PROTOTYPE ANTHRACITE CULM COMBUSTION BOILER/HEATER UNIT

CITY OF WILKES-BARRE, PENNSYLVANIA

QUARTERLY TECHNICAL REPORT NO. 3

APRIL 1 - JUNE 30, 1979

PREPARED FOR

THE DEPARTMENT OF ENERGY

UNDER DOE CONTRACT NO. ET-78-C-01-2652

BY

CITY OF WILKES-BARRE

WITH

POPE, EVANS AND ROBBINS INCORPORATED

AND

FOSTER WHEELER BOILER CORPORATION

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ABSTRACT

There are currently about 910 million cubic yards of anthracite culm (mine refuse) contained in 800 separate banks in a 480 square mile area in the Wilkes-Barre (W-B) anthracite mining region. Although this material represents a significant fuel value, equivalent to approximately 1.25 billion barrels of fuel oil, the culm banks have accumulated because no satisfactory method of combusting this fuel was available until the relatively recent development of the atmospheric fluidized bed (AFB) steam generator.

A program was initiated in October 1978 to design, construct and evaluate a 100,000 pph AFB steam generator burning anthracite culm with the addition of fresh anthracite, if required. The unit is to demonstrate the technical, economical and environmental feasibility of producing 150 psig saturated steam for district heating in downtown W-B.

Phase I of the program consists of the design of the atmospheric fluidized bed (AFB) plant and a hot model test program.

Phase II of the program consists of construction, operation, testing and evaluation of the boiler and boiler plant.

PROGRAM OBJECTIVES AND SCOPE

OBJECTIVES

The objectives of this program are:

1. Establish the technical and economic feasibility of firing anthracite culm in an AFB steam generator producing steam for district heating in downtown W-B.
2. Establish the relationships among the variables of excess air, bed temperature, culm analysis, heating value, and limestone to culm ratio in order to identify commercially acceptable operating conditions for the combustion of anthracite culm/anthracite mixtures in an AFB steam generator.
3. Limit sulfur dioxide and nitrogen oxide emissions to current air quality standards of 1.2 and .7 $lb/10^6$ Btu respectively.

SCOPE

The AFB steam generator will be located in a boiler plant formerly owned by the Stegmaier Brewery Co. and presently owned by the City of Wilkes-Barre. Culm will be reclaimed from culm banks in the W-B area. Where applicable, existing systems and equipment for materials receiving, handling and storage and existing buildings shall be utilized as part of the plant design. All work shall be performed in accordance with two distinct phases as follows:

