FOSTER WHEELER DEVELOPMENT CORPORATION

Monthly Report

Start Date: 07/01/2000

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FOESTER WHEELER DEVELOPMENT CORPORATION

12 Peach Tree Hill Road

Livingston, NJ 07039

TECHNICAL PROGRESS REPORT NUMBER 21023R64
FOR MONTH 148 (JULY 2000) -- PHASE 2

No work was performed; the two remaining Multi Annular Swirl Burner test campaigns are on hold pending selection of a new test facility (replacement for the shut down UTSI burner test facility) and identification of associated testing costs.

TECHNICAL PROGRESS REPORT NUMBER 21023R65
FOR MONTH 117 (JULY 2000) -- PHASE 3

Commercial Plant Design Update

Introduction

The Second-Generation PFB Combustion Plant conceptual design prepared in 1987 is being updated to reflect the benefit of pilot plant test data and the latest advances in gas turbine technology. The updated plant is being designed to operate with 95 percent sulfur capture and a single Siemens Westinghouse (SW) 501G gas turbine. Using carbonizer and gas turbine data generated by Foster Wheeler (FW) and SW respectively, Parsons Infrastructure & Technology prepared preliminary plant heat and material balances based on carbonizer operating temperatures of 1700 and 1800EF; the former yielded the higher plant efficiency and has been selected for the design update.

The 501G gas turbine has an air compressor discharge temperature of 811EF and an exhaust temperature of 1140EF. Both of these streams represent high sources of heat and must be cooled, the air to 600EF to be compatible with a 650EF PCFB pressure vessel design temperature and the exhaust for a 275EF stack gas temperature. Because of their relatively high temperature, they can be used for feed water heating, steam generation and/or steam superheating and reheating. As a result, the plant could have one boiler (the PCFB boiler), or as many as three boilers if their cooling is used to generate steam. Three different plant arrangements using one, two and then three boilers were considered with the three-boiler arrangement minimizing the feedwater flow/steam turbine size and maximizing the plant efficiency. After reviewing the three arrangements it was felt the operating complexity associated with a three-boiler plant did not justify the ½ point increase in plant efficiency it provided and a two-boiler plant was selected.

Parsons generated a preliminary full load heat and material balance for the plant shown in Fig. 1. The estimated performance of the plant is:

Gross Power, MWe	
Gas Turbine	239.25
Steam Turbine	267.46
Total	506.71
Auxiliary Power, MWe	24.89
Net Power, MWe	481.82
Plant HHV Efficiency, %	47.5
Plant HHV Heat Rate, Btu/kwhr	7184

