COAL DESULFURIZATION IN A ROTARY KILN COMBUSTOR

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Contracting Officer's Technical Officer: Douglas Gyorke

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August 15, 1990

Submitted to:

U.S. Department of Energy
Pittsburgh Energy Technology Center
Pittsburgh, PA

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INTRODUCTION

BCR National Laboratory (BCRNL) has initiated a project aimed at evaluating the technical and economic feasibility of using a rotary kiln, suitably modified, to burn Pennsylvania anthracite wastes, co-fired with high-sulfur bituminous coal. Limestone will be injected into the kiln for sulfur control, to determine whether high sulfur capture levels can be achieved with high sorbent utilization.

The principal objectives of this work are:

1. to prove the feasibility of burning anthracite refuse, with co-firing of high-sulfur bituminous coal and with limestone injection for sulfur emissions control, in a rotary kiln fitted with a Universal Energy International (UEI) air injector system;
2. to determine the emissions levels of SO_x and NO_x , and specifically to identify the Ca/S ratios that are required to meet New Source Performance Standards;
3. to evaluate the technical and economic merits of a commercial rotary kiln combustor in comparison to fluidized bed combustors; and,
4. to ascertain the need for further work, including additional combustion tests, prior to commercial application, and to recommend accordingly a detailed program towards this end.

In carrying out the third objective, the project team will be attentive to the particulate loading in the kiln exhaust gas when the UEI air injection system (AIS) is used, in comparison with particulate loading from fluidized bed combustors.

In carrying out the fourth objective, the project team will be attentive to the general aspects of kiln combustion and the possibility of a "kiln combustion R&D program," which would involve kiln boilers and water-wall kilns, in addition to the adiabatic kiln combustor which is the focus of this project.

During the first quarter of this program, the following activities have been conducted:

1. the details of the workplan and schedule have been defined;
2. environmental permit applications have been submitted;
3. subcontracts have been prepared, and all but one have been executed;

4. visits to the project site and to two equipment suppliers have been made;
5. flow diagrams and material and energy balances have been prepared for three representative operating conditions expected during the test program;
6. many of the necessary equipment modifications and installations have been specified and work initiated;
7. the entire project team has held a process review meeting and a project coordination meeting;
8. two presentations in August 1990 have been planned.

SCHEDULE

The schedule for the project is shown in Appendix A.

ENVIRONMENTAL PERMIT APPLICATIONS

On April 24, 1990 two environmental permit applications were submitted to

Mr. Larry Wonders
Regional Air Quality Control Manager
Pennsylvania Department of Environmental Resources
Bureau of Air Quality Control
1012 Water Street
Meadville, Pennsylvania 16335

They are (1) Application for Plan Approval to Reactivate a Source, Modify an Existing Source and Install an Air Cleaning Device and (2) Request for Approval to Store a Residual Waste Stream at Humphrey Charcoal Corporation (HCC), Brookville, Pennsylvania, which is the site for this project. Copies of these two environmental permit applications are provided in Appendices B and C.

Notifications of this submission were sent to Mr. L. Reid Henry of Pine Creek Township and Mr. Keith Snyder of Jefferson County.

Mr. Devendra Verma, Air Pollution Control Engineer of the Bureau of Air Quality Control at the Meadville Office of PennDER, has sent a letter, dated June 18, 1990, to BCRNL, requesting further information before issuing the permits. That information is being developed for transmittal in early July. A copy of Mr. Verma's letter is provided in Appendix D.

SITE VISITS

In addition to the project review and project coordination meetings, three site visits by project team members have been made during this period:

1. J. T. Cobb, J. A. Kost, M. L. Pomerantz and W. E. Young of BCRNL visited Nicholas Babich of Babich & Stotler, Yukon, PA, on May 11 to examine the first-stage cooler, baghouse and induced-draft fan that will be used in the particulate control system for the kiln. Numerous photographs and measurements were taken of all three pieces of equipment.
2. N. Babich, J. T. Cobb, J. A. Kost, M. L. Pomerantz and W. E. Young visited James Humphrey of HCC, at Brookville, PA, on May 15 to view the project site and the existing kiln, stack and feed system. Drawings of the site and the equipment were obtained. Numerous photographs and measurements were taken of the site and the equipment. Numerous notes were made regarding utilities and operating procedures.
3. M. L. Pomerantz visited John Gagliardi of U. S. Industrial Fabricators, Inc., Jefferson Boro, PA, on June 3 to examine a U. S. Varidrive Motor and obtain its specifications for use in providing variable rotation speeds on the kiln.

FLOW DIAGRAM AND MATERIAL AND ENERGY BALANCES

The flow diagram for the equipment to be used at Humphrey Charcoal Corporation is shown on the first page of Appendix E. Material and energy balances for three representative operating conditions have been prepared:

1. sawdust being fed at 1770 pounds (6 million Btu) per hour;
2. anthracite residue being fed at 2000 pounds (6 million Btu) per hour;
3. high-sulfur bituminous coal being fed at 1660 pounds (20 million Btu) per hour.

These balances together with some relevant calculations are included in Appendix E. The first phase of the program includes shakedown tests of the first two fuels noted under (1) and (2) above. For reasons set forth below, the combustion of bituminous coal under the third set of conditions may not be feasible. Accordingly, depending on the results from the Phase I tests, the program may be modified, and the third fuel may be either bituminous coal wastes, or high sulfur bituminous coal fired with anthracite culm.

The rated thermal loading for a kiln combustor of the size being used in this project is approximately 24 million Btu per hour. Thus, the initial operating conditions represent about one quarter of the rated throughput of the unit.

Several constraints affect the operation of the kiln in its present configuration. First, the temperature of the kiln should be maintained below about 1800°F to prevent formation of ash clinkers. A large body of data on sulfur capture suggests that the most effective temperature insofar as limestone utilization is concerned lies around 1600°F, and accordingly, we have regarded 1600°F as the operating temperature of the kiln. This temperature, and the fact that the kiln is refractory lined and has no internal heat absorbing surfaces, place a limit on heat that can be released in the kiln. In the heat balances presented in Appendix E, we have arbitrarily allowed for the injection of water as the means of controlling the temperature. The injection of a small amount of water may be acceptable in an experimental facility, and, depending on economic considerations, even in a commercial plant. In fact, it may not be necessary for conditions (1) and (2) shown above because of leakage of air into the kiln and some radiative heat losses. However, for combustion of bituminous coal at 1660 pounds per hour (Condition 3), the amount of water needed for control of temperature is 5600 pounds per hour, clearly an unacceptable circumstance.

Indeed, the above leads to the conclusions that the refractory-lined kiln is suitable for the combustion of only rather lean fuels. For fuels of heating values in excess of 2000 to 3000 Btu per pound, heat removal surface needs to be incorporated into the kiln. The Pedco unit and Westinghouse's O'Conner system are designed in this manner. Staged combustion can also permit processing of fuels of higher grades.

At the initial reduced throughput, the flow rate of combustion gases from the unit is approximately 8000 pounds per hour, which translates into about 3200 ACFM to the baghouse. Increasing the throughput to 10 million Btu per hour, which results from the feed rate of anthracite residue called for under the terms of the contract, will raise the flow rate of combustion gases to about 5300 ACFM to the baghouse. As noted on page 5 of the air permit application in Appendix B, the baghouse is rated for 7000 ACFM. Thus, the tests of anthracite residue are well within the capability of the equipment at HCC.

The flow rate of combustion gases, corresponding to the maximum feed rate of high-sulfur bituminous coal is nearly 11,000 ACFM. This is much in excess of the design limit of this piece of equipment.

Because of the unsuitability of the refractory-lined, open kiln to combust high-quality fuels, as well as the limit on the design ACFM to the baghouse of this particular unit, BCRNL plans to modify the work statement of this project. The tests of high-sulfur bituminous coal, originally planned, will be replaced with tests of co-firing of high-sulfur bituminous coal with a low-quality fuel, such as an anthracite refuse. Also being considered are test firings of bituminous coal wastes. Changes to the test

program for Phase I have been included in the revised table of the Test Program for Phase I, shown in Appendix F.

EQUIPMENT SPECIFICATIONS AND MODIFICATIONS

Kiln System

Stainless Steel Seals. To reduce severe air leakage through the existing seals, new ones are being purchased. The least expensive ones, suitable for the test program, have been specified.

Air Injection System. The new four-stage AIS is being constructed by UEI, with the added capability of staged water injection. A system of four pitot tubes is being designed to measure the staged air flows.

Secondary Air Blower. An existing blower is being relocated to HCC.

Variable Speed Rotational Drive. A motor is being purchased and a linkage is being designed to allow a range of kiln rotational speeds between 1 and 3 RPM.

Refractory. Bricks to replace broken ones are being purchased.

Ash Removal System

Conveyor Drive. A motor is being purchased to increase the power to the screw conveyor, which removes ash from the kiln. This is being done in anticipation of larger amounts of solids flowing at that point.

Ash Cooling System. A water spray system is being designed to cool the ash leaving the kiln.

Weigh System. A method for weighing the ash leaving the kiln is being designed.

Feed System

Mixer. The existing mixer is being inspected and evaluated for its ability to blend anthracite residue, coal and limestone.

Bucket Elevator. The existing bucket elevator, which carries fuel from the mixer sump to the active fuel storage bin, is being inspected and evaluated for its ability to transport mixed fuel in sufficient quantity.

Conveyor Drive. A variable-speed motor is being purchased to allow control of the amount of feed, which can

be transferred from the active fuel storage bin through the screw conveyor at the bin outlet.

Weigh System. A design is being prepared for a weigh system to be installed in the feed conveying system between the active fuel storage bin and the kiln. The in-line weigh system will incorporate a load cell which is being purchased for this purpose.

Feedstocks. To protect the refractory from abrasion, the top size of anthracite residue, high-sulfur bituminous coal and bituminous coal waste will be limited to one inch. The top size of limestone will be limited to 1/8 inch, in accordance with experience gained in fluidized bed combustors. (It should be noted, however, that the Pedco Rotary Cascading Bed Boiler uses 3/8 inch limestone.) Limestone sourcing will be discussed with Westinghouse and Pennsylvania State University. Bituminous coal waste specifications are being developed. All other feed specifications remain unchanged and are as listed in the contract.

Particulate Control System

The PCS consists of a first and second stage gas cooler, baghouse and induced-draft fan. A sketch of the PCS is given in Appendix G.

First Stage Gas Cooler. An existing radiant gas-to-gas cooler, owned by Babich & Stotler, is being modified to a convective gas-to-boiling water/steam cooler for relocation to HCC. Modifications are being guided by Jobst Seehausen, the original designer of the cooler. Correspondence with Mr. Seehausen is shown in Appendix H.

Second Stage Gas Cooler. An existing air heater, donated to Carnegie-Mellon University by Westinghouse for use in BCRNL's combustion work, is being modified to a convective gas-to-boiling water/steam cooler for relocation to HCC. Mr. Seehausen is guiding the modification of this cooler also (see Appendix H).

Baghouse. The baghouse, described on page 5 of the air permit application in Appendix B, owned by Babich & Stotler, is being refurbished for relocation to HCC. A new air control system for back-blowing the bags is being purchased and installed. An existing star-wheel feeder is being installed to control ash removal from the bottom of the baghouse.

Induced-Draft Fan. A 150-HP existing blower, owned by Babich & Stotler, is being inspected and refurbished for relocation to HCC. A step-starter is being sought to reduce the amperage required to initiate the fan's rotation.

Ducts and Flanges. Ducts and flanges are being purchased for connecting the PCS equipment and secondary combustor into the system at HCC.

Utilities

Water Line. A new water line is being installed to supply the larger flows required for the two gas coolers, the water feed to the AIS and the water spray for ash cooling.

Electrical Line. A new electrical line is being installed to supply the larger power required for the mixer, the bucket elevator, the induced-draft fan, the secondary air blower and the larger conveyor drive motor in the ash removal system.

Electrical Distribution Center. To accomodate the additional electrical connections needed for this project, an existing electrical distribution center is being relocated to HCC.

Instrumentation. A thorough evaluation has been conducted of the system variables controlling operation and those to be used in analyzing the performance of the kiln. They are listed in Table 1 of Appendix I. Tables 2 and 3 of Appendix I identify those parameters that will be measured -- solid stream analyses being listed in Table 2 and other variables being listed in Table 3. An assessment by G/C, reproduced in Table 4 of Appendix I, was used extensively in this review.

PROJECT INITIATION MEETINGS

A process review meeting was held on June 20, 1990 and a project coordination meeting was held the following day at BCRNL. The reports on these two meetings are reproduced in Appendices J and K.

FUTURE PRESENTATIONS

Presentations are being prepared for:

Sixth Annual Coal Preparation, Utilization and Environmental Control Contractors Conference, August 6-9, 1990.

Seventh U.S./Korea Workshop on Coal Utilization Technology, August 26-29, 1990, Vista Hotel, Pittsburgh, Pennsylvania.