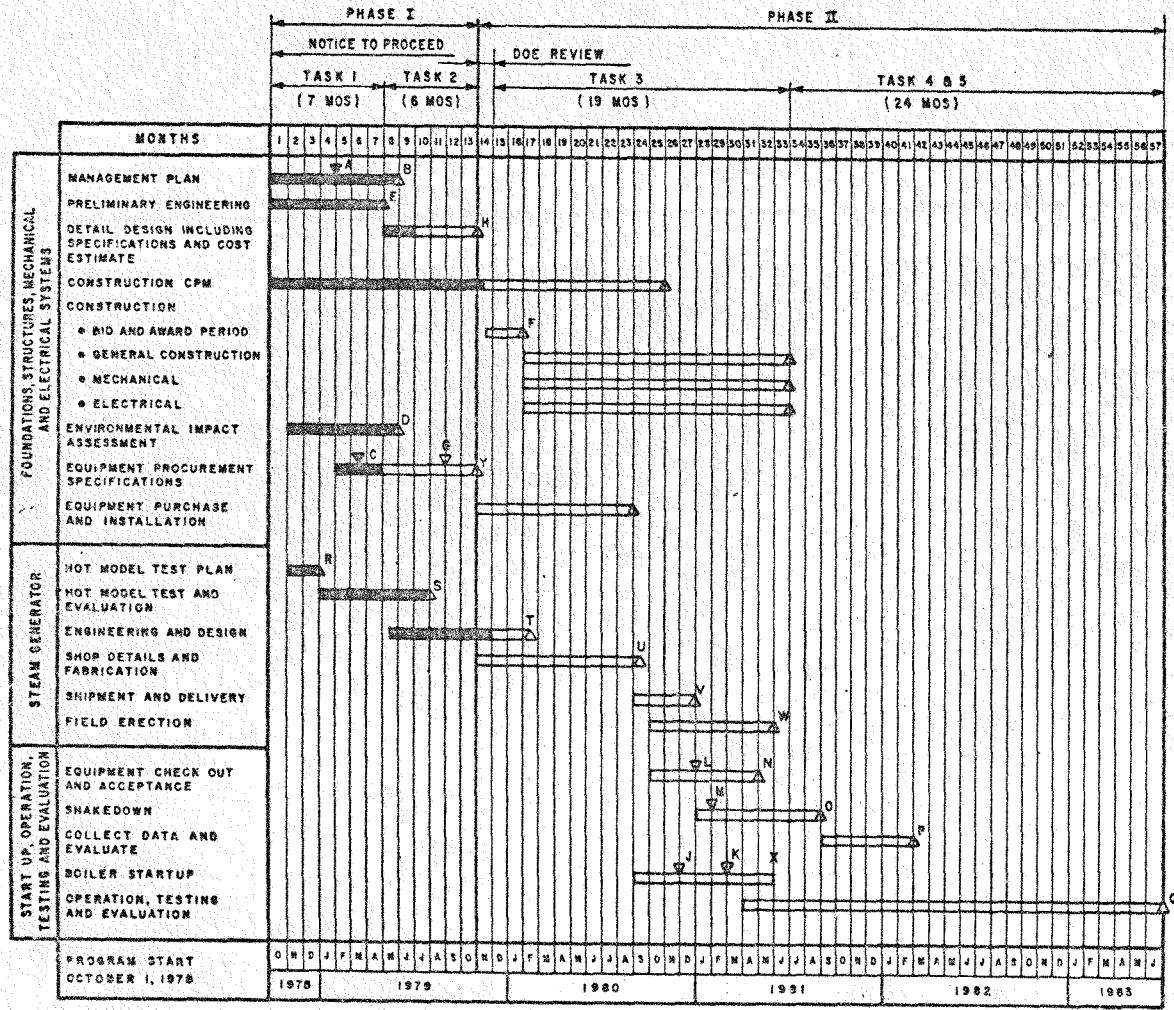
Phase I - Development Engineering and Design

This phase consists of all necessary engineering and design work prior to construction of the AFB steam generator and facility. The estimated period of performance of Phase I is thirteen months. The term includes time allowed for hot model testing, process selection, approval of designs, plans, specifications, construction bid packages, and the placement of subcontracts for long lead equipment items required under Phase II.

Phase II - Construction, Operation, Testing and Evaluation

This phase consists of equipment procurement, construction, operation, testing and evaluation of the AFB steam generator and facility. The total estimated period of performance is 44 months, consisting of a 20 month construction task and 24 months for operation testing and evaluation. (See Exhibit A).

PROGRAM SCHEDULE AND MILESTONE REPORT



NOTES

A. SUBMIT PROGRAM PLAN CPM (2/8/79)
B. SUBMIT MANAGEMENT PLAN
C. SUBMIT PRELIMINARY EQUIPMENT LIST (2/8/79)
D. SUBMIT ENVIRONMENTAL IMPACT ASSESSMENT
E. SUBMIT PRELIMINARY ENGINEERING REPORT (5/4/79)
F. COMPLETE BIDDING AND AWARD CONSTRUCTION CONTRACTS
G. SUBMIT LONG LEAD EQUIPMENT SPECIFICATIONS
H. SUBMIT FINAL CONSTRUCTION CONTRACT DOCUMENTS.
J. SUBMIT STARTUP PROGRAM
K. BEGIN BOILER START UP
L. SUBMIT EQUIPMENT ACCEPTANCE PLAN
M. SUBMIT EQUIPMENT SHAKEDOWN PLAN
N. SUBMIT EQUIPMENT CHECKOUT AND ACCEPTANCE REPORT
O. SUBMIT REPORT OF SHAKEDOWN TESTS
P. SUBMIT OPTIMIZATION REPORT
Q. SUBMIT FINAL REPORT
R. SUBMIT HOT MODEL TEST PLAN (1/9/79)
S. SUBMIT HOT MODEL TEST AND EVALUATION REPORT
T. COMPLETE BOILER ENGINEERING AND DESIGN
U. COMPLETE BOILER SHOP FABRICATION
V. COMPLETE SHIPMENT OF BOILER PARTS
W. COMPLETE BOILER ERECTION
X. COMPLETE BOILER START-UP
Y. APPROVAL FOR PROCURMENT SPECIFICATIONS