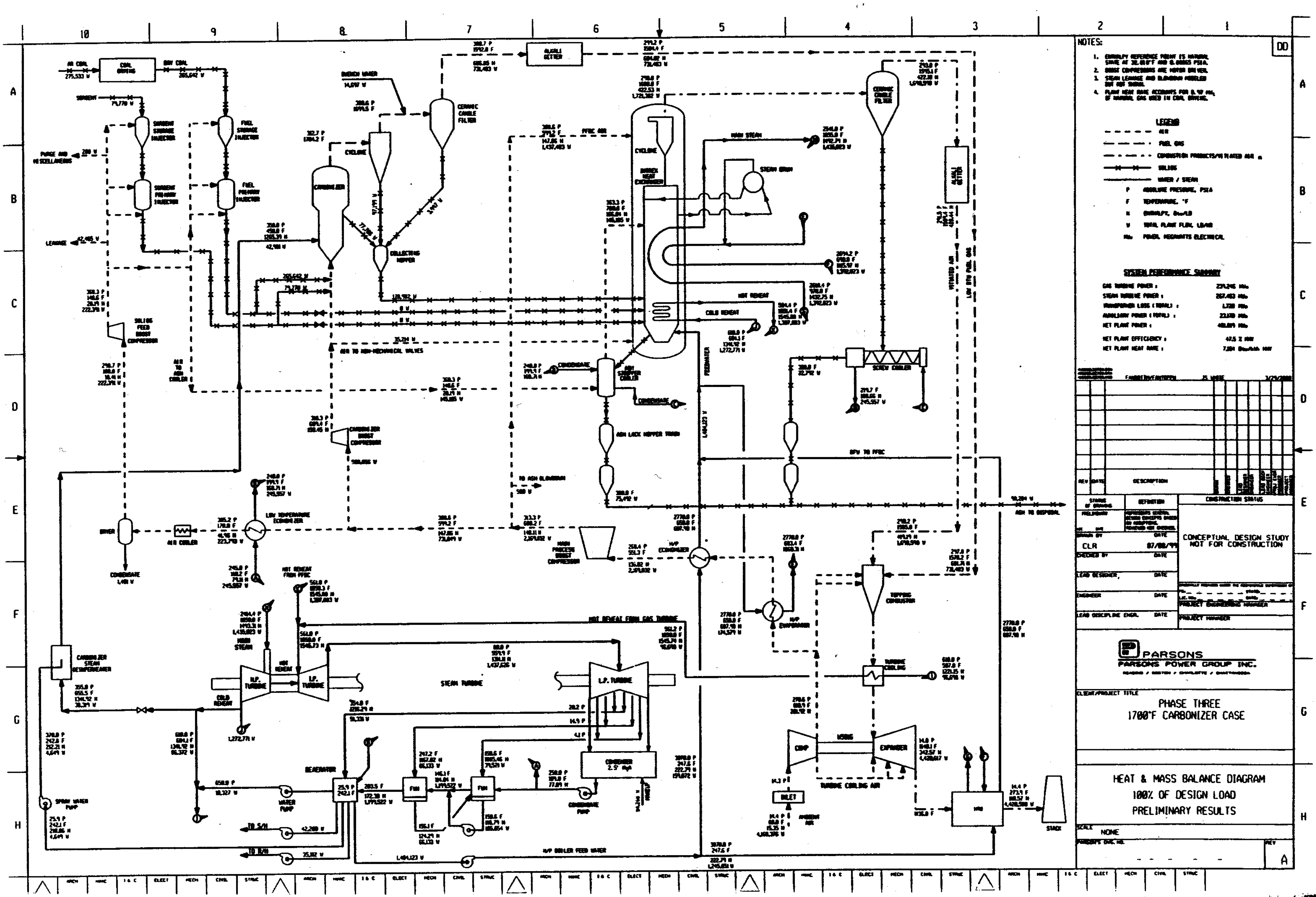

Figure 1 Preliminary Full Load Plant Heat and Material Balance

The carbonizer required by the plant is shown in Fig. 2; it is a 15-ft ID vertical, refractory-lined pressure vessel approximately 47 ft high, with a conical bottom. The unit operates with a 25-ft-deep jetting fluidized bed, a superficial gas velocity of approximately 3.5 ft/s, a 20-ft tall freeboard, and is described in greater detail in the April Progress Report.

<u>Work Performed in July 2000</u>

Process flow diagrams were prepared by FW for the carbonizer and PCFB legs of the plant and are shown in Figures 3 and 4 respectively. As discussed in the June report, coal and dolomite will be fed as a blend to both the carbonizer and the PCFB by the lock hopper type systems shown in these figures. The carbonizer and PCFB both have two gas outlet lines. To control gas alkali levels minus 325 mesh emathlite will be injected into each of these lines downstream of their respective cyclones. The injected emathlite will become part of the filter dust cake thereby assuring alkali removal, and it will be injected as a 25% solids – 75% water slurry. As shown in Fig. 3 the slurry system consists of two 24-hour storage tanks, a slurry recirculation system, two carbonizer metering pumps with a spare, and two PCFB metering pumps also with a spare. The slurry will be injected at a rate of about 3 gpm into each of two carbonizer syngas lines and at about 0.6 gpm into each of the two PCFB flue gas lines. Each gas line contains two slurry spray nozzles, one of which is a spare.

Two 100% capacity bed drain lines are provided at the bottom of the carbonizer and PCFB. The carbonizer bottom drains are used intermittently to prevent oversized material/ agglomerates from accumulating in the unit, whereas the PCFB drains are used continuously to maintain bed level/inventory. The bottom drained material is cooled to 500°F by a cooler internal to the carbonizer and two coolers external to the PCFB. Each bottom drain contains block valves, a delumper to break up oversized material, and a rotary valve to control drain rates. The carbonizer bottoms drain by gravity to the char collecting hoppers for eventual transfer to the PCFB, whereas the PCFB bottom ash is pneumatically transported to the PCFB filter ash surge hopper.

Two 100% overflow nozzles at the top of the carbonizer bed allow material to continuously drain (maintains a constant bed level) by gravity to the two char collecting hoppers. Elutriated bed material collected by the two carbonizer cyclones and four filter vessels also drains to the two char collecting hoppers. The latter operate at the filter pressure, and since the bed overflow and cyclone drains originate from points of higher pressure, loop seals/J-valves are provided in each of these lines.

