QUARTERLY TECHNICAL PROGRESS REPORT 1
OCTOBER - DECEMBER, 1992

ENGINEERING DEVELOPMENT OF ADVANCED PHYSICAL FINE COAL CLEANING FOR PREMIUM FUEL APPLICATIONS

DOE/PC/92208--T1

DE93 013177

Prepared for
U. S. Department of Energy
Pittsburgh Energy Technology Center
Pittsburgh, Pennsylvania 15236

By
Frank J. Smit
Mahesh C. Jha
AMAX Research & Development Center
Golden, Colorado 80403-7499

DOE Contract No. DE-AC22-92PC92208
Amax R&D Project No. 91455

January 18, 1993

LEGAL NOTICE

THIS REPORT WAS PREPARED BY AMAX RESEARCH & DEVELOPMENT CENTER AS AN ACCOUNT OF WORK SPONSORED BY THE PITTSBURGH ENERGY TECHNOLOGY CENTER. NEITHER AMAX RESEARCH & DEVELOPMENT CENTER NOR ANY PERSON ACTING ON ITS BEHALF:

(A) MAKES ANY WARRANTY, EXPRESSED OR IMPLIED, WITH RESPECT TO THE USE OF ANY INFORMATION, APPARATUS, METHOD, OR PROCESS DISCLOSED IN THIS REPORT OR THAT SUCH USE MAY NOT INFRINGE PRIVATELY OWNED RIGHTS; OR

(B) ASSUMES ANY LIABILITIES WITH RESPECT TO THE USE OF, OR FOR THE DAMAGES RESULTING FROM THE USE OF, ANY INFORMATION, APPARATUS, METHOD, OR PROCESS DISCLOSED IN THIS REPORT.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This project is a step in the Department of Energy's program to show that ultra-clean fuel can be produced from selected coals and that the fuel will be a cost-effective replacement for oil and natural gas now fueling boilers in this country.

The replacement of premium fossil fuels with coal can only be realized if retrofit costs are kept to a minimum and retrofit boiler emissions meet national goals for clean air. These concerns establish the specifications for maximum ash and sulfur levels and combustion properties of the ultra-clean coal.

The cost-sharing contract effort is for 48 months beginning September 30, 1992. This report discusses technical progress made during the quarter from September 30 to December 31, 1992.

SPECIFIC OBJECTIVES OF PROJECT

The project has three major objectives:

- The primary objective is to develop the design base for prototype commercial advanced fine coal cleaning facilities capable of producing ultra-clean coals suitable for conversion to coal-water slurry fuel. The fine coal cleaning technologies are advanced column flotation and selective agglomeration.

- A secondary objective is to develop the design base for near-term commercial integration of advanced fine coal cleaning technologies in new or existing coal preparation plants for economically and efficiently processing minus 28-mesh coal fines.

- A third objective is to determine the distribution of toxic trace elements between clean coal and refuse when applying the advance column flotation and selective agglomeration technologies.

APPROACH

The project team consists of Amax Research & Development Center (Amax R&D), Amax Coal Industries, Bechtel Corporation, Center for Applied Energy Research (CAER) at the University of Kentucky, and Arcanum Corporation. Dr. Douglas Keller is a consultant to the project.

The engineering development effort has been divided into four phases which are further divided into eleven tasks which include coal selection, laboratory and bench-scale process optimization, design construction, and operation of a 1.8 tonne/hour process development unit (PDU). Tonnage quantities of the ultra-clean

coals will be produced in the PDU. Near-term applications of the advanced cleaning technologies to existing coal preparation plants will also be studied.

ACCOMPLISHMENTS DURING QUARTER

The project team members met with the DOE project management representatives at the Pittsburgh Energy Technology Center on November 5, 1992, to review project plans. After review and comment by the DOE, the Project Work and Management Plans were issued on December 9, 1992.

A draft Coal Selection Plan was distributed to PETC project management and to the team members describing the candidate coals and method used for selecting six coals for study during the project. Based upon published sulfur analyses, current production status, and available information related to the cleanability of the coals, fourteen candidate coals were identified for possible use in the program.