LEGEND

SCHEDULED ACTIVITY
COMPLETED ACTIVITY
MAJOR MILESTONE
SCHEDULED — COMPLETED
INTERMEDIATE EVENT

EXHIBIT "A"

SUMMARY OF PROGRESS DURING THIS REPORT PERIOD

A. Hot Model Testing

Foster Wheeler testing of the Pine Ridge Banks anthracite culm in the fluid bed pilot plant unit consisted of the completion of the last four batch tests using revised fuel grinds of -#6 mesh x 0. Lab analysis of the Pine Ridge anthracite culm samples from the batch tests were performed. During this report period Foster Wheeler was notified of the inavailability of the Pine Ridge anthracite culm bank for the AFB Boiler Demonstration period and consequently developed a revised Hot Model Test Plan Matrix for performing batch tests using anthracite from Kaminski Bank No. 14.

These batch tests were run for expanded bed heights of 4 and 5 feet, excess air values of 22%, bed temperatures of 1750°F to 1900°F, and superficial fluidizing velocities from 4 to 8 ft./sec. Four of these tests were run with flyash recycle and the remaining tests were run with no flyash recycle. In-bed limestone injection was used for SO_2 control. The anthracite culm used in these tests was crushed to -#6 mesh x 0.

Lab analysis of the Kaminski Bank No. 14 anthracite culm samples from the batch tests were performed during this period. The results of the revised batch test matrix indicated the need to perform a limited number of additional batch tests in order to determine the operating conditions for the 100 hour verification test. Based on data from these additional batch tests and the revised batch test matrix data the following boiler design parameters have been selected.

- A 1750°F bed temperature must be maintained to meet the EPA maximum NO_x level of 520 ppm (0.7 lb/10^6Btu) while injecting limestone for SO_2 control. At bed temperatures greater than 1800°F and limestone injection the NO_x levels exceed the EPA limit.

- At a 1750°F bed temperature and no flyash recycle the carbon combustion efficiency is 80.3%. At a 1750°F bed temperature and flyash recycle equivalent to recycle from two of four multiclones the carbon combustion efficiency is 85.7%. This data will be finalized upon completion of the 100 hour verification test.

The results of all the Kaminski No. 14 batch tests were forwarded to performance engineering personnel for their use in boiler design. Results of the 100 hour verification test will provide additional data to finalize the design parameters. These results will be forwarded to performance engineering personnel upon completion. The 100 hour verification test was initiated.

B. Boiler Design

Foster Wheeler initiated the preliminary design of the steam generator during this report period based on preliminary hot model batch test data obtained from the pilot plant fluidized bed combustor. Preliminary boiler related performance data and release dates were issued to Pope, Evans and Robbins for their use in defining their system equipment design parameters and dimensional outlines.

As mentioned above, the boiler design parameters were established, and preliminary design of the boiler proceeded based on this data. Preliminary boiler design is scheduled for completion in July, 1979 at which time the final design phase will begin.

C. Preliminary Design

Completed Preliminary Design was submitted and reviewed by DOE.