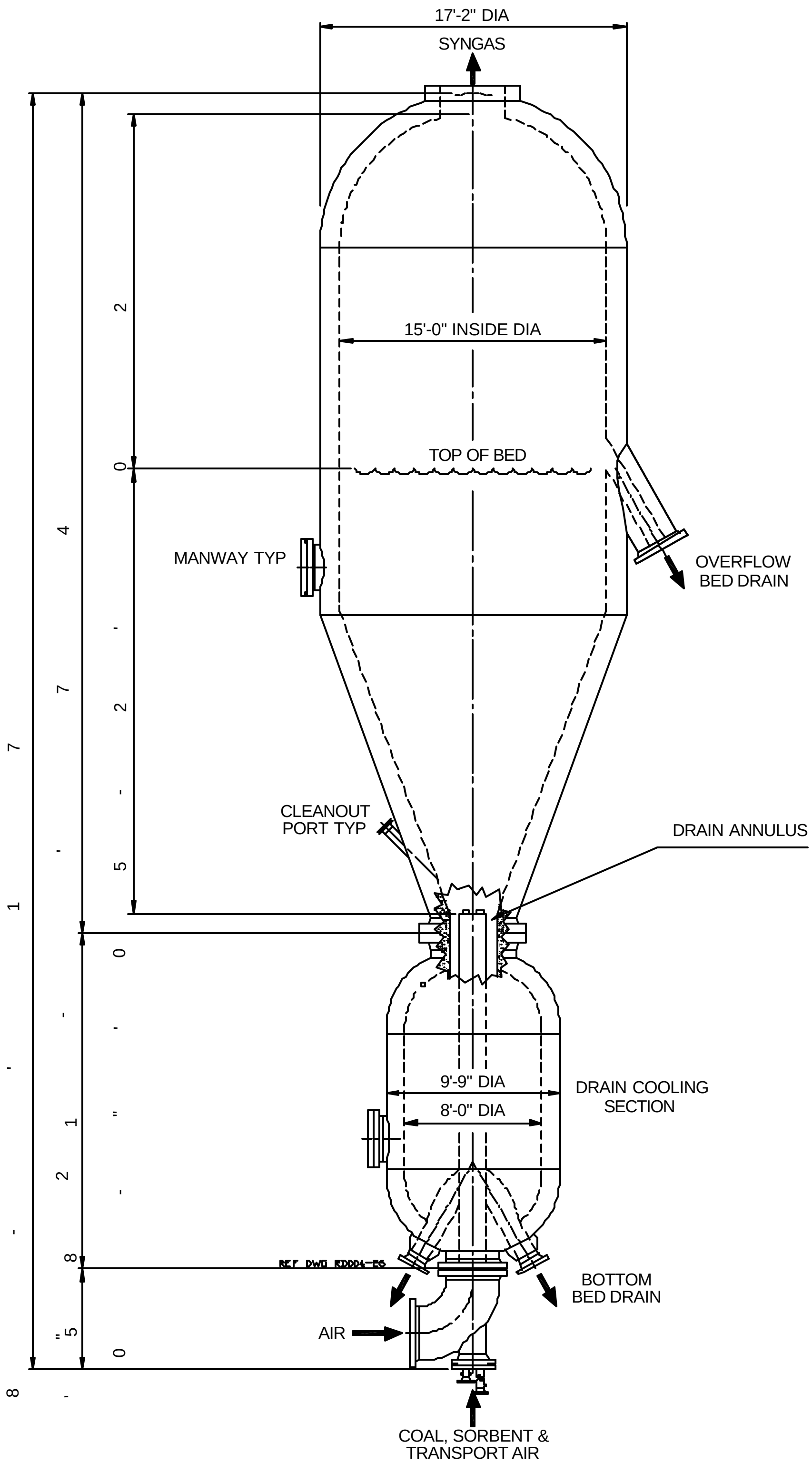

Figure 2 Carbonizer Arrangement

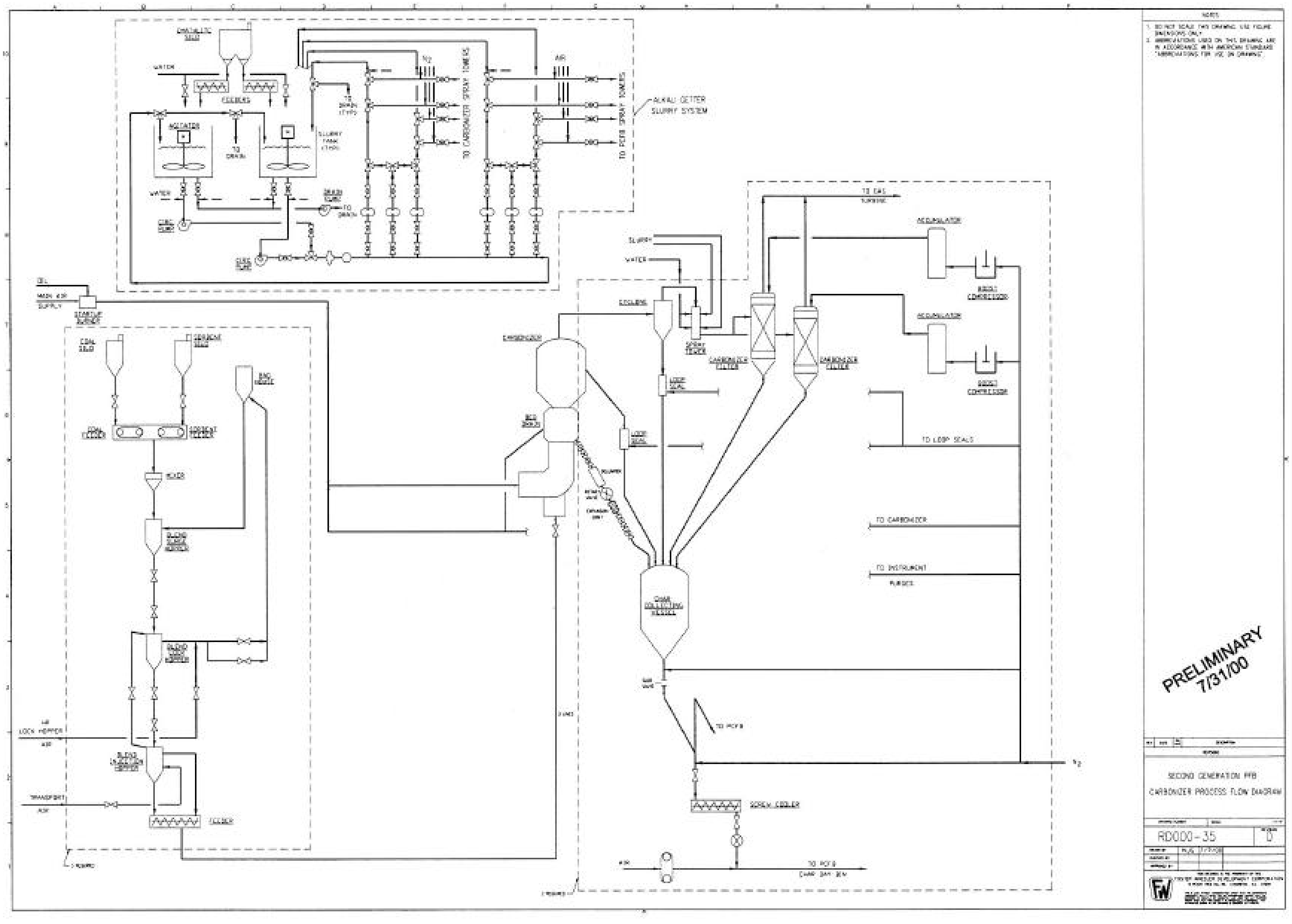

Figure 3 Carbonizer Process Flow Diagram

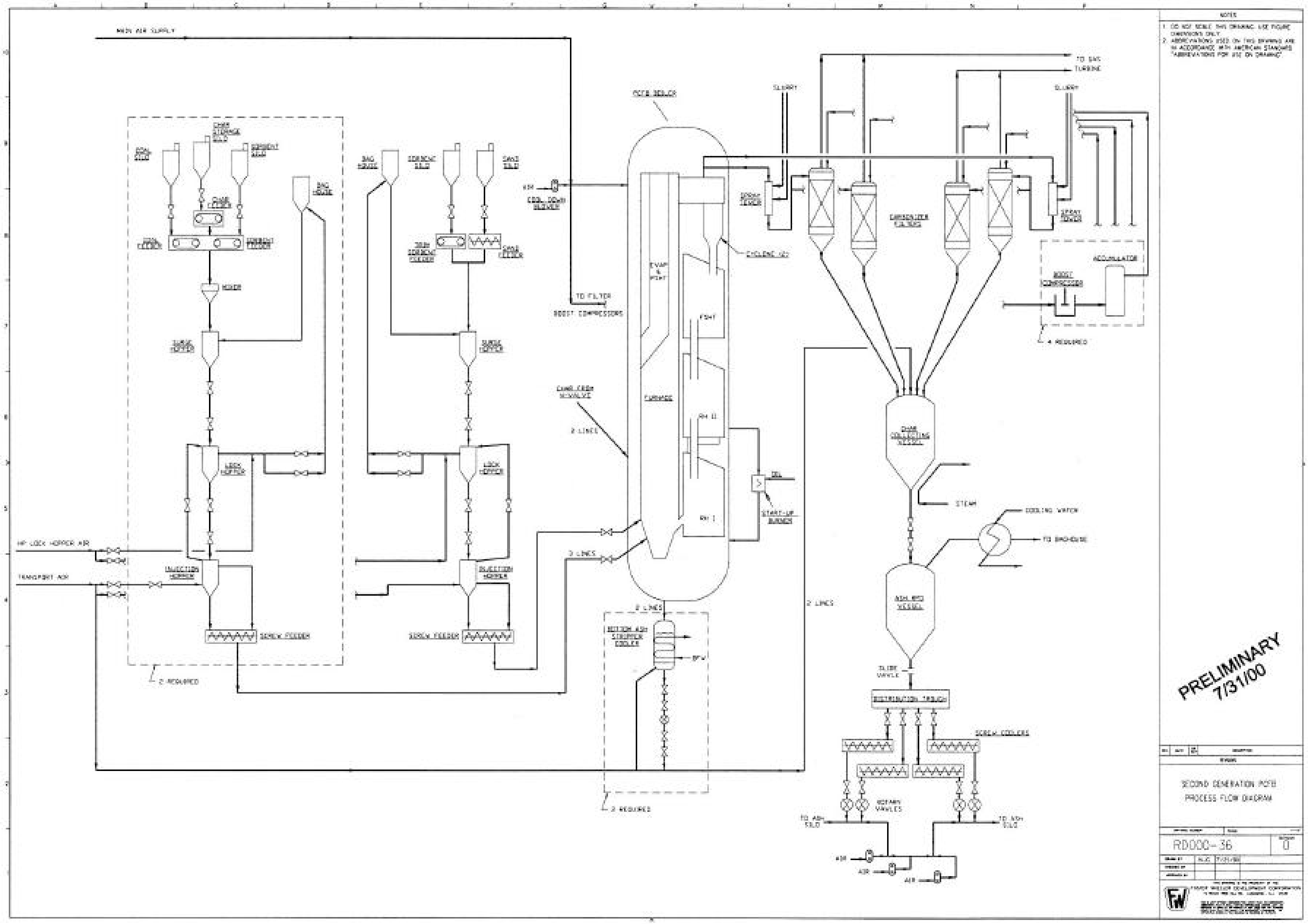

Figure 4 PCFB Process Flow Diagram

Char-sorbent residue drains by gravity from each char collecting hopper through a downwardly inclined pipe to a vertical riser/pipe fluidized by nitrogen forming an N-shaped non-mechanical valve. Nuclear level indicators monitor the char level in the collecting hoppers and by varying the riser aeration rate, the char-sorbent level and transfer rate to the PCFB can be controlled. A refractory lined slide valve is provided at the bottom of each char collecting hopper to provide isolation and assist in the control of char-sorbent transfer. An isolation valve and water-cooled screw cooler are provided below the riser aeration point. At shut down, after the plant is depressured, they are used to drain, cool, and transfer all remaining char to the char day bin atop the PCFB feed system.

The 1600°F flue gas exiting the two PCFB cyclones is cleaned of particulate by four candle filter vessels operating in parallel. The collected material/fly ash drains to a common surge hopper along with the 500°F PCFB bottom ash yielding about a 1300°F mix temperature. A restricted pipe discharge provided under the fly ash surge hopper depressures the fly ash. Ball valves are provided for isolation, and a gate valve operating in conjunction with nuclear level indicators in the fly ash surge hopper controls the ash drain rate. The depressured ash drains by gravity to a mechanically agitated trough that distributes the material to four 33% capacity, water cooled screws that cool the ash to 500°F for pneumatic transport to ash silos.

With regard to equipment physical arrangement, work continued on further development of the carbonizer leg of the plant. The carbonizer setting was shifted to allow bed bottom drain material to drain by gravity to the char collecting hopper. Char transfer N-valve definition, atmospheric pressure screw coolers that facilitate cooling and draining all char material at shut down, and PCFB bed drain cooler dimensions were established and added to the Fig. 5 arrangement drawing.

