FE-2583-15
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CONCEPTUAL DESIGN FOR AN ATMOSPHERIC FLUIDIZED-BED DIRECT COMBUSTION POWER GENERATING PLANT
Phase I - Commercial Plant Conceptual Design

Final Progress Report for the
Period January 14, 1977-March 31, 1978

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Boston, Massachusetts 02107

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PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Under Contract No. EF-77-C-01-2583

ABSTRACT

The conceptual design of a commercial size (560 MW), complete power generating station incorporating an atmospheric fluidized-bed boiler was developed for two parallel cases presenting the boiler designs of two major boiler manufacturers. These were preceded by the presentation of the basis for comparison, which was also a 560 MW unit, that incorporated a conventional pulverizer coal suspension fired boiler with associated facilities including, particularly, a wet limestone flue gas scrubber.

This report accounts for the completion progress of the individual tasks that constituted the project. All of the deliverable material items were issued by the end of the contract. They, rather than this report, contain the technical substance of the work.

OBJECTIVE AND SCOPE OF WORK

The overall objective of the project has been to prepare a conceptual design for an electric power generating plant that will directly combust high sulfur coal in an atmospheric fluidized-bed boiler and generate electric power in an environmentally acceptable manner.

The work to attain the overall objective was originally planned in two overlapping phases. Phase I involved the development of conceptual designs and examination of merit of contemporary size (560 MW) plants including atmospheric fluidized-bed boilers. The designs were projected by each of two major boiler manufacturers, specifically Babcock & Wilcox (B&W) and Foster-Wheeler (FWEC). The purpose of this first phase was to provide convincing evidence to the electric utilities to show that fluidized-bed combustion is a better choice for future coal burning facilities than current conventional methods such as suspension burning of pulverized coal.

Phase II was to have been the conceptual design of a suitably sized demonstration plant, based on the results of Phase I. However, at the direction of DoE, Phase II was deleted from the scope of work. The AFB Model Analysis for Load Following Capability was assigned in its place.

SUMMARY OF PROGRESS DURING THE CONTRACT

The description of the conventional plant base for comparison of the AFB combustion equivalent plants was issued to DoE at the outset of the second quarter in the form of technical notes. Subsequently, modifications and additions were made to the Part I section. Parts IIIA and IIIB were submitted to DoE in December 1977, as preliminary. Part II covers the updated State of the Art (as of October 1977), and Part III represents the two complete AFB plant designs - one for each manufacturer's AFB design. Part IV covers the evaluation of the merit of AFB combustion, and Part V covers the mathematical model of AFB control. The final drafts for Parts II through V were submitted in March 1978, as part of the four volumes forming the Technical Notes.

The product of the project was presented to DoE in the form of technical notes comprised of four volumes containing five parts:

Volume I	Part I	570 MWe Base Plant Definition and General Design Criteria
	Part II	AFB State of the Art
Volume II	Part IIIA	570 MWe Babcock & Wilcox AFB Plant Definition

Volume III	Part IIIB	570 MWe Foster-Wheeler AFB Plant Definition
Volume IV	Parts IVA & B	Evaluation of Merit
	Part V	Atmospheric Fluidized-Bed Plant Model Analysis for Load Following Capability

Part I was submitted to DoE in July 1977. Parts II through V were submitted to DoE March 31, 1978. Part V, which was originally AFB Demonstration Plant Definition, was replaced, per directive of DoE, by Atmospheric Fluidized-Bed Plant Model Analysis for Load Following Capability.

Eleven electric utility companies were contacted in the course of the year to apprise them of the AFB project and to engage their interest in review of the progress of the project as it developed. Oral and visual presentations were made to engineers of each company, and a copy of the Base Plant Reference dated June 1977, was given to them at the presentation or soon thereafter. Later in the year, a second volume entitled, Comparison Plant Exhibits, Incorporating Manufacturers' Unique AFB Boiler Design and Ancillary Systems, dated December 1977, was distributed for comparison to the base. A third document entitled, Comparison and Evaluation of AFB Combustion Exhibits with Conventional Base Plant, covering systematic comparison with the base of the cost and functional aspects of the AFB cases, was issued in March 1978.