APPENDIX A
ROTARY KILN PROJECT SCHEDULE

ROTARY KILN SCHEDULE

April	May	June	July	Aug	Sept	Oct	Nov	Dec
XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX	XX					
		XXXXXXXXXX						
		XXXXXXXXXXXX						
			XXXXXXXXXXXX					
			XXXXXXXXXXXX					
				XXXXXXXXXXXX				
			XXXXXXXXXX					
				XXXXXXXXXX				
				XXXXXXXXXX				
					XXXXXX			
						XXX		
							XXX	
								XXX
								XXXXXX

Phase 1 Facility Preparation
Commissioning, and Shakedown Tests

PADER Permit

Task 1 Modify Kiln

- Specify Equipment
- Procure Equipment
- Install Equipment

Task 2 Instrumentation

- Design/Specify
- Procure
- Install

Task 3 Procure Fuel & Limestone

Task 4 Cold Commissioning

Task 5 Shakedown Tests

Task 6 Shutdown, Inspection, Data
Analysis, and Phase 2 Recom-
mendations

Phase 2 - Test Program

APPENDIX B

**APPLICATION FOR PLAN APPROVAL TO REACTIVATE A SOURCE,
MODIFY AN EXISTING SOURCE AND INSTALL AN AIR CLEANING DEVICE**

Submit in Triplicate

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF AIR QUALITY CONTROL

COMBUSTION

Application for Plan Approval to Construct, Modify or
Reactivate an Air Contamination Source and/or Air Cleaning Device and for a Permit to Operate

Section A Identity and Location of Air Contamination Source

1A. Application is being made for: ☐ Construction of New Source/Operating Permit ☒ Reactivation of a Source/Operating Permit ☒ Modification of Existing Source/Operating Permit ☒ Installation of Air Cleaning Device/Operating Permit ☐ Amendment to a Previous Application Previous Application No. _____ ☐ Other _____		OFFICIAL USE ONLY Application No. _____ Plant Code _____ Unit ID _____ Date Received _____ Reviewed By _____ Potential Emissions (TPY) PM _____ SO ₂ _____ VOC _____ NOX _____ CO _____ Other _____ Actual Emissions (TPY) PM _____ SO ₂ _____ VOC _____ NOX _____ CO _____ Other _____ Change in Actual Emissions (+ or -) PM _____ SO ₂ _____ VOC _____ NOX _____ CO _____ Other _____	
1B. Type of source Rotary Combustor			
1C. Plant in which source is located ☐ NEW ☒ EXISTING			
1D. If source is new, does it replace another source ☐ YES ☐ NO (describe source replaced)		1E. Expected date of completion 9/1/90	
2A. Owner of source Humphrey Charcoal Corp.		2B. Employer I.D. No. (Federal IRS No.) 25 - 1065 - 078	
3A. Owners designation of source and/or plant if any Tunnel Kiln	3B. Location of source (Street address or Route No.) R. D. #1 Pine Creek	Political Subdivision (Township, etc.) Jefferson	County Jefferson
3C. Mailing address (Street or P.O. Box, City, Zip Code) P.O. Box 440, Brookville, PA 15825		3D. Telephone No. 814/849-2302	
4A. Person to contact regarding this Application (Name and title) M. L. Pomerantz, Proj. Mgr.	4B. Mailing address (Street or P.O. Box, City, State, Zip Code) BCR National Laboratory 500 William Pitt Way Pittsburgh, PA 15208	4C. Telephone No. (412) 826-3030	
5. Official signing application must be an agent of the Company having primary responsibilities for operation of the facility to which this application applies. Although he may not have participated in the design of the facility he should be responsible for approval of the design.			

AFFIDAVIT

I, James L. Humphrey, being duly sworn according to law depose and say that I am the official having primary responsibility for the design and operation of the facilities to which this application applies and that the information included in the foregoing application is true to the best of my knowledge, information and belief.

Sworn to and subscribed before me this 26 day

of [illegible]

Signature

Not

Section B.2 Combustion Units Information

1. COMBUSTION UNITS

Rotary Kiln, and Secondary Combustor

A. Manufacturer	B. Model No.	C. No. of units
Industrial Boiler Company	Special Unit	One
D. Rated heat input (Btu/hr)	E. Peak heat input (Btu/hr)	F. Use
30×10^6	20×10^6	Burning Coal Wastes and tires

G. Method of firing
Chain Conveyor

2. FUEL REQUIREMENTS

TYPE	QUANTITY HOURLY	ANNUALLY	SULFUR	% ASH (WEIGHT)	BTU CONTENT
OIL NUMBER	GPH @ 60°F	$\times 10^3$ Gal.	% by wt.		Btu/Gal. @ 60°F
NATURAL GAS	SCFH	$\times 10^6$ SCF	gr/100 SCF		Btu/SCF
GAS (OTHER)	SCFH	$\times 10^6$ SCF	gr/100 SCF		Btu/SCF
COAL	0.83 TPH	N/A Tons	6.01 % by wt.	14.35	11,800 Btu/lb.
OTHER	See Note 1				

3. COMBUSTION AIDS, CONTROLS, AND MONITORS

See Note 2

☒ A. Overfire jets	Type	UEI Combustion	Number	20	Height above grate	2.5'
☒ B. Draft controls	Type	FD and ID Fans, Dampers				
☐ C. Oil preheat	Temperature (°F)					
☐ D. Soot cleaning	Method		Frequency			
☐ E. Stack sprays						
☐ F. Opacity monitoring device	Type		Method		Cost	
☒ G. Sulfur oxides monitoring device	Type	Lancom	Method		Cost	
☒ H. Nitrogen oxides monitoring device	Type	Lancom	Method		Cost	
☒ I. Fuel metering and/or recording devices	Type	Starwheels	Method		Cost	
☐ J. Atomization interlocking device	Type		Method		Cost	
☐ K. Collected flyash re-entrainment preventative device	Type					
☒ L. Modulating controls	☒ Step		☐ Automatic			

4. ☐ Flyash reinjection Describe operation

N/A

5. Describe method of supplying make up air to the furnace room

Natural Draft

Section B.2 Combustion Units Information, Continued**6. OPERATING SCHEDULE**24 hours/day7 days/week Not to exceed 120 days ~~year~~ ^{including downtime}**7. SEASONAL PERIODS (MONTHS) Bituminous coal, anthracite**Operating using primary fuel refuse, tires Operating using secondary fuel _____9/1/90 to 11/30/90

_____ to _____

Non-operating

_____ to _____

See Note 3

8. If heat input is in excess of 250×10^6 Btu/hr., describe fully the facilities provided to record the following: rate of fuel burned; heating value, sulfur and ash content of fuels; smoke, sulfur oxides and nitrogen oxides emissions; and if electric generating plant, the average electrical output and the minimum and maximum hourly generation rate.

N/A

9. Describe modifications to boiler in detail.

See Attached, Note 4

10. Type and method of disposal of all waste materials generated by this boiler.
(Is a Solid Waste Disposal Permit needed? ☒ Yes ☐ No)

The ash will be stockpiled for analysis after the experiment is completed. After the analysis is completed, a permit will be obtained for disposal of the ash.

11. Briefly describe the method of handling the waste water from this boiler and its associated air pollution control equipment.
(Is a Water Quality Management Permit needed? ☐ Yes ☒ No)

No waste water will leave the process.

12. Attach any and all additional information necessary to perform a thorough evaluation of this boiler.

See attached notes.

Section C Control Equipment

1. POTENTIAL PROCESS EMISSIONS (OUTLET FROM PROCESS, BEFORE ANY CONTROL EQUIPMENT)

A. Outlet particulate loading (lbs/hr or gr/SCF Dry)

1,937 lb/hr

B. Specific gravity of particulate (not bulk density)

≈ 2.5

C. Attach outlet particle size distribution information

Not Available

D. Specify gaseous contaminants and concentration

Contaminant	Concentration	VOC	Contaminants	Concentration
(1) SO _x	_____ ppm (Vol.) <u>76</u> lbs/hr	(4)	_____	_____ ppm (Vol.) _____ lbs/hr
(2) NO _x	_____ ppm (Vol.) <u>4.89</u> lbs/hr	(5)	_____	_____ ppm (Vol.) _____ lbs/hr
(3) CO	_____ ppm (Vol.) <u>0.9</u> lbs/hr	(6)	_____	_____ ppm (Vol.) _____ lbs/hr

2. GAS CONDITIONER (IF APPLICABLE)

A. Water quenching ☐ Yes ☒ No

Water injection rate _____ GPM

B. Radiation and convection cooling ☒ Yes ☐ No

C. Air dilution ☐ Yes ☒ No
_____ CFM

D. Gas conditioner outlet

N/A _____ ACFM @ _____ °F

3. SETTLING CHAMBERS (IF APPLICABLE)

N/A

A. Manufacturer

B. Volume of gas handled

_____ ACFM @ _____ °F

C. Gas velocity

D. Length of expansion chamber (ft)

E. Width of expansion chamber (ft)

F. Height of expansion chamber (ft)

G. Number of trays

H. Inlet concentration
(lbs/hr or gr/SCF Dry)

I. Outlet concentration
(lbs/hr or gr/SCF Dry)

J. Overall efficiency (%)

K. Water injection

☐ Yes ☐ No

L. Water injection rate (GPM)

M. Attach particle size Efficiency curve

Section C Control Equipment, Continued

12. COSTS

A. Cost of all control equipment including installation costs (List individual controls separately)

Baghouse Approx. \$20,000
 Install. \$10,000

B. Estimated annual operating costs of control equipment only.

Only a 120 Day test period.

13. Describe modifications to control equipment in detail.

N/A

14. Describe in detail the method of dust removal from the air cleaning and methods of controlling fugitive emissions from dust removal, handling and disposal.

The baghouse contains a collecting hopper and an airlock for material discharge into drums for storage.

15. Does air cleaning device employ hopper heaters, hopper vibrators or hopper level detectors? If so describe.

No.

16. Attach manufacturer's performance guarantees and/or warranties for each of the major components of the control system (or complete system).

Maintenance as required for the test period.

17. Attach the maintenance schedule for the control equipment and any part of the process equipment that if in disrepair would increase the air contaminant emissions. Periodic maintenance reports are to be submitted to the Department.

18. Attach any and all additional information necessary to thoroughly evaluate the control equipment.

Section D Flue and Air Contaminant Emission Information

1. STACK AND EXHAUSTER

A. Exhauster (attach fan curves)		N/A		HP @	RPM
B. Stack height (ft) (Existing)		30'		C. Stack diameter (ft) (Existing)	
				3'	
				D. Weather Cap	
				☐ Yes ☒ No	

E. Indicate on an attached sheet the location of sampling ports with respect to exhaust fans, breeching, etc. Give all necessary dimensions.

See Figure 1

F. Can the control equipment be bypassed? (If Yes, explain) ☒ Yes ☐ No
Control equipment has a bypass damper, but there is no intention of using it during operation.

2. ATMOSPHERIC EMISSIONS

A. Particulate matter emissions (lbs/hr or gr66F-Dry)

4.94

B. Gaseous contaminant emissions

Contaminants Concentration

(1) SO ₂	_____ ppm (Vol.)	68.0 lbs/hr	See Note 6
(2) NO _x	_____ ppm (Vol.)	4.9 lbs/hr	
(3) CO	_____ ppm (Vol.)	0.9 lbs/hr	

C. Outlet volume of exhaust gases

13834 CFM

@ 450 °F

5.8 % Moisture

Section E Miscellaneous Information

1. Describe fully facilities to monitor and record the emission of air contaminants. Provide detailed information to show that the facilities provided are adequate. Include cost and maintenance information. Periodic maintenance reports are to be submitted to the Department.

See Attached Note 2.

-
2. Attach Air Pollution Episode Strategy (if applicable)

N/A

-
3. The following requirements are applicable only to construction of a new source:
- Briefly describe the nature of the area in which the proposed source is located. Attach a copy of the appropriate portion of the quadrangle map (7 1/2" scale) published by the U.S. Geological Survey and identify the location of proposed source.

N/A

- Demonstrate that the establishment of the new source is justifiable as a result of necessary economic or social development.

N/A

-
4. Attach calculations and any additional information necessary to thoroughly evaluate compliance with all the applicable requirements of Article III of the rules and regulations of the Department of Environmental Resources and those requirements promulgated by the Administrator of the United States Environmental Protection Agency pursuant to the provisions of the Clean Air Act.

See Attachments

-
5. List all attachments made to this Application.

Notes 1-6 Calculations. Figure 1.

Note 1 - Fuel Requirements

Attachment to Application for Plan Approval to Construct Modify
or Reactivate an Air Contamination Source and/or Air Cleaning
Device and for a Permit to Operate

Filed by Humphrey Charcoal Corporation

Fuel requirements are variable, as the combustion unit will be intermittently operated for approximately twelve weeks from approximately September 1 to November 30, 1990. The feed will vary in amount and composition during a developmental test of the unit. Materials for blending and their maximum feed rates in these blends are:

Type	Maximum Quantity (tons/hr)	Percent Sulfur (Weight)	Percent Ash (Weight)	Btu Content (Btu/lb)
Coal (1)	0.83	6.0	14.4	11,800
Limestone (2)	0.47	0.0	56.0	0
Anthracite Refuse (3)	1.67	0.3	55.0	3,000
Sawdust (4)	1.42	0.0	1.0	3,600
Tires (5)	0.76	14.8	10.0	13,080

- (1) AC Valley Power Corporation base coal for its proposed synthetic fuels project in the early 1980s.
- (2) Based upon a Ca/S atomic ratio of 1/1, but a range of Ca/S ratios will be used during testing.
- (3) "District Heating System Renovation Study for Community Central Energy Corporation," Scranton, PA, Final Report, January 20, 1987, Burns and Roe Company.
- (4) Page 28, "Continuous Pyrolysis of Biomass Feedstocks in Rotary Kiln Converters," H. H. Hicks, Jr., et. al, Final Report on U.S. DOE Project Number DE-AC06-800S84003.
- (5) Based on tests at Stanislaus County.

LAND

combustion

Land Combustion
2525-B Pearl Buck Road
Bristol, PA 19007-6807
Tel: (215) 781-0810
Telex: 4976004
Fax: (215) 781-0798

Land Combustion
Suite 110-G
17300 El Camino Real
Houston, TX 77058
Tel: (713) 480-7262
Fax: (713) 480-7672

Quotation

University of Pittsburgh
BCR National Laboratories
500 William Pitt Way
Pittsburgh, PA 15238

Attention: Mr. William Young

NO.: 2047A-Page 1 of 4

DATE: November 14, 1989

BILLING TERMS: NET 30 DAYS

F.O.B.:

Bristol, PA
PRICE FIRM FOR: 60 DAYS

Delivery: 4-6 Weeks ARO

Item	Qty.		Unit Price	Total
1	1	LANCOM TM MODEL 3200 PORTABLE FLUE GAS ANALYZER	\$7,010.00	
		Measured Quantities: Combustion Gas Temperature O ₂ CO SO ₂ NO _x Draft Smoke		
		Calculated Quantities: CO ₂ and combustion efficiency		
		TECHNICAL DATA:		
		Ranges:		
		Oxygen O ₂ 0-20.9% vol.		
		Carbon Monoxide CO 0-2000 ppm		
		Carbon Dioxide CO ₂ 0-99.9%		
		Efficiency 0-100%		
		Draft +/- 20" w.g.		
		Smoke Test by paper filter		
		Sulfur Dioxide SO ₂ 0-2000 ppm		
		Nitrogen Oxide NO _x 0-2000 ppm		
		Flue Gas Temp. 0-1000° F		

B-11

The warranty and conditions on the reverse side of this page are a part of this quotation and constitute a part of any order resulting

Land Combustion, Inc.