D. Final Design

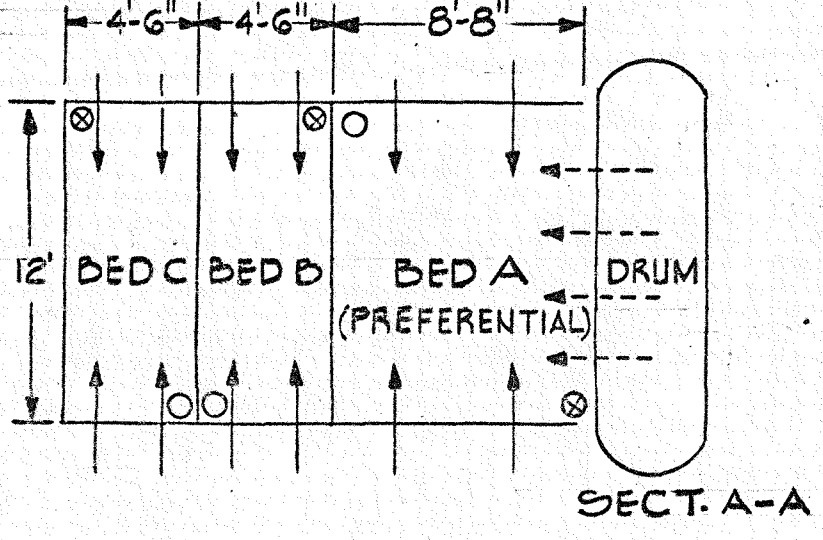
1. Final Plant Design was initiated based on the following boiler design parameters from Foster Wheeler Boiler Corporation:
   a. Nominal Boiler Size
      12 ft ± 18 ft ± (See Exhibit B)
   b. Maximum boiler weight including bed material = 660,000 lbs.
   c. Maximum number of feedpoints = 12
      Four feed points for each bed.
   d. One preferential bed approximately 8'-8" ± wide.
      Two secondary beds each 4'-6" ± wide.
   e. One fuel feed splitter for preferential bed and
      One fuel feed splitter for the two secondary beds.
   f. Preliminary air pressure of 100 in. wg for the performance condition of MCR operation with a maximum bed depth (1750°F and 5.5 ft. bed height).