Bechtel, Amax Coal, and Amax R&D representatives discussed potential near-term applications of the advanced coal cleaning technologies, and Bechtel has begun the engineering analysis of an application at the Ayrshire Mine.

INTRODUCTION/BACKGROUND

The purpose of this contract is to continue development of advanced column flotation and selective agglomeration technologies for cleaning coal. Development of these technologies is an important step in the Department of Energy program to show that ultra-clean fuel can be produced from selected United States coals and that the fuel will be a cost-effective replacement for a portion of the premium fuels (oil and natural gas) burned by electric utility and industrial boilers in this country. Capturing a relatively small fraction of the total utility and industrial oil-fired boiler fuel market would have a significant impact on domestic coal production and reduce national dependence on petroleum fuels. Significant potential export markets also exist in Europe and the Pacific Rim for cost-effective premium fuels prepared from ultra-clean United States coal.

The replacement of premium fossil fuels with coal can only be realized if retrofit costs and boiler derating are kept to a minimum. Also, retrofit boiler emissions must be compatible with national goals for clean air. These concerns establish the specifications for the ash and sulfur levels and combustion properties of ultra-clean coal.

The contract effort is for 48 months beginning September 30, 1992, and ending September 30, 1996. This report discusses the technical progress made during the first 3 months of the project, September 30 to December 31, 1992.

SPECIFIC OBJECTIVES OF PROJECT

The three major objectives of this project are discussed below.

The primary objective is to develop, by FY 1997, the design base for prototype commercial advanced fine coal cleaning facilities capable of producing ultra-clean coals suitable for conversion to stable, highly loaded coal-water slurry fuels which contain less than 860 grams ash per gigajoule HHV and preferably less than 430 grams ash per gigajoule HHV and less than 258 grams of sulfur per gigajoule HHV. These amounts are equivalent to the 2 pounds of ash and preferably less than 1 pound of ash per million Btu HHV and less than 0.6 pound of sulfur per million Btu HHV stated in the solicitation. The advanced fine coal cleaning technologies to be employed will be advanced column froth flotation and selective agglomeration. Operating conditions during the advanced cleaning processes will allow recovery of at least 80 percent of the carbon in run-of-mine source coals at an annualized cost of less than $2.37 per gigajoule ($2.50 per million Btu), including the mine mouth cost of the raw coal.

A secondary objective of the work is to develop, by FY 1997, the design base for near-term commercial applications of advanced fine coal cleaning technologies suitable for integration in new or existing coal preparation plants for

the purpose of economically and efficiently processing minus 28-mesh coal fines. The design base will also include the auxiliary systems required to yield a shippable, marketable product such as a dry clean coal product.

A third objective of the work is to determine the distribution of toxic trace elements between clean coal product and refuse during the cleaning of various coals by advanced froth flotation and selective agglomeration technologies. Eleven toxic trace elements have been identified. The eleven are antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium. The results will show the potential of removing these toxic trace elements from coal by advanced physical cleaning.

APPROACH

A team headed by Amax Research & Development Center (Amax R&D) was formed to accomplish the project objectives. Amax R&D is managing the project and also providing laboratory and pilot plant facilities and expertise in the areas of coal characterization and coal slurry fuel preparation. Amax Coal Industries will provide operating and coal marketing experience and some of the coals to be used during the program. Bechtel Corporation will provide engineering and design capabilities and the operating experience it gained while managing similar proof-of-concept projects for the DOE. The Center for Applied Energy Research (CAER) at the University of Kentucky will provide research and operating experience in the column flotation area, and Arcanum Corporation will provide similar experience in the selective agglomeration area. Dr. Douglas Keller will serve as a consultant in the area of coal source selection and selective agglomeration. Figure 1 shows the project organization chart.