Note 3 Operating Schedule and Seasonal Periods

Attachment to Application for Plan Approval to Construct Modify
or Reactivate an Air Contamination Source and/or Air Cleaning
Device and for a Permit to Operate

Filed by Humphrey Charcoal Corporation

Following the certification of the system, a set of six-to-seven-hour tests will be made by BCR National Laboratory (BCRNL) and Humphrey Charcoal Corporation to evaluate the parameters of a test plan devised by BCRNL. Different feedstocks will be tested with limestone injection: large-particle coal, small-particle coal, anthracite refuse, (AR) and tires. It is hoped that 20 such tests can be performed, based upon the physical integrity of the unit, the time required for assuring the nature and quality of the data, and the budget. The final week or two weeks devoted to this activity will be used for two extended tests to obtain steady-state conditions and to collect data for thorough material and energy balances. The selection of the feed stocks for these extended tests will be made later, but are tentatively set for: (1) Anthracite Refuse and (2) Bituminous Coal.

The variables that will be investigated are:

- Bituminous Coal feed rate
- Anthracite Refuse feed rate
- Tire Feed Rate
- Limestone feed rate (Ca/S ratio)
- Coal particle size
- Airflow rate
- Kiln rpm.

Table 1 shows the low, average, and high ranges of the parameters.

Table 1

Test Parameter Ranges

	<u>Low</u>	<u>Average</u>	<u>High</u>
1. Bituminous Coal Particle Size	14 mesh	---	2" x 0"
2. Anthracite Refuse Particle Size	---	2" x 0"	---
3. Tire Size	---	24" x 0"	---
4. Limestone Particle Size	14 mesh	---	2" x 0"
5. Airflow Rate (excess air)	5%	---	20%
6. Kiln rpm	4	---	8
7. Bituminous Coal Feed Rate	16 tpd	---	20 tpd
8. Anthracite Refuse Feed Rate	---	40 tpd	---
9. Tire Feed Rate	3 tpd	---	15 tpd
10. Sawdust Feed Rate	12 tpd	---	34 tpd
11. Limestone Feed Rate	0 tpd	---	34 tpd
12. Calcium Feed Rate (Ca/S ratio)	1.0/1	---	3.0/1

Note 3 - Operating Schedule and Seasonal Periods (Continued)

- The low coal particle size, 14 mesh, was based on work done on another experimental kiln which resulted in an SO_2 capture of 90 percent.
- Excess air range was based on tests done with the other kiln.
- The coal, AR, and tire feed rates are realistic, based on past performance.
- The calcium/sulfur (Ca/S) ratios are typical for coal-burning tests.

Data that will be collected during the tests will include, as a minimum:

- Solids temperature
- Inside wall temperature
- Gas temperature
- Pressure
- Airflow rate
- Coal feed rate
- Tire feed rate
- Limestone feed rate
- Gas analysis: CO , CO_2 , O_2 , NO_x , and SO_x
- Solids analysis

The solids analysis will be performed at BCRNL's laboratories by existing standard methods.

The anticipated test program is shown in Table 2 and Table 3.

Note 3 - Operating Schedule and Seasonal Periods (Cont.)TABLE 2. TEST PROGRAM FOR PHASE 1

<u>Day</u>	<u>Activity</u>	<u>Maximum Feed Rate (Ton/hr)</u>				<u>Total Feed Req. (Tons)</u>		
		<u>AR</u>	<u>Coal</u>	<u>Limestone</u>	<u>Other</u>	<u>AR</u>	<u>Coal</u>	<u>Limestone</u>
1	Heat up	--	--	---	Sawdust and Gas	--	--	---
2	Heat up	--	--	---	Sawdust and Gas	--	--	---
3	AR Shakedown	1.67	--	---	---	40	--	---
4	AR Balances (2)	1.67	--	0.05	---	40	--	1
5	LPBC Shakedown	--	0.83	0.47	---	--	20	12
6	LPBC Balances (2)	--	0.83	0.47	---	--	20	12
7	Tires/Limestone	--	--	0.35	<u>6</u>	<u>--</u>	<u>--</u>	<u>3</u>
				Total	6	80	40	28
	Total (Including 20% contingency)				7	96	48	34

Comments

1. One purpose of these test is to determine the time needed to change from one steady state to another. At present, it is assumed that 6 hours will be needed for this transition, and each balance period will require three hours.
2. The balance periods will be run at 10% excess air: one period will be run at high kiln RPM, the other at low RPM.
3. At the end of these tests, the unit will be shut down and inspected, the data analyzed, and the results shall serve as the basis for a decision to proceed to Phase 2, and for any modifications needed for Phase 2.

Legend

AR - Anthracite refuse
 LPBC - Large particle bituminous coal

Note 3 - Operating Schedule and Seasonal Periods (Cont.)TABLE 3. TEST PROGRAM FOR PHASE 2

<u>Day</u>	<u>Activity</u>	<u>Maximum Feed Rate (Ton/hr)</u>			<u>Total Feed Req. (Tons)</u>		
		<u>AR</u>	<u>Coal</u>	<u>Limestone</u>	<u>AR</u>	<u>Coal</u>	<u>Limestone</u>
1	Heat up	--	--	---	--	--	---
2	Heat up	--	--	---	--	--	---
3	LPBC Startup & Balances (2)	--	0.83	0.47	--	20	12
4	LPBC Balances (2)	--	0.83	0.23	--	20	6
5	SPBC Startup & Balances (2)	--	0.83	0.47	--	20	20
6	SPBC Balances (2)	--	0.83	0.23	--	20	6
7	AR Startup and Balances (2)	1.67	--	---	40	--	---
8	AR + Limestone	1.67	--	0.05	40	--	1
* Shutdown, inspection, data reduction, and analysis before start of extended run							
9-10	Heat up				--	--	---
11-15	Extended run with AR				200		Assumed small requirements
10-20	Extended run with coal				--	100	42
Total					280	180	87
Total (Including 10% contingency)					310	200	90

Comments

1. Before the extended runs, the unit will be shutdown, data and results will be reviewed, and recommendations will be prepared for discussion by all participating parties on the specific conditions of the extended runs, and whether one or two extended runs will be conducted, and the duration of each run.
2. For the purpose of preparing the budget, it was assumed that in each extended run there will be eight 2-hour balance periods.
3. Each pair of balance test periods will be run at high and low kiln RPM.

Legend

AR - Anthracite Refuse
 LPBC - Large particle Bituminous Coal
 SPBC - Small particle Bituminous Coal

Note 4 - Modification to Boiler

Attachment to Application for Plan Approval to Construct Modify
or Reactivate an Air Contamination Source and/or Air Cleaning
Device and for a Permit to Operate

Filed by Humphrey Charcoal Corporation

The rotary kiln will be modified by a set of subcontractors with new stainless-steel seals, an updated UEI proprietary air injection system with data acquisition capabilities, and a secondary air blower. A variable-speed drive motor will be installed by Humphrey Charcoal Corporation.

The new air injection system will be located directly above the tumbling bed in the rotary kiln for direct oxidation of the bed. In its current configuration, the air injection system is located remotely to promote pyrolysis, control devolatilization, and carbonization, and thus, to maximize carbon yields. This modification will lead to the most critical test in the project. In the UEI kiln configuration, the fuel bed remains on the carrying side of the furnace and establishes a churning or tumbling pattern, thus aiding the burning process. The patent (and patent-pending) air distributor introduces air in a tangential pattern, which creates turbulent airflow to penetrate the evolving product gases of combustion and further aid the burning process. At the same time, the overall air and solid flow patterns assist in maintaining or centrifuging particulates to the vicinity of the kiln wall, thus reducing entrainment in the kiln effluent. In effect, the UEI system avoids cascading by controlling combustion air patterns either against (or countercurrent to) kiln rotation.

The data acquisition system in the kiln will consist of a series of thermocouples and pressure transducers located along the air injection system. The secondary blower will provide air to the secondary combustor.

BCRNL and Humphrey Charcoal Corporation will install other ancillaries not currently associated with the kiln at Brookville. These will include three additional feed hoppers and a feed conveyor. One feed hopper will be assigned to each of the co-feeds: anthracite refuse, bituminous coal, and limestone. The bituminous coal, anthracite refuse and limestone will each pass through a starwheel feeder to the new conveyor, which will carry them to the existing conveyor. The existing sawdust feed bin remain in use during startup and between runs. The tires will be fed by hand.

Note 5 - Control Equipment

Attachment to Application for Plan Approval to Construct Modify
or Reactivate an Air Contamination Source and/or Air Cleaning
Device and for a Permit to Operate

Filed by Humphrey Charcoal Corporation

PARTICULATE CONCENTRATIONS

The total emissions for 816 hours of operations are:

- Uncontrolled Emissions = 754,848 lb
- Emissions from Kiln = 754,848 lb (100% - 99.5%)/100% = 3,774 lb
- Emissions from Baghouse = 3,774 (100% - 99.5%)/100% = 19 lb

On an hourly basis, the average is:

- Uncontrolled Emissions = 754,848/816 = 925 lb/hr
- Emissions from Kiln = 4.62 lb/hr
- Emissions from Baghouse = 0.023 lb/hr

The worst uncontrolled case is Case 4, (see Table 4 on the following page), in which Anth. Ref. is used with limestone (1,937 lb/hr). It is expected that the removal efficiency in the kiln will rise to 99.84% at heavy particulate loadings. The baghouse is expected to be always at 99.5% removal efficiency. All cases are well under the permissible rate of 0.4 pounds per million Btu for combustors between 2.5 and 50 million Btu/hr.

The expected operating schedule for the period of the permit and the expected particulate loading are shown in Table 4 on the following page.

See Note 1, page 9, for fuel properties.

Table 4 - Expected Particulate Loadings

Case	Feed	Feed Rate (t/hr)	Heat Input (10 ⁶ Btu/hr)	Cumulative Duration (hrs)	Loading (lb/hr)			Cumulative Uncontrolled Loading (lb)	Cumulative Controlled Loading (lb)
					Uncontrolled	Kiln	From Baghouse		
1	Sawdust	1.42	10.2	144	28	3	0.015	4,032	2.16
2	Sawdust	0.42	3.0	144	8	1	0.005	1,152	0.72
3	Anth. Ref.	1.67	10.0	132	1,837	3	0.015	242,484	1.98
4	Anth. Ref. Limestone	1.67 0.05	10.0	84	1,937	3	0.015	162,708	1.26
5	Bit. Coal Limestone	0.83 0.47	19.6	156	1,238	6	0.03	193,128	4.68
6	Bit. Coal Limestone	0.83 0.23	19.6	108	908	6	0.03	98,064	3.24
7	Tires Limestone	0.76 0.35	20.0	48	1,110	6	0.028	53,280	1.34
Total				816				754,848	15.38

Note 6 - Sulfur Dioxide and Other Emissions

Attachment to Application for Plan Approval to Construct Modify
or Reactivate an Air Contamination Source and/or Air Cleaning
Device and for a Permit to Operate

Filed by Humphrey Charcoal Corporation

The combustor will maintain the sulfur dioxide concentration at or below the permissible thirty-day running average of 3.7 pounds per million Btu heat input.

The expected sulfur dioxide concentrations for the period of the permit are:

<u>SO₂ CONCENTRATION (LB/HR)</u>			
<u>Case</u>	<u>Feed</u>	<u>Uncontrolled</u>	<u>Emitted</u>
1	Sawdust	0	0
2	Sawdust	0	0
3	Anth. Ref.	20	20
4	Anth. Ref./Limestone	20	6
5	Bit. Coal/Limestone	202	61
6	Bit. Coal/Limestone	202	61
7	Tires/Limestone	225	68

The worst uncontrolled conditions are Cases 5, 6, and 7. It is expected that the limestone will be a sufficient scavenger of sulfur dioxide to maintain the sulfur dioxide concentration below 4 pounds per million Btu heat input, the permissible daily average not to be exceeded more than two days in any running thirty-day period and well below 4.8 pounds per million Btu heat input, the permissible daily average maximum not to be exceeded at any time in non-air basin areas.

Please note that the expected capture of sulfur dioxide by the limestone varies between 70 and 90 percent. We have used the 70 percent value for our calculations.

Nature of the Test

This is a development test of the kiln combustor and the UEI air injection system to determine its operating characteristics with these feeds. In approaching all test conditions, the project team will start from a known permissible condition and gradually change toward the unknown one with careful monitoring. If it is clear that the new test condition lies in a region of non-permissible operation, the test program will be adjusted to place the revised test condition in the permissible range.

The information collected from the test program will be used to design and permit commercial kiln combustors.

Note 6 - Sulfur Dioxide and Other Emissions (Continued)

Attachment to Application for Plan Approval to Construct Modify
or Reactivate an Air Contamination Source and/or Air Cleaning
Device and for a Permit to Operate

Filed by Humphrey Charcoal Corporation

Fugitive Emissions

It is expected that the moisture content of the feedstocks and the cooled ash from the combustor will be sufficiently high to maintain fugitive emissions well below that level at which they would be visible at the point they pass outside the property of Humphrey Charcoal Company. In addition, the feed and ash handling equipment attached to the combustor are located inside the combustor shed.

Visible Emissions

The control equipment for reduction of particulate and sulfur dioxide emissions will reduce the levels of these contaminants to the point where the remaining emissions are of minor significance, with respect to causing air pollution and are not preventing or interfering with the attainment or maintenance of any ambient air quality standard.