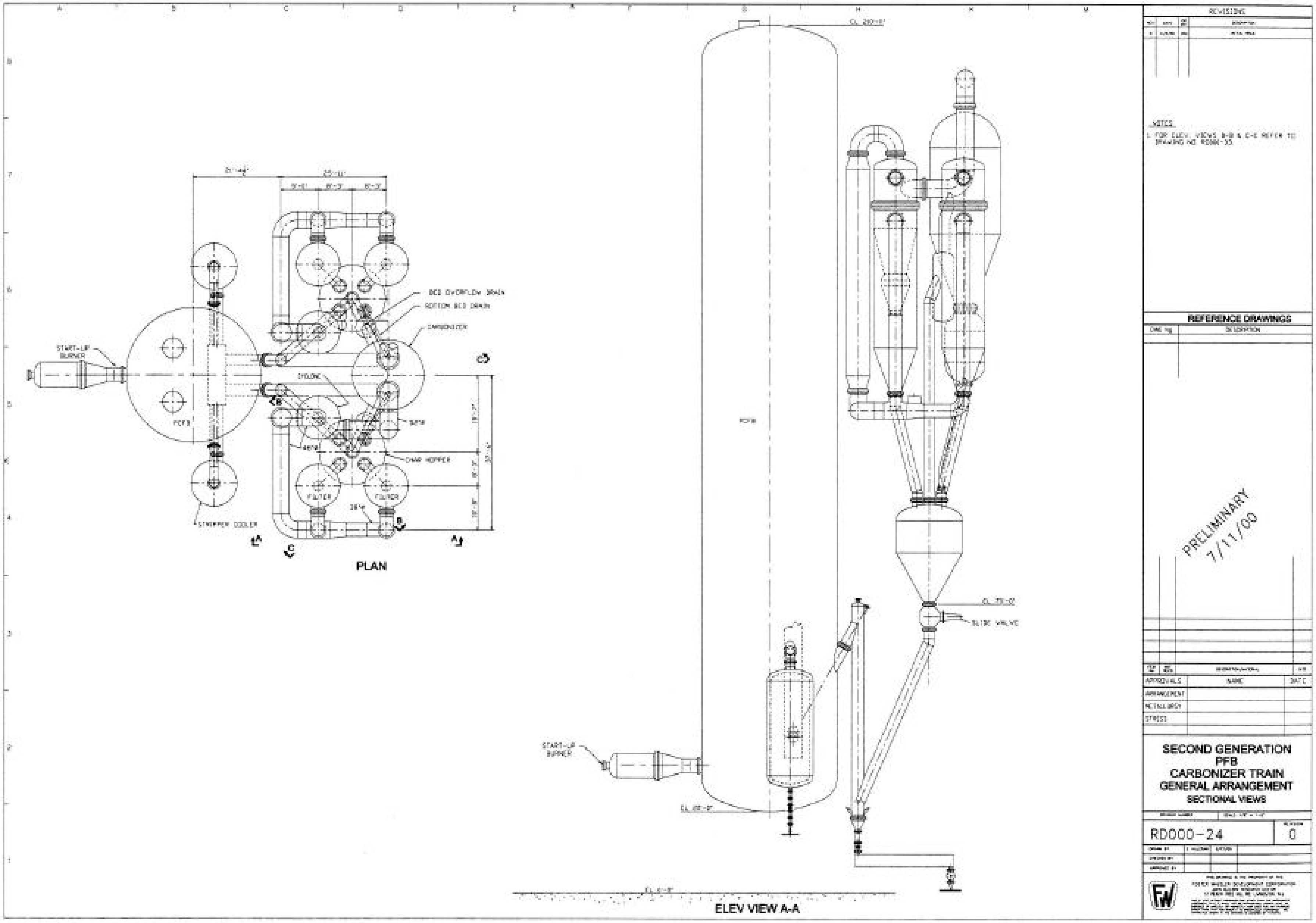

Figure 5 Dual Syngas Flow Path Arrangement

Siemens Westinghouse continued developing concepts for integrating the topping combustion MASBs into the 16 burner locations of the 501G gas turbine. Initial manifolding concepts were developed for the export of air to the process and return of syngas and vitiated air. The compressed air, syngas, and vitiated air systems have similar configurations: a toroidal (“ring”) manifold surrounds the gas turbine, with the major axis of the manifold aligned with the major axis of the turbine. Each manifold is connected to the 16 combustors and also to one or two large pipes (ducts) in the carbonizer/PFBC area. The main piping parameters are summarized in Table 1.

Table 1 Air and Gas Piping Summary

	Units	Compressed Air	Syngas	Vitiated Air
Main Nozzles	No.	1	1	2
Main Nozzle Size	in.	34	42	42
Ring Manifold Size	in.	24	30	32
Combustor Spur Size	in.	8	20	22
Combustors	No.	16	16	16
Refractory Lining	in.	--	7	7
S.S. Lining	in.	--	0.125	0.125

Syngas, vitiated air, and compressed air flow to and from each combustor as shown in Fig. 6. Compressed air leaves the compressor and enters the housing around each combustor. Some of the air is mixed with vitiated air, and the rest is extracted through a perpendicular nozzle. Vitiated air enters each combustor, where it combines with compressed air to form the oxidizing mixture for the MASB. Except for mixing air, the compressed air is separated from the vitiated air by a containment sleeve. Syngas (or natural gas during start up) is injected into each MASB nozzle and burned, and the products of combustion are delivered to the gas turbine expander through individual transition ducts.

The syngas, vitiated air, and compressed air toroidal (“ring”) manifolds for are shown in Fig. 7.

Using component dimensions and arrangements developed by FW and SW, Parson started overall plant layout, balance of plant, steam and feed water, water make-up, and compressed air system drawings.

A paper discussing the demonstration of Second Generation PFB technology was presented at the Globe Ex 2000 conference in Las Vegas on July 25.

Schedule: Because of heavy workloads, summer vacations and a forthcoming move/relocation of the Parsons design group, we are anticipating a possible eight week slippage in the Fig. 8 schedule.

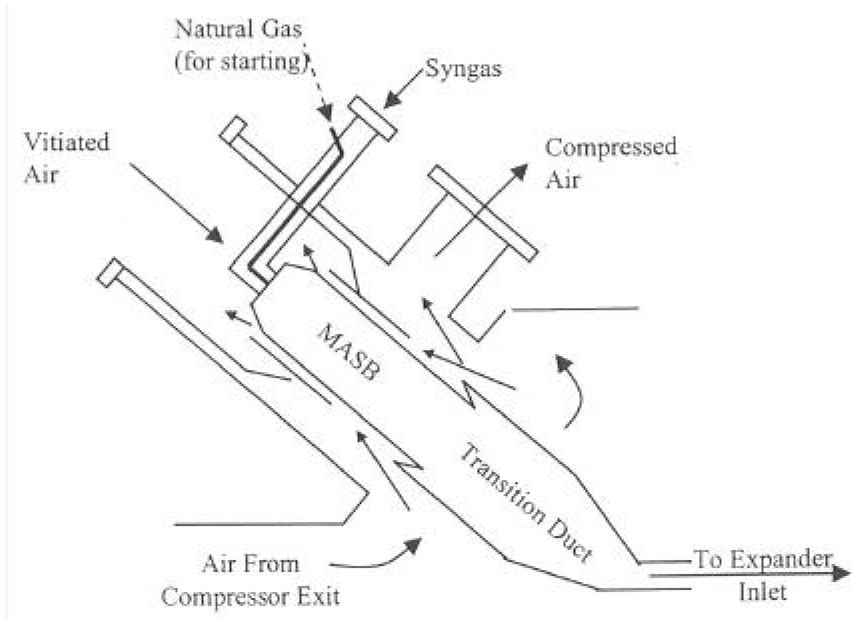

Figure 6 Syngas Combustor Flow Arrangement

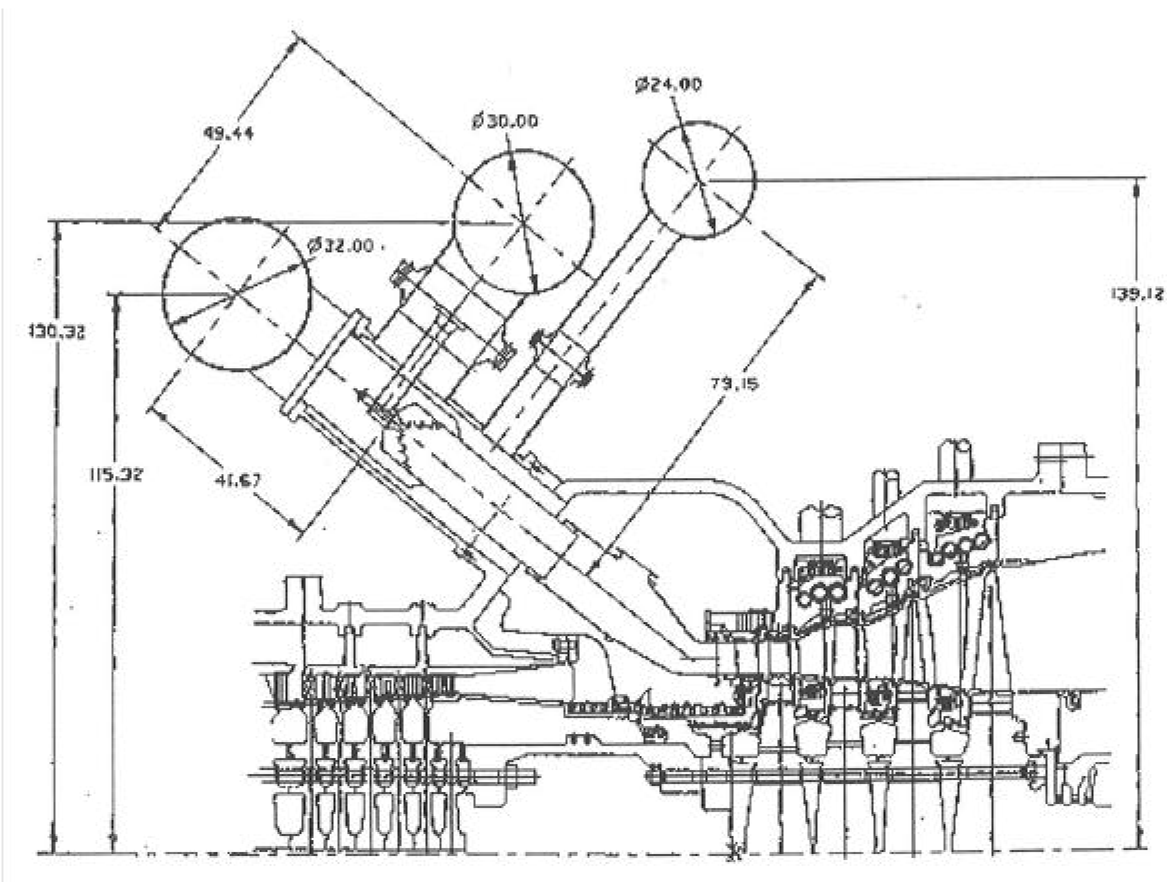

Figure 7 Syngas Combustor Manifold Connections

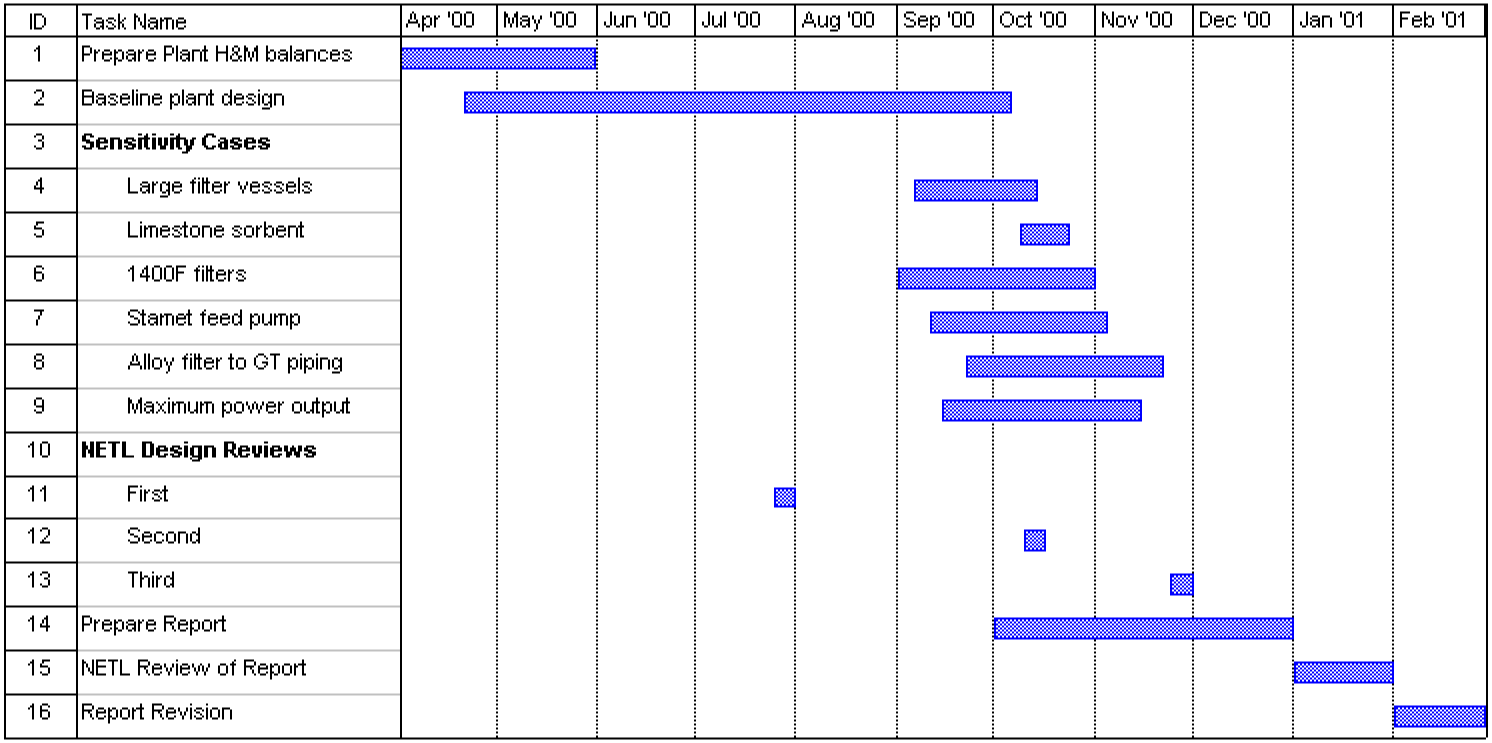

Figure 8 Schedule for Commercial Plant Design Update