The overall engineering development effort has been divided into four phases with specific activities as follows:

Phase I encompasses preparation of a detailed Project Work Plan, selection and acquisition of the test coals, and laboratory and bench-scale testing. The laboratory and bench-scale work will be to determine the cleaning potential of the selected coals and to establish design parameters and operating guidelines for a process development unit (PDU) containing advanced column flotation and selective agglomeration modules. A conceptual engineering design will be prepared for a fully integrated and instrumented 1.8-tonne/hour PDU incorporating the features determined from the laboratory and bench-scale studies. A generic approach will be followed during the laboratory studies for selection of the flotation and agglomeration systems for the PDU which will best meet project objectives.

The properties of slurry fuels prepared from the ultra-clean coals also will be determined during Phase I, and test lots of ultra-clean coals will be prepared by bench-scale column flotation and bench-scale selective agglomeration for end-use

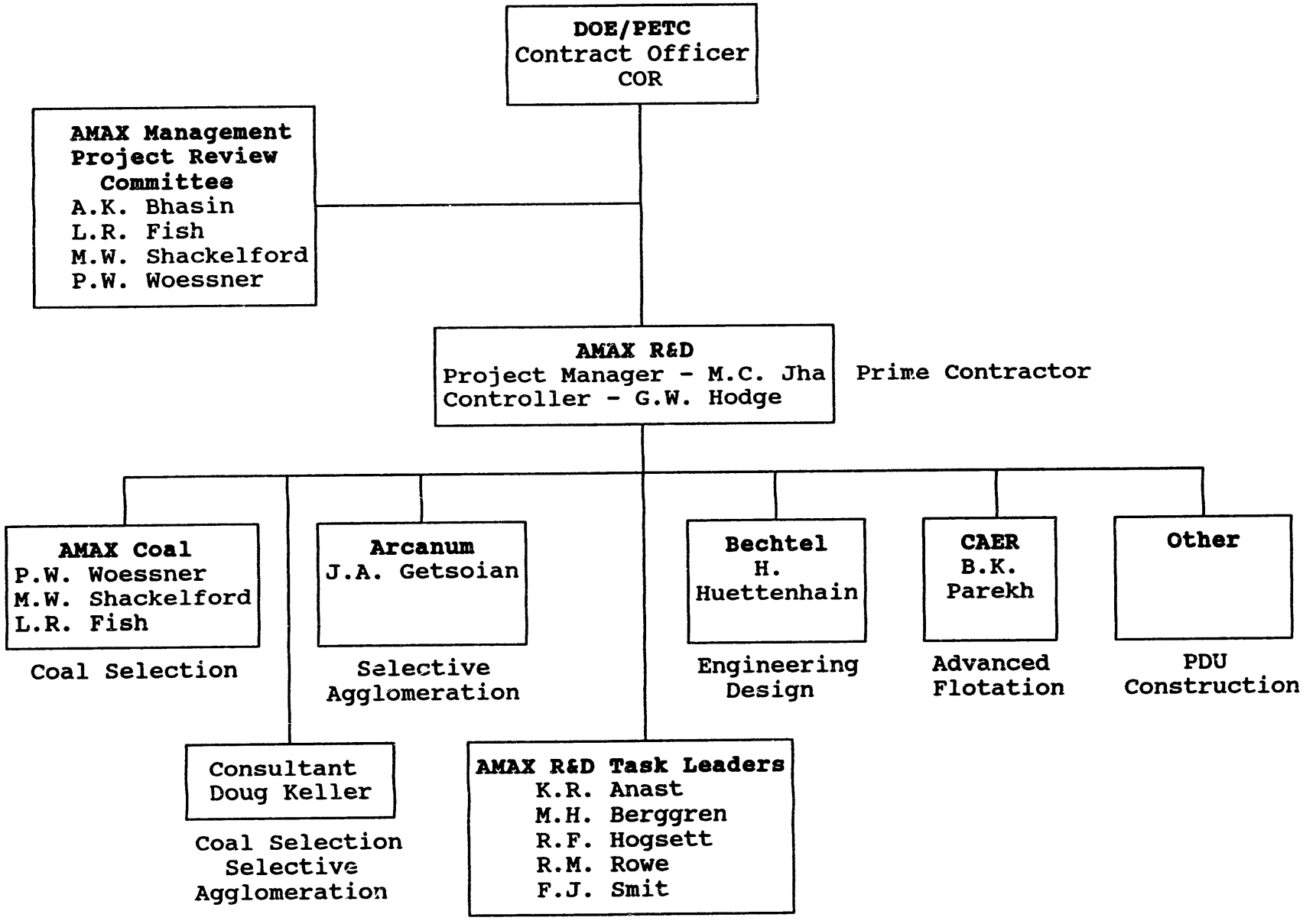

Figure 1. Project management organization chart.

testing by the DOE. The distribution of toxic trace elements will be determined during production of these test lots.

In addition, methods for applying the advanced cleaning technologies in existing coal preparation plants in the near term will be studied during Phase I.

Phases II and III cover the construction and operation of the 1.8-tonne/hour PDU. Phase II will be for advanced column flotation and Phase III will be for selective agglomeration. Process performance will be optimized at the PDU-scale, and 180-tonne lots of ultra-clean coal will be prepared by column flotation and selective agglomeration from each of three test coals. Toxic trace element distributions will also be determined during the production runs. The ultra-clean coals will be delivered to the DOE for end-use testing.

In addition and as part of Phases II and III, existing preparation plant streams will be tested in the PDU to determine the performance of the advanced column flotation and selective agglomeration technologies during near-term applications.

Phase IV covers decommissioning the PDU, restoration of the host site, and preparation of the final project report.

ACCOMPLISHMENTS DURING QUARTER