Calculations

Attachment to Application for Plan Approval to Construct Modify
or Reactivate an Air Contamination Source and/or Air Cleaning
Device and for a Permit to Operate

Filed by Humphrey Charcoal Corporation

Carbon Monoxide (Typical)

$$(60 \text{ lb Mole CO} / 1 \times 10^6 \text{ lb Mole Air}) \times (1 \text{ lb Mole Air} / 28.8 \text{ lb Air}) \times 28 \text{ lb CO} / 1 \text{ lb Mole CO}) \times (765 \text{ lb Air} / 10^6 \text{ Btu}) = 0.045 \text{ lb CO} / 10^6 \text{ Btu}$$

Nitrogen Oxides (Typical)

$$(200 \text{ lb Mole NO}_2 / 1 \times 10^6 \text{ lb Mole Air}) \times (1 \text{ lb Mole Air} / 28.8 \text{ lb Air}) \times 46 \text{ lb NO}_2 / 1 \text{ lb Mole NO}_2) \times (765 \text{ lb Air} / 10^6 \text{ Btu}) = 0.244 \text{ lb NO}_2 / 10^6 \text{ Btu}$$

Particulate

Case 3, Table 4 (Typical Uncontrolled)

$$1.67 \text{ t/hr} \times 132 \text{ hr} \times 0.55 \text{ Ash} \times 2000 \text{ lb/t} = 242,484 \text{ lb (For 132 hours)}$$

99.5% Control Efficiency - Kiln

99.5% Control Efficiency - Baghouse

$$242,484 \text{ lb} \times (100 - 99.5\%) \times (100 - 99.5\%) = 6.06 \text{ lb (For 132 hours)}$$

$$= 0.05 \text{ lb/hr}$$

Total Operating Time = 816 Hours

Total Emissions = 754,848 lb (Uncontrolled)

$$754,848 \text{ lb} / 816 \text{ hrs} = 925 \text{ lb/hr (Uncontrolled)}$$

$$925 \text{ lb/hr} \times (100 - 99.5\%) \times (100 - 99.5\%) = .02 \text{ lb/hr (Controlled)}$$

Sulfur Dioxide (Typical)

Case 5 and 6 - Uncontrolled

$$0.83 \text{ t/hr} \times 0.06 \text{ S} \times 2000 \text{ lb/t} \times 2 = 199 \text{ lb/hr}$$

$$\text{At } 11,800 \text{ Btu/lb (} 19.59 \times 10^6 \text{ Btu/hr)} \text{ the SO}_2 \text{ emission is: } = 10.2 \text{ lb} / 10^6 \text{ Btu}$$

With limestone, the capture will be 70-90%, therefore the maximum expected emission is $(0.3) (10.2) = 3.06 \text{ lb} / 10^6 \text{ Btu}$

Moisture Content and Dew Point (Typical)

Case 5

$$8013 \text{ ACFM steam} / 13834 \text{ ACFM stack gas} = 0.58$$

$$0.58 \text{ atm} \times 14.7 \text{ psia/atm} = 8.5 \text{ psia}$$

The vapor pressure of water at 186°F is 8.566 psia

Figure 1. Rotating Kiln System

APPENDIX C

REQUEST FOR APPROVAL TO STORE A RESIDUAL WASTE

PA DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF WASTE MANAGEMENT
MODULE 1

DATE PREPARED

DATE REVISED

DEPARTMENT USE ONLY

REQUEST FOR APPROVAL TO TREAT, STORE, OR DISPOSE OF A HAZARDOUS OR RESIDUAL WASTE STREAM

SEE INSTRUCTIONS BEFORE COMPLETING THIS FORM

I. GENERAL INFORMATION (must be completed by TSD facility)

A. Treatment, Storage, or Disposal Site

1. Name of facility Humphrey Charcoal Corporation
Address R.D. #1 P.O. Box 440, Brookville, PA 15825
Municipality Pine Creek Township County Jefferson
2. Identification number (if applicable) 25-1065078
3. Solid waste permit number(s) for treatment, storage or disposal facility to be utilized
Requested
4. Facility contact person
Name James L. Humphrev Title Secretary
Phone no. (814) 849-2302

B. Generator of the Waste

1. Name of company Humphrey Charcoal Corporation
Mailing address P.O. Box 440, Brookville, PA 15825
Location of site if different
from mailing address R.D. #1, Brookville, PA 15825
Municipality Pine Creek Township County Jefferson
2. If a subsidiary, name
of parent co. _____
3. Identification number (if applicable) 25-1065078
4. Company contact person
Name James L. Humphrev title Secretary
Phone no. (814) 849-2302

DATE PREPARED
DATE REVISED

DEPARTMENT USE ONLY

II. WASTE DESCRIPTION (Must be completed by Generator)

A. General Properties

1. pH range 7.5 to 8.0 (based on ~~past~~ analyses or knowledge)
2. Physical state:
 - a. ☐ liquid (less than 20% solids by dry wt. or flowable)
 - b. ☐ gas (ambient temperature and pressure)
 - c. ☒ solid (equal to or greater than 20% by dry wt. and non-flowable)
 - d. ☐ Check here if c. above was checked and waste contains free liquids.
3. Physical appearance:

Color Grey Odor None

Number of solid or liquid phases of separation One

Describe each phase of separation

Ash from the combustion of mixtures of bituminous coal, anthracite refuse, tires, and limestone in a rotary kiln combustor.
4. U.S. DOT proper shipping name UN/NA number, and hazard class (if applicable):

N/A
5. Typical volume of waste to be shipped to treatment storage or disposal facility:
 - a. Monthly 400 gal., tons (circle one)
 - b. Annually N/A gal., tons (circle one)
6. Treatment or disposal frequency: _____ times per year; ☒ one time
7. Current volume to be shipped to treatment storage or disposal facility None gal., tons (circle one)
8. a. Is the waste a hazardous waste as defined in 75.261? ☐ Yes ☒ No
 - b. If yes, describe the hazardous waste according to its description and hazardous waste number in 75.261.
9. Has the waste been delisted as a hazardous waste by DER? ☐ Yes ☒ No ☐ N/A

If yes or N/A, check the appropriate box(es) in Item 10.

DATE PREPARED
DATE REVISED

DEPARTMENT USE ONLY

10. Is the waste a residual waste or a delisted hazardous waste? ☒ Yes ☐ No
If yes, check the following box(es) as applicable:

☐ discarded commercial chemical product	☐ process waste
☐ tank bottom	☐ infectious waste
☐ off-specification species	☐ baghouse dust
☐ manufacturing chemical intermediate	☐ wastewater treatment plant residue (industrial)
☐ still bottom	☐ wastewater treatment plant residue (sewage)
☐ spent catalyst	☐ water treatment plant residue
☒ flyash	☐ incinerator residue
☒ bottom ash	☐ acid mine drainage treatment sludge
☐ slag	☐ spill residue
☐ foundry sand	☐ other (specify) _____
☐ SO ₂ scrubber sludge	

B. Chemical Analyses — *Please attach the following:*

- The results of the total analysis of the waste as described in the instructions.
The waste has not yet been generated.
- The results of the leaching tests as described in the instructions and the leaching method.
- A description of the sampling method.
- The range of concentrations of the constituents based on knowledge or past analyses.

C. Process Description and Schematic — *Please attach the following:*

- The substantiation for a confidentiality claim as described in the instructions, if portions of the information you have submitted are confidential.
- A detailed description of the manufacturing and/or pollution control processes producing the hazardous or residual waste as specified in the instructions.
- A schematic of the manufacturing and/or pollution control processes producing the hazardous or residual waste as specified in the instructions.

See Application for Plan Approval to Modify and Reactivate *

III. Liner Compatibility Evaluation (must be completed by TSD facility)

Attach the results of the liner compatibility evaluation or supporting data as specified in the instructions.

N/A

* an Air Contamination Source and Air Cleaning Device and for a Permit to Operate, filed this date simultaneous with this filing.

DATE PREPARED
DATE REVISED

DEPARTMENT USE ONLY

IV. PROPOSED TREATMENT, STORAGE, AND/OR DISPOSAL METHOD (must be completed by TSD facility. Use additional sheets if necessary.)

A. Proposed Treatment Method

N/A

B. Proposed Storage Method and Length of Storage

Approximately 400 tons will be placed in several (two or three) beehive kilns, 30 feet diameter, 10 ft. average height, 7,000 cu. ft. volume, with concrete floors and sealed brick roofs and walls for moisture exclusion, for up to six months while analyses are made and a disposal permit is sought.

C. Proposed Disposal Method

N/A

V. ALTERNATIVES TO PROPOSED TREATMENT AND/OR DISPOSAL METHOD (must be completed by generator. Use additional sheets if necessary.)

A. What Other Treatment, Disposal, Recycle, Reuse, or Reclamation Method(s) Can be Used? Briefly describe viable alternatives to your proposal.

None

B. Why was the Treatment and/or Disposal Method in Section IV Chosen?

It was the only alternative.

DATE PREPARED
DATE REVISED

FOR DEPARTMENT USE ONLY

VI. CERTIFICATION OF GENERATOR

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based upon my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Name of Responsible Official James L. Humphrey Title Secretary
 Signature *James L. Humphrey* Date 4-26-90

Taken, sworn and subscribed before me, this

26 day of April A.D. 19 90
Dick J. Lowe

Notary Seal
 Vicki J. Lowe, Notary Public
 Brookville Boro, Jefferson County
 My Commission Expires April 2, 1994
 Member, Pennsylvania Association of Notaries

VII. CERTIFICATION OF REGISTERED PROFESSIONAL ENGINEER FOR TREATMENT STORAGE AND/OR DISPOSAL FACILITY

This is to certify that I have personally reviewed all engineering information contained in the accompanying modules, drawings, specifications, and other documents which are part of this application and that I have found it to be of good engineering quality, true and correct, and is in conformance with the requirements of the Department of Environmental Resources, and it does not, to the best of my knowledge, withhold information that is pertinent to a determination of compliance with the requirements of the Department.

NOTICE: It is an offense under Pennsylvania Crimes Code to affirm a false statement in documents submitted to the Department.

Name Martin L. Pomerantz
 Signature *Martin L. Pomerantz*
 Date April 23, 1990
 Address BCR National Laboratory
500 William Pitt Way
Pittsburgh, PA 15238
 Phone No. (412) 826-3030

APPENDIX D

LETTER TO BCRNL FROM MR. DEVENDRA VERMA, JUNE 18, 1990

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

1012 Water Street
Meadville, Pennsylvania 16335
Telephone: A. C. 814/332-6940
June 18, 1990

Mr. M. L. Pomerantz, Project Manager
EPA National Laboratory
500 William Pitt Way
Pittsburgh, PA 15238

Dear Mr. Pomerantz:

This letter is concerning your application to reactivate, modify, and install an air cleaning device on a rotary combustor. In a prior telephone conversation with you, I mentioned the need for incorporating tests of VOC in the exhaust gases in view of waste tires being used as fuel. So far, we have not received any revision to this effect.

On the second page of the application, it is mentioned that there will be a secondary chamber. However, in the above-referenced telephone conversation, you gave me the impression that there will be no secondary chamber. Please clarify in writing as to what is being installed.

Although a baghouse is being proposed to control emissions resulting from the combustion of various solid fuels, it is not clear how the emissions at the discharge end of the rotary combustor will be controlled. Please send me a drawing of the process layout, identify the point of emissions and explain how these will be controlled. Information regarding handling of sawdust, limestone and bituminous coal fines should also be included.

The allowable SO_x emission rate for this limited purpose/duration kiln is 4.0 lb/MMBTU. An optional emission rate of 3.7 lb/MMTU on a 30 day running average basis is available, however, the source owner/operator is required to install a continuous SO_x emission monitoring system that complies with the requirements of 25 Pa. Code Chapter 139 and the Department's continuous source monitoring manual. Please specify in writing as to the emission rate you intend to comply with.

On page 5 of the application in Item 6G and 6I, exhaust volumes are mentioned as 5,821 and 7,000 acfm respectively. However, on page 7 of the application in Item 2C an exhaust volume of 13,834 acfm is mentioned. Please clarify this apparent discrepancy.

Please respond in writing to the issues raised above. If you have any questions, please contact me.

Sincerely,

Devendra Verma
Air Pollution Control Engineer
Bureau of Air Quality Control

APPENDIX E
FLOW DIAGRAM AND MATERIAL AND ENERGY BALANCES

KILN PROJECT FLOWSHEET

6/18/90 JTC

SAWDUST

Stream	1	5	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23
Temp (°F)	70	70	70	1600	70	1600	1600	1600	70	212						70	70	70
Pressure (In. H ₂ O)						-1		-1		-2		1		-2	-2			
Total Flow (lb/hr)	1710	1710	5880	20	20	8480										20	880	
CO ₂ (lb/hr)						1380					1380	1380		1380	1380			
H ₂ O (lb/hr)						2200										20	880	
N ₂ (lb/hr)			4650			4650					4650	4650		4650	4650			
O ₂ (lb/hr)			1230			250					250	250		250	250			
SO ₂																		
H/C (lb/hr)																		
Particulate (lb/hr)	1710	1710		20	20													

CALCULATIONS FOR SAWDUST

Stream 7 -- (1710 lb sawdust/hour) x (3500 Btu/lb) x (715 lb air per 10^6 Btu) = 4700 lb air/hour. The air requirement is from Tables 25-1 and 25-2 of Combustion Engineering, O. de Lorenzi (ed.), 1947. This represents zero percent excess air. Twenty-five percent excess air will be fed to the kiln: (4700 lb air/hour) x (1.25) = 5880 lb air/hour. Oxygen: (5880 lb air/hour) x (0.21 lb oxygen/lb air) = 1230 lb oxygen/hour. Nitrogen: (5880 lb air/hour) x (0.79 lb nitrogen/lb air) = 4650 lb nitrogen/hour.

Stream 8 -- (1710 lb sawdust/hour) x (0.01 lb ash/lb sawdust) = 20 lb ash/hour.

Stream 10 -- (1710 lb sawdust/hour) x (0.22 lb C/lb sawdust) x (44 lb CO_2 /12 lb C) = 1380 lb CO_2 /hour. Moisture content of sawdust (including bound moisture in carbohydrates) = $1.00 - 0.01 - 0.22 = 0.77$: (1710 lb sawdust/hour) x (0.77 lb H_2O /lb sawdust) = 1320 lb H_2O /hour. To obtain 1600°F from the kiln, the 6 million Btu/hour of heat will be removed by CO_2 = (1380 lb/hour) x (11.7 Btu/mole $^\circ\text{F}$) x (1530 $^\circ\text{F}$) x (1/(44 lb/mole)) = 560,000 Btu/hour, by H_2O : = (132)(9.1)(1530)(1/18) = 1,020,000 Btu/hour, by N_2 : = (4650)(7.4)(1530)(1/28) = 1,880,000 Btu/hour, by O_2 : = (250)(7.9)(1530)(1/32) = 90,000 Btu/hour, and by ash: = (20)(1)(1530) = 30,000 Btu/hour, for a total of 4,390,000 Btu/hour.