   g. Flyash reinjection will be off 2 of the 4 multiclone collectors. The economizer will be located in a horizontal gas flue with no hopper.
2. Equipment selection and plant layout was modified to suit DOE and McKee comments and to generally improve reliability while keeping cost impact at a minimum (See Exhibit C). The plant design was also modified to suit Foster Wheeler recommendations.

E. Alternate Source of Anthracite Culm Supply

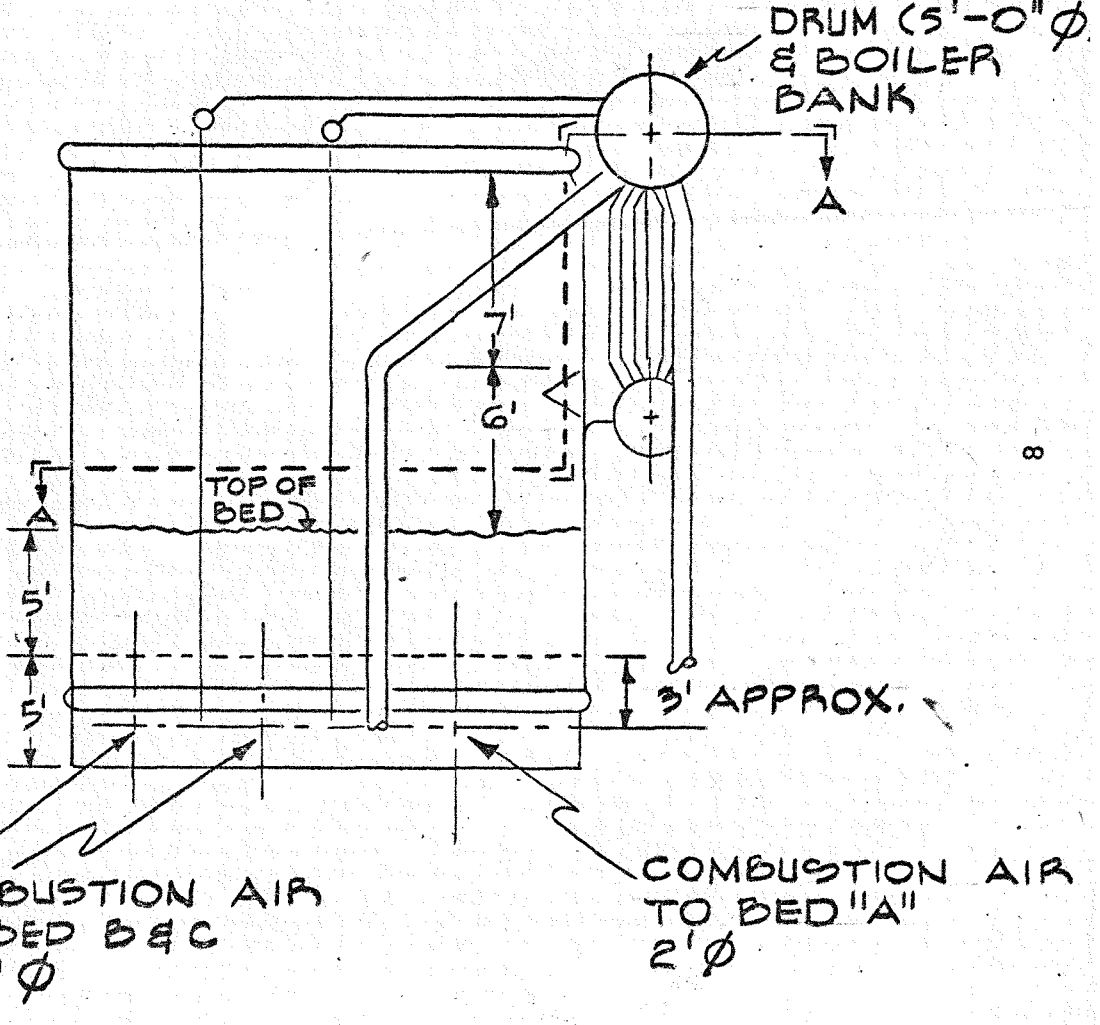
The City of Wilkes-Barre held a pre-bid conference on 11 May 1979 to introduce the anthracite culm specification to potential suppliers.