The project activities during the year, divided among nine major tasks, numbered 1,000 through 9,000. The following pages describe the work under each in greater detail.

II DETAILED DESCRIPTION OF CONTRACT TECHNICAL PROGRESS

Task 1000 - Preliminary Engineering and General Administration

Work Accomplished

Planning Program and Network Diagram - Throughout the contract, the progress of the work was monitored in terms of the individual activities shown graphically on the network diagram. The diagram was updated with each monthly report and interpreted in the accompanying Schedule Analysis. The final update and analysis is included at the end of this report. This completed Task 1000 for this contract.

Task 2000 - Base Plant Definition

Work Accomplished

The base plant description, in technical notes form, was issued and transmitted to DoE on July 21, 1977. This report included the pulverized coal plant description of work, heat and material balances, flow diagrams, plant arrangement drawings, and all other design drawings for related power plant equipment. This base plant report was used as a basis for comparison with the AFB plant designs developed during the project. An additional report entitled, Base Plant Reference, Conventional Coal-Fired Power Plant, was distributed to 11 electric utilities for their use in comparing subsequent AFB plant designs.

At DoE's request, additional detail of the flue gas desulfurization system and cost estimate was prepared and issued on January 15, 1978. This remained within the original budget. This completed Task 2000 for this contract.

Task 3000 - Pope, Evans & Robbins

Work Accomplished

Pope, Evans, & Robbins (PER) provided review and evaluation of the boiler manufacturers' designs. Their efforts were primarily concentrated on plant material balances, AFB related system design evaluations, and three State of the Art reports on AFB technology, research and development needs, and sorbent regeneration. The State of the Art report designated as Part II of the Technical Notes was issued to DoE on February 28, 1978, as preliminary. During the months of February and March, PER assisted Stone & Webster Engineering Corporation (S&W) in the completion and review of the evaluation of merit of the two AFB plant designs and the comparison of AFB versus pulverized coal plant designs, Part IV of the Technical Notes. Parts II and IV were submitted to DoE on March 31, 1978, in final form as part of the Technical Notes. This completed Task 3000 for this contract.

Task 4100 - Babcock & Wilcox Company

Work Accomplished

A conceptual design was developed for a 570 MW atmospheric fluidized-bed boiler (AFB) capable of burning high sulfur coal in an environmentally acceptable manner without recourse to flue gas desulfurization. This preliminary design is described in Babcock & Wilcox's (B&W) final report dated November 30, 1978, which is included in Appendix IIIA-C of the Technical Notes. Their report includes design drawings, material and energy balances, boiler thermodynamic design, material handling systems, and other AFB related systems and equipment. In addition, B&W prepared a capital cost estimate of the AFB boiler and related equipment for use by S&W in developing overall plant cost.

The B&W AFB Definition was issued to DoE on March 31, 1978, in final form as Part IIIB-C of the Technical Notes. B&W's work on this contract is complete.

This completed Task 4100 for this contract.

Task 4200 - Foster-Wheeler Energy Corporation

Work Accomplished

Foster-Wheeler (FW) has completed the AFB conceptual design effort and submitted their report dated November 1977. Their report was incorporated as Appendix IIIB-C of the Technical Notes. The report includes boiler design drawings, material and energy balances, boiler thermodynamic design, material handling systems, and other AFB related systems and equipment. In addition, FW prepared a capital cost estimate of the AFB boiler and related equipment for use by S&W in developing overall plant cost.

The FW AFB Plant Definition was issued to DoE on March 31, 1978, in final form as Part IIIB-C of the Technical Notes. FW's work on this contract is complete.

This completed Task 4200 for this contract.

Task 5000 - AFB Design and Description

Subtask 5100 - AFB Turbine Room

Work Accomplished

Based on the boiler manufacturers' designs, it was determined that little redesign of the base plant turbine room was required. One needed modification was the addition of a turbine bypass system for protection of superheater and reheater surfaces in the event of a turbine trip.