Stream 22 -- A weight W_T of water must be added to the kiln to absorb the additional heat of $(6 - 4.39) \times 10^6 = 1.61 \times 10^6$ Btu/hour = (1840 Btu/lb) x W_T , which yields a value of W_T of 880 lb/hour. This neglects any heat loss from the barrel of the kiln through convection, which may be on the order of several hundred thousand Btu/hour.

Stream 21 -- A weight W_A of water must be sprayed onto the ash to cool it: (1840 Btu/lb) x $W_A = 0.03 \times 10^6$ Btu/hour, which yields a value of W_A of 20 lb/hour. This neglects air cooling of the ash.

Stream 10 (continued) -- The average molecular weight = $(1380 + 2200 + 4650 + 250) / ((1380/44) + (2200/18) + (4650/28) + (250/32)) = 27.6$ lb/mole. the ACFM = (8480 lb/hour) x (hour/60 min) x (mole/27.6 lb) x (380 cuft/mole) x (2060 $^\circ\text{R}$ /530 $^\circ\text{R}$) = 7300 cuft/min. This leads to a volume of (7300) x (910/2060) = 3220 cuft/min to the baghouse at 450 $^\circ\text{F}$.

AR AND LIMESTONE

Stream	3	4	5	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22
Temp (°F)	70	70	70	70	1600	70	1600	1600	1600	70	212						70	70
Pressure (in. H ₂ O)						-10	-10	-10	-10	-2	-2	-11	1	-2	-2	-2		
Total Flow lb/hr	2000	60	2060	5890	1090	1090	7630	30	7600								910	760
CO ₂ (lb/hr)							1380		1380			1380	1380	1380	1380	1380		
H ₂ O (lb/hr)							1290		1290	1730	1730						910	760
N ₂ (lb/hr)				4650			4650		4650			4650	4650	4650	4650	4650		
O ₂ (lb/hr)				1240			250		250			250	250	250	250	250		
SO ₂ (lb/hr)																		
H/C (lb/hr)																		
Particulate	2000	60	2060		1090	1090	60	30	30	30		30	30	30	0.2	0.2		

CALCULATIONS FOR AIR AND LIMESTONE

Stream 7 -- (2000 lb AR/hour) x (3000 Btu/lb) x (785 lb air per 10^6 Btu) = 4710 lb air/hour. The air requirement is from Tables 25-1 and 25-2 of Combustion Engineering, O. de Lorenzi (ed.), 1947. This represents zero percent excess air. Twenty-five percent excess air will be fed to the kiln: (4710 lb air/hour) x (1.25) = 5890 lb air/hour. Oxygen: (5890 lb air/hour) x (0.21 lb oxygen/lb air) = 1240 lb oxygen/hour. Nitrogen: (5890 lb air/hour) x (0.79 lb nitrogen/lb air) = 4650 lb nitrogen/hour.

Stream 8 -- (2000 lb AR/hour) x (0.55 lb ash/lb AR) = 1100 lb ash/hour. Five percent of the ash leaves as fly ash in Stream 10: (1100 lb ash/hour) x (0.05) = 60 lb fly ash/hour. Total ash: (1040 lb AR ash/hour) + (50 lb calcined/sulfated limestone/hour) = 1090 lb per hour.

Stream 10 -- (2000 lb AR/hour) x (0.185 lb C/lb AR) x (44 lb CO_2 /12 lb C) = 1360 lb CO_2 /hour. Add 20 lb CO_2 from calcining of limestone. Moisture content of AR = $1.00 - 0.55 - 0.185 = 0.265$: (2000 lb AR/hour) x (0.265 lb H_2O /lb AR) = 530 lb H_2O /hour. (2000 lb AR/hour) x (0.003 lb S/lb AR) x (64 lb SO_2 /32 lb S) = 10 lb SO_2 per hour. To obtain 1600°F from the kiln, the 6 million Btu/hour of heat will be removed by CO_2 = (1380 lb/hour) x (11.7 Btu/mole $^\circ\text{F}$) x (1530 $^\circ\text{F}$) x (1/(44 lb/mole)) = 560,000 Btu/hour, by H_2O : = (530)(9.1)(1530)(1/18) = 410,000 Btu/hour, by N_2 : = (4650)(7.4)(1530)(1/28) = 1,880,000 Btu/hour, by O_2 : = (250)(7.9)(1530)(1/32) = 90,000 Btu/hour, and by ash: = (1090)(1)(1530) = 1,670,000 Btu/hour, for a total of 4,610,000 Btu/hour.

Stream 22 -- A weight W_T of water must be added to the kiln to absorb the additional heat of $(6 - 4.61) \times 10^6 = 1.39 \times 10^6$ Btu/hour = (1840 Btu/lb) x W_T , which yields a value of W_T of 760 lb/hour. This neglects any heat loss from the barrel of the kiln through convection, which may be on the order of several hundred thousand Btu/hour.

Stream 21 -- A weight W_A of water must be sprayed onto the ash to cool it: (1840 Btu/lb) x $W_A = 1.67 \times 10^6$ Btu/hour, which yields a value of W_A of 910 lb/hour. This neglects air cooling of the ash.

Stream 10 (continued) -- The average molecular weight = $(1380 + 1290 + 4650 + 250) / ((1380/44) + (1290/18) + (4650/28) + (250/32)) = 27.3$ lb/mole. the ACFM =

(7570 lb/hour) x (hour/60 min) x (mole/27.3 lb) x
(380 cuft/mole) x (2060°R/530°R) = 6830 cuft/min.
This leads to a volume of (6830) x (910/2060) =
3020 cuft/min to the baghouse at 450°F.

COAL AND MAXIMUM LIMESTONE

Stream	2	4	5	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22
Temp (°F)	70	70	70	70	1600	70	1600	1600	1600	70	212						70	70
Pressure (in. H ₂ O)							-1		-1		-2	-9	6		-2	-2		
Total Flow (lb/hr)	1660	940	2600	18730	818	818	26002	6	25996								680	5610
CO ₂ (lb/hr)							4190		4190			4190	4190	4190	4190	4190		
H ₂ O (lb/hr)							6210		6210	5380	5380						680	5610
N ₂ (lb/hr)				14800			14800		14800			14800	14800	14800	14800	14800		
O ₂ (lb/hr)				3930			770		770			770	770	770	770	770		
SO ₂ (lb/hr)							20		20			20	20	20	20	20		
H/C (lb/hr)																		
Particulate	1600	940	2600		818	818	12	6	6	6		6	6		0.03	0.03		

CALCULATIONS FOR COAL AND MAXIMUM LIMESTONE

Stream 7 -- (1660 lb coal/hour) x (11800 Btu/lb) x (765 lb air per 10^6 Btu) = 14980 lb air/hour. The air requirement is from Tables 25-1 and 25-2 of Combustion Engineering, O. de Lorenzi (ed.), 1947. This represents zero percent excess air. Twenty-five percent excess air will be fed to the kiln: (14980 lb air/hour) x (1.25) = 18730 lb air/hour. Oxygen: (18730 lb air/hour) x (0.21 lb oxygen/lb air) = 3930 lb oxygen/hour. Nitrogen: (18730 lb air/hour) x (0.79 lb nitrogen/lb air) = 14800 lb nitrogen/hour.

Stream 8 -- (1660 lb coal/hour) x (0.1435 lb ash/lb coal) = 240 lb ash/hour. Five percent of the ash leaves as fly ash in Stream 10: (240 lb ash/hour) x (0.05) = 12 lb fly ash/hour. Total ash: (228 lb coal ash/hour) + (530 lb CALCINED limestone/hour) + (60 lb per hour to account for SO₂ pick-up) = 818 lb per hour.

Stream 10 -- (1660 lb coal/hour) x (0.62 lb C/lb coal) x (44 lb CO₂/12 lb C) = 3780 lb CO₂/hour. Add 410 lb CO₂/hour from calcining of limestone. (1660 lb coal/hour) x (0.04 lb H/lb coal) x (18 lb H₂O/2 lb H) = 600 lb H₂O/hour. (1660 lb coal/hour) x (0.06 lb S/lb coal) x (64 lb SO₂/32 lb S) = 200 lb SO₂ per hour. To obtain 1600°F from the kiln, the 20 million Btu/hour of heat will be removed by CO₂ = (4190 lb/hour) x (11.7 Btu/mole°F) x (1530 °F) x (1/(44 lb/mole)) = 1,700,000 Btu/hour, by H₂O: = (600)(9.1)(1530)(1/18) = 460,000 Btu/hour, by N₂: = (14800)(7.4)(1530)(1/28) = 5,980,000 Btu/hour, by O₂: = (770)(7.9)(1530)(1/32) = 290,000 Btu/hour, by SO₂: = (20)(12.0)(1530)(1/64) = negligible, and by ash: = (818)(1)(1530) = 1,250,000 Btu/hour, for a total of 9,680,000 Btu/hour.

Stream 22 -- A weight W_T of water must be added to the kiln to absorb the additional heat of (20 - 9.68) x 10⁶ = 10.32 x 10⁶ Btu/hour = (1840 Btu/lb) x W_T, which yields a value of W_T of 5610 lb/hour. This neglects any heat loss from the barrel of the kiln through convection, which may be on the order of several hundred thousand Btu/hour.

Stream 21 -- A weight W_A of water must be sprayed onto the ash to cool it: (1840 Btu/lb) x W_A = 1.25 x 10⁶ Btu/hour, which yields a value of W_A of 680 lb/hour. This neglects air cooling of the ash.

Stream 10 (continued) -- The average molecular weight = $(4190 + 6210 + 14800 + 770 + 20) / ((4190/44) + (6210/18) + (14800/28) + (770/32) + (20/64)) = 26.1 \text{ lb/mole.}$
the ACFM = $(26000 \text{ lb/hour}) \times (\text{hour}/60 \text{ min}) \times (\text{mole}/26.1 \text{ lb}) \times (380 \text{ cuft/mole}) \times (2060^{\circ}\text{R}/530^{\circ}\text{R})$
 $= 24520 \text{ cuft/min.}$ This leads to a volume of $(24520) \times (910/2060) = 10830 \text{ cuft/min}$ to the baghouse at 450°F.

APPENDIX F
TEST PROGRAMS FOR PHASE I

TEST PROGRAM FOR PHASE 1

Day	Activity	Maximum Feed Rate (ton/hr)				Total Feed Req. (tons)		
		AR	Coal	Limestone	Other	AR	Coal	Limestone
1	Heat up	--	--	--	Gas	--	--	--
2	Balance	--	--	--	Gas	--	--	--
3	Shakedown	--	--	--	Sawdust	--	--	--
4	Balance	--	--	--	Sawdust	--	--	--
5	AR Shakedown	1.00	--	0.03	--	40	--	1
6	AR Balances (2)	1.00	--	0.03	--	40	--	1
7	Other	--	--	--	--	--	--	--
8	Other	--	--	--	--	--	--	--
Total						80		2
Total (Including 20% contingency)						96		2.4

Comments

- One purpose of these tests is to determine the time needed to change from one steady state to another. At present, it is assumed that six hours will be needed for this transition, and each balance period will require three hours.
- The balance periods will be run at 10% excess air; one period will be run at high kiln rpm, the other at low rpm.
- At the end of these tests, the unit will be shut down and inspected, the data analyzed, and the results will serve as the basis for a decision to proceed to Phase 2, and for any modifications needed for Phase 2.

Legend

AR - Anthracite refuse (culm)
 RC - Bituminous coal
 BCW - Bituminous coal waste

B1801

APPENDIX G
PARTICULATE CONTROL SYSTEM

Particulate Control System (PCS) Layout

APPENDIX H

**CORRESPONDENCE BETWEEN JOBST SEEHAUSEN AND WILLIAM E. YOUNG
CONCERNING THE FIRST AND SECOND STAGE COOLERS,
DATED JUNE 1 AND JUNE 7, 1990**

BCR National Laboratory

Affiliated with the University of Pittsburgh

BCRNL

June 1, 1990

Mr. Jobst Seehausen
Energy Conversion Technology, Inc.
1700 N. Highland Road
Pittsburgh, PA 15241

Subject: 1. Gas Coolers for the Kiln
Program
2. High-Temperature Air Heaters

Dear Jobst,

Enclosed are several sketches which apply to the above two subjects.

As I had told you on the phone, we have a contract to rebuild and operate a rotating kiln which previously could not meet environmental requirements. We propose adding one or more gas coolers, then going through an I.D. fan, and finally into a baghouse. The gas flow into the baghouse will be 7000 ACFM at 350°F, and it is estimated that the gas temperature out of the kiln will be 1550°F at approximately atmospheric pressure. A wet scrubber may be added to protect the Lamson blower, in which case the temperature into the baghouse might be about 176°F.

The assembly of the MHD low-temperature air heater shows the conditions under which it ran during the MHD program. We now propose putting water through the tubes and generating steam. Can you estimate roughly what the gas temperature might be out of this unit?

We then go through your 4 lb/sec air heater, but again run water through the tubes and make steam. I have the design spec for your 2 lb/sec air heater, but unfortunately, don't have the 4 lb/sec figures. So again, can you estimate the outlet gas temperature?

Finally, we run the gas through an I.D. fan and into the baghouse. But we probably will have to spray in a little water to lower the temperature, and at the same time, knock out particulates that might damage the Lamson blower. You may ask why we want to include cooler(s). One reason is that we want to keep the gas flow into the baghouse down around 7000 ACFM. Also, we may eventually go back to air heating to optimize kiln operation.

We are also interested in system pressure drops and what size pipes to use. I note that originally the MHD inlet was 15" pipe and the outlet was 12". I assume we should use Schedule 10 stainless on the inlet, but probably carbon steel from thereon. Do you agree, and if so, what kind of pressure drops per foot should we expect?