For management purposes, the four phases of the project have been divided into tasks and subtasks as listed in Table 1. Each task and subtask has specific objectives which can be inferred from its title. Work was done on Tasks 1, 2, and 3 during the October 1 to December 31, 1992, quarterly reporting period.

SUBTASK 1.1. PROJECT WORK PLAN

The Project Work and Management Plans were prepared and discussed at the project kick-off meeting at Pittsburgh Energy Technology Center (PETC) on November 5, 1992. All of the team members participated in the meeting. After review and comment by PETC project management, the Project Work and Management Plans were issued in final form on December 9, 1992. Figure 2 shows the project schedule as revised on January 12, 1993. The various phases and tasks often overlap. Phase I began on September 30, 1992, and will be completed in October 1994. Phase II (construction and operation of flotation PDU) is scheduled to begin in January 1994 and be completed in November 1995, while Phase III (construction and operation of selective agglomeration PDU) is scheduled to begin in October 1994 and be completed in July 1996. Work on Phase IV will start at the end of Phase III, and project completion is set for September 30, 1996.

TASK 2. COAL SELECTION AND PROCUREMENT

Successful accomplishment of the project objectives will depend upon selection of suitable source coals, since not all United States coals are likely to be acceptable feedstock for preparation of premium fuel. Economic factors also restrict interest in some coals as feedstock because of the their limited availability and possibly their remote location. The target product quality and production specifications set by the Department of Energy set the following guidelines for selection of the test coals:

1. Source Coal Properties

   a. Well under 258 g/GJ (grams per gigajoule) of sulfur in the organic form. For bituminous coals, this is equivalent to about 0.88 percent organically bound sulfur on a dry coal basis and to about 0.75 percent organically bound sulfur on a dry coal basis for low-rank coals. Low sulfur coals meeting this requirement are plentiful in certain coal formations of the United States but not in others.

   b. Ash minerals and pyrite in coal must be sufficiently liberated by practical comminution methods so that target ash and total sulfur specifications may be met by an efficient cleaning procedure. Practical comminution technology exists for grinding no finer than nominally passing 10 μm