PRELIMINARY BOILER LAYOUT

O – BED DRAINS – 6"Ø
⊗ – LIMESTONE FEED – GRAVITY FEED TO TOP OF BED



SECT. A-A



→ ANTH. CULM FEED NEEDLES
--→ FLY-ASH REINJECTION

ITEM	CELL		
	A	B	C
CULM FEED POINTS	4	4	4
FLY ASH REIN. PTS.	4	0	0
SQ.FT/CULM FEED ft.	26	13.5	13.5

EXHIBIT B

Bids will be based on the following specification:

- o High Heat Value — 6000 Btu/lb Nominal; 7000 Maximum; 5000 Minimum
- o Ash Content (Dry Basis) — 50% Nominal; 55% Maximum; No Minimum
- o Moisture Content — 6% Maximum
- o Approximate Quantity Required — 40,000 tons/yr for two years
- o Possible Variation In Annual Quantity — ± 15,000 tons
- o Required Size Range of Anthracite Refuse - 1 1/2 inch top size; 1/4 inch bottom size
- o Delivery Rate (Based on 20 Tons Payload)

  Maximum — 15 trucks per day during peak heating season

  Minimum — 1 to 3 trucks per day during beginning and end of heating season

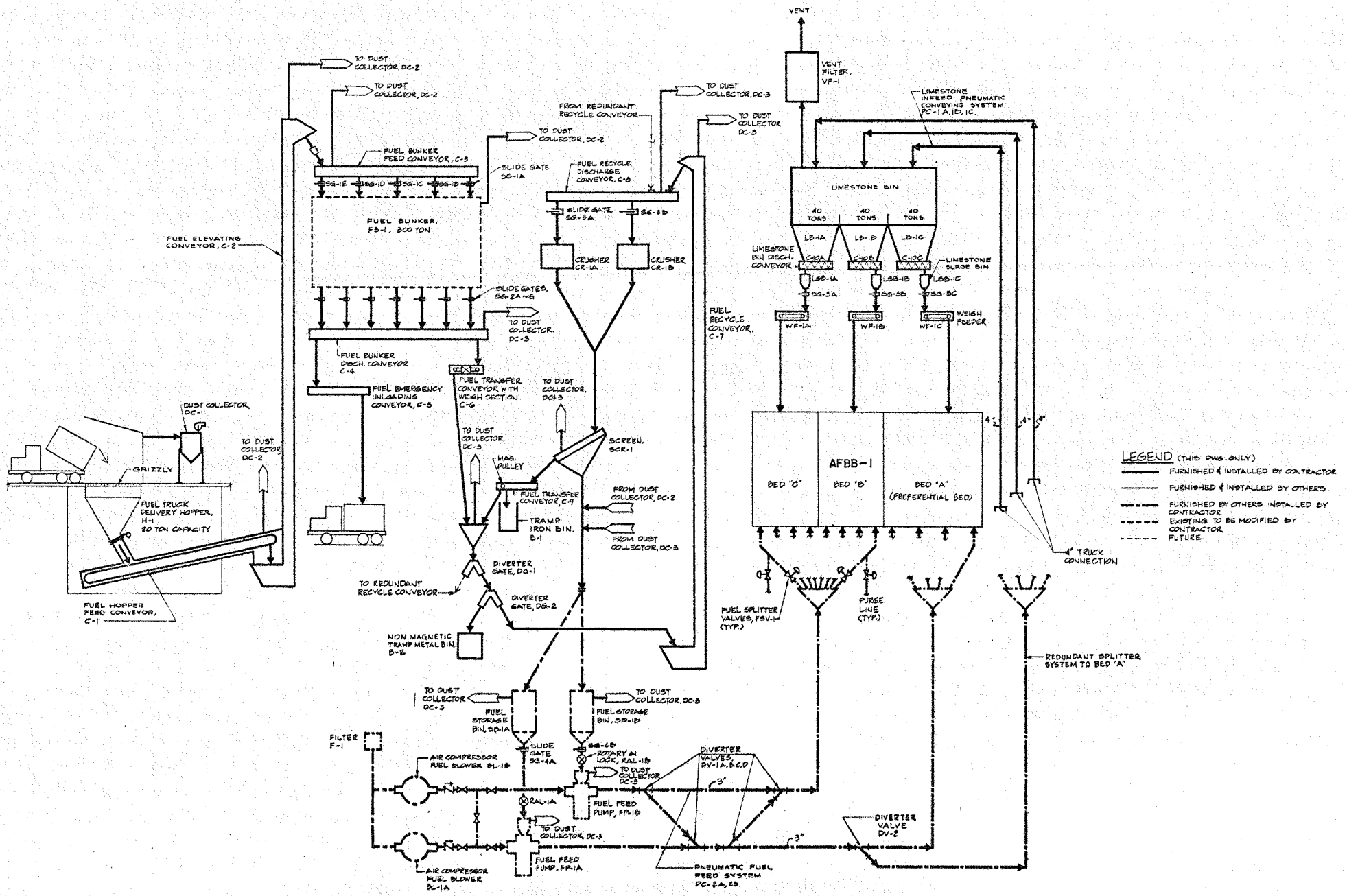
  No summertime delivery will be accepted
- o Tramp Metals - The contractor is to ensure that all tramp metals (iron, brass, aluminum etc.) are removed.

It is the intent of the City to purchase specification fuel from local suppliers and have it delivered to the plant.

F. Environmental Impact Assessment (EIA).

The EIA was completed and submitted to DOE for their review and approval.

PLANT FEED SYSTEM



POPE, EVANS AND ROBBINS

EXHIBIT "C"

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G. Fuel Feed System

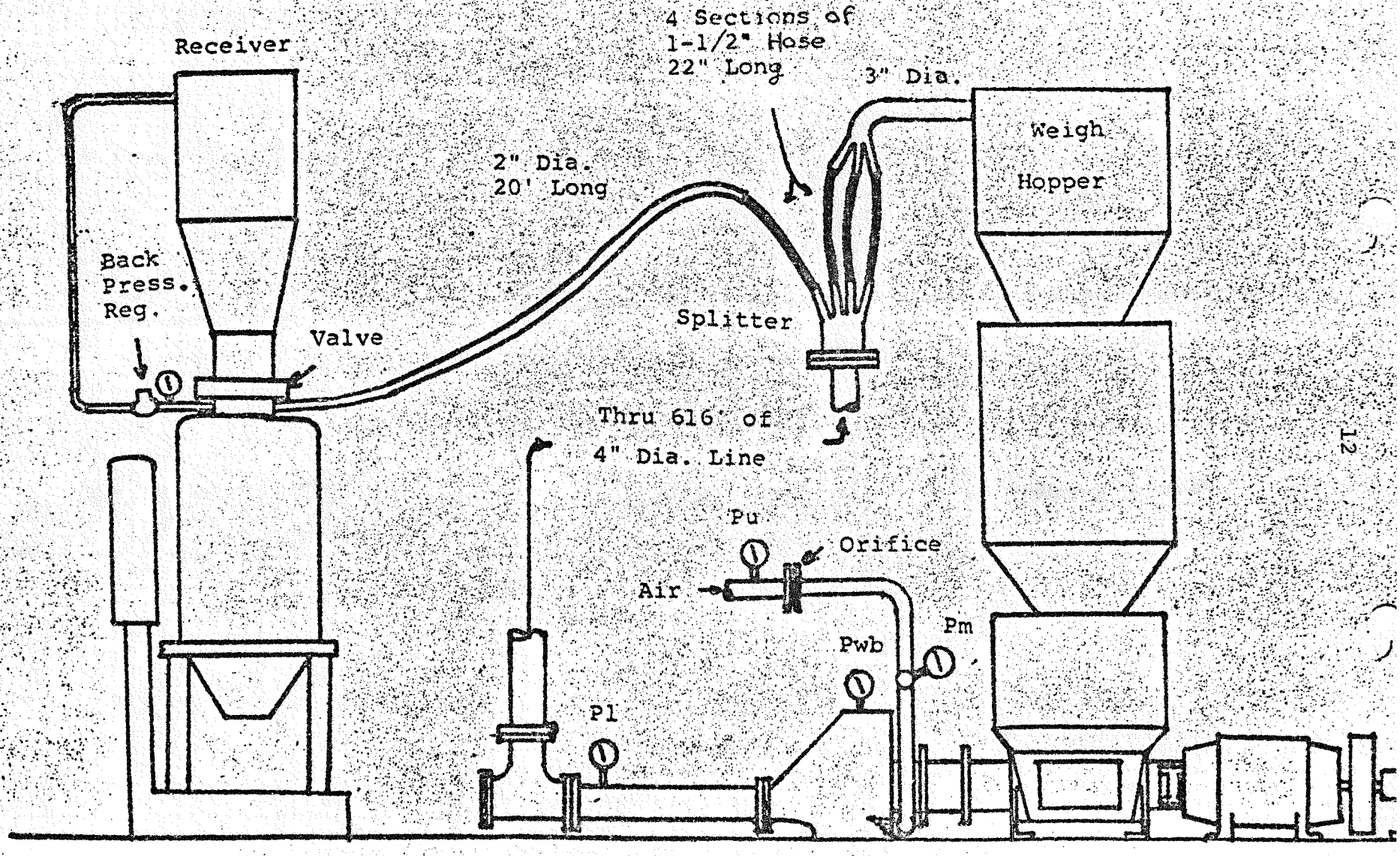
In order to demonstrate the capabilities of Fuller-Kinyon System to properly split the fuel and deliver it to the boiler it was suggested that a system might be installed at the Rivesville Facility. A meeting was held at the Rivesville site to evaluate the feasibility and cost of installing a system to feed fuel to the "C" Cell of the Rivesville AFB Boiler. The conclusions reached at that meeting are as follows:

- The coal pumps could be installed in the basement (El. 872' - 0") on the north side of the boiler.
- 8" diameter stainless steel pipes from the north vibrating feeder inlets for A and C cells will transport the coal/ limestone mixture to the coal pump hoppers.
- Two compressors, including motors and intake filter are to be located north of the pumps in the sub-basement east of the ash cooler (EL. 864' - 0").
- Splitters can be placed at the north and south side of C-Cell at the present vibrating feeder areas.
- The estimated cost for this installation was estimated at $117,200.

Fuller Equipment	-	$ 72,800.
Installation	-	44,400.
Total		$117,200.

Another meeting was held at Fuller Company's headquarters in Bethlehem, Pennsylvania. The operation of the Fuller-Kinyon splitter was demonstrated at this meeting. The material tested was limestone of a size distribution similar to that being proposed for the Wilkes-Barre AFB Boiler.

Fig. #1 - Stream splitter test set-up



Blow Tank with Scale

Fuller Kinyon Pump

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EXHIBIT D

Material was fed from a bin through a rotary feeder into a type M pump that discharded to a horizontal run and then a vertical run of 28 feet. An 8-way splitter box was set at the top of the vertical column. Each splitter port was connected to a rubber hose by a common elbow. This converted a column of 5-inch pipe into eight 1 1/2-inch paths. The split streams were piped to small receivers set at the top of the initial feed bin (See Exhibit D).

Instrumentation by load cell showed that the material was fed at a constant rate from the bin and that the return material appeared to return at a uniform rate to each of the collectors. The actual test showed the following:

Material pumped at 206 lb/min from feed bin
Returned material as indicated in the following table:

Tank No.	Wgt. Collected(lb)	% Collected	% Deviation From Equal Flow
1	150	9.4	- 24.3
2	195	12.2	- 2.4
3	240	15.0	+ 20.0
4	220	13.7	+ 9.6
5	195	12.2	- 2.4
6	230	14.4	+ 15.2
7	170	10.6	- 15.2
8	200	12.5	0.0
TOTAL	1600	100.0	

H. Demolition

Site demolition adjacent to the boiler plant has been completed. Demolition of one of the two existing boilers is nearly complete and demolition of the second boiler is approximately 50% complete.

WORK TO BE ACCOMPLISHED DURING THE NEXT REPORTING PERIOD

A. Hot Model Testing

1. The 100 hour verification test will be completed and results forwarded to Foster Wheeler performance engineering personnel for their use in boiler design.
2. Writing of the Hot Model Test and Evaluation Report will begin.

B. Boiler Design

1. Foster Wheeler will complete work on the preliminary boiler design based on final test results from the Hot Model Program.
2. The general arrangement drawings and final design of the boiler will be initiated.
3. Foster Wheeler will initiate writing specifications for selected vendor supplied equipment. This will include the following:
   - Ignitor
   - Combustion Controls and furnace safety system
   - Drum safety valves
   - Water column and gage glass
   - Remote level indicator
   - Economizer
   - Thermocouples
   - Feedwater control valve
4. Material procurement for use by the Foster Wheeler manufacturing facilities will be initiated.

C. Plant Design

Pope, Evans and Robbins will continue on final plant design.

D. Environmental

1. Prevention of Significant Air Quality Deterioration (PSD) application will be made to the United States Environmental Protection Agency, Region III.
2. An Application for Plan Approval to Construct will be made to the Pennsylvania Department of Environmental Resources.

E. Anthracite Culm Supply

Formal Bids will be requested for supply of anthracite culm for the two year demonstration period.

DISCUSSION OF POTENTIAL PROBLEM AREAS

A. Boiler Feed System

Because the reliability of the plant is extremely dependent on the feed system and since the Fuller-Kinyon system appears to be the most reliable available system, it is intended to purchase the Fuller-Kinyon system on a sole source basis.

B. Plant Reliability

In order to increase plant reliability while keeping the cost impact at a minimum, the following design modifications are being addressed:

- Providing for the addition of a redundant bucket elevator in the fuel preparation area.
- Providing for the addition of a redundant fuel splitter system for the preferential bed.
- Looking into the elimination of rotary valves having a pressure differential, utilizing instead, a double tank and valve approach.
- Providing interchangeability of fuel feed compressors and pumps.
- Eliminating redler type conveyors wherever feasible and replacing them with belt or flight type conveyors.

PROGRAM CONTROL

A. Schedule

1. Hot Model Testing
   The Foster Wheeler Hot Model Batch Test Matrix testing was completed on schedule. The 100 hour verification test was initiated and will be completed by July 3, 1979. The Hot Model Test and Evaluation Report will be completed in August 1979; however all results from this program have been or will be provided to Foster Wheeler performance engineering personnel so as not to impact any design activities.

2. Boiler Design
   Boiler Design is proceeding on schedule. The preliminary design phase will be completed by mid-July, 1979.

3. Plant Design
   Overall plant design is proceeding on schedule.

B. Cost

1. Expenditures for the Hot Model Testing Program and the boiler design activities are currently within the budget estimate.

2. Foster Wheeler is currently evaluating the possible increase in cost of the boiler due to design changes related to the change in feed system and fuel size.

3. Modifications to the plant layout and design based on preliminary design review comments by DOE and McKee and the latest Foster Wheeler preliminary design information will have an impact on the cost of the overall plant. The total cost impact will not be known until the completion of final design and associated cost estimate.