Subtasks 5200 and 5300 - Boiler Rooms for B&W and FW

The objective of this subtask was to prepare a description of work of the AFB electric generating plant with related drawings for comparison with the base plant design. This effort required equipment designs, flow and utility diagrams, general arrangements, composite drawings, structural steel designs, control logic diagrams, and electrical drawings to be prepared. The result of this work was an understanding of differences in plant design features between the base plant and the AFB plants to enable system designs to be developed. Major areas of difference between the base plant and the AFB plant include:

Boiler Plant
Particulate Control Equipment
Materials Handling and Feed Systems
Ash Handling Systems
FD Fans
Control System
Electrical System
Waste Treatment System

The above systems were designed and incorporated in plant drawings as a basis for preparing a capital cost estimate of the AFB plant designs. The scope summarized above is presented in Part III of the Technical Notes and was issued to DoE on March 31, 1978, incorporating all boiler manufacturers' comments. This completed Task 5000 for this contract.

Task 6000 - AFB Plant Investment & Performance

Cost Development

Work Accomplished

As a result of the engineering and design work in Task 5000, capital cost estimates for the B&W and FW electric power generating plants were prepared. The basis for the estimate was to change the base plant cost estimate only for the areas of difference as identified in Task 5000. Equipment and system costs were solicited from suppliers as well as S&W in-house data for use in developing the plant costs.

The results of the cost estimates were included in Part III of the Technical Notes. This completed Task 6000 for this contract.

Task 7000 - Evaluation of Merit

Work Accomplished

The evaluation of each of the boiler manufacturers' designs and the AFB designs compared with the base plant was conducted during the final months of the contract and is included in Parts IVA and IVB, respectively, of the Technical Notes. Preliminary drafts of Parts IVA and IVB were submitted to DoE in February 1978, while being reviewed within S&W and PER.

Parts IVA and IVB were issued to DoE on March 31, 1978, in final form as additions to the Technical Notes.

During the course of the year, the following electric utility companies were enlisted to follow the work as it developed:

- New England Power Service Company
- Boston Edison Company
- Tampa Electric Company
- New England Gas and Electric Company
- Consumers Power Company
- Florida Power Company
- Kentucky Utilities Company
- East Kentucky Power Company
- Wisconsin Electric Power Company
- Savannah Electric Company
- Detroit Edison Company

Separate documents describing first, the base plant; second, the AFB combustion plants; and third, the comparison of the AFB cases with the base, were sent to each company in the course of the project. This completed Task 7000 for this contract.

Task 8000 - Reports

Work Accomplished

The following reports were issued during the last 15 months:

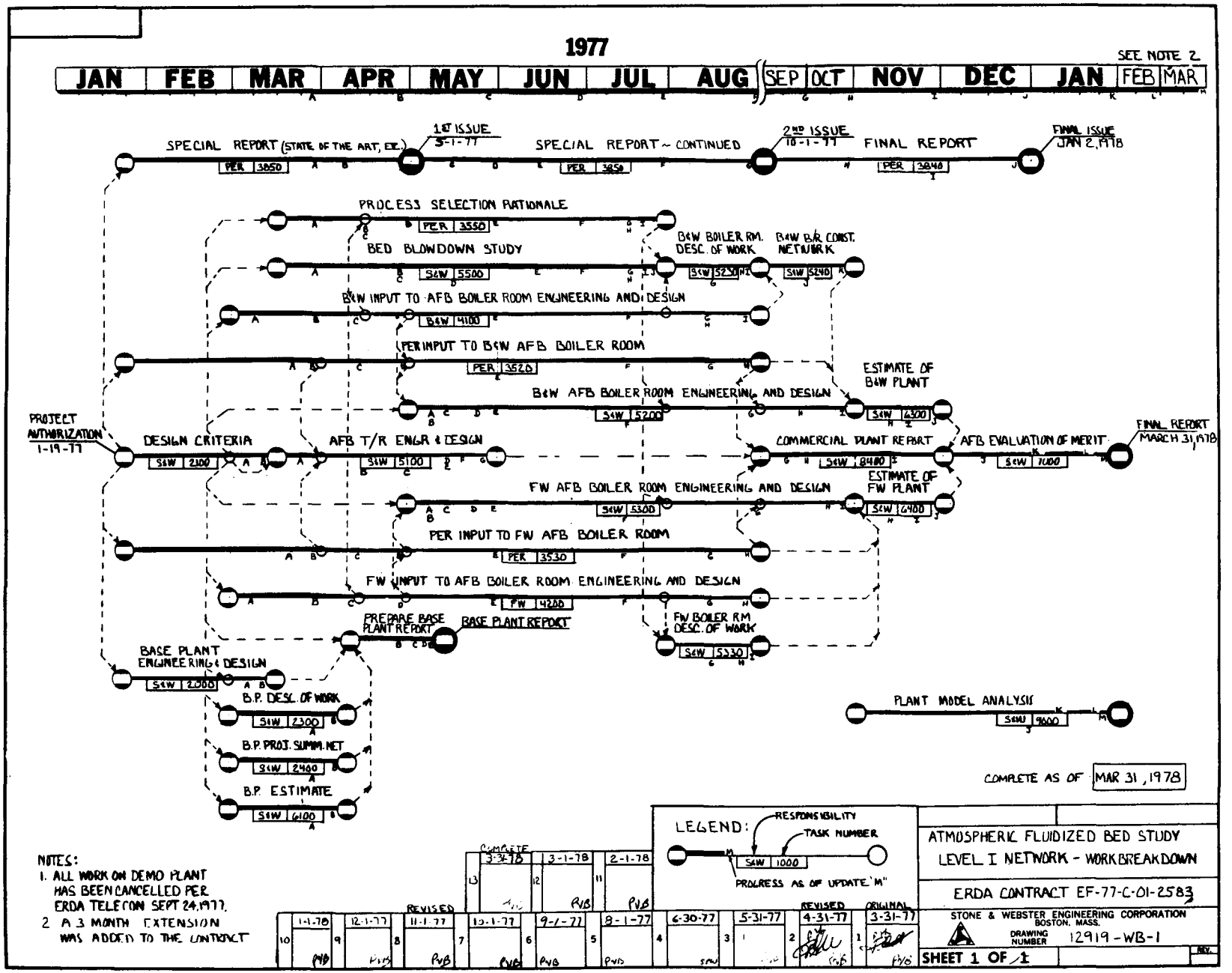
- Part I of the Technical Notes
- Part II of the Technical Notes (Draft and Final)
- Part IIIA and IIIB of the Technical Notes (Draft and Final)
- Part IVA and IVB of the Technical Notes (Draft and Final)
- Part V of the Technical Notes (Draft and Final)
- Base Plant Reference - Conventional Coal-Fired Power Plant
- Comparison Plant Exhibits - Incorporating Manufacturers' Unique AFB Boiler Design and Ancillary Systems
- Comparison and Evaluation of AFB Combustion Exhibits with Conventional Base Plant
- Monthly and Quarterly Progress Reports
- Annual Report
- Monthly Financial Reports

Monthly progress meetings have been held with DoE, Radian, Hartford Steam Boiler and Insurance Company, PER, and S&W to review the project status.

Task 9000 - AFB Plant Model Analysis for Load Following Capability

Work Accomplished

The objective of the study was to predict the open loop response characteristics of the FW AFB plant to step changes in control variables for comparison with typical results for conventional pulverized coal-fired, once-through utility unit, in order to ascertain the AFB load following capabilities. The computer model to predict the load following capability of the once-through boiler has been completed and programmed. A preliminary draft was issued to DoE in February 1978. Step response runs were made with the system model for comparison with the Base Plant. A final draft was issued to DoE on March 31, 1978, as Part V of the Technical Notes. This completed Task 9000 for this contract.