Table 1. Outline of Work Breakdown Structure

Phase I. Engineering Analysis and Laboratory and Bench-Scale R&D

Task 1.	Project Planning
Subtask 1.1.	Project Work Plan
Subtask 1.2.	Project Work Plan Revisions
Task 2.	Coal Selection and Procurement
Subtask 2.1.	Coal Selection
Subtask 2.2.	Coal Procurement, Precleaning and Storage
Task 3.	Development of Near-Term Applications
Subtask 3.1.	Engineering Analyses
Subtask 3.2.	Engineering Development
Task 4.	Engineering Development of Advanced Froth Flotation for Premium Fuels
Subtask 4.1.	Grinding
Subtask 4.2.	Process Optimization Research
Subtask 4.3.	CWF Formulation Studies
Subtask 4.4.	Bench-Scale Testing and Process Scale-up
Subtask 4.5.	Conceptual Design of the PDU and Advanced Froth Flotation Module
Task 5.	Detailed Engineering Design of the PDU and Advanced Flotation Module
Task 6.	Selective Agglomeration Laboratory Research and Engineering Development for Premium Fuels
Subtask 6.1.	Agglomeration Agent Selection
Subtask 6.2.	Grinding
Subtask 6.3.	Process Optimization Research
Subtask 6.4.	CWF Formulation Studies
Subtask 6.5.	Bench-Scale Testing and Process Scale-up
Subtask 6.6.	Conceptual Design of the Selective Agglomeration Module
Task 7.	Detailed Engineering Design of the Selective Agglomeration Module

Phase II. PDU and Advanced Column Flotation Module Testing and Evaluation

Task 8.	PDU and Advanced Column Froth Flotation Module
Subtask 8.1.	Coal Selection and Procurement
Subtask 8.2.	Construction
Subtask 8.3.	PDU and Advanced Coal Cleaning Module Shakedown and Test Plan
Subtask 8.4.	PDU Operation and Clean Coal Production
Subtask 8.5.	Froth Flotation Topical Report

Phase III. Selective Agglomeration Module Testing and Evaluation

Task 9.	Selective Agglomeration Module
Subtask 9.1.	Construction
Subtask 9.2	Selective Agglomeration Module Shakedown and Test Plan
Subtask 9.3.	SA Module Operation and Clean Coal Production
Subtask 9.4.	Selective Agglomeration Topical Report