The combined cycle system shown on the third sketch is part of a patent issued to Bob Hamm and me (and assigned to Westinghouse). I will be sending a copy to Ed Parsons with a note as to how your high-temperature air heater, and eventually a ceramic heat exchanger, could be incorporated. The plan would be to make the system as close to a hot air turbine as possible. Your 1700°F metallic air heater goes a long way, and a 2000°F ceramic heater might just do it. However, there is some advantage to burning a clean fuel for start-up and control, and perhaps going to a 2200°F turbine inlet temperature. We showed

Mr. Jobst Seehausen

June 1, 1990

Page -2-

other arrangements in the patent, i.e., with gasifiers and carbonizers and putting the product into the combustor. However, such an arrangement would require hot gas clean-up, and I would prefer to see the use of natural gas or diesel oil in the combustor to achieve the 2200°F temperature.

Another feature of this cycle is the use of steam fed back into the combustion system so the expander runs as a combined gas/steam turbine. The steam lowers the NO_x level of the combustion product, but also can be used to replace much of the cooling and combustion air so the compressor becomes much smaller and the useful power from the expander is increased. I have pointed this out to Ed Parsons.

Finally, Bob Hamm is interested in pursuing this cycle with us. As you may remember, Bob is the "retired" Westinghouse expert in cycle analysis.

Let me know what you think of all this, Jobst. I agree that we should pay a visit to Ed Parsons at METC.

Sincerely,

W. E. Young, Consultant
Combustion Systems, BCRNL

WEY:dng
6206

Particulate Control System (PCS) Layout

Figure 16. Combined Cycle Steam/Gas Turbine with Cogeneration

7:30 PM
ENERGY CONVERSION TECHNOLOGY, INC.

P.O. BOX 12904, 1700 NORTH HIGHLAND ROAD, PITTSBURGH, PA 15241, TELEPHONE 412-831-3501

FAX NO 412-831-5099

DATE: 6-7-90

THIS IS A FAX-MESSAGE

TO MR/Ms/MRSX Dr. Bill Young

COMPANY: BCR National Laboratory

ADDRESS: 500 William Pitt Way, Pittsburgh, PA 15238

FAX NO: 826-3094

FROM: Jobst Seehausen

REF: Gas coolers for Kiln Project

THIS MESSAGE CONTAINS 2 PAGES INCLUDING THIS COVER PAGE.

MESSAGE:

Dear Bill

We have investigated the use of the two existing Air Heaters as coolers for the Off gas from the kiln operation. In your letter and sketch of June 1, 1990 you show the MHD heat exchanger and the heat exchanger of the indirect fired heater downstream of the kiln outlet. Both cooler heat exchangers will be water/steam cooled.

Our preliminary analysis shows that these two units together will have sufficient and suitable heating surfaces to cool the gas down to 300°F to 350°F.

The heat exchange surface of the MHD heater is designed for gas radiation heat transfer at higher temperatures and, therefore will not be as effective, since in this case the gas inlet temperature is only at 1550°F, and the gas radiation is relatively low because the highly diluted products of combustion of coal contain mostly CO₂ and only small amounts of H₂O.

The gas temperature leaving the MHD heater will be about 1475°F to 1500°F. Further cooling in convective type heat exchanger of the indirect fired air heater will be much more effective, because of the arrangement of the tubes and the relatively high gas velocity around the tubes. This creates, of course a pressure loss of the gas within this heat exchanger, while there is none or very little in the MHD heater. A total loss of 2.5 IN WC loss in these heat exchangers can be expected

and an additional 1 IN WC in the ducts between the kiln, MHD heater and air heater, all depending, of course, on the overall arrangement and complexity of the installation. We estimate that a 30" ID pipe for the hot gas will be sufficient. The design of this pipe can be based on stainless steel pipe externally insulated or a carbon steel pipe internally insulated. Both have their advantage and disadvantages.

The heat exchanger of the air heater was ASME Section I certified after manufacturing, for 150 PSIG at 1050 °F. Whether or not the MHD unit was code-stamped I don't know. In any case, both heat exchangers must be carefully checked and re-certified if we want to cool them with water/steam. The operating temperature of the tubes will be much lower now since the cooling will be by much lower temperature water/steam, this will be helpfull against any corrosion from the high temperature off-gas from the coal fired kiln. Condensation of the off-gas must be avoided.

Physical changes of both heat exchanger casings must be made to facilitate the gas in- and outlets for both units.

As you can see, there will be a lot of paperwork as well as fabrication to re-use these units.

Please, let me know if you need any further involvement from us in this project.

Regards,

APPENDIX I
INSTRUMENTATION

SYSTEM VARIABLES

1. Kiln

a. Variables controlling operation

- (1) solid feed rate
- (2) throttling of primary forced-draft fan
- (3) damping for staged air injection
- (4) staged water injection
- (5) speed of rotation
- (6) internal pressure

b. Variables for measurement

- (1) solids feed rate
- (2) air flow in AIS ducts (4)
- (3) water flow to AIS ducts (4)
- (4) rpm
- (5) discharge temperature
- (6) bottom ash flow rate
- (7) FD fan discharge pressure
- (8) kiln pressure
- (9) solid residence time (using ceramic balls)

2. Air Injection System (AIS)

Variables for measurement

- (1) temperature profile
- (2) water flow rate to air injection system
- (3) inlet AIS pressure will be measured for each duct

B1804

3. Fuel Feed System

a. Variables controlling operation

- (1) composition (by amounts mixed together)
- (2) auger speed

b. Variables for measurement

- (1) mass flow rate to kiln
- (2) component compositions determined by amounts mixed together
- (3) feed samples at cross flow conveyor
- (4) solids temperature (how ? ask ESA)

4. Secondary Combustion Chamber

a. Variables controlling operation

- (1) air flow from blower (SCC FD fan)

b. Variables for measurement

- (1) FD fan measurements
- (2) ash (?) LOI (?) etc.
- (3) gas temperature

5. Particulate Control System (PCS)

a. Variables for controlling operation

- (1) ID fan suction throttle
- (2) BH cleaning frequency

b. Variables for measurement

- (1) temperatures
BH inlet, cooler exits (2)
- (2) pressures
BH, ID fan outlet or inlet

B1804

- (3) water flow rates to coolers
- (4) pressure of baghouse back flush system
- (5) collected ash flow rates (3)
BH, secondary combustion chamber, stack
- (6) gas composition
- (7) hydrocarbons in gas

B1804

ANALYSIS OF SOLID SAMPLES IN PHASES 1 AND 2

<u>Sample</u>	<u>Test/Analysis</u>	<u>Frequency</u>
Fuel	Proximate	Once in each phase
	Ultimate	Once every 2-hour balance on composite sample
	Heating value (HHV?) (LHV?)	Once every 2-hour balance on composite sample
	Ash composition	Once in each phase
	Ash fusion characteristics (define?)	Once in each phase
Limestone	Ca and Mg contents	Once in each phase
	Sieve analyses	Once in each phase
Bottom Ash	Unburned carbon	Once every balance period on composite sample
	Total sulfur	Once every balance period on composite sample
	Ca compounds	Once every balance period on composite sample
Fly Ash	Unburned carbon	Once every balance period on composite sample
	Total sulfur	Once every balance period on composite sample

Note

1. Define time period for samples, i.e., are they done simultaneously, sequentially, or after predetermined time intervals?

51604

DATA MEASUREMENTS

Item	Range & Units	Frequency/Remarks
Solids temperature	70-1800°F	Continuous, method to be developed
Gas temperature in kiln	70-1800°F	Continuous using AIS
Gas temperature in secondary combustor and first cooler	70-2500°F	Continuous at both points
Gas temperature in second cooler	70-1500°F	Continuous
Gas temperature in baghouse	70-500°F	Continuous
Pressure	0-30" H ₂ O	Continuous at blower discharges in kiln, and across baghouse
Airflow rate	0-6 lb/sec	Oxygen analysis in the gas
Water flow rates	0-2 lb/sec	Orifice meters
Fuel feed rate	0-2 lb/sec	Weigh system
Limestone feed rate	0-20 lb/min	Ratio in fuel feed
Ash flow rate	0-50 lb/min	Scale
Gas analysis		Lancom-3200
CO	0-0.01%	
CO ₂	0-20%	
O ₂	0-20%	
NO _x	0-0.1%	
SO _x	0-1%	
Smoke	(?)	

Note:

Recorder(s) needed: Battery-powered mV recorders; K-Data Logger (mV) with at least 25 channels.

B1204

G/C ASSESSMENT OF I/C REQUIREMENTS

Warren Weidman of G/C talked with Jim Humphrey (814-849-2302), who owns the Kiln, who related the following:

1. Kiln is 24 feet long; 9 feet O.D.; 8 feet I.D.
2. Kiln heads are stationary
3. Air header stationary to Kiln headers, but is to be replaced by new design.
4. Primary combustion fan (20 hp) will remain.
5. Kiln speed presently 1-1/2 rpm, but will be changed to variable speed with a maximum speed of 5-6 rpm.
6. Only one TE exists at the exhaust end.
7. Six (6) 2" collars for TE's exist on the unit/duct.
8. Two existing input conveyors to be modified and another one added, or entire system re-designed.

Jim also advised that G/C should review the Kiln before any final instrumentation design is finalized, since a number of items are not functioning.

Based on Jim's comment, the lack of scope, flow diagram and detail drawings; limited knowledge on proposed design changes to the Kiln; and to the conveyor input and discharge systems, etc. makes this instrumentation estimate the best we can provide at this time.

The attached sheets are in accordance with Task 1, III Data Collection Systems, Item 1.a, except solids feed rates and solid withdrawal rates which will be handled by Jim Humphrey.

1. Solid Temperatures in Kiln

What is presently being done in the cement industry, we assume can be applied for this task. Three thermocouples are inserted from the outside through the kiln wall up to the depth of the refractory, in a circular ring, 120 degrees apart. The area in the refractory is grooved or pocketed around the thermocouples so as to hold the solid for measurement. The three thermocouples are paralleled for a single reading.

Since you want to measure the solid in three places (#9, 10, 11), you will need nine (9) Type E or Type K thermocouples.

Estimated cost for Type E or Type K duplex (Thermo-Electric) thermocouples plus wells is \$300.00 each, for a total of \$2700.00.

2. Gas Temperature in Kiln

What is presently being done in the cement industry, we assume can be applied for this task. The thermocouples are inserted from the outside through kiln wall and refractory to the kiln center. The thermocouple is enclosed in a protecting tube, except for the last inch.

Since you want to measure the gas in four (4) places (#2, 3, 4, 5) the estimated cost is \$400.00 each, for each Type E or Type K duplex thermocouples plus protecting tube, for a total of \$1600.00. To replace the only working thermocouple located in the stationary head (#1), add another \$400.00.

3. Gas Temperature Outside of Kiln

Since there are no thermocouples located at #6 and 7, just holes, you will need to add them, along with those on each side of the secondary combustion chamber(s) (again just holes exist). To obtain an accurate reading of the gas temperature to the scrubbers (#8), add three TE's across duct (holes to be added) and average them for one reading.

Overall this means you will need seven (7) Type E or Type K, duplex thermocouples, plus protecting tubes for a cost of \$400.00 each, for a total of \$2800.00.

4. Temperature at Furnace Inner Wall

If this means the wall surface under the 6" refractory, add two type thermocouples plus wells at a cost of \$300 each, for a total cost of \$600.00.

If this means the outside wall of the rotating Kiln, then add \$4000.00 for two optical pyrometers. (Capintec, Inc.)

5. System Pressure

Since this area is not defined, we assumed the following:

- a) pressure at discharge of primary combustion fan;
- b) pressure at discharge of secondary combustion air fan;
- c) pressure in stack to scrubbers; and atmosphere pressure measurement.

The estimated cost is approximately \$750.00 per transmitter plus two valve manifold, for a total cost for the four transmitters (Rosemount) with manifolds of \$3000.00.

6. Air Flow Rate

To measure the air flow after the primary combustion fan, you can insert one pitot tube or four (4) pitot tubes (one/90 degrees) depending on the type of measurement that is required.

The estimated cost for a pitot tube, transmitter and valves (Dietrich Standard) is \$1500.00 each, for a total of four (4) at \$6000.00.

7. Gas Flow

There was nothing stated that you need to measure the gas flow or control the start-up gas flow. However, if this is desired, then add the following:

- a) One flow element, (orifice-Daniels) plus flow transmitter (Rosemount) and three-way valve manifold at a cost of \$1200.00.
- b) One control valve, with explosion proof electric operator. (4-20 mADC input) at a cost of \$3000.00.

8. Monitoring Instrumentations

Since this unit will only be on test for 3-4 weeks, we suggest the following assuming that the existing control switches for the fans are functionable and the variable speed device for the Kiln will be supplied by the Owner.

- a) One 120V Yokogawa Recorder (Model 4081-39-3-AK02/S21N41) to receive the (4) pressure transmitter signals and (5) flow transmitter signals.

Estimated Cost \$3,875.00

- b) One 120V Yokogawa Recorder (Model 4081-35-3-AK02) to receive the gas temperatures outside of Kiln (7); replacement for the existing TE in the exhaust head (1); and the 6 MV signals from the wireless data coupler system.

Estimated Cost \$3,995.00

- c) Since the transmitters are no longer powered from the microprocessor system, a NEMA 24V power supply will be required.

Estimated Cost \$3,000.00

- d) If a gas valve is required, add a controller (Moore 352E) at a cost of \$1,800.00.

Total Monitoring Instrumentation \$12,670.00

Items A through D will need to be mounted in a Hoffman style cabinet, and that price is included as part of Item 10.

9. Wireless Data Couplers

To get the signal from the thermocouples in Items 1 and 2 to the Bailey NET 90 System, you need to employ wireless data couplers. (Acurex/Auto Data Model 1400A-10). This model is a six channel device which meets the exact requirements for the number of TE's being monitored (3 + 3). The estimated cost for this instrument package is \$23,000.

APPENDIX J

REPORT OF THE PROJECT REVIEW MEETING ON JUNE 20, 1990

MEETING REPORT

Rotary Kiln Process Review Meeting - June 20, 1990,

Attendees:

BCRNL

UEI

J. T. Cobb, Jr.
J. A. DeMarchis
J. A. Kost
M. L. Pomerantz
J. Yerushalmi
W. E. Young

J. F. Angelo

HCC

J. L. Humphrey

B&W

G/C

D. P. Finn

Y. K. Ahn

SUMMARY

A meeting was held at BCRNL to: review project goals and objectives; discuss operation and control of the kiln, air injection system (AIS), fuel system, particulate control system (PCS), and the data-collection system; and to discuss how test conditions will provide sufficient data for the commercial assessment.