1977
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
SEE NOTE 2.
SPECIAL REPORT (STATE OF THE ART, ETC.)
1ST ISSUE 5-1-77
SPECIAL REPORT - CONTINUED
2ND ISSUE 10-1-77
FINAL REPORT
FINAL ISSUE JAN 2, 1978
PER 3050
PER 3850
PER 3840
PROCESS SELECTION RATIONALE
PER 3550
BED BLOWDOWN STUDY
S&W 5500
B&W BOILER RM. DESC. OF WORK
B&W 5250
B&W B/R CONST. NETWORK
S&W 5240
B&W INPUT TO AFB BOILER ROOM ENGINEERING AND DESIGN
B&W 4100
PER INPUT TO B&W AFB BOILER ROOM
PER 3520
ESTIMATE OF B&W PLANT
B&W AFB BOILER ROOM ENGINEERING AND DESIGN
S&W 5200
S&W 4300
PROJECT AUTHORIZATION 1-19-77
DESIGN CRITERIA
S&W 2100
AFB T/R ENGR & DESIGN
S&W 5100
COMMERCIAL PLANT REPORT
S&W 8480
AFB EVALUATION OF MERIT
S&W 1000
FINAL REPORT MARCH 31, 1978
ESTIMATE OF FW PLANT
FW AFB BOILER ROOM ENGINEERING AND DESIGN
S&W 5300
S&W 6400
PER INPUT TO FW AFB BOILER ROOM
PER 3530
FW INPUT TO AFB BOILER ROOM ENGINEERING AND DESIGN
FW 4200
PREPARE BASE PLANT REPORT
BASE PLANT REPORT
FW BOILER RM DESC. OF WORK
S&W 5230
BASE PLANT ENGINEERING & DESIGN
S&W 2000
B.P. DESC. OF WORK
S&W 2300
B.P. PROJ. SUMM. NET
S&W 2400
B.P. ESTIMATE
S&W 6100
PLANT MODEL ANALYSIS
S&W 9600
COMPLETE AS OF MAR 31, 1978
NOTES:
1. ALL WORK ON DEMO PLANT HAS BEEN CANCELLED PER ERDA TELECON SEPT 24, 1977.
2. A 3 MONTH EXTENSION WAS ADDED TO THE CONTRACT
LEGEND:
RESPONSIBILITY
TASK NUMBER
S&W 1000
PROGRESS AS OF UPDATE "M"
REVISED
ORIGINAL
1-1-78
12-1-77
11-1-77
10-1-77
9-1-77
8-1-77
6-30-77
5-31-77
4-31-77
3-31-77
ATMOSPHERIC FLUIDIZED BED STUDY
LEVEL I NETWORK - WORK BREAKDOWN
ERDA CONTRACT EF-77-C-01-2583
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.
DRAWING NUMBER 12919-WB-1
SHEET 1 OF 1
REV.

SCHEDULED ANALYSIS
AS OF MARCH 31, 1978

TASK 1000

All activities scheduled for this task are completed.

TASK 2000

All activities scheduled for this task are completed.

TASK 3000

All activities scheduled for this task are completed.

TASK 4000

Subtask 4100 - All Babcock & Wilcox work was completed as of November 30, 1977.
Subtask 4200 - All Foster-Wheeler work was completed as of November 30, 1977.

TASK 5000

All activities scheduled for this task are completed.

TASK 6000

All activities scheduled for this task are completed.

TASK 7000

All activities scheduled for this task are completed.

TASK 8000

All activities scheduled for this task are completed.

TASK 9000

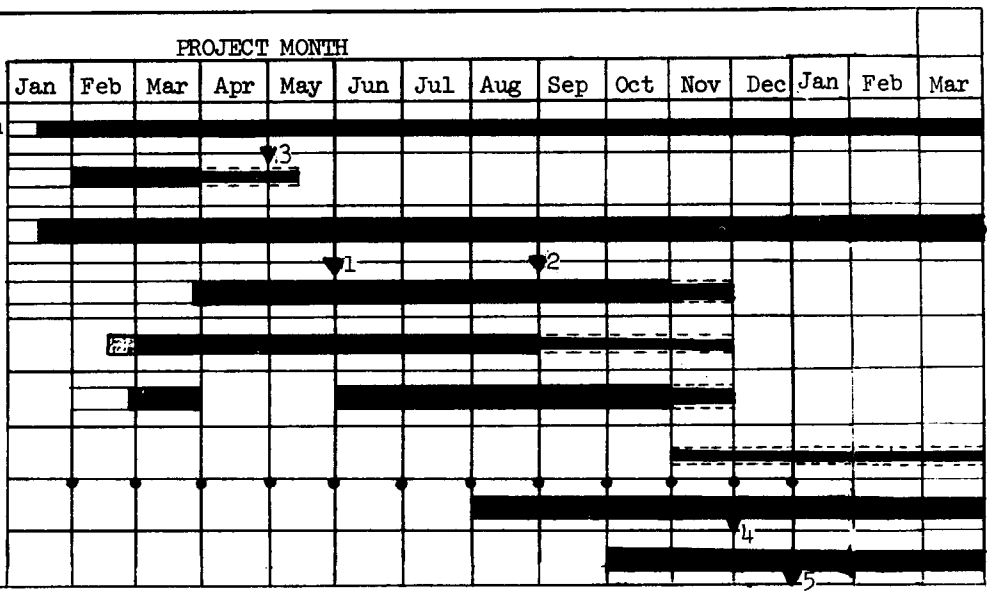
All activities scheduled for this task are completed.

J.O.No. 12919

PLANNING PROGRAM CONTROL
DOE - AFB STUDY

Issued: Sept. 2, 1976
Revised: March 31, 1978

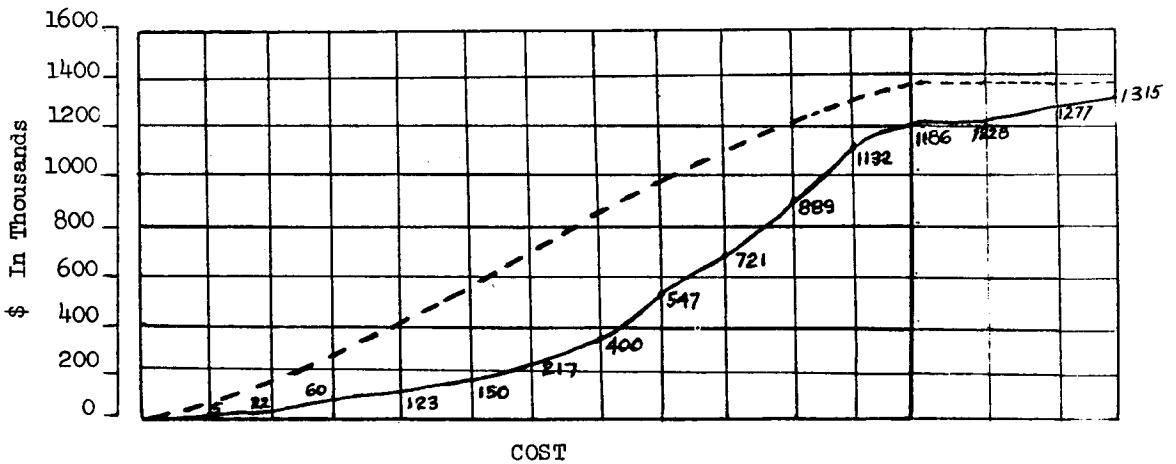
TASK	DESCRIPTION
1000	Preliminary Engineering and General Administration
2000	Base Plant Definition
3000	Pope, Evans & Robbins Efforts
4000	Boiler Manufacturer's Efforts
5000	AFB Plant Design & Description of Work
6000	Investment & Performance Cost Development
7000	Evaluation of Merit
8000	Reports
9000	Plant Model Analysis



- ● Monthly Progress Reports
- ▼1 Boiler Manufacturer's Technical Data
- ▼2 Boiler Manufacturer's Pricing Data
- ▼3 Base Plant Report
- ▼4 Commercial Plant Report
- ▼5 Demonstration Plant Report

BUDGET REPORT (1000's)

	$	MH
Total	1354	52.4
Spent	1315	50.6
Planned	1354	52.4
Variance	39	1.8



*U.S. GOVERNMENT PRINTING OFFICE: 1978-740-306/4283, Region 4.