2,049,500	0	18.7%
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	3,831,600	0	3,831,600	0	35.0%
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	10,933,200	0	10,933,200	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-901	WATER SEPARATOR		6	130,800	213,000		
		8' DIA X 24' T/T						
		W/ EPOXY LINING & 6" TK.						
		TP-304 SS DEMISTER						
		VERT. OR HORIZ.:	V					
		SUPPORT:	SKIRT					
		MATERIAL:	SA-285C					
		STRESS RELIEVE:	NO					
		X-RAY:	SPOT					
		JOINT EFF.:	85%					
		WALL THICKNESS:	1/2"					
		CORR. ALLOW.:	.250"					
		DESIGN - PSIG/TEMP:	25/225					
		ASME CODE:	VIII D1					
		NOZ/MW RATING:	150#					
		SOURCE:	1					
		SUBTOTAL :		6	130,800	213,000	0	0
		FREIGHT	0.0%			0		
		DEVELOPMENT	0.0%			0		
		TOTAL :		6	130,800	213,000	0	0
		TOTAL CODE: 130		6	130,800	213,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
140	BN-901	SPENT SHALE SURGE BIN 60'L X 30'W X 55'H 86000 FT3 VOLUME TOP: CS/ BOTTOM 304LSS	6		1,890,000		
		SOURCE: 1					
		SUBTOTAL	6	0	1,890,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	1,890,000	0	0
140	BN-902	MOISTURIZED SHALE HOPPER 1300 FT3 VOLUME 304SS MATERIAL BOTTOM DISCHARGE 12'L X 12'W X 8'H	6		148,200		
		SUBTOTAL	6	0	148,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	148,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 140	12	0	2,038,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
230	E-901	COOLER	6		1,662,000		
		TOTAL BARE SQ FT.: 9200 NO. OF BAYS: 2 TUBE MATERIAL: CS TUBE LENGTH: 32' PLOT SIZE: 40' X 32' NO. OF FANS/BAY: 2 HP EACH: PRESS/TEMP: 50/175 SOURCE: 1					
		SUBTOTAL	6	0	1,662,000	0	0
		FREIGHT 3.0%			49,860		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	1,711,860	0	0
		TOTAL CODE: 230	6	0	1,711,860	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-901A/B	RECIRCULATING PUMP	12		202,200		
		GPM: 2300					
		HD. FT.: 95					
		PSI:					
		S.G.: 60.7#/FT3					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 100					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	12	0	202,200	0	0
		FREIGHT 3.0%			6,070		
		DEVELOPMENT 0.0%			0		
		TOTAL	12	0	208,270	0	0
		TOTAL CODE: 310	12	0	208,270	0	0

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
320	B-901	VENT BLOWER		6		135,000		
		COMP TYPE:	CENTRIF					
		INLET CAP ACFM:	20000					
		INLET PSIG:	-3" H20					
		OUTLET PSIG:	2" H20					
		GAS HANDLED:						
		K VALVE (CP/CV):						
		MATERIAL:	CS					
		DRIVER TYPE:	M					
		DRIVER H.P.						
		SOURCE:	1					
			SUBTOTAL	6	0	135,000	0	0
		FREIGHT	3.0%			4,050		
		DEVELOPMENT	0.0%			0		
			TOTAL	6	0	139,050	0	0
320	B-902	CONVEYOR BLOWER		6		150,000		
		COMP TYPE:	CENTRIF					
		INLET CAP ACFM:	20000					
		INLET PSIG:	-.5" H20					
		OUTLET PSIG:	3.5" H20					
		GAS HANDLED:						
		K VALVE (CP/CV):						
		MATERIAL:	CS/EPOXY LINED					
		DRIVER TYPE:	M					
		DRIVER H.P.						
		SOURCE:	1					
			SUBTOTAL	6	0	150,000	0	0
		FREIGHT	3.0%			4,500		
		DEVELOPMENT	0.0%			0		
			TOTAL	6	0	154,500	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : JAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 320	12	0	293,550	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	A-902	VENTURI SCRUBBER	6		330,000		
		GAS FEED: 33231#/HR					
		WATER FEED: 830000#/HR					
		GAS TEMP: 195 DEG F					
		WATER TEMP: 140 DEG F					
		GAS PRES. : -1" H2O					
		WATER PRES. : 20 PSIG					
		MAT'L: 304 SS					
		SOURCE: 1					
		SUBTOTAL :	6	0	330,000	0	0
		FREIGHT 3.0%			9,900		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	339,900	0	0
350	F-901	BAG FILTER	6		240,000		
		AIR: 20000 ACFM					
		INCOMING DUST: 550#/HR					
		COLLECTED DUST: 500#/HR					
		EMISSIONS: 50#/HR					
		INLET PRES. -0.5" H2O					
		OPER. TEMP. 350 DEG F					
		AUTO. BAG CLEANING					
		SOURCE: 1					
		SUBTOTAL :	6	0	240,000	0	0
		FREIGHT 3.0%			7,200		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	247,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
		TOTAL CODE: 350	12	0	587,100	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-901	CONVEYOR, SCREW TYPE W/ 24" DOUBLE SCREWS 420 TPH DESIGN CAPACITY 70#/FT3 SOLID BULK DENSITY 400 DEG F DESIGN TEMP C.S. CONSTRUCTION 70' LONG SOURCE: 1	6		183,000		
		SUBTOTAL :	6	0	183,000	0	0
		FREIGHT 3.0%			5,490		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	188,490	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-902	MOISTURIZED SHALE CONVEYOR, BELT TYPE 30" WIDE X 200' LONG W/ COVERED HOOD 480 TPH CAPACITY 175 DEG F OPER. TEMP SOURCE: 1	6		399,000		
		SUBTOTAL :	6	0	399,000	0	0
		FREIGHT 3.0%			11,970		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	410,970	0	0
360	CV-903	TRANSFER CONVEYOR, BELT TYPE 30"W X 600' AVG. LENGTH W/ COVERED HOOD 480 TPH CAPACITY 175 DEG F OPER TEMP	6		861,000		
		SUBTOTAL :	6	0	861,000	0	0
		FREIGHT 3.0%			25,830		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	886,830	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-904	CROSS CONVEYOR, BELT TYPE 42"W X 400'L W/ COVERED HOOD 960 TPH CAPACITY 175 DEG F OPER. TEMP.	4		546,800		
		SUBTOTAL :	4	0	546,800	0	0
		FREIGHT 3.0%			16,400		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	563,200	0	0
		TOTAL CODE: 360	22	0	2,049,490	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE MOISTURIZING SECT. 900

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 1
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
390	A-901	PUG MILL ENCLOSED HORIZ. CAPACITY: DRY 420/TPH WET 480/TPH 400 DEG F DES. TEMP. ATM. DES. PRES. WATER FEED: 480 GPM VAPOR DISCHARGE: 615000 CFPH SOURCE: 1	6		3,720,000		
		SUBTOTAL	6	0	3,720,000	0	0
		FREIGHT 3.0%			111,600		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	3,831,600	0	0
		TOTAL CODE: 390	6	0	3,831,600	0	0

APPENDIX B-9

EQUIPMENT COST DATA

FEED PREPARATION - UNIT 1000

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	0	0	0	0	
140	STORAGE TANKS	0	17,195,200	17,195,200	0	24.1%
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	0	0	0	0	
320	COMPRESSORS	3,842,900	0	3,842,900	0	5.4%
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	494,400	0	494,400	0	0.7%
350	MATERIALS PROCESSING	11,682,500	0	11,682,500	0	16.4%
360	MATERIALS TRANSPORT	18,083,600	19,200,000	37,283,600	0	52.3%
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	824,000	0	824,000	0	1.2%
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	34,927,400	36,395,200	71,322,600	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
140	V-1001A/C	RECEIVER, 20'W X 30'L X 28'H 10000 FT3 CAPACITY, W/ 30 DEG PYRAMID BOTTOM	6			541,200	
		SOURCE: 1					
		SUBTOTAL :	6	0	0	541,200	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	0	541,200	0
140	V-1003A/C	FEED BIN, 20'W X 20'L X20'H W/ 30 DEG PYRAMID BOTTOM, CS CONSTRUCTION	6			339,000	
		SOURCE: 1					
		SUBTOTAL :	6	0	0	339,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	0	339,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
140	V-1004A/C	FEED BIN, 20'L X 20'W X 20'H CS CONSTRUCTION W/ 30 DEG PYRAMID BOTTOM	6			339,000	
		SOURCE: 1					
		SUBTOTAL :	6	0	0	339,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	0	339,000	0
140	V-1005	RETORT FEED SILO, 60'W X 600'L X 91'H CONCRETE/ CS CONSTRUCTION W/ ROTARY FEEDERS	2			15,976,000	
		SOURCE: 1					
		SUBTOTAL :	2	0	0	15,976,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	15,976,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 140	20	0	0	17,195,200	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED B : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	B-1001	PRIMARY CRUSHING BLOWER		4		283,200		
		15530#/HR DUST FLOW RATE						
		COMP TYPE:	CENTRIF					
		INLET CAP ACFM:	120900					
		INLET PSIG:						
		OUTLET PSIG:	1" H2O					
		GAS HANDLED:						
		K VALVE (CP/CV):						
		MATERIAL:	CS					
		DRIVER TYPE:	M					
		DRIVER H.P.						
		SOURCE:	3 Buffalo Forge					
			SUBTOTAL :	4	0	283,200	0	0
		FREIGHT	3.0%			8,500		
		DEVELOPMENT	0.0%			0		
			TOTAL :	4	0	291,700	0	0
320	B-1002	SECONDARY CRUSHING BLOWER		4		1,512,800		
		87540#/HR DUST FLOW RATE						
		COMP TYPE:	CENTRIF					
		INLET CAP ACFM:	681240					
		INLET PSIG:						
		OUTLET PSIG:	1" H2O					
		GAS HANDLED:						
		K VALVE (CP/CV):						
		MATERIAL:	CS					
		DRIVER TYPE:	M					
		DRIVER H.P.	1092 BHP					
		SOURCE:	3 Buffalo Forge					
			SUBTOTAL :	4	0	1,512,800	0	0
		FREIGHT	3.0%			45,380		
		DEVELOPMENT	0.0%			0		
			TOTAL :	4	0	1,558,180	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : T&B

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	B-1003	TERTIARY CRUSHING BLOWER 98480#/HR DUST FLOW RATE	4		1,580,000		
		COMP TYPE: CENTRIF INLET CAP ACFM: 766400 INLET PSIG: OUTLET PSIG: 1" H2O GAS HANDLED: K VALVE (CP/CV): MATERIAL: CS DRIVER TYPE: M DRIVER H.P. 1357 BHP SOURCE: 3 Buffalo Forge					
		SUBTOTAL :	4	0	1,580,000	0	0
		FREIGHT 3.0%			47,400		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	1,627,400	0	0
320	B-1004	STACKING BOOM BLOWER 12.2#/HR DUST FLOW RATE	2		43,400		
		COMP TYPE: CENTRIF INLET CAP ACFM: 24640 INLET PSIG: OUTLET PSIG: 1" H2O GAS HANDLED: K VALVE (CP/CV): MATERIAL: CS DRIVER TYPE: M DRIVER H.P. 30 SOURCE: 3 Buffalo Forge					
		SUBTOTAL :	2	0	43,400	0	0
		FREIGHT 3.0%			1,300		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	44,700	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/97
REV. : 0
PREPARED BY : TA[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	B-1005	SILO BLOWER 16700#/HR DUST FLOW RATE	4		311,600		
		COMP TYPE: CENTRIF INLET CAP ACFM: 130000 INLET PSIG: OUTLET PSIG: 1" H2O GAS HANDLED: K VALVE (CP/CV): MATERIAL: CS DRIVER TYPE: M DRIVER H.P. 147 BHP SOURCE: 3 Buffalo Forge					
		SUBTOTAL	4	0	311,600	0	0
		FREIGHT 3.0%			9,350		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	320,950	0	0
		TOTAL CODE: 320	18	0	3,842,930	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED B : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
340	PK-1001	SAMPLING STATION INCLUDING: 1- PRIMARY STATION 1- BELT FEEDER 2- CRUSHERS 1- SECONDARY COLLECTOR	2		260,000		

SOURCE: 3 Wilmot Engr. Co.