The design condition for solid fuels will be 10 MM Btu/hr. A higher rate may be achieved during tire incineration tests. Bituminous coal as a separate fuel was eliminated, but will be used to enhance (cofire with) waste fuel. Bituminous waste may be added to the program.

The ID fan placement will be examined to determine if it should be located downstream of the baghouse (BH). Electrical requirements must be closely examined because of the starting demand of the 150 hp ID fan.

Definition of process variables and instrumentation is needed for the tire test.

A variable speed drive will be purchased for the fuel feed system.

Balance readings will be taken for gas and sawdust at steady-state conditions to provide a more complete baseline and gain familiarity with kiln operation.

Culm and limestone specification properties must be changed because of combustion problems reported by FBC projects.

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DISCUSSION

1.0 Design and Test Conditions

The particulate control will be designed for 10 MM Btu/hr for the combustion of solid fuels. After completion of the PEDDA Phase 2 test program, the tire combustion test may be tried at 10 to 20 MM Btu/hr (the latter being preferred by B&W) because of the lower ash (particulate) content.

Initial Phase 1 Culm Test will be at 6 MM Btu/hr. Depending upon results, the second Phase 1 test will be enriched culm at 10 MM Btu/hr or bituminous coal waste at 6 MM Btu/hr. Phase 2 tests will start with culm at 6 MM Btu/hr and then proceed to 10 MM Btu/hr. Cofiring with bituminous coal will take place during Phase 1 or Phase 2 or both.

Bituminous coal by itself has been eliminated from the Phase 1 and Phase 2 tests because of the need to concentrate on waste (low-heating value) fuels and the problems of maintaining the proper conditions for sulfur removal because of test kiln limitations.

2.0 Kiln Operation and Control

2.1 RPM

The expected solids residence time of 15 minutes at the current speed of 1.5 rpm is considered to be too short; therefore, the variable speed drive will be used to extend the range from 1.0 to 3.0 rpm.

2.2 Ash-Removal System

Design for 2,000 lb/hr (dry).

2.3 Anticipated Problems and Possible Solutions.

1. Control of maximum kiln temperature

1.1 AIS water injection

1.2 Discharge head water injection

- 1.3 Vary rpm
- 1.4 Vary excess air
- 2. Control of temperature profile
 - 2.1 Zonal AIS water injection
 - 2.2 Zonal AIS air dampers
 - 2.3 Vary excess air
- 3. Maintenance of negative pressure (-0.5 to -1.0" water)
 - 3.1 Place vacuum gage on kiln or secondary combustion chamber
 - 3.2 Throttle inlet to ID fan
- 3.0 Air Injection System (AIS)
 - 3.1 Design conditions
 - 20 hp motor, ???? Model Fan, ????? scfm.
 - 3.2 Ability to vary flow
 - 3.2.1 Vary air to entire duct by throttling FD fan inlet
 - 3.2.2 Vary each zone by damper. Measure with pitot tube.
 - 3.3 Method of water injection
 - By zone
- 4.0 Fuel Feed System
 - 4.1 Fuel and limestone specifications and procurement
 - 4.1.1 Bituminous coal as a separate fuel was eliminated. Bituminous coal waste (3,000 Btu/lb) may be used
 - 4.1.2 Anthracite refuse (culm) may have 70% ash
 - 4.1.3 Fuel top size was reduced to 1 inch
 - 4.1.4 Limestone top size was reduced to 1/8 inch (3 mm)

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4.2 Fuel and limestone feed rates

4.2.1 Initial tests will be at 6 MM Btu/hr, may go to 10 MM Btu/hr

4.2.2 Use Ca/S ratio of 2.5 to 4.0 for culm

4.2.3 Use Ca/S ratio of 2.0 to 2.5 for bituminous waste

4.3 Weigh System specifications

4.3.1 BCRNL to design system to maintain 5% accuracy

4.3.2 Limestone and fuel will be blended before loading into bins

4.3.3 A variable speed drive will be obtained for the auxiliary bin (more \$\$)

5.0 Particulate Control System (PCS)

5.1 Design conditions

5.1.1 10 MM Btu/hr for solid fuel

5.1.2 Exit loading of 0.08 g/scf at 65 tons/day operation

5.2 Layout

5.2.1 Should ID fan should be before or after baghouse (BH)?

5.2.2 Examine BH design conditions and capability to determine maximum allowable positive and negative pressure

5.3 Operation, measurement, and control

5.3.1 Throttle ID fan inlet

5.3.2 Reduce electric starting demand

6.0 Utility Connections (requirements and action to be taken)

6.1 Electricity

1. Reduce ID fan (150 hp) starting demand. Use BCRNL starter assembly

2. Estimate starting and running current. Check adequacy of wiring to PP&L transformer

6.2 Water

1. May need 30 gpm for PCS (2 coolers) and 30 gpm for AIS water injection at 10 MM Btu/hr. To be checked
2. Change water supply lines from 1/2" to 2 inches if needed
3. Meter water to PCS and AIS

6.3 Gas

1. Lines are adequate. System uses 2 Mcf/hr (2,060 Btu/hr) to heat kiln to 800°F. This process takes 24 hr (48 Mcf) and 800°F is the maximum temperature attainable on gas

6.4 Compressed Air

1. Existing system is a 25 hp, 150 psig system that distributes compressed air through 1" pipe around the facility. This is adequate for the project

PEDA Grant Agreement Objectives

1. To prove the feasibility of burning high-sulfur bituminous coal and anthracite refuse, with limestone injection for sulfur emissions control, in a rotary kiln fitted with a Universal Energy International air distributor;
2. to determine the emissions levels of SO_x and NO_x , and specifically to identify the Ca/S ratios that are required to meet New Source Performance Standards;
3. to evaluate the technical and economic merits of a commercial rotary kiln combustor in comparison to fluidized-bed combustors; and
4. to ascertain the need for further work, including additional combustion tests,, prior to commercial application, and to recommend accordingly a detailed program towards this end.

Enhanced Objectives (discuss)

1. Determine the particulate loading in the kiln exhaust gas when the UEI air injection system (AIS) is used. Compare with particulate loading from fluid-bed combustors.
2. Study the characteristics of the kiln combustor using quartered tires as a feed (or a portion thereof).
3. Examine the need for a "kiln combustion R&D center."

B1804

TEST PROGRAM FOR PHASE 1

Day	Activity	Maximum Feed Rate (ton/hr)				Total Feed Req. (tons)		
		AR	BCW	Limestone	Other	AR	BCW	Limestone
1	Heat up	--	--	--	Gas	--	--	--
2	Balance	--	--	--	Gas	--	--	--
3	Heat up	--	--	--	Sawdust	--	--	--
4	Balance	--	--	--	Sawdust	--	--	--
5	AR Shakedown	1.00	--	0.03	--	40	--	1
6	AR Balances (2)	1.00	--	0.03	--	40	--	1
7	Other	--	--	--	--	--	--	--
8	Other	--	--	--	--	--	--	--
Total						80		2
Total (Including 20% contingency)						96		2.4

Comments

1. One purpose of these tests is to determine the time needed to change from one steady state to another. At present, it is assumed that six hours will be needed for this transition, and each balance period will require three hours.
2. The balance periods will be run at 10% excess air; one period will be run at high kiln rpm, the other at low kiln rpm.
3. At the end of these tests, the unit will be shut down and inspected, the data analyzed, and the results will serve as the basis for a decision to proceed to Phase 2, and for any modifications needed for Phase 2.

Legend

AR - Anthracite refuse (culm)
BCW - Bituminous coal waste

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SYSTEM VARIABLES

1. Kiln

a. Variables controlling operation

- (1) solid feed rate
- (2) throttling of primary forced-draft fan
- (3) damping for staged air injection
- (4) staged water injection
- (5) speed of rotation
- (6) internal pressure

b. Variables for measurement

- (1) solids feed rate
- (2) air flow in AIS ducts (4)
- (3) water flow to AIS ducts (4)
- (4) rpm
- (5) discharge temperature
- (6) bottom ash flow rate
- (7) FD fan discharge pressure
- (8) kiln pressure
- (9) solid residence time (using ceramic balls)

2. Air Injection System (AIS)

Variables for measurement

- (1) temperature profile
- (2) water flow rate to air injection system
- (3) inlet AIS pressure will be measured for each duct

3. Fuel Feed System

a. Variables controlling operation

- (1) composition (by amounts mixed together)
- (2) auger speed

b. Variables for measurement

- (1) mass flow rate to kiln
- (2) component compositions determined by amounts mixed together
- (3) feed samples at cross flow conveyor
- (4) solids temperature (how ? ask ESA)

4. Secondary Combustion Chamber

a. Variables controlling operation

- (1) air flow from blower (SCC FD fan)

b. Variables for measurement

- (1) FD fan measurements
- (2) ash (?) LOI (?) etc.
- (3) gas temperatures

5. Particulate Control System (PCS)

a. Variables for controlling operation

- (1) ID fan suction throttle
- (2) BH cleaning frequency

b. Variables for measurement

- (1) temperatures
BH inlet, cooler exits (2)
- (2) pressures
BH, ID fan outlet or inlet

- (3) water flow rates to coolers
- (4) pressure of baghouse back flush system
- (5) collected ash flow rates (3)
BH, secondary combustion chamber, stack
- (6) gas composition
- (7) hydrocarbons in gas

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ANALYSIS OF SOLID SAMPLES IN PHASES 1 AND 2

<u>Sample</u>	<u>Test/Analysis</u>	<u>Frequency</u>
Fuel	Proximate	Once in each phase
	Ultimate	Once every 2-hour balance on composite sample
	Heating value (HHV?) (LHV?)	Once every 2-hour balance on composite sample
	Ash composition	Once in each phase
	Ash fusion characteristics (define?)	Once in each phase
Limestone	Ca and Mg contents	Once in each phase
	Sieve analyses	Once in each phase
Bottom Ash	Unburned carbon	Once every balance period on composite sample
	Total sulfur	Once every balance period on composite sample
	Ca compounds	Once every balance period on composite sample
Fly Ash	Unburned carbon	Once every balance period on composite sample
	Total sulfur	Once every balance period on composite sample

Note

1. Define time period for samples, i.e., are they done simultaneously, sequentially, or after predetermined time intervals?

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DATA MEASUREMENTS

Item	Range & Units	Frequency/Remarks
Solids temperature	70-1800°F	Continuous, method to be developed
Gas temperature in kiln	70-1800°F	Continuous using AIS
Gas temperature in secondary combustor and first cooler	70-2500°F	Continuous at both points
Gas temperature in second cooler	70-1500°F	Continuous
Gas temperature in baghouse	70-500°F	Continuous
Pressure	0-30" H ₂ O	Continuous at blower discharges in kiln, and across baghouse
Airflow rate	0-6 lb/sec	Oxygen analysis in the gas
Water flow rates	0-2 lb/sec	Orifice meters
Fuel feed rate	0-2 lb/sec	Weigh system
Limestone feed rate	0-20 lb/min	Ratio in fuel feed
Ash flow rate	0-50 lb/min	Scale
Gas analysis		Lancom-3200
CO	0-0.01%	
CO ₂	0-20%	
O ₂	0-20%	
NO _x	0-0.1%	
SO _x	0-1%	
Smoke	(?)	

Note:

Recorder(s) needed: Battery-powered mV recorders; K-Data Logger (mV) with at least 25 channels.

B1804

APPENDIX K

REPORT OF THE PROJECT COORDINATION MEETING ON JUNE 21, 1990

MEETING REPORT

Coordination Meeting - June 21, 1990

Attendees:	<u>BCRNL</u>	<u>UEI</u>
	J. T. Cobb, Jr.	J. F. Angelo
	J. A. DeMarchis	
	J. A. Kost	
	M. L. Pomerantz	<u>HCC</u>
	J. Yerushalmi	J. L. Humphrey
	W. E. Young	
	<u>PETC</u>	<u>G/C</u>
	D. F. Gyorke	Y. K. Ahn
	<u>PEDA</u>	
	J. J. Garbacik	

Purpose

Review expanded task list and current schedule, especially the Phase 1 tasks needed to modify the kiln, including utility connections and permits.

Summary

Changes were made to the expanded sub-task and deliverables list. Critical items are:

1. Test of particulate control system (PCS) induced draft (ID) fan.
2. Adequacy of electrical supply and distribution.

Revised task lists are enclosed for UEI, HCC, and G/C review. The BCRNL sub-task and deliverables list will be forthcoming.

We discussed limestone sourcing and will contact Westinghouse and Penn State.

Please review task list and fill out the duration column. We will prepare network schedule. Estimate the activity start dates, but remember, they may change. If you are not sure, leave the start date open

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TABLE 1. RESPONSIBILITY MATRIX

	<u>BCRNL</u>	<u>HCC</u>	<u>UEI</u>	<u>G/C</u>
<u>Phase 1</u>				
<u>Task 1 - Modify Kiln</u>				
1. Stainless Steel Seals	Procure	Install	Specify	
2. UEI Air Injection System	Procure	Install	Design Fabricate Supervise Install	
3. Secondary Air Blower	Procure	Install	Specify	
4. Variable Speed Motor Drive	Procure	Install	Specify	
5. Bag House	Specify Procure	Install		
6. Gas Cooler	Specify Procure	Install		
7. I.D. Fan	Specify Procure	Install		
8. Modify Feed System	Specify Procure	Install		
9. Repair Refractory	Procure	Specify Install		
10. Electrical Distribution	Design	Install	*	
11. Ash-Removal System	Procure	Renovate		
12. Utility Connections	Procure	Specify Install		
13. Estimated Heat and Mass Balances	Prepare			

*indicates changes

TABLE 1. RESPONSIBILITY MATRIX
(continued)

	<u>BCRNL</u>	<u>HCC</u>	<u>UEI</u>	<u>G/C</u>
<u>Task 2 - Design, Specify, Procure, and Connect Instrumentation</u>				
1. Emissions Testing Equip. (PWRC may have VOC)*	Design Specify Install	Install		Review
2. Kiln Instrumentation	Design Specify Procure	Install		Review
3. Air Injection System Instrumentation	Procure	Install	Specify Install	
4. Data Collection Formats for Steady State Balance Periods	Prepare	Review	Review	Review
<u>Task 3 - Procure Coal and Limestone</u>				
1. Sawdust	Procure	Specify		
2. Bituminous Coal)	Specify			
2. Anthracite Refuse)	Procure			
3. Limestone)				
<u>Task 4 - Cold Commissioning</u>				
1. Kiln Operating Procedures	Approve	Prepare	Prepare	
2. Data Collection Procedures	Prepare			Review
3. Safety Procedures for Con- struction, Operation, OSHA	Review	Prepare		
4. Complete Systems Check	Supervise	Perform	Perform	Supervise
<u>Task 5 - Shakedown Tests</u>				
1. Initial Kiln Testing	Supervise	Operate	Supervise	Consult
2. Final Heat and Mass Balances for Phase 1	Prepare			Review

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TABLE 1. RESPONSIBILITY MATRIX
(concluded)

	<u>BCRNL</u>	<u>HCC</u>	<u>UEI</u>	<u>G/C</u>
<u>Task 6 - Shutdown, Inspection, Data Analysis, and Phase 2 Recommendations</u>				
1. Kiln Inspection	Observe	Perform	Perform	
2. Data Analysis	Perform		Review	Review
3. Phase 2 Decision	X	X	X	X
<u>Phase 2 - Test Program</u>				
Task 1 - Kiln Operating Procedures	Review	Review	Consult	Review
Task 2 - Data Collection and Test Procedures	Review	Review	Consult	Review
Task 3 - Test Program	Supervise	Operate	Consult	Consult
<u>Phase 3</u>				
1. Final Heat and Mass Balances	Prepare			Review
2. Assessment	Prepare		Consult	Review
3. Data Base	Prepare			Prepare
4. Reporting	Prepare		Review	Review
<u>Phase 4</u>				
1. Commercial Evaluation	Review		Consult	Prepare
2. Final Report	Prepare		Review	Review

TABLE 2. UEI SUB-TASKS AND DELIVERABLES

1. Provide drawings of a four-zone Air Injection System (AIS) and specifications ready for fabrication. Coordinate with HCC to match air manifold and existing forced draft (FD) fan.*
2. Order materials.*
3. Receive materials.*
4. Start fabrication of AIS duct.*
5. Complete fabrication of AIS duct.*
6. Ship AIS duct to HCC.
7. One set of "as built" AIS drawings.
8. Supervision of AIS installation.
9. Written report providing details of the AIS installation and operation.
10. Recommend AIS instrumentation requirements and provide specifications for BCRNL procurement.
11. Install AIS instrumentation.
12. Check out AIS instrumentation.
13. Specify kiln rotating seals.
14. Assist HCC with preparation of a set of kiln operating procedures for review and approval by BCRNL.*
15. Help HCC to perform a complete kiln system checkout during cold commissioning.*
16. Participate and provide advice during Phase 1 tests.*
17. Participate in inspection, data analysis, and recommendation for Phase 2 tests.
18. Provide consultation during Phase 2 and review Phase 3 and Phase 4 reports.

*Indicates changes

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TABLE 3. UEI SCHEDULE

Work to be performed as described in Table 2, UEI Sub-Tasks and Deliverables.

<u>Task</u>	<u>Duration (Days)</u>	<u>Estimated Start</u>	<u>Estimated Completion</u>
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

TABLE 4. HCC SUB-TASKS AND DELIVERABLES

Phase 1 - Task 1

1. Install stainless steel seals
2. Install AIS duct
3. Modify and adapt existing AIS forced draft (FD) fan (mechanical/electrical)*
4. Install AIS water injection
5. AIS mechanical/electrical checkout
6. Install secondary air blower (mechanical/electrical)
7. Checkout (M/E) secondary air blower
Design variable speed drive (VSD) system
8. Install variable speed kiln drive
9. Checkout (M/E) variable speed kiln drive
10. Prepare baghouse (BH) foundations
11. Install baghouse
12. Connect baghouse ducting
13. Connect baghouse to existing compressed air system
14. Install electrical connection for baghouse
15. Test BH compressed air system
16. Prepare first-stage gas cooler (FSGC) foundation
17. Install FSGC

*Indicates change

TABLE 4. HCC SUB-TASKS AND DELIVERABLES

(continued)

18. Connect FSGC ducting
 19. Connect FSGC cooling water system to water supply (100 psig)*
 20. Install FSGC water meter (or pressure gage)*
 21. Test FSGC water system
 22. Prepare second-stage gas cooler (SSGC) foundation
 23. Install SSGC
 24. Connect SSGC ducting
 25. Connect SSGC cooling water system to water supply (100 psig)*
 26. Install SSGC water meter (or pressure gage)*
 27. Test SSGC water system
 28. Prepare Induced Draft fan (IDF) foundation
 29. Install IDF
 30. Connect IDF ducting
 31. Connect IDF electrical system
 32. Test IDF electrical system
 33. Test complete particulate control system (PCS)
-

*indicates change

TABLE 4. HCC SUB-TASKS AND DELIVERABLES

(continued)

- 34. Modify fuel feed system
 - 34.1 check bucket elevator and mixer capacity to determine if the system can handle 2 ton/hr*
 - 34.2 Modify auxiliary feed system and install variable speed screw feeder*
 - 34.3 Modify mixer and bucket elevator*
 - 34.4 Check out all feeders
 - 34.5 Check out all conveyors
 - 34.6 Install fuel weigh system
 - 34.7 Check out fuel weigh system
- 35. Repair refractory
 - 35.1 Remove old refractory
 - 35.2 Install new refractory
 - 35.3. Cure new refractory
- 36. Install electrical distribution center*
- 37. Refurbish ash-removal system
 - 37.1 Repair ash-removal conveyors and motors*
 - 37.2 Connect ash system spray cooler
 - 37.3 Install ash weigh system*
 - 37.4 Mechanical/electrical test of ash system

*indicates change

TABLE 4. HCC SUB-TASKS AND DELIVERABLES

(continued)

- 38. Install larger water line*
- 39. Check, refurbish, or replace main electrical wiring from transformer to facility*
- 40. Test kiln gas burners
- 41. Connect remaining electrical components
- Phase 1 - Task 2
- 42. Install emissions testing equipment in cooperation with BCRNL
- 43. Install kiln instrumentation in cooperation with BCRNL
- Phase 1 - Task 3
- 44. Specify sawdust quality and quantity and recommend sources
- Phase 1 - Task 4
- 45. Prepare kiln operating and safety procedures*
- 46. Perform complete mechanical and electrical system check*
- Phase 1 - Task 5
- 47. Start kiln on gas, operate for balance test
- 48. Load sawdust bin
- 49. Operate with sawdust (heat up and balance)
- 50. Load fuel bin with culm and limestone (Fuel #1)

*indicates change

TABLE 4. HCC SUB-TASKS AND DELIVERABLES

(concluded)

- 51. Operate with fuel #1 (heat up and balance)
- 52. Load fuel bin with Fuel #2 (Bituminous coal and culm or bituminous coal and gas)*
- 53. Operate with fuel #2 (heat up and balance)*
- 54. Shut down for data review

Phase 1 - Task 6

- 55. Inspect kiln, report on condition
- 56. Participate in Phase 2 recommendation
- 57. Recommend any changes in operating/test procedures

Phase 2 - Task 1

- 58. Prepare revised operating procedures
- 59. Operate kiln system on extended

Tire test**

*indicates change

**separate item after PEDDA/PETC test program

TABLE 5. HCC SCHEDULE

Work to be performed as described in Table 4, HCC Sub-Tasks and Deliverables.

<u>Task</u>	<u>Duration (Days)</u>	<u>Estimated Start</u>	<u>Estimated Completion</u>
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____
10	_____	_____	_____
11	_____	_____	_____
12	_____	_____	_____
13	_____	_____	_____
14	_____	_____	_____
15	_____	_____	_____
16	_____	_____	_____
17	_____	_____	_____
18	_____	_____	_____
19	_____	_____	_____
20	_____	_____	_____
21	_____	_____	_____
22	_____	_____	_____
23	_____	_____	_____
24	_____	_____	_____
25	_____	_____	_____
26	_____	_____	_____
27	_____	_____	_____
28	_____	_____	_____
29	_____	_____	_____
30	_____	_____	_____

TABLE 5. HCC SCHEDULE
(concluded)

<u>Task</u>	<u>Duration (Days)</u>	<u>Estimated Start</u>	<u>Estimated Completion</u>
31	_____	_____	_____
32	_____	_____	_____
33	_____	_____	_____
34	_____	_____	_____
35	_____	_____	_____
36	_____	_____	_____
37	_____	_____	_____
38	_____	_____	_____
39	_____	_____	_____
40	_____	_____	_____
41	_____	_____	_____
42	_____	_____	_____
43	_____	_____	_____
44	_____	_____	_____
45	_____	_____	_____
46	_____	_____	_____
47	_____	_____	_____
48	_____	_____	_____
49	_____	_____	_____
50	_____	_____	_____
51	_____	_____	_____
52	_____	_____	_____
53	_____	_____	_____
54	_____	_____	_____
55	_____	_____	_____
56	_____	_____	_____
57	_____	_____	_____
58	_____	_____	_____
59	_____	_____	_____
60	_____	_____	_____

TABLE 6. G/C SUB-TASKS AND DELIVERABLES

Phase 1 - Task 1

Consultation as needed*

Task 2

1. Review specifications and location of emissions testing equipment
2. Review specifications and location of kiln instrumentation
3. Review data-collection formats

Task 3

Consultation as needed*

Task 4

Review kiln operating procedures as needed*

4. Review data-collection procedures
5. Supervise complete kiln system check

Task 5

Consult on test, answer questions as needed*

(information to be sent to G/C office)

Task 6

6. Review Phase 1 data, analyze results
7. Participate in Phase 2 recommendation

Phase 2 - Task 1

8. Review Phase 2 kiln operating procedures
-

*indicates change

TABLE 6. G/C SUB-TASKS AND DELIVERABLES

(continued)

Task 2

9. Review Phase 2 data-collection and test procedure

Task 3

10. Review Phase 2 test program, answer questions

Phase 3

G/C activities in Phase 3 are in support of BCRNL to ensure that the

11. Phase 3 results will be useful for Phase 4*

Review Phase 2 heat and mass balances prepared by BCRNL

12. Assess the correlation and relationship of dependent variables with operating conditions, prepared by BCRNL*

13. Prepare a data base with BCRNL that will serve as a basis for the Phase 4 work*

14. Review BCRNL Phase 3 report

Phase 4

See attached p4, Schedule A from PEDA agreement

15. Decide on combustor size (MM Btu/hr) for evaluation
16. Prepare site specific conceptual design, use Phase 3 data*
(CCEC is the site, culm is the fuel)**
17. Prepare cost estimate (capital and operating)

*indicates change

**G/C will concentrate on culm fuel, BCRNL will discuss use of bituminous coal cofiring as a supplement to culm or bituminous waste

TABLE 6. G/C SUB-TASKS AND DELIVERABLES
(concluded)

18. Compare to AFBC options (bubbling and circulating)
19. Identify additional R&D requirements
20. Prepare draft commercial assessment report*
21. Participate in review of draft commercial assessment report*
22. Prepare final commercial assessment report*
23. Review, as needed, final project report prepared by BCRNL*

*indicates change

TABLE 7. G/C SCHEDULE

Work to be performed as described in Table 6, G/C Sub-Tasks and Deliverables.

<u>Task</u>	<u>Duration (Days)</u>	<u>Estimated Start</u>	<u>Estimated Completion</u>
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____
10	_____	_____	_____
11	_____	_____	_____
12	_____	_____	_____
13	_____	_____	_____
14	_____	_____	_____
15	_____	_____	_____
16	_____	_____	_____
17	_____	_____	_____
18	_____	_____	_____
19	_____	_____	_____
20	_____	_____	_____
21	_____	_____	_____
22	_____	_____	_____
23	_____	_____	_____
24	_____	_____	_____
25	_____	_____	_____

Phase 3 - Data Collection Reduction and Analysis

Task 1.

Prepare data collection formats for the steady state balance periods. (This in fact will be carried out during Phase 1.)

Task 2. - Heat and Mass Balances

Heat and mass balances will be prepared for each 2-hr balance period.

Task 3. - Assessment

Assess and, if possible, correlate the dependence of key dependent parameters -- carbon conversions, SOx and NOx emissions, limestone utilization -- on the operating conditions.

Task 4. - Data Base

BCRNL and G/C will prepare a data base that will serve for the work of Phase 4.

Task 5. - Reporting

Prepare Phase 3 report; include recommendations, if any, for further tests.

Phase 4. - Assessment of Commercial Application

Task 1. - Commercial Evaluation by Gilbert/Associates

A site-specific conceptual design and cost estimate will be performed for a commercial kiln installation at Community Central Energy Corporation (CCEC) Steam Plant in Scranton, PA. The design will be based on retrofitting an existing oil/gas fired 120,000 PPH Steam Boiler with an anthracite culm fired rotary kiln. The design will be based on the scale-up of the AR sustained run in Task 3 and will include inspection of the CCEC site for space availability, confirmation with the local environmental regulations, and inspection of existing equipment to determine auxiliary equipment requirements. Capital and O&M costs will be estimated based on the site-specific conceptual design. An assessment will also be made for the potential to operate in a cogeneration mode.

Based on the results of the extended runs in Phase 2, an assessment will be made if a scrubber will be needed in the CCEC commercial kiln plant site, in view of new NSPS requirements. The conceptual design, therefore, may or may not include a scrubber.

The site-design data will be adjusted to evaluate the use of atmospheric bubbling and circulating fluidized bed combustors. A comparison of the technical and economic performance of the kiln to these AFBC units will be made for application to the CCEC Steam Plant.

Deliverable will include a plot plan, process flow diagrams with material and energy balances, list of major equipment for both new and existing systems, a plant description and identification of the capital and O&M costs for the CCEC commercial kiln plant. A comparison table between kiln and AFBC's will be provided for performance and cost. Recommendation will also be made if the commercial kiln project is to be implemented and technical and cost risks, if any, will be identified. Insights will also be drawn regarding the potential for cofiring high-sulfur bituminous coal or coal wastes with municipal wastes.

END

**DATE
FILMED**

12 / 15 / 92