Phase IV. PDU Final Disposition

Task 10.	Disposition of the PDU
Task 11.	Project Final Report

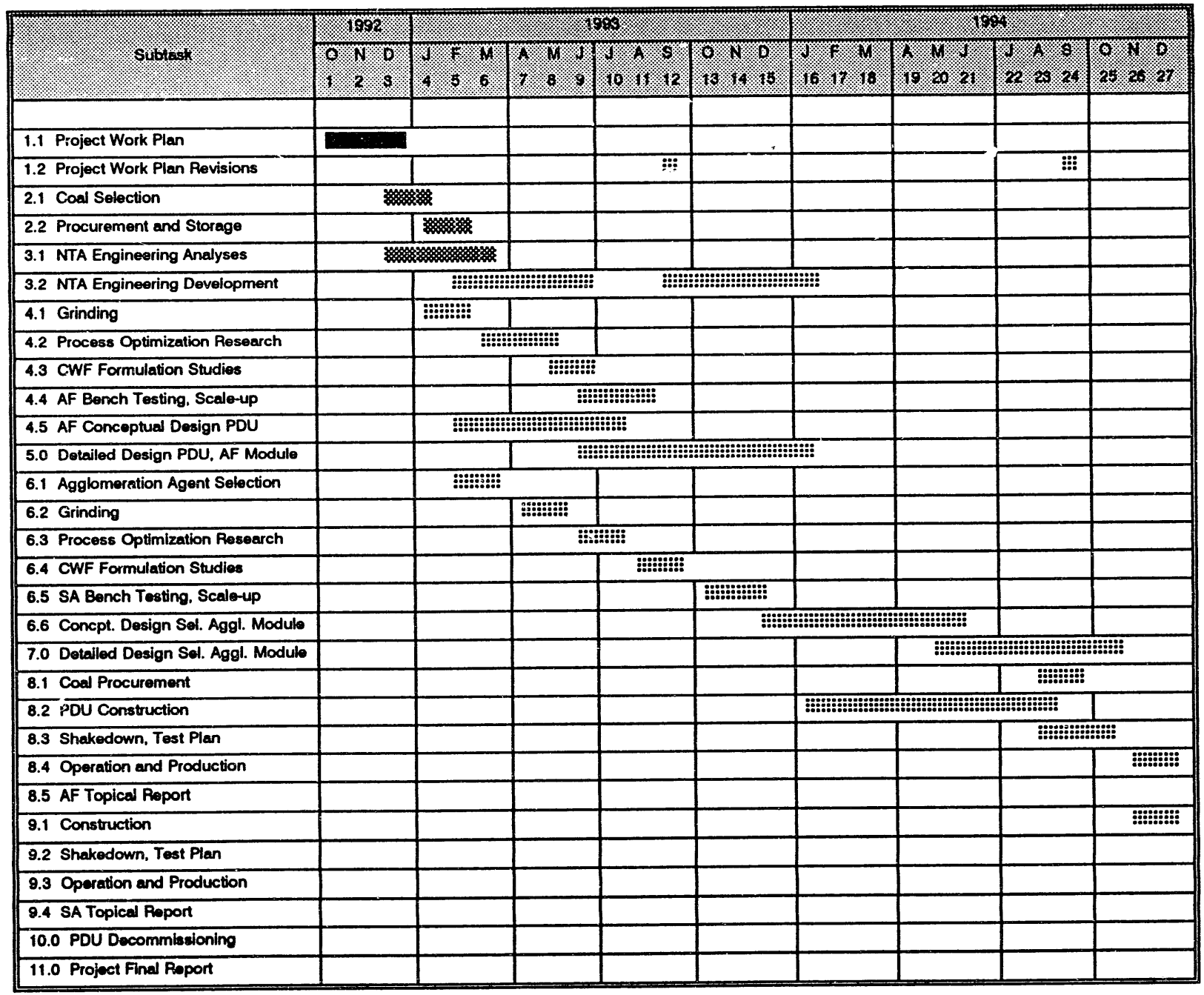

Figure 2. Project schedule.

Revised January 12, 1993

Subtask	1995												1996								
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1.1 Project Work Plan																					
1.2 Project Work Plan Revisions																					
2.1 Coal Selection																					
2.2 Procurement and Storage																					
3.1 NTA Engineering Analyses																					
3.2 NTA Engineering Development																					
4.1 Grinding																					
4.2 Process Optimization Research																					
4.3 CWF Formulation Studies																					
4.4 AF Bench Testing, Scale-up																					
4.5 AF Conceptual Design PDU																					
5.0 Detailed Design PDU, AF Module																					
6.1 Agglomeration Agent Selection																					
6.2 Grinding																					
6.3 Process Optimization Research																					
6.4 CWF Formulation Studies																					
6.5 SA Bench Testing, Scale-up																					
6.6 Concpt. Design Sel. Aggl. Module																					
7.0 Detailed Design Sel. Aggl. Module																					
8.1 Coal Procurement																					
8.2 PDU Construction																					
8.3 Shakedown, Test Plan																					
8.4 Operation and Production																					
8.5 AF Topical Report																					
9.1 Construction																					
9.2 Shakedown, Test Plan																					
9.3 Operation and Production																					
9.4 SA Topical Report																					
10.0 PDU Decommissioning																					
11.0 Project Final Report																					

Figure 2. Project schedule (continued).

Revised January 12, 1993

(micrometers). Few United States coals contain mineral matter which can be fully liberated by such grinding.