	SUBTOTAL	2	0	260,000	0	0
FREIGHT	3.0%			7,800		
DEVELOPMENT	0.0%			0		
	TOTAL	2	0	267,800	0	0

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
340	PK-1002	SAMPLING STATION INCLUDING: 2- PRIMARY STATIONS 1- BELT FEEDER 1- CRUSHER 1- SECONDARY COLLECTOR	2		220,000		

SOURCE: 3 Wilmot Engr. Co.

	SUBTOTAL	2	0	220,000	0	0
FREIGHT	3.0%			6,600		
DEVELOPMENT	0.0%			0		
	TOTAL	2	0	226,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	340	4	0	494,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TSC

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	K-1001A/C	PRIMARY CRUSHER	6		1,665,000		
		SOLID ROTOR IMPACTOR, 850 TPH 40" FEED & 6" DISCHARGE 450 HP					
		SOURCE: 3 Penna. Crusher					
		SUBTOTAL :	6	0	1,665,000	0	0
		FREIGHT 3.0%			49,950		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	1,714,950	0	0
350	K-1002A/C	SECONDARY CRUSHER	6		1,031,400		
		REVERSIBLE IMPACTOR 850 TPH 6" FEED & 2" DISCHARGE 1000 HP					
		SOURCE: 3 Penna. Crusher					
		SUBTOTAL :	6	0	1,031,400	0	0
		FREIGHT 3.0%			30,940		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	1,062,340	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	K-1003	TERTIARY CRUSHER	6		1,779,600		
		REVERSIBLE IMPACTOR 1350 TPH 2" FEED & 1/4" DISCHARGE 1500 HP					
SOURCE: 3		Penna. Crusher					
		SUBTOTAL :	6	0	1,779,600	0	0
		FREIGHT 3.0%			53,390		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	1,832,990	0	0
350	S-1001A/C	40" GRIZZLY	6		595,200		
		20' X 40' CS					
		SOURCE: 1					
		SUBTOTAL :	6	0	595,200	0	0
		FREIGHT 3.0%			17,860		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	613,060	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	S-1002A/C	6" GRIZZLY	6		162,000		
		8' X 10'					
		CS					
		SOURCE: 1					
		SUBTOTAL :	6	0	162,000	0	0
		FREIGHT 3.0%			4,860		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	166,860	0	0
350	S-1003A/C	2 INCH SCREEN	6		90,000		
		9' X 12'					
		CS					
		850 TPH CAPACITY					
		SOURCE: 1					
		SUBTOTAL :	6	0	90,000	0	0
		FREIGHT 3.0%			2,700		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	92,700	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO: : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAT

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	S-1004A/C	6 mm SCREEN 9' X 12' CS 1450 TPH CAPACITY SOURCE: 1	6		90,000		
		SUBTOTAL :	6	0	90,000	0	0
		FREIGHT 3.0%			2,700		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	92,700	0	0
350	S-1005A/C	6 mm SCREEN 12' X 16' CS 1350 TPH CAPACITY SOURCE: 1	6		174,000		
		SUBTOTAL :	6	0	174,000	0	0
		FREIGHT 3.0%			5,220		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	179,220	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED B : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	F-1001	PRIMARY CRUSHING BAGHOUSE 120900 ACFM 20850#/HR CS	2		406,000		
		SOURCE: 3 *Cino Equip Co.*					
		SUBTOTAL :	2	0	406,000	0	0
		FREIGHT 3.0%			12,180		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	418,180	0	0
350	F-1002	SECONDARY CRUSHING BAGHOUSE 681240 ACFM 118820#/HR CS	2		2,200,000		
		SOURCE: 3 *Cino Equip Co.*					
		SUBTOTAL :	2	0	2,200,000	0	0
		FREIGHT 3.0%			66,000		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	2,266,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	F-1003	TERTIARY BAGHOUSE	2		2,400,000		
		766400 ACFM 133670#/HR CS					
		SOURCE: 3 Cino Equip Co.					
		SUBTOTAL :	2	0	2,400,000	0	0
		FREIGHT 3.0%			72,000		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	2,472,000	0	0
350	F-1004	STACKING BOOM BAGHOUSE	2		84,000		
		24640 ACFM 1252#/HR CS					
		SOURCE: 3 Cino Equip. Co.					
		SUBTOTAL :	2	0	84,000	0	0
		FREIGHT 3.0%			2,520		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	86,520	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TRT

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	F-1005	SILO BAGHOUSE	2		436,000		
		130000 ACFM 22667#/HR CS					
		SOURCE: 3 Cino Equip Co.					
		SUBTOTAL :	2	0	436,000	0	0
		FREIGHT 3.0%			13,080		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	449,080	0	0
350	X-1006	HYDRAULIC ROCK BUSTER	2		216,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	216,000	0	0
		FREIGHT 3.0%			6,480		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	222,480	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAT

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	X-1005	MAGNETIC SEPARATOR 48" BELT WIDTH	2		13,000		
		SOURCE: 1					
		SUBTOTAL	2	0	13,000	0	0
		FREIGHT 3.0%			390		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	13,390	0	0
		TOTAL CODE: 350	62	0	11,682,470	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED B : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	A-1001A/C	APRON FEEDERS 76"W X 20'L 850 TPH	6		270,000		

SOURCE: 1

	SUBTOTAL	6	0	270,000	0	0
FREIGHT	3.0%			8,100		
DEVELOPMENT	0.0%			0		
	TOTAL	6	0	278,100	0	0

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	A-1002A/C	APRON FEEDER 102"W X 18'L 850 TPH	6		330,000		

SOURCE: 1

	SUBTOTAL	6	0	330,000	0	0
FREIGHT	3.0%			9,900		
DEVELOPMENT	0.0%			0		
	TOTAL	6	0	339,900	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	A-1003A/C	APRON FEEDER 102"W X 18'L 1400 TPH	6		330,000		
		SOURCE: 1					
		SUBTOTAL :	6	0	330,000	0	0
		FREIGHT 3.0%			9,900		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	339,900	0	0
360	CV-1001A/C	PRIMARY CRUSHER CONVEYOR 36"W X 120'L 850 TPH	6		311,100		
		SOURCE: 1					
		SUBTOTAL :	6	0	311,100	0	0
		FREIGHT 3.0%			9,330		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	320,430	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-1002	TRANSFER CONVEYOR 48"W X 360'L 3000 TPH	2		414,800		
		SOURCE: 1					
		SUBTOTAL	2	0	414,800	0	0
		FREIGHT 3.0%			12,440		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	427,240	0	0
360	CV-1003	STACKER CONVEYOR 48"W X 1600'L 3000 TPH	2		1,843,200		
		SOURCE: 1					
		SUBTOTAL	2	0	1,843,200	0	0
		FREIGHT 3.0%			55,300		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	1,898,500	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-1004A/B	COARSE SHALE CONVEYOR 48"W X 350'L 3000 TPH	4		806,400		
		SOURCE: 1					
		SUBTOTAL :	4	0	806,400	0	0
		FREIGHT 3.0%			24,190		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	830,590	0	0
360	CV-1005A/C	SECONDARY CRUSHER CONVEYOR 36"W X 220'L 850 TPH	6		570,000		
		SOURCE: 1					
		SUBTOTAL :	6	0	570,000	0	0
		FREIGHT 3.0%			17,100		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	587,100	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-1006A/C	TERTIARY CRUSHER CONVEYOR 36"W X 160'L 850 TPH	6		414,600		
		SOURCE: 1					
		SUBTOTAL :	6	0	414,600	0	0
		FREIGHT 3.0%			12,440		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	427,040	0	0
360	CV-1007A/B	TERTIARY CRUSHING CONVEYOR 48"W X 350'L 2600 TPH	4		806,400		
		SOURCE: 1					
		SUBTOTAL :	4	0	806,400	0	0
		FREIGHT 3.0%			24,190		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	830,590	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-1008A/C	RECYCLE CONVEYOR 30"W X 150'L 520 TPH	6		324,000		
		SOURCE: 1					
		SUBTOTAL :	6	0	324,000	0	0
		FREIGHT 3.0%			9,720		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	333,720	0	0
360	CV-1009A/B	TRANSFER CONVEYOR 48"W X 60'L 2600 TPH	4		138,400		
		SOURCE: 1					
		SUBTOTAL :	4	0	138,400	0	0
		FREIGHT 3.0%			4,150		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	142,550	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-1010A/B	TRANSVERSE CONVEYOR 48"W X 550'L 2600 TPH	4		1,267,200		
		SOURCE: 1					
		SUBTOTAL :	4	0	1,267,200	0	0
		FREIGHT 3.0%			38,020		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	1,305,220	0	0
360	CV-1011A/B	LOWER TRANSVERSAL CONVEYOR 48"W X 550'L 2600 TPH	4		1,267,200		
		SOURCE: 1					
		SUBTOTAL :	4	0	1,267,200	0	0
		FREIGHT 3.0%			38,020		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	1,305,220	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-1012A/B	RETORT FEED CONVEYOR 48"W X 750'L 2600 TPH	4		2,288,000		
		SOURCE: 1					
		SUBTOTAL	4	0	2,288,000	0	0
		FREIGHT 3.0%			68,640		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	2,356,640	0	0
360	CV-1013A/B	RETORT DISTRIBUTION CONVEYOR 48"W X 540'L 2600 TPH	4		1,244,000		
		SOURCE: 1					
		SUBTOTAL	4	0	1,244,000	0	0
		FREIGHT 3.0%			37,320		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	1,281,320	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	CV-1014	CROSS TRANSFER CONVEYOR 48"W X 260'L 2600 TPH	2		299,600		
		SOURCE: 1					
		SUBTOTAL	2	0	299,600	0	0
		FREIGHT 3.0%			8,990		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	308,590	0	0
360	X-1003	BELT CONVEYOR SCALE 3000 TPH	2		16,000		
		SOURCE: 1					
		SUBTOTAL	2	0	16,000	0	0
		FREIGHT 3.0%			480		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	16,480	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
360	X-1004	BELT CONVEYOR SCALE 3000 TPH	2		16,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	16,000	0	0
		FREIGHT 3.0%			480		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	16,480	0	0
360	X-1001	TRAVELING BOOM STACKER FREIGHT INCLUDED	2		4,738,000		
		SOURCE: 3 KRUPP IND.					
		SUBTOTAL :	2	0	4,738,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	4,738,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
360	X-1002	BUCKET WHEEL RECLAIMER	4			19,200,000	
		SOURCE: 3 KRUPP IND.					
		SUBTOTAL	4	0	0	19,200,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	0	19,200,000	0
		TOTAL CODE: 360	86	0	18,083,610	19,200,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FEED PREPARATION SECT. 1000

JOB NO. : 11-36265
DATE : 04/14/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
490	V-1002	TRAVELING HOPPER (TRIPLE HOPPER RAIL CAR) 1750 CU. FT. CAPACITY	20		800,000		
		SOURCE: 3 BETHLEHEM STEEL					
		SUBTOTAL	20	0	800,000	0	0
		FREIGHT 3.0%			24,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	20	0	824,000	0	0
		TOTAL CODE: 490	20	0	824,000	0	0

APPENDIX B-10

EQUIPMENT COST DATA

SPENT SHALE DISPOSAL - UNIT 1100

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE DISPOSAL SECT. 1100

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	0	0	0	0	
140	STORAGE TANKS	0	312,000	312,000	0	0.6%
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	7,800	0	7,800	0	0.0%
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	53,152,000	0	53,152,000	0	99.4%
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	53,159,800	312,000	53,471,800	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE DISPOSAL SECT. 1100

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
141	TK-1101	WATER STORAGE TANK API TYPE	1			312,000	
		SIZE: 110' DIA X 36' H TYPE OF ROOF: CONE CAP. IN BARRELS: 60000 MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL	1	0	0	312,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	1	0	0	312,000	0
		TOTAL CODE: 141	1	0	0	312,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE DISPOSAL SECT. 1100

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-1101A/B	WATER PUMP	2		7,600		
		GPM: 500					
		HD. FT.: 250					
		PSI:					
		S.G.: 1.0					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 50					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	2	0	7,600	0	0
		FREIGHT 3.0%			230		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	7,830	0	0
		TOTAL CODE: 310	2	0	7,830	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE DISPOSAL SECT. 1100

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TH

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
390	X-1101	HAUL TRUCKS	25		37,500,000		
		DUMP BOTTOM 100 YD3 CAPACITY 1500 HP DIESEL DRIVE					
		SOURCE: 3					
		SUBTOTAL	25	0	37,500,000	0	0
		FREIGHT 1.5%			562,500		
		DEVELOPMENT 0.0%			0		
		TOTAL	25	0	38,062,500	0	0
390	X-1102	CRAWLER BULLDOZER	8		3,200,000		
		400 HP					
		SOURCE: 3					
		SUBTOTAL	8	0	3,200,000	0	0
		FREIGHT 3.0%			96,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	8	0	3,296,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE DISPOSAL SECT. 1100

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED B : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
390	X-1103	PUSHER DOZER 400 HP	3		1,200,000		
		SOURCE: 3					
		SUBTOTAL	3	0	1,200,000	0	0
		FREIGHT 3.0%			36,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	3	0	1,236,000	0	0
390	X-1104	SCRAPER, TRACTOR TOWED 54 YD3 CAPACITY	10		8,700,000		
		SOURCE: 3					
		SUBTOTAL	10	0	8,700,000	0	0
		FREIGHT 3.0%			261,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	10	0	8,961,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE DISPOSAL SECT. 1100

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
390	X-1105	SCRAPER, TRACTOR TOWED 20 YD3 CAPACITY	2		680,000		
		SOURCE: 3					
		SUBTOTAL	2	0	680,000	0	0
		FREIGHT 3.0%			20,400		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	700,400	0	0
390	X-1106	GRADER, 140 HP	2		300,000		
		SOURCE: 3					
		SUBTOTAL	2	0	300,000	0	0
		FREIGHT 3.0%			9,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	309,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : SPENT SHALE DISPOSAL SECT. 1100

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
390	X-1107	SEGMENTED COMPACTOR	2		180,000		
		4000#					
		SOURCE: 3					
		SUBTOTAL	2	0	180,000	0	0
		FREIGHT 3.0%			5,400		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	185,400	0	0
390	X-1108	TRACTOR, 100 HP	2		300,000		
		RUBBER TIRED					
		SOURCE: 3					
		SUBTOTAL	2	0	300,000	0	0
		FREIGHT 3.0%			9,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	309,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : SPENT SHALE DISPOSAL SECT. 1100

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAH

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
390	X-1109	WATER TANK TRUCK	2		90,000		
		5000 GAL CAPACITY					

SOURCE; 1

SUBTOTAL :		2	0	90,000	0	0
FREIGHT	3.0%			2,700		
DEVELOPMENT	0.0%			0		
TOTAL :		2	0	92,700	0	0
TOTAL CODE:	390	56	0	53,152,000	0	0

APPENDIX B-11

EQUIPMENT COST DATA

RAW WATER TREATMENT - UNIT 2000

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	33,100	0	33,100	0	2.0%
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	18,400	0	18,400	0	1.1%
140	STORAGE TANKS	96,800	462,300	559,100	0	34.0%
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	70,800	0	70,800	0	4.3%
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	83,200	0	83,200	0	5.1%
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	323,400	0	323,400	0	19.7%
940	WASTE TREATING	556,200	0	556,200	0	33.8%
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	1,181,900	462,300	1,644,200	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
110	T-2051	DEGASSER, 5' X 12' VERT. 9' X 10' HORIZ. W/ 300 SCFM 5 HP FAN HORIZ. DRUM W/ VERT. STRIPPER	1	17,900	33,100		
		VERT. OR HORIZ.: V/H					
		SUPPORT: SDLS					
		MATERIAL: CS					
		STRESS RELIEVE: NO					
		X-RAY: SPOT					
		JOINT EFF.: 85%					
		WALL THICKNESS: 3/8" & 5/16"					
		CORR. ALLOW.: 1/8"					
		DESIGN - PSIG/TEMP: 25&FV/650					
		ASME CODE: VIII D1					
		NOZ/MW RATING: 150#					
		SOURCE: 1					
		SUBTOTAL :	1	17,900	33,100	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	1	17,900	33,100	0	0
		TOTAL CODE: 110	1	17,900	33,100	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TRF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2054	ACID STORAGE DRUM 6' DIA X 16' T/T VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: CS STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 5/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: 25/650 ASME CODE: ASME VIII D1 NOZ/MW RATING: 150# SOURCE: 1	1	8,400	9,200		
		SUBTOTAL	1	8,400	9,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	1	8,400	9,200	0	0
130	D-2055	CAUSTIC STORAGE DRUM 6' DIA X 16' T/T VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: CS STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 5/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: 25/650 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1	1	8,400	9,200		
		SUBTOTAL	1	8,400	9,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	1	8,400	9,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 130	2	16,800	18,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
141	TK-2002	TREATED RAW WATER STORAGE TANK	1			224,000	
		SIZE: 80' DIA X 48' H					
		TYPE OF ROOF: CONE					
		CAP. IN BARRELS: 42973					
		MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL :	1	0	0	224,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	1	0	0	224,000	0
141	TK-2052	DEMINERALIZED WATER STORAGE TANK	1			93,700	
		SIZE: 40' DIA X 32' H					
		TYPE OF ROOF: CONE					
		CAP. IN BARRELS: 7162					
		MATERIAL: CS/EPOXY LINED					
		SOURCE: 1					
		SUBTOTAL :	1	0	0	93,700	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	1	0	0	93,700	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
141	TK-2053	POTABLE WATER STORAGE TANK	1			144,600	

SIZE: 50' DIA X 42' H
TYPE OF ROOF: CONE
CAP. IN BARRELS: 14688
MATERIAL: CS/EPOXY LINED

SOURCE: 1

	QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL	1	0	0	144,600	0
FREIGHT 0.0%			0		
DEVELOPMENT 0.0%			0		
TOTAL	1	0	0	144,600	0

	QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
TOTAL CODE: 141	3	0	0	462,300	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TA?

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
142	TK-2001	HEAD TANK		2	66,000	62,600		
		15' DIA X 32' H						
		OPEN TOP						
		VERT. OR HORIZ.:	V					
		SUPPORT:						
		MATERIAL:	CS					
		STRESS RELIEVE:	NO					
		X-RAY:	SPOT					
		JOINT EFF.:	85%					
		WALL THICKNESS:	7/16"					
		CORR. ALLOW.:	1/8"					
		DESIGN - PSIG/TEMP:	ATM/AMB					
		ASME CODE:	NO					
		NOZ/MW RATING:	STD					
		SOURCE:	1					
			SUBTOTAL :	2	66,000	62,600	0	0
		FREIGHT	0.0%			0		
		DEVELOPMENT	0.0%			0		
			TOTAL :	2	66,000	62,600	0	0
142	TK-2051A/B	NEUTRALIZATION TANK		2	19,600	34,200		
		10' DIA X 18' T/T						
		EPOXY LINED						
		VERT. OR HORIZ.:	V					
		SUPPORT:						
		MATERIAL:	CS					
		STRESS RELIEVE:	NO					
		X-RAY:	SPOT					
		JOINT EFF.:	85%					
		WALL THICKNESS:	1/4"					
		CORR. ALLOW.:	EPOXY LINED					
		DESIGN - PSIG/TEMP:	ATM/AMB					
		ASME CODE:	VIII D1					
		NOZ/MW RATING:	150#					
		SOURCE:	1					
			SUBTOTAL :	2	19,600	34,200	0	0
		FREIGHT	0.0%			0		
		DEVELOPMENT	0.0%			0		
			TOTAL :	2	19,600	34,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 142	4	85,600	96,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2001A/D	CLARIFIER UNDERFLOW PUMP	4		5,600		
		GPM: 95 HD. FT.: 58 PSI: S.G.: PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 5 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL	4	0	5,600	0	0
		FREIGHT 3.0%			170		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	5,770	0	0
310	P-2002A/D	SANDFILTER DISCHARGE PUMP	4		22,400		
		GPM: 1905 HD. FT.: 69 PSI: S.G.: PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 50 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL	4	0	22,400	0	0
		FREIGHT 3.0%			670		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	23,070	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2003A/C	CARBON FILTER FEED PUMP	3		23,100		
		GPM: 1905 HD. FT.: 173 PSI: S.G.: PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 125 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL :	3	0	23,100	0	0
		FREIGHT 3.0%			690		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	0	23,790	0	0
310	P-2051A/B	NEUTRALIZED WATER PUMP	2		2,800		
		GPM: 130 HD. FT.: 69 PSI: S.G.: PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 5 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL :	2	0	2,800	0	0
		FREIGHT 3.0%			80		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	2,880	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2052A/B	DEMINERALIZED WATER PUMP	2		5,400		
		GPM: 520					
		HD. FT.: 127					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 30					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	2	0	5,400	0	0
		FREIGHT 3.0%			[illegible]		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	5,560	0	0
310	P-2053A/B	DEGASIFIER DISCHARGE PUMP	2		6,000		
		GPM: 600					
		HD. FT.: 173					
		PSI:					
		S.G.:					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 40					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	2	0	6,000	0	0
		FREIGHT 3.0%			180		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	6,180	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2054A/B	POTABLE WATER PUMP	2		3,400		

GPM:	200
HD. FT.:	185
PSI:	
S.G.:	1
PUMP TYPE:	HC
PUMP MATERIAL:	CS
DRIVE TYPE:	M
DRIVE HP:	20
SHOP OR FIELD MT.:	S
SOURCE:	1

		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
SUBTOTAL		2	0	3,400	0	0
FREIGHT	3.0%			100		
DEVELOPMENT	0.0%			0		
TOTAL		2	0	3,500	0	0
TOTAL CODE:	310	19	0	70,750	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED B : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	F-2001A/H	CLARIFIED WATER SANDFILTER 12' DIA X 8' T/T, VERTICAL GRAVITY TYPE 25 PSIG DESIGN 4' BED HEIGHT	8		80,800		
		SOURCE: 1					
		SUBTOTAL :	8	0	80,800	0	0
		FREIGHT 3.0%			2,420		
		DEVELOPMENT 0.0%			0		
		TOTAL :	8	0	83,220	0	0
		TOTAL CODE: 350	8	0	83,220	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED B[illegible] : TA[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
930	X-2001	CHEMICAL FEED SYSTEM INCLUDING: LIME & ALUM SLURRY TANKS PUMPS, AGITATOR, MISC. PIPING. ALL SKID MOUNTED	1		29,000		
		SOURCE: 1					
		SUBTOTAL :	1	0	29,000	0	0
		FREIGHT 3.0%			870		
		DEVELOPMENT 0.0%			0		
		TOTAL :	1	0	29,870	0	0
930	D-2051A/B	CATION EXCHANGER 520 GPM 12' DIA X 12' T/T CS/EPOXY LINED 125 PSIG DESIGN PRESSURE 8' BED HEIGHT	2		59,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	59,000	0	0
		FREIGHT 3.0%			1,770		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	60,770	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED B : TAT

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
930	D-2052A/B	ANION EXCHANGER	2		59,000		
		520 GPM 12' DIA X 12' T/T CS/EPOXY LINED 125 PSIG DESIGN PRESSURE 8' BED HEIGHT					
		SOURCE: 1					
		SUBTOTAL	2	0	59,000	0	0
		FREIGHT 3.0%			1,770		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	60,770	0	0
930	D-2053A/B	MIXED BED EXCHANGER	2		59,000		
		520 GPM 12' DIA X 12' T/T CS/EPOXY LINED 125 PSIG DESIGN PRESSURE 8' BED HEIGHT					
		SOURCE: 1					
		SUBTOTAL	2	0	59,000	0	0
		FREIGHT 3.0%			1,770		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	60,770	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TA[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
930	F-2051A/B	ACTIVATED CARBON FILTER	2		63,000		
		720 GPM					
		12'6" DIA X 14' T/T					
		CS					
		125 PSIG DESIGN PRESSURE					
		8' BED HEIGHT					
		SOURCE: 1					
		SUBTOTAL :	2	0	63,000	0	0
		FREIGHT 3.0%			1,890		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	64,890	0	0
930	PG-2051	ACID INJECTION PACKAGE	2		30,000		
		1 GPM					
		INCLUDING: DILUTION TANK &					
		TWO PUMPS, TYPE 316SS					
		SOURCE: 1					
		SUBTOTAL :	2	0	30,000	0	0
		FREIGHT 3.0%			900		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	30,900	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
930	PG-2052	CAUSTIC INJECTION PACKAGE	2		0		
		INCLUDING:					
		CAUSTIC HEATER & 2 PUMPS					
		CS					
		COST INCLUDED W/ PG-2051					
		SOURCE: 1					
		SUBTOTAL :	2	0	0	0	0
		FREIGHT 3.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	0	0
930	PG-2053	POTABLE WATER CHLORINATOR, 200 GPM	2		15,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	15,000	0	0
		FREIGHT 3.0%			450		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	15,450	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 930	15	0	323,420	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : RAW & BF WATER TREATMENT SECT. 2000

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
940	CL-2001A/B	CLARIFIER SOFTENER 75' DIA X 10' STR. SIDES CS CONE BOTTOM	2		540,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	540,000	0	0
		FREIGHT 3.0%			16,200		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	556,200	0	0
		TOTAL CODE: 940	2	0	556,200	0	0

APPENDIX B-12

EQUIPMENT COST DATA

STEAM AND POWER GENERATION - UNIT 2100

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY: TAR

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	57,200	0	57,200	0	0.5%
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	1,034,100	0	1,034,100	0	8.2%
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	704,500	0	704,500	0	5.6%
320	COMPRESSORS	157,400	0	157,400	0	1.3%
330	ELECTRICAL GENERATORS	9,867,400	0	9,867,400	0	78.5%
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	749,000	0	749,000	0	6.0%
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	12,569,600	0	12,569,600	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2101A/B	CONDENSATE DRUM 7'6" DIA X 15' T/T	4	47,600	57,200		
		VERT. OR HORIZ.: V SUPPORT: LEGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 7/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: 15&FV/150 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL	4	47,600	57,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	47,600	57,200	0	0
TOTAL CODE: 130			4	47,600	57,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
280	E-2101A/B	STEAM SURFACE CONDENSER	4		1,004,000		
		16650 FT2 PER SHELL TUBES: CS/100PSI/150 DEG F SHELL: CS/15&FV/175 DEG F					

SOURCE: 1

:	SUBTOTAL :	4 :	0 :	1,004,000 :	0 :	0 :
FREIGHT	3.0%			30,120		
DEVELOPMENT	0.0%			0		
:	TOTAL :	4 :	0 :	1,034,120 :	0 :	0 :

:	TOTAL CODE: 280 :	4 :	0 :	1,034,120 :	0 :	0 :

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2101A/B	H.P. BFW PUMP	4		139,200		
		GPM: 625					
		HD. FT.: 1630					
		PSI:					
		S.G.: 1.0					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: T					
		DRIVE HP: 350					
		SHOP OR FIELD MT.: F					
		SOURCE: 3 WORTHINGTON					
		SUBTOTAL	4	0	139,200	0	0
		FREIGHT 3.0%			4,180		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	143,380	0	0
310	P-2101C/F	H.P. BFW PUMP	8		358,400		
		GPM: 625					
		HD. FT.: 1630					
		PSI:					
		S.G.: 1					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 350					
		SHOP OR FIELD MT.: F					
		SOURCE: 3 WORTHINGTON					
		SUBTOTAL	8	0	358,400	0	0
		FREIGHT 3.0%			10,750		
		DEVELOPMENT 0.0%			0		
		TOTAL	8	0	369,150	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2102A	M.P./L.P. BFW PUMP	2		30,000		
		GPM: 350					
		HD. FT.: 440					
		PSI:					
		S.G.: 1					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: T					
		DRIVE HP: 75					
		SHOP OR FIELD MT.: S					
		SOURCE: 3					
		WORTHINGTON					
		SUBTOTAL :	2	0	30,000	0	0
		FREIGHT 3.0%			900		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	30,900	0	0
310	P-2102B/C	M.P./L.P. BFW PUMP	4		39,600		
		GPM: 350					
		HD. FT.: 440					
		PSI:					
		S.G.: 1					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 75					
		SHOP OR FIELD MT.: S					
		SOURCE: 3					
		WORTHINGTON					
		SUBTOTAL :	4	0	39,600	0	0
		FREIGHT 3.0%			1,190		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	40,790	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2103A/H	CONDENSATE PUMP	16		116,800		
		GPM: 700					
		HD. FT.: 160					
		PSI:					
		S.G.: 1					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 40					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	16	0	116,800	0	0
		FREIGHT 3.0%			3,500		
		DEVELOPMENT 0.0%			0		
		TOTAL	16	0	120,300	0	0
		TOTAL CODE: 310	34	0	704,520	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	C-2101A/D	VACUUM PUMP	8		152,800		

COMP TYPE: CENTRIF
INLET CAP ACFM: 800
INLET PSIG: 2" Hg ABS
OUTLET PSIG: ATM
GAS HANDLED:
K VALVE (CP/CV):
MATERIAL: CS
DRIVER TYPE: M
DRIVER H.P. 75
SOURCE: 1

		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
SUBTOTAL		8	0	152,800	0	0
FREIGHT	3.0%			4,580		
DEVELOPMENT	0.0%			0		
TOTAL		8	0	157,380	0	0
TOTAL CODE:	320	8	0	157,380	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
330	TG-2101	H.P. TURBOGENERATOR	2		6,200,000		
		CONDENSING TYPE					
		600 PSI INLET STEAM					
		2" Hg ABS OUTLET STEAM					
		346515 #/HR STEAM FLOW					
		27.56 MW					
		SOURCE: 1					
		SUBTOTAL :	2	0	6,200,000	0	0
		FREIGHT 3.0%			186,000		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	6,386,000	0	0
330	TG-2102	M.P. TURBOGENERATOR	2		3,380,000		
		CONDENSING TYPE					
		150 PSIG INLET STEAM					
		2" Hg ABS OUTLET STEAM					
		240012 #/HR STEAM FLOW					
		12.55 MW					
		SOURCE: 1					
		SUBTOTAL :	2	0	3,380,000	0	0
		FREIGHT 3.0%			101,400		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	3,481,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	330	4	0	9,867,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
930	DH-2101A/B	H.P. BFW DEAERATOR 600000#/HR OUTLET 50 PSIG @ 275 DEG F DESIGN CS	4		489,200		
		SOURCE: 1					
		SUBTOTAL :	4	0	489,200	0	0
		FREIGHT 3.0%			14,680		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	503,880	0	0
930	DH-2102A/B	M.P./L.P. DEAERATOR 165000#/HR OUTLET 50 PSIG @ 275 DEG F DESIGN CS	4		238,000		
		SOURCE: 1					
		SUBTOTAL :	4	0	238,000	0	0
		FREIGHT 3.0%			7,140		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	245,140	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STEAM & POWER GEN. SECT. 2100

JOB NO. : 11-36265
DATE : 04/24/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	930	8	0	749,020	0	0

APPENDIX B-13

EQUIPMENT COST DATA

COOLING WATER SYSTEM - UNIT 2200

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO.
UNIT : COOLING WATER SYS. SECT. 2200

JOB NO. : 11-36265
DATE : 04/28/87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	0	0	0	0	
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	[illegible]	[illegible]	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	1,798,400	0	1,798,400	0	32.5%
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	3,740,000	3,740,000	0	67.5%
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	1,798,400	3,740,000	5,538,400	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT :COOLING WATER SYS. SECT. 2200

JOB NO. : 11-36265
DATE : 04/28/87
REV. : 0
PREPARED BY : T[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2201A/C	COOLING WATER CIRC. PUMPS & SPARE FOR CT-2201A/B	6		1,164,000		
		GPM: 47550					
		HD. FT.: 196					
		PSI: 85					
		S.G.: 1.0					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 3000					
		SHOP OR FIELD MT.: F					
		SOURCE: 3 WORTHINGTON					
		SUBTOTAL	6	0	1,164,000	0	0
		FREIGHT 3.0%			34,920		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	1,198,920	0	0
310	P-2202A/C	COOLING WATER CIRC. PUMPS & SPARE FOR CT-2202	3		582,000		
		GPM: 43520					
		HD. FT.: 196					
		PSI: 85					
		S.G.: 1					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 3000					
		SHOP OR FIELD MT.: F					
		SOURCE: 3 WORTHINGTON					
		SUBTOTAL	3	0	582,000	0	0
		FREIGHT 3.0%			17,460		
		DEVELOPMENT 0.0%			0		
		TOTAL	3	0	599,460	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT :COOLING WATER SYS. SECT. 2200

JOB NO. : 11-36265
DATE : 04/28/87
REV. : 0
PREPARED BY : TPF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	310	9	0	1,798,380	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT :COOLING WATER SYS. SECT. 2200

JOB NO. : 11-36265
DATE : 04/28/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
920	CT-2201A/B	COOLING TOWER (PACKAGE) FOR UNIT 2100 86427 GPM 4 CELL 10.3 FEG F DELTA T 63 DEG F WET BULB 17 DEG F APPROACH 60' W X 246' L ONE 125 HP MOTOR/CELL PKG. INCLUDES CHEM. ADDITION SYSTEMS: BIOCIDE, CORROSION INHIBITOR, DISPERSANT & ACID SOURCE: 1	2			2,700,000	
		SUBTOTAL :	2	0	0	2,700,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	2,700,000	0
920	CT-2202	COOLING TOWER PACKAGE 79130 GPM 6 CELL 30 DEG F DELTA T 63 DEG F WET BULB 17 DEG F APPROACH 54' W X 294' L ONE 200 HP MOTOR/CELL PKG. INCLUDES CHEM ADDITION SYSTEMS: BIOCIDE, CORROSION INHIBITOR, DISPERSANT & ACID SOURCE: 1	1			1,040,000	
		SUBTOTAL :	1	0	0	1,040,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	1	0	0	1,040,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT :COOLING WATER SYS. SECT. 2200

JOB NO. : 11-36265
DATE : 04/28/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
	TOTAL CODE:	920	3	0	0	3,740,000	0

APPENDIX B-14

EQUIPMENT COSI DATA

PLANT AND INSTRUMENT AIR - UNIT 2300

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : PLANT & INST. AIR SECT. 2300

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	47,100	0	47,100	0	6.4%
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	24,100	0	24,100	0	3.3%
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	0	0	0	0	
320	COMPRESSORS	553,100	0	553,100	0	75.2%
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	35,900	0	35,900	0	4.9%
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	75,100	0	75,100	0	10.2%
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	735,300	0	735,300	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : PLANT & INST. AIR SECT. 2300

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
130	D-2301	AIR RECEIVER 5'6" DIA X 7' T/T VERT. OR HORIZ.: V SUPPORT: LEGS MATERIAL: CS STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: V CORR. ALLOW.: V DESIGN - PSIG/TEMP: 150/V ASME CODE: Y NOZ/MW RATING: 150# SOURCE: 1	3		47,100		
		SUBTOTAL :	3	0	47,100	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	0	47,100	0	0
		TOTAL CODE: 130	3	0	47,100	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : PLANT & INST. AIR SECT. 2300

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TP[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-2301A/C	AIR COMPRESSOR AFTERCOOLER 516000 BTU/HR DUTY	3		23,400		
		TYPE: V SHELL ID IN.: V TUBE LENGTH FT.: V NO. OF SHELLS: 1 SQ. FT. PER SHELL: TOTAL SQ FT.: 233 SHELL - PSIG/TEMP: V TUBE - PSIG/TEMP: V MATL. - SHELL/TUBE: CS SOURCE: 1					
		SUBTOTAL	3	0	23,400	0	0
		FREIGHT 3.0%			700		
		DEVELOPMENT 0.0%			0		
		TOTAL	3	0	24,100	0	0
		TOTAL CODE: 210	3	0	24,100	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : PLANT & INST. AIR SECT. 2300

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED B Th

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	C-2301A/C	AIR COMPRESSOR W/ 3 STAGE WATER-COOLED INTERCOOLERS	3		537,000		
		COMP TYPE: CENTRIF					
		INLET CAP ACFM: 2900 SCFM					
		INLET PSIG:					
		OUTLET PSIG: 125					
		GAS HANDLED: AIR					
		K VALVE (CP/CV):					
		MATERIAL: CS					
		DRIVER TYPE: M					
		DRIVER H.P. 1250					
		SOURCE: 1					
		SUBTOTAL	3	0	537,000	0	0
		FREIGHT 3.0%			16,110		
		DEVELOPMENT 0.0%			0		
		TOTAL	3	0	553,110	0	0
		TOTAL CODE: 320	3	0	553,110	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : PLANT & INST. AIR SECT. 2300

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED B : TH-

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
350	F-2301A/C	SUCTION AIR FILTER W/ REPLACEABLE GLASS FIBER FILTER SECTIONS 2900 SCFM CS	3		13,500		
		SOURCE: 1					
		SUBTOTAL	3	0	13,500	0	0
		FREIGHT 3.0%			410		
		DEVELOPMENT 0.0%			0		
		TOTAL	3	0	13,910	0	0
350	F-2302A/C	AIR PREFILTER 900 SCFM FLOW 4126#/HR CARTRIDGE TYPE CS	3		15,300		
		SOURCE: 1					
		SUBTOTAL	3	0	15,300	0	0
		FREIGHT 3.0%			460		
		DEVELOPMENT 0.0%			0		
		TOTAL	3	0	15,760	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : PLANT & INST. AIR SECT. 2300

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
350	F-2303A/C	AIR AFTERFILTER 900SCFM FLOW 4126#/HR CARTRIDGE TYPE CS	3		6,000		

SOURCE: 1

		QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
SUBTOTAL		3	0	6,000	0	0
FREIGHT	3.0%			180		
DEVELOPMENT	0.0%			0		
TOTAL		3	0	6,180	0	[illegible]
TOTAL CODE:	350	9	0	35,850	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : PLANT & INST. AIR SECT. 2300

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TAH

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
390	DR-2301A/C	INSTRUMENT AIR DRYER DUAL SYSTEM DRY TO -40 DEG F 900 SCFM CS	3		72,900		
		SOURCE: 1					
		SUBTOTAL	3	0	72,900	0	0
		FREIGHT 3.0%			2,190		
		DEVELOPMENT 0.0%			0		
		TOTAL	3	0	75,090	0	0
		TOTAL CODE: 390	3	0	75,090	0	0

APPENDIX B-15

EQUIPMENT COST DATA

WASTE WATER TREATMENT - UNIT 2400

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY: RWE

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	35,200	0	35,200	0	1.0%
140	STORAGE TANKS	35,200	0	35,200	0	1.0%
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	174,600	0	174,600	0	4.9%
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	254,900	0	254,900	0	7.1%
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	3,086,400	0	3,086,400	0	86.1%
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	3,586,300	0	3,586,300	0	100.0%

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2401	NUTRIENT STORAGE DRUM	2	2,800	8,800		
		VERT. OR HORIZ.: VERT SUPPORT: LEGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: ATM/170F ASME CODE: VIII D1 NOZ/MW RATING: 150 LB SOURCE: 1					
		SUBTOTAL :	2	2,800	8,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	2,800	8,800	0	0
130	D-2402	CAUSTIC DAY TANK	2	2,800	8,800		
		VERT. OR HORIZ.: VERT SUPPORT: LEGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: ATM/170 F ASME CODE: VIII D1 NOZ/MW RATING: 150 LB SOURCE: 1					
		SUBTOTAL :	2	2,800	8,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	2,800	8,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED B : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2403	ACID DAY DRUM	2	2,800	8,800		
		VERT. OR HORIZ.: VERT SUPPORT: LEGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: ATM/170 F ASME CODE: VIII D1 NOZ/MW RATING: 150 LB SOURCE: 1					
		SUBTOTAL	2	2,800	8,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	2,800	8,800	0	0
130	D-2404	ALUM STORAGE TANK	2	2,800	8,800		
		VERT. OR HORIZ.: VERT SUPPORT: LEGS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/16" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: ATM/170 F ASME CODE: VIII D1 NOZ/MW RATING: 150 LB SOURCE: 1					
		SUBTOTAL	2	2,800	8,800	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	2,800	8,800	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RNE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
		TOTAL CODE: 130	8	11,200	35,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
141	TK-2402	BACKWASH HOLDING TANK	2		35,200		

SIZE: 11-6 DIA X 9-6
TYPE OF ROOF: CONE
CAP. IN BARRELS: 176
MATERIAL: CS

SOURCE: 1

		QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL		2	0	35,200	0	0
FREIGHT	0.0%			0		
DEVELOPMENT	0.0%			0		
TOTAL		2	0	35,200	0	0
TOTAL CODE:	141	2	0	35,200	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
190	BA-2402	RECOVERD OIL SUMP	2		6,300		
		VERT. OR HORIZ.:					
		SUPPORT:					
		MATERIAL: CONCRETE-14CY					
		STRESS RELIEVE:					
		X-RAY:					
		JOINT EFF.:					
		WALL THICKNESS:					
		CORR. ALLOW.:					
		DESIGN - PSIG/TEMP:					
		ASME CODE:					
		NOZ/MW RATING:					
		SOURCE: 1					
		SUBTOTAL	2	0	6,300	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	6,300	0	0
190	BA-2404	AERATION BASIN	2		126,000		
		VERT. OR HORIZ.:					
		SUPPORT:					
		MATERIAL: CONCRETE-280CY					
		STRESS RELIEVE:					
		X-RAY:					
		JOINT EFF.:					
		WALL THICKNESS:					
		CORR. ALLOW.:					
		DESIGN - PSIG/TEMP:					
		ASME CODE:					
		NOZ/MW RATING:					
		SOURCE: 1					
		SUBTOTAL	2	0	126,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	126,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
190	BA-2405	RETURN SLUDGE SUMP	2		12,600		
		VERT. OR HORIZ.:					
		SUPPORT:					
		MATERIAL: CONCRETE-28CY					
		STRESS RELIEVE:					
		X-RAY:					
		JOINT EFF.:					
		WALL THICKNESS:					
		CORR. ALLOW.:					
		DESIGN - PSIG/TEMP:					
		ASME CODE:					
		NOZ/MW RATING:					
		SOURCE: 1					
		SUBTOTAL	2	0	12,600		
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	12,600	0	0
190	BA-2406	PRIMARY SLUDGE SUMP	2		9,000		
		VERT. OR HORIZ.:					
		SUPPORT:					
		MATERIAL: CONCRETE-20CY					
		STRESS RELIEVE:					
		X-RAY:					
		JOINT EFF.:					
		WALL THICKNESS:					
		CORR. ALLOW.:					
		DESIGN - PSIG/TEMP:					
		ASME CODE:					
		NOZ/MW RATING:					
		SOURCE:					
		SUBTOTAL	2	0	9,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	9,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
190	BA-2409	FILTER FEED SUMP	2		13,500		
		VERT. OR HORIZ.:					
		SUPPORT:					
		MATERIAL: CONCRETE-30CY					
		STRESS RELIEVE:					
		X-RAY:					
		JOINT EFF.:					
		WALL THICKNESS:					
		CORR. ALLOW.:					
		DESIGN - PSIG/TEMP:					
		ASME CODE:					
		NOZ/MW RATING:					
		SOURCE: 1					
			2	0	13,500		
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	13,500	0	0
190	BA-2410	SPLITTER BOX	2		7,200		
		VERT. OR HORIZ.:					
		SUPPORT:					
		MATERIAL: CONCRETE-8CY					
		STRESS RELIEVE:					
		X-RAY:					
		JOINT EFF.:					
		WALL THICKNESS:					
		CORR. ALLOW.:					
		DESIGN - PSIG/TEMP:					
		ASME CODE:					
		NOZ/MW RATING:					
		SOURCE: 1					
		SUBTOTAL	2	0	7,200	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL :	2	0	7,200	0	0
		TOTAL CODE: 190	12	0	174,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RME

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2401A/B	STORM WATER BASIN PUMP	4		12,880		

GPM: 200
HD. FT.:
PSI: 25
S.G.: 1.0
PUMP TYPE: VC
PUMP MATERIAL: CS
DRIVE TYPE: M
DRIVE HP: 5.0
SHOP OR FIELD MT.: S
SOURCE: 1

		QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL		4	0	12,880	0	0
FREIGHT	3.0%			390		
DEVELOPMENT	0.0%			0		
TOTAL		4	0	13,270	0	0

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2402A/C	API SEPARATOR PUMP	6		17,040		

GPM: 210
HD. FT.:
PSI: 30
S.G.:
PUMP TYPE: VC
PUMP MATERIAL: CS
DRIVE TYPE: M
DRIVE HP: 10
SHOP OR FIELD MT.: S
SOURCE: 1

		QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL		6	0	17,040	0	0
FREIGHT	3.0%			510		
DEVELOPMENT	0.0%			0		
TOTAL		6	0	17,550	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2403A/B	RECOVERED OIL PUMP	4		12,880		
		GPM: 25 HD. FT.: PSI: 70 S.G.: PUMP TYPE: VC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 2 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL	4	0	12,880	0	0
		FREIGHT 3.0%			390		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	13,270	0	0
310	P-2404A/B	NUTRIENT METERING PUMP	4		4,000		
		GPM: 2.0 GPH HD. FT.: PSI: 10 S.G.: PUMP TYPE: METERING PUMP MATERIAL: SS DRIVE TYPE: M DRIVE HP: 1 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL	4	0	4,000	0	0
		FREIGHT 3.0%			120		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	4,120	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2405A/B	CAUSTIC METERING PUMP	4		8,000		
		GPM: 1.6					
		HD. FT.:					
		PSI: 10					
		S.G.:					
		PUMP TYPE: METERING					
		PUMP MATERIAL: SS					
		DRIVE TYPE: M					
		DRIVE HP: 1					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	8,000	0	0
		FREIGHT 3.0%			240		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	8,240	0	0
310	P-2406A/B	ACID METERING PUMP	4		8,000		
		GPM: 1.6					
		HD. FT.:					
		PSI: 10					
		S.G.:					
		PUMP TYPE: METERING					
		PUMP MATERIAL: SS					
		DRIVE TYPE: M					
		DRIVE HP: 1					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	8,000	0	0
		FREIGHT 3.0%			240		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	8,240	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED B : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2407A/C	EQUILIZATION BASIN PUMP	6		24,960		
		GPM: 1200					
		HD. FT.:					
		PSI: 35					
		S.G.:					
		PUMP TYPE: VC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 35					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	6	0	24,960	0	0
		FREIGHT 3.0%			750		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	25,710	0	0
310	P-2408A/B	PRIMARY SLUDGE PUMP	4		12,880		
		GPM: 120					
		HD. FT.:					
		PSI: 25					
		S.G.:					
		PUMP TYPE: VC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 3					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL :	4	0	12,880	0	0
		FREIGHT 3.0%			390		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	13,270	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0.
PREPARED B : RHE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2409A/B	RETURN SLUDGE PUMP	4		16,640		
		GPM: 1200 HD. FT.: PSI: 35 S.G.: PUMP TYPE: VC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 35 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL :	4	0	16,640	0	0
		FREIGHT 3.0%			500		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	17,140	0	0
310	P-2410A/B	ALUM METERING PUMP	4		8,000		
		GPM: 1.6 HD. FT.: PSI: 10 S.G.: PUMP TYPE: METERING PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 1 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL :	4	0	8,000	0	0
		FREIGHT 3.0%			240		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	8,240	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2411A/B	BELT FILTER PRESS PUMP	4		4,000		
		GPM: 50					
		HD. FT.:					
		PSI: 15					
		S.G.:					
		PUMP TYPE: DIAPHRAGM					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 1					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	4,000	0	0
		FREIGHT 3.0%			120		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	4,120	0	0
310	P-2412A/C	FILTER FEED PUMP	6		24,960		
		GPM: 1200					
		HD. FT.:					
		PSI: 15					
		S.G.:					
		PUMP TYPE: VC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 15					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	6	0	24,960	0	0
		FREIGHT 3.0%			750		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	25,710	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2413A/C	BACKWASH PUMP	6		46,800		
		GPM: 1450 HD. FT.: PSI: 60 S.G.: PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 75 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL	6	0	46,800	0	0
		FREIGHT 3.0%			1,400		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	48,200	0	0
310	P-2414AB	TREATED EFFLUENT PUMP	4		33,520		
		GPM: 1200 HD. FT.: PSI: 50 S.G.: 1 PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 50 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL	4	0	33,520	0	0
		FREIGHT 3.0%			1,010		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	34,530	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY RWL

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2415A/B	CLEAN STORMWATER PUMP	4		12,880		
		GPM: 200					
		HD. FT.:					
		PSI: 50					
		S.G.: 1					
		PUMP TYPE: VC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 5					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	4	0	12,880	0	0
		FREIGHT 3.0%			390		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	13,270	0	0
		TOTAL CODE: 310	68	0	254,880	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED B : RWF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
940	BA-2407A/B	API SEPARATOR	4		179,600		
		325 GPM HYDROGARD MODEL 210					
		SOURCE: 1					
		SUBTOTAL :	4	0	179,600	0	0
		FREIGHT 3.0%			5,390		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	184,990	0	0
940	S-2403	DECANTATION VALVE	2		4,900		
		#2-B121 BELFIELD DECANTATION VALVE MODEL MS/STD					
		SOURCE: VENDOR QUOTE					
		SUBTOTAL :	2	0	4,900	0	0
		FREIGHT 3.0%			150		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	5,050	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWL

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
940	BA-2408	TRICKLING FILTER	2		256,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	256,000	0	0
		FREIGHT 3.0%			7,680		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	263,680	0	0
940	L-2411	TRICKLING FILTER MEDIA	LOT		32,000		
		SOURCE: 1					
		SUBTOTAL :	0	0	32,000	0	0
		FREIGHT 3.0%			960		
		DEVELOPMENT 0.0%			0		
		TOTAL :	0	0	32,960	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED B. : RHB

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
940	L-2410	ROTARY DISTRIBUTOR	2		72,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	72,000	0	0
		FREIGHT 3.0%			2,160		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	74,160	0	0
940	L-2401	IAF POLYMER FEED SYSTEM	2		25,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	25,000	0	0
		FREIGHT 3.0%			750		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	25,750	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
940	L-2402	EQUALIZATION BASIN DIFFUSION SYSTEM	2		61,600		
		SOURCE: 1					
		SUBTOTAL	2	0	61,600	0	0
		FREIGHT 3.0%			1,850		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	63,450	0	0
940	L-2403	AERATION BASIN DIFFUSION SYSTEM	2		246,000		
		SOURCE: 1					
		SUBTOTAL	2	0	246,000	0	0
		FREIGHT 3.0%			7,380		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	253,380	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED B : RWL

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
940	L-2412A/B	PRESSURE FILTERS	4		412,000		
		SOURCE: 1					
		SUBTOTAL	4	0	412,000	0	0
		FREIGHT 3.0%			12,360		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	424,360	0	0
940	TK -2401	SLUDGE HOLDING TANK	2		196,000		
		SOURCE: 1					
		SUBTOTAL	2	0	196,000	0	0
		FREIGHT 3.0%			5,880		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	201,880	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
940	L-2404A/B	ACTIVATED SLUDGE CLARIFIER	4		1,046,400		
		SOURCE: 1					
		SUBTOTAL :	4	0	1,046,400	0	0
		FREIGHT 3.0%			31,390		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	1,077,790	0	0
940	S-2402A/B	INDUCED AIR FLOTATION SYSTEM	4		320,000		
		SOURCE: VENDOR QUOTE					
		SUBTOTAL :	4	0	320,000	0	0
		FREIGHT 3.0%			9,600		
		DEVELOPMENT 0.0%			0		
		TOTAL :	4	0	329,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : WASTE WATER TREATING SECT 2400

JOB NO. : 11-36265
DATE : 05/05/87
REV. : 0
PREPARED B : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
940	PK-2401	SANITARY WASTEWATER TREATMENT SYSTEM	1		145,000		
		SOURCE: 1					
		SUBTOTAL	1	0	145,000	0	0
		FREIGHT 3.0%			4,350		
		DEVELOPMENT 0.0%			0		
		TOTAL	1	0	149,350	0	0
		TOTAL CODE: 940	31	0	3,086,400	0	0

APPENDIX B-16

EQUIPMENT COST DATA

INERT GAS SYSTEM - UNIT 2500

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : 2500 INERT GAS GENERATION

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY: RWB

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN., CONVER.	0	0	0	0	
130	DRUMS	50,700	0	50,700	0	8.5%
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	25,300	0	25,300	0	4.2%
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	[illegible]	[illegible]	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	0	0	0	0	
320	COMPRESSORS	337,800	0	337,800	0	56.4%
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	185,400	0	185,400	0	30.9%
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	599,200	0	599,200	0	100.0%

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : 2500 INERT GAS GENERATION

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
210	E-2501	INERT GAS COOLER	2		24,600		
		TYPE: AES					
		SHELL ID IN.:					
		TUBE LENGTH FT.:					
		NO. OF SHELLS: 1					
		SQ. FT. PER SHELL: 503					
		TOTAL SQ FT.: 503					
		SHELL - PSIG/TEMP:					
		TUBE - PSIG/TEMP:					
		MATL. - SHELL/TUBE: CS					
		SOURCE: 1					
		SUBTOTAL	2	0	24,600	0	0
		FREIGHT 3.0%			740		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	25,340	0	0
		TOTAL CODE: 210	2	0	25,340	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : 2500 INERT GAS GENERATION

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
320	C-2501A/B	INERT GAS COMPRESSOR	4		328,000		

COMP TYPE: SCREW
INLET CAP ACFM: 3856
INLET PSIG: 10.5 PSIA
OUTLET PSIG: 55
GAS HANDLED:
K VALVE (CP/CV):
MATERIAL:
DRIVER TYPE: MOTOR
DRIVER H.P. 600
SOURCE: 1

		QTY	WEIGHT	MATERIALS COST	SUBCONTRACT D&E	DIRECT LABOR MANHOURS
SUBTOTAL		4	0	328,000	0	0
FREIGHT	3.0%			9,840		
DEVELOPMENT	0.0%			0		
TOTAL		4	0	337,840	0	0
TOTAL CODE:	320	4	0	337,840	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : 2500 INERT GAS GENERATION

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : RWL

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
910	PG-2501	INERT GAS GENERATOR PACKAGE	2		180,000		
		153,300 SCF/HR P=10' H2O T=100F					
		SOURCE:					
		SUBTOTAL	2	0	180,000	0	0
		FREIGHT 3.0%			5,400		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	185,400	0	0
		TOTAL CODE: 910	2	0	185,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN CO
UNIT : 2500 INERT GAS GENERATION

JOB NO. : 11-36265
DATE : 05/06/87
REV. : 0
PREPARED BY : RWE

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2501	INERT GAS SURGE DRUM	2		50,700		

VERT. OR HORIZ.: HORIZONTAL
SUPPORT: SADDLES
MATERIAL: SA-516-70
STRESS RELIEVE: NO
X-RAY: SPOT
JOINT EFF.: 85%
WALL THICKNESS: 7/16"
CORR. ALLOW.: 1/8"
DESIGN - PSIG/TEMP: 80/150
ASME CODE: VIII D1
NOZ/MW RATING: 150 LB
SOURCE: 1

	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
SUBTOTAL	2	0	50,700	0	0
FREIGHT 0.0%			0		
DEVELOPMENT 0.0%			0		
TOTAL	2	0	50,700	0	0
TOTAL CODE: 130	2	0	50,700	0	0

APPENDIX B-17

EQUIPMENT COST DATA

FLARE SYSTEM - UNIT 2600

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY: TAR

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	147,400	811,600	959,000	0	27.2%
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	[illegible]	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	1,504,900	0	1,504,900	0	42.8%
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	1,055,800	0	1,055,800	0	30.0%
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	2,708,100	811,600	3,519,700	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2601A/F	K.O. DRUM FOR UNIT 100 14' DIA X 42' T/T W/ 3' X 2' WATER BOOT	6	320,400		310,800	
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 7/16" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/400 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	6	320,400	0	310,800	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	320,400	0	310,800	0
130	D-2602A/B	K.O. DRUM FOR UNIT 300 12'6" DIA X 37'6" T/T W/ 3' X 2' WATER BOOT	2	76,600		81,200	
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/8" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/400 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	76,600	0	81,200	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	76,600	0	81,200	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0[illegible]
PREPARED B[illegible] : TR[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2603A/B	K.O. DRUM FOR UNIT 400/500	2	53,800	43,000		
		10' DIA X 30' T/T					
		W/ 3' X 2' WATER BOOT					
		VERT. OR HORIZ.: H					
		SUPPORT: SDLS					
		MATERIAL: SA-516-70					
		STRESS RELIEVE: NO					
		X-RAY: SPOT					
		JOINT EFF.: 85%					
		WALL THICKNESS: 3/8"					
		CORR. ALLOW.: .125"					
		DESIGN - PSIG/TEMP: 50/400					
		ASME CODE: VIII D1					
		NOZ/MW RATING: 150#					
		SOURCE: 1					
		SUBTOTAL :	2	53,800	43,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	53,800	43,000	0	0
130	D-2604A/B	K.O. DRUM FOR UNIT 600	2	35,600	31,400		
		8'6" DIA X 26' T/T					
		VERT. OR HORIZ.: H					
		SUPPORT: SDLS					
		MATERIAL: SA-516-70					
		STRESS RELIEVE: NO					
		X-RAY: SPOT					
		JOINT EFF.: 85%					
		WALL THICKNESS: 5/16"					
		CORR. ALLOW.: .125"					
		DESIGN - PSIG/TEMP: 50/400					
		ASME CODE: VIII D1					
		NOZ/MW RATING: 150#					
		SOURCE: 1					
		SUBTOTAL :	2	35,600	31,400	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	35,600	31,400	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED B : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2605A/B	K.O. DRUM FOR UNIT 700 8'6" DIA X 25'6" T/T	2	35,200	31,000		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 5/16" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/400 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	35,200	31,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	35,200	31,000	0	0
130	D-2606A/B	K.O. DRUM FOR UNIT 800 10' DIA X 30' T/T	2	52,600	42,000		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/8" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/400 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	52,600	42,000	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	52,600	42,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2607A/C	K.O. DRUM FOR FL-2601A/C 16' DIA X 48' T/T W/ 3' X 2' WATER BOOT	3	231,300		219,600	
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 1/2" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/400 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	3	231,300	0	219,600	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	231,300	0	219,600	0
130	D-2608A/B	FLARE K.O. DRUM FOR FL-2602A/B 19' DIA X 57' T/T W/ 3' X 2' WATER BOOT	2	215,000		200,000	
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 1/2" CORR. ALLOW.: .125" DESIGN - PSIG/TEMP: 50/400 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL :	2	215,000	0	200,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	215,000	0	200,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 130	21	1,020,500	147,400	811,600	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2601A/F	UNIT 100 K.O. DRUM PUMP	6		450,000		
		GPM: 230					
		HD. FT.: 607					
		PSI: 150					
		S.G.: 0.56					
		PUMP TYPE: RECIP					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 30					
		SHOP OR FIELD MT.: S					
		SOURCE: 3 WORTHINGTON					
		SUBTOTAL	6	0	450,000	0	0
		FREIGHT 3.0%			13,500		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	463,500	0	0
310	P-2602A/F	UNIT 100 K.O. DRUM WATER BOOT PUMP	6		16,800		
		GPM: 25					
		HD. FT.: 162					
		PSI: 70					
		S.G.: 0.994					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 5					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	6	0	16,800	0	0
		FREIGHT 3.0%			500		
		DEVELOPMENT 0.0%			0		
		TOTAL	6	0	17,300	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2603A/B	UNIT 300 K.O. DRUM PUMP	2		66,000		
		GPM: 65					
		HD. FT.: 398					
		PSI: 100					
		S.G.: 0.56					
		PUMP TYPE: RECIP					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 7 1/2					
		SHOP OR FIELD MT.: S					
		SOURCE: 3 WORTHINGTON					
		SUBTOTAL	2	0	66,000	0	0
		FREIGHT 3.0%			1,980		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	67,980	0	0
310	P-2604A/B	UNIT 300 K.O. DRUM WATER BOOT PUMP	2		5,400		
		GPM: 15					
		HD. FT.: 116					
		PSI: 50					
		S.G.: 0.994					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 3					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	2	0	5,400	0	0
		FREIGHT 3.0%			160		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	5,560	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED B : TR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
310	P-2605A/B	UNITS 400/500 K.O. DRUM PUMP	2		66,000		
		GPM: 82 HD. FT.: 398 PSI: 100 S.G.: 0.56 PUMP TYPE: RECIP PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 7 1/2 SHOP OR FIELD MT.: S SOURCE: 3 WORTHINGTON					
		SUBTOTAL :	2	0	66,000	0	0
		FREIGHT 3.0%			1,980		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	67,980	0	0
310	P-2606A/B	UNITS 400/500 K.O. DRUM WATER BOOT PUMP	2		5,600		
		GPM: 25 HD. FT.: 162 PSI: 70 S.G.: 0.994 PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 5 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL :	2	0	5,600	0	0
		FREIGHT 3.0%			170		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	5,770	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
310	P-2607A/B	UNIT 600 K.O. DRUM PUMP	2		5,400		
		GPM: 25					
		HD. FT.: 116					
		PSI: 50					
		S.G.: 0.994					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 3					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	2	0	5,400	0	0
		FREIGHT 3.0%			160		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	5,560	0	0
310	P-2608A/B	UNIT 700 K.O. DRUM PUMP	2		16,000		
		GPM: 50					
		HD. FT.: 607					
		PSI: 150					
		S.G.: 0.56					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 20					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	2	0	16,000	0	0
		FREIGHT 3.0%			480		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	16,480	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TA[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2609A/B	UNIT 800 K.O. DRUM PUMP	2		66,000		
		GPM: 50 HD. FT.: 607 PSI: 150 S.G.: 0.56 PUMP TYPE: RECIP PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 7 1/2 SHOP OR FIELD MT.: S SOURCE: 3 WORTHINGTON					
		SUBTOTAL :	2	0	66,000	0	0
		FREIGHT 3.0%			1,980		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	67,980	0	0
310	P-2610A/F	FLARE K.O. DRUM PUMP FOR D-2607A/C	6		450,000		
		GPM: 200 HD. FT.: 607 PSI: 150 S.G.: 0.56 PUMP TYPE: RECIP PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 30 SHOP OR FIELD MT.: S SOURCE: 3 WORTHINGTON					
		SUBTOTAL :	6	0	450,000	0	0
		FREIGHT 3.0%			13,500		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	463,500	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2611A/C	FLARE K.O. DRUM WATER BOOT PUMP FOR D-2607A/C	3		8,400		
		GPM: 35 HD. FT.: 162 PSI: 70 S.G.: 0.994 PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 5 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL	3	0	8.400	0	0
		FREIGHT 3.0%			250		
		DEVELOPMENT 0.0%			0		
		TOTAL	3	0	8,650	0	0
310	P-2612A/D	FLARE K.O. DRUM PUMP FOR D-2608A/B	4		300,000		
		GPM: 300 HD. FT.: 607 PSI: 150 S.G.: 0.56 PUMP TYPE: RECIP PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 50 SHOP OR FIELD MT.: S SOURCE: 3 WORTHINGTON					
		SUBTOTAL	4	0	300,000	0	0
		FREIGHT 3.0%			9,000		
		DEVELOPMENT 0.0%			0		
		TOTAL	4	0	309,000	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED B : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2613A/B	FLARE K.O. DRUM WATER BOOT PUMP FOR D-2608A/B	2		5,500		

GPM: 45
HD. FT.: 162
PSI: 70
S.G.: 0.994
PUMP TYPE: HC
PUMP MATERIAL: CS
DRIVE TYPE: M
DRIVE HP: 7 1/2
SHOP OR FIELD MT.: S
SOURCE: 1

		QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL		2	0	5,500	0	0
FREIGHT	3.0%			170		
DEVELOPMENT	0.0%			0		
TOTAL		2	0	5,670	0	0
TOTAL CODE:	310	41	0	1,504,930	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED B. : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
920	FL-2601A/C	FLARE FOR RETORTING MODULES	3		663,000		
		GUY SUPPORTED					
		270' TIP ELEVATION					
		36" TIP DIA					
		0 - 400 DEG F					
		CS CONSTRUCTION					
		SOURCE: 1					
		SUBTOTAL :	3	0	663,000	0	0
		FREIGHT 3.0%			19,890		
		DEVELOPMENT 0.0%			0		
		TOTAL :	3	0	682,890	0	0
920	FL-2602A/B	FLARE FOR UPGRADING MODULES	2		362,000		
		GUY SUPPORTED					
		190' TIP ELEVATION					
		30" TIP DIA					
		0 - 400 DEG F					
		CS CONSTRUCTION					
		SOURCE: 1					
		SUBTOTAL :	2	0	362,000	0	0
		FREIGHT 3.0%			10,860		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	372,860	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FLARE SYSTEM SECT. 2600

JOB NO. : 11-36265
DATE : 04/16/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 920	5	0	1,055,750	0	0

APPENDIX B-18

EQUIPMENT COST DATA

PLANT FUEL SYSTEM - UNIT 2700

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : PLANT FUEL GAS SECT. 2700

JOB NO. : 11-36265
DATE : 05/13/87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	24,900	0	24,900	0	100.0%
140	STORAGE TANKS	0	0	0	0	
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	0	0	0	0	
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	24,900	0	24,900	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : PLANT FUEL GAS SECT. 2700

JOB NO. : 11-36265
DATE : 05/13/87
REV. : 0
PREPARED BY : TAI

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
130	D-2701	FUEL GAS DRUM 10' DIA X 17' T/T	1	31,100	24,900		
		VERT. OR HORIZ.: H SUPPORT: SDLS MATERIAL: SA-516-70 STRESS RELIEVE: NO X-RAY: SPOT JOINT EFF.: 85% WALL THICKNESS: 3/4" CORR. ALLOW.: 1/8" DESIGN - PSIG/TEMP: 150/650 ASME CODE: VIII D1 NOZ/MW RATING: 150# SOURCE: 1					
		SUBTOTAL	1	31,100	24,900	0	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0	0	
		TOTAL	1	31,100	24,900	0	0
		TOTAL CODE: 130	1	31,100	24,900	0	0

APPENDIX B-19

EQUIPMENT COST DATA

STORAGE FACILITIES - UNIT 2800

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	0	0	0	0	
140	STORAGE TANKS	26,000	11,281,000	11,307,000	0	98.2%
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	209,300	0	209,300	0	1.8%
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	0	0	0	0	
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	235,300	11,281,000	11,516,300	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED B : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
141	T-2801A/B	RAW OIL INTERMEDIATE STORAGE TANK	2			2,528,000	
		SIZE: 200' X 48'					
		TYPE OF ROOF: FLOAT					
		CAP. IN BARRELS: 260000					
		MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL :	2	0	0	2,528,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	2,528,000	0
141	T-2802A/B	NAPTHA STORAGE TANK	2			486,000	
		SIZE: 60' X 60'					
		TYPE OF ROOF: FLOAT					
		CAP. IN BARRELS: 30000					
		MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL :	2	0	0	486,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	486,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
141	T-2803A/B	DIESEL OIL STORAGE TANK	2			584,000	
		SIZE: 67' X 64'					
		TYPE OF ROOF: FLOAT					
		CAP. IN BARRELS: 40000					
		MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL	2	0	0	584,000	[illegible]
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	0	584,000	0
141	T-2804A/B	BOTTOM PRODUCT TANK	2			1,520,000	
		SIZE: 160' X 56'					
		TYPE OF ROOF: CONE					
		CAP. IN BARRELS: 200000					
		MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL	2	0	0	1,520,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	0	1,520,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TAS

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
141	T-2805A/B	SULFUR TANK (HEATED)	2			138,000	
		SIZE: 30' X 40' TYPE OF ROOF: CONE CAP. IN BARRELS: 5000 MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL :	2	0	0	138,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	138,000	0
141	T-2807	RAW WATER TANK	1			440,000	
		SIZE: 150' X 32' TYPE OF ROOF: CONE CAP. IN BARRELS: 100000 MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL :	1	0	0	440,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	1	0	0	440,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
141	T-2808	FILTERED WATER TANK	2			500,000	
		SIZE: 80' X 56' TYPE OF ROOF: CONE CAP. IN BARRELS: 50000 MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL :	2	0	0	500,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	500,000	0
141	T-2809	SOUR WATER TANK	2			1,934,000	
		SIZE: 180' X 40' TYPE OF ROOF: FLOAT CAP. IN BARRELS: 180000 MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL :	2	0	0	1,934,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	1,934,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
141	T-2810	STRIPPED WATER TANK	2			1,934,000	
		SIZE: 180' X 40'					
		TYPE OF ROOF: FLOAT					
		CAP. IN BARRELS: 180000					
		MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL :	2	0	0	1,934,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	0	1,934,000	0
141	T-2812	POTABLE WATER TANK	1			63,000	
		SIZE: 30' X 40'					
		TYPE OF ROOF: CONE					
		CAP. IN BARRELS: 5000					
		MATERIAL: CS					
		SOURCE: 1					
		SUBTOTAL :	1	0	0	63,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL :	1	0	0	63,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
141	T-2813	CAUSTIC SODA TANK	1			40,000	

SIZE: 20' X 36'
TYPE OF ROOF: CONE
CAP. IN BARRELS: 2000
MATERIAL: CS

SOURCE: 1

		QTY	WEIGHT	MATERIALS COST	SUBCONTRACT D&E	MANHOURS
SUBTOTAL		1	0	0	40,000	0
FREIGHT	0.0%			0		
DEVELOPMENT	0.0%			0		
TOTAL		1	0	0	40,000	0

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
141	T-2814	SLOP OIL TANK	1			90,000	

SIZE: 36' X 56'
TYPE OF ROOF: CONE
CAP. IN BARRELS: 10000
MATERIAL: CS

SOURCE: 1

		QTY	WEIGHT	MATERIALS COST	SUBCONTRACT D&E	MANHOURS
SUBTOTAL		1	0	0	90,000	0
FREIGHT	0.0%			0		
DEVELOPMENT	0.0%			0		
TOTAL		1	0	0	90,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TA?

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
141	T-2815	SPONGE OIL TANK	1			84,000	

SIZE: 30' X 40'
TYPE OF ROOF: FLOAT
CAP. IN BARRELS: 5000
MATERIAL: CS

SOURCE: 1

		QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL		1	0	0	84,000	0
FREIGHT	0.0%			0		
DEVELOPMENT	0.0%			0		
TOTAL		1	0	0	84,000	0
TOTAL CODE:	141	21	0	0	10,341,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLD
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TA[illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
142	T-2806A/B	AMMONIA STORAGE SPHERE 65'4" DIA	2			940,000	
		VERT. OR HORIZ.: N/A SUPPORT: STD MATERIAL: SA-515-70 STRESS RELIEVE: PER CODE X-RAY: PER CODE JOINT EFF.: PER CODE WALL THICKNESS: 3/4" CORR. ALLOW.: STD DESIGN - PSIG/TEMP: 300/CODE ASME CODE: YES NOZ/MW RATING: 300# SOURCE: 1					
		SUBTOTAL	2	0	0	940,000	0
		FREIGHT 0.0%			0		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	0	940,000	0
142	T-2811	GASOLINE TANK 12' DIA X 46' T/T UNDERGROUND	1		25,200		
		VERT. OR HORIZ.: H SUPPORT: MFG STD MATERIAL: FRP STRESS RELIEVE: NO X-RAY: NO JOINT EFF.: MFG STD WALL THICKNESS: MFG STD CORR. ALLOW.: MFG STD DESIGN - PSIG/TEMP: 5 (AIR)/AMB ASME CODE: NO NOZ/MW RATING: MFG STD SOURCE: 1					
		SUBTOTAL	1	0	25,200	0	0
		FREIGHT 3.0%			760		
		DEVELOPMENT 0.0%			0		
		TOTAL	1	0	25,960	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 142	3	0	25,960	940,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2801-8A/B	TRANSFER PUMPS	16		120,000		
		GPM: 800					
		HD. FT.:					
		PSI: 50					
		S.G.: (A) 1.0					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 40					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	16	0	120,000	0	0
		FREIGHT 3.0%			3,600		
		DEVELOPMENT 0.0%			0		
		TOTAL	16	0	123,600	0	0
310	P-2809A/B	SULFUR PUMP (STEAM TRACED)	2		23,400		
		GPM: 50					
		HD. FT.:					
		PSI: 50					
		S.G.: (A) 1.4					
		PUMP TYPE: HC					
		PUMP MATERIAL: SS					
		DRIVE TYPE: M					
		DRIVE HP: 5					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	2	0	23,400	0	0
		FREIGHT 3.0%			700		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	24,100	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TAF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2810A/B	AMMONIA PUMP	2		11,800		
		GPM: 50 HD. FT.: PSI: 50 S.G.: .96 PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 3/4 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL :	2	0	11,800	0	0
		FREIGHT 3.0%			350		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	12,150	0	0
310	P2811-13A/B	TRANSFER PUMP	6		48,000		
		GPM: 200 HD. FT.: PSI: 50 S.G.: 1.0 PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 15 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL :	6	0	48,000	0	0
		FREIGHT 3.0%			1,440		
		DEVELOPMENT 0.0%			0		
		TOTAL :	6	0	49,440	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : STORAGE FACILITIES SECT. 2800

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TAP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
		TOTAL CODE: 310	26	0	209,290	0	0

APPENDIX B-20

EQUIPMENT COST DATA

GENERAL PLANT FACILITIES - UNIT 2900

FOSTER WHEELER USA CORP.

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FIREWATER SYSTEM SECT. 2900

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY: TAF

EQUIPMENT SUMMARY

FW CODE NO.	DESCRIPTION	CODE 1000 DIRECT MATERIALS	CODE 2000 SUBCONTRACT D&E	TOTAL	CODE 4000 LABOR MANHOURS	% OF TOTAL
	VESSELS					
110	TOWERS	0	0	0	0	
120	REACTORS, REGEN.,CONVER.	0	0	0	0	
130	DRUMS	0	0	0	0	
140	STORAGE TANKS	0	250,000	250,000	0	32.6%
150	TOWERS (FIELD FABRICATED)	0	0	0	0	
160	PROCESS DUCTS	0	0	0	0	
180	VESSEL TESTING	0	0	0	0	
190	SPECIAL VESSELS	0	0	0	0	
	HEAT TRANSFER EQUIPMENT					
210	SHELL & TUBE EXCHANGERS	0	0	0	0	
220	DOUBLE PIPE EXCHANGERS	0	0	0	0	
230	AIR COOLED EXCHANGERS	0	0	0	0	
240	FIRED PROCESS EQUIPMENT	0	0	0	0	
270	VACUUM EQUIPMENT	0	0	0	0	
280	STM. TURBINE SURFACE COND.	0	0	0	0	
290	OTHER HEAT TRANSFER EQUIP.	0	0	0	0	
	MECHANICAL EQUIPMENT					
310	PUMPS	146,800	0	146,800	0	19.1%
320	COMPRESSORS	0	0	0	0	
330	ELECTRICAL GENERATORS	0	0	0	0	
340	MATERIALS HANDLING	0	0	0	0	
350	MATERIALS PROCESSING	0	0	0	0	
360	MATERIALS TRANSPORT	0	0	0	0	
370	THERMO/MECHANICAL	0	0	0	0	
380	DRIVERS	0	0	0	0	
390	OTHER MECHANICAL EQUIPMENT	0	0	0	0	
	MISC. EQUIPMENT					
490	ELV, CRANE, HOIST	0	0	0	0	
910	PACKAGE SYSTEMS	0	0	0	0	
920	UTILITY THERMAL SYSTEMS	0	0	0	0	
930	WATER TREATING	0	0	0	0	
940	WASTE TREATING	0	0	0	0	
950	BLDG. & MAINT. EQUIPMENT	370,800	0	370,800	0	48.3%
960	CATALYST & CHEMICALS	0	0	0	0	
	TOTAL EQUIPMENT	517,600	250,000	767,600	0	100.0%

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FIREWATER SYSTEM SECT. 2900

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TA

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
141	TK-2901	FIREWATER STORAGE TANK API TYPE	1			250,000	

SIZE: 80' X 56'
TYPE OF ROOF: CONE
CAP. IN BARRELS: 50000
MATERIAL: CS

SOURCE: 1

	QTY	WEIGHT	CODE 1000	CODE 2000	CODE 4000
SUBTOTAL	1	0	0	250,000	0
FREIGHT 0.0%			0		
DEVELOPMENT 0.0%			0		
TOTAL	1	0	0	250,000	0
TOTAL CODE: 141	1	0	0	250,000	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FIREWATER SYSTEM SECT. 2900

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED B : TP

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
310	P-2901A/B	FIREWATER PUMP	2		50,000		
		GPM: 2500					
		HD. FT.:					
		PSI:					
		S.G.: 1.0					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: M					
		DRIVE HP: 300					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	2	0	50,000	0	0
		FREIGHT 3.0%			1,500		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	51,500	0	0
310	P-2902A/B	FIREWATER PUMP	2		90,000		
		GPM: 2500					
		HD. FT.:					
		PSI:					
		S.G.: 1.0					
		PUMP TYPE: HC					
		PUMP MATERIAL: CS					
		DRIVE TYPE: D					
		DRIVE HP: 300					
		SHOP OR FIELD MT.: S					
		SOURCE: 1					
		SUBTOTAL	2	0	90,000	0	0
		FREIGHT 3.0%			2,700		
		DEVELOPMENT 0.0%			0		
		TOTAL	2	0	92,700	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FIREWATER SYSTEM SECT. 2900

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : TAR

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR MANHOURS
310	P-2903	FIREWATER JOCKEY PUMP	1		2,500		
		GPM: 50 HD. FT.: PSI: S.G.: 1.0 PUMP TYPE: HC PUMP MATERIAL: CS DRIVE TYPE: M DRIVE HP: 5 SHOP OR FIELD MT.: S SOURCE: 1					
		SUBTOTAL	1	0	2,500	0	0
		FREIGHT 3.0%			80		
		DEVELOPMENT 0.0%			0		
		TOTAL	1	0	2,580	0	0
		TOTAL CODE: 310	5	0	146,780	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FIREWATER SYSTEM SECT. 2900

JOB NO. : 11-36265
DATE : 04/17/87
REV. : 0
PREPARED BY : [illegible]

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
950	A-2901	FIRE TRUCK COMPLETE W/ STD ACCESSORIES 1000 GAL CAPACITY	2		340,000		
		SOURCE: 1					
		SUBTOTAL :	2	0	340,000	0	[illegible]
		FREIGHT 3.0%			10,200		
		DEVELOPMENT 0.0%			0		
		TOTAL :	2	0	350,200	0	0
950	A-2902	FOAM TRAILER 1000 GAL CAPACITY W/ FIBERGLASS TANK & PIPING	1		20,000		
		SOURCE: 1					
		SUBTOTAL :	1	0	20,000	0	0
		FREIGHT 3.0%			600		
		DEVELOPMENT 0.0%			0		
		TOTAL :	1	0	20,600	0	0

CUSTOMER: DOE/METC
LOCATION: WESTERN COLO
UNIT : FIREWATER SYSTEM SECT. 2900

JOB NO. : 11-36265
DATE : 04/17/97
REV. :
PREPARED BY : TRF

EQUIPMENT DETAIL

FW CODE NO.	ITEM NO.	DESCRIPTION	QTY	WEIGHT	CODE 1000 MATERIALS COST	CODE 2000 SUBCONTRACT D&E	CODE 4000 DIRECT LABOR: MANHOURS
		TOTAL CODE: 950	3	0	370,800	0	0