2. Economic Factors - Coal Availability

   a. Selected coal must be obtained from actively mined seams with large reserves, preferably exceeding 500 million tons.

   b. Sufficient quantities must be available for purchase from the same source (seam, county, and mine) to meet the total needs of the project (Phases I, II, and III).

   c. Market value of the coal at the mine should be less than about $1.18 per GJ ($1.25/mmBtu - approximately $30/short ton) to allow a reasonable amount for the incremental cost of advanced cleaning and still allow the production cost of the ultra-clean coal to be less than the goal of $2.37 per GJ ($2.50/mmBtu).

3. Economic Factors - Fuel Preparation

   Variation in key properties of prospective source coals can have significant impact upon the cost of preparing premium CWF from available coals. These effects lead to the following preferences when selecting test coals for advanced processing:

   a. Lower ash content.
   b. Lower total and pyritic sulfur content.
   c. Ash-mineral and pyrite liberation at coarser sizes.
   d. Lower inherent moisture .
   e. Higher Hardgrove grindability.
   f. Higher hydrophobicity (but still wettable with water).

   In addition to the specifications and preferences listed above, the contract Statement of Work also specifies that at least one low-rank coal be included among the recommended coals. The Amax R&D team will also strive for geographic diversity among the recommendations and will recommend at least one bituminous coal from each coal mining region (eastern, midwestern, and western).

Subtask 2.1. Coal Selection Plan

A draft coal selection plan was prepared and submitted to the DOE on December 18, 1992, for review and comment. The plan is for the selection of six coals and their recommendation to the DOE for use during Phase I and specifically for Task 4, Engineering Development of Advanced Froth Flotation for Premium

Fuels, and Task 6, Selective Agglomeration Laboratory Research and Engineering Development for Premium Fuels. The draft plan calls for purchase of one truck load (about 20 tonnes) of each of the selected coals for the Phase I testing. Three of the coals will be tested further in the PDU during Phases II and III. (Selection of test coals for investigation of near-term applications is covered under Task 3.)

A two-step process was followed for selection of coals for use during the program. The first step was a screening process based upon readily available information. Fourteen candidate coals were identified in this manner based upon sulfur analyses, current production status, and any information available to the project team related to cleanability. The first step will be followed by a second quantitative ranking step for identifying the six best prospects among the candidates using a matrix format.

Candidate Source Coals

The initial screening identified candidate source coals in Pennsylvania, West Virginia, Virginia, Kentucky, Alabama, Indiana, Illinois, Wyoming, Colorado, and Utah. Names of active producers of the prospective coals were obtained from the Keystone Directory and from Amax files. The list was narrowed to one or two producers from each area based upon their production and published information, recommendations by project team members, and internal information available to Amax R&D concerning the response of specific coals to advanced cleaning processes. The fourteen candidate coals are listed in Table 2 (arranged geographically).

Table 2. Candidate Coals for Preparation of Premium Fuels

	Coal Seam	Organic Sulfur, %	State	County	Mine	Mine Operator
1.	Brookville/Clarion	0.8	PA	Various	Various	Adobe Mining
2.	Upper Freeport	0.6	PA	Indiana	Helen	Helen Mining
3.	Stockton/Mercer	0.6	WV	Kanawha	130 Mine	Amax - Cannelton
4.	Winifrede	0.7	WV	Boone	Sandlick	Amax - Cannelton
5.	Upper Elkhorn 3/ Taggart	0.6	VA	Wise	Wentz	Westmoreland
6.	High Splint	0.6	KY	Harlan	Lynch	Arch of Kentucky
7.	Hazard 4A/5A	0.7	KY	Knott	Ky Prince	Roaring Creek
8.	Brookwood Gp	0.7	AL	Tuscaloosa	Kellerman	Drummond
9.	Indiana VII	0.5	IN	Sullivan	Minnehaha	Amax - Midwest
10.	Illinois No. 5	0.8	IL	Wabash	Wabash	Amax - Midwest
11.	Wyodak	0.4	WY	Campbell	Belle Ayr	Amax - West
12.	Maxwell	0.5	CO	Las Animas	Golden Eagle	Basin Resources
13.	O'Connor	0.5	UT	Carbon	Skyline	Utah Fuels
14.	Sunnyside	0.5	UT	Carbon	Sunnyside	Sunnyside

Production, analytical, and washability data are being compiled for these coals. In most cases, samples have also been requested for performing flotation and/or agglomeration amenability tests as well. Amax Coal Company has also been asked to provide estimates of the current market value of coal from each of the mines following a consistent marketing scenario.

Selection Matrix

A selection matrix is being devised for ranking the fourteen coals according to their desirability as feed for production of premium fuel. Weights were assigned in the matrix to the significant selection criteria elements described above. Half of the weighting was assigned to coal properties which would affect the quality of the clean coal product, 30 percent of the weighting was assigned to properties which would influence the cost of preparing ultra-clean CWF, and the final 20 percent of the weighting was assigned to availability (production and reserve) factors. The maximum weighting assigned to each element in each category are listed in Table 3.

Table 3. Maximum Weighting Assigned to Elements in Each Category in Coal Selection Matrix

Category	Element	Maximum Weighting
Product Quality	Potential Sulfur Content	20
	Potential Ash Content	20
	Ash-Free Inherent Moisture	10
	Subtotal	50
Production Cost	Price of Coal at Mine	15
	Liberation Size	6
	Ash Content of Feed Coal	3
	Hydrophobicity	3
	Grindability	3
	Subtotal	30
Availability	Production of Source Mine	10
	Reserves	10
	Subtotal	20
	Grand Total - Maximum Points	100

The rationale for assigning points within each category for an individual coal is discussed in the draft plan which is being circulated for comment among team members and PETC project management. The draft plan calls for basing point assignments as follows:

Potential Sulfur Content	Organic sulfur analysis plus 20 percent of the pyritic sulfur.
Potential Ash Content	Ash in the 1.60-specific gravity float fraction of the minus 325-mesh coal.
Ash-free Inherent Moisture	ASTM equilibrium moisture determination as indication of potential slurry quality.
Price of Coal at the Mine	Amax Coal Company current market assessment.
Coarse Liberation	Ash in the 1.60-specific gravity float fractions of minus 100 and minus 325- mesh coal.
Ash Content of Feed Coal	Dry ash content of the feed coal.
Hydrophobicity	MAF higher heating value as indication of rank.
Grindability	Hardgrove grindability index.
Mine Production	Production capacity of source mine.
Reserves	Published regional recoverable reserves of coal from specified seam and from closely related seams.

TASK 3. DEVELOPMENT OF NEAR-TERM APPLICATIONS

Amax R&D, together with Bechtel and Amax Coal Company, will conduct engineering analyses of near-term applications of advanced froth flotation and selective agglomeration technology for processing coal fines in existing and new preparation plants. The goal will be to produce additional coal or lower-cost coal in this manner which can be sold in the existing marketplace.

The near-term application will achieve one or both of the following objectives:

- Improve the percentage of recovery of marketable coal from the preparation plant.
- Improve the quality of the marketable coal (heating value, sulfur and ash contents, and handling characteristics) in a cost effective manner.

A visit was made to the 1,200-tph preparation plant at the Ayrshire Mine of Amax Coal Midwest in Indiana. A potential near-term application was identified there. Minus 28-mesh underflows from the jig plant dewatering screens are now cycloned and the minus 100-mesh overflow discarded to a slurry pond. The cyclone underflow is dewatered with EBW centrifuges and combined with the clean coal from the jig plant. Significant amounts of clean coal are lost in the cyclone overflow slurry, and the quality of the overall plant production is degraded by the excess amount of moisture and ash retained in the EBW centrifuge cake. Application of one of the advance cleaning technologies could recover additional clean coal from the slurry and, perhaps with a grinding step, improve the quality of the EBW centrifuge product. Bechtel has begun a Subtask 3.1 engineering analysis of this application, and samples have been requested from the Ayrshire plant for laboratory studies at Golden.

A similar visit is planned in January 1993 to the Lady Dunn preparation plant of Cannelton in order to evaluate near-term application opportunities at a West Virginia operation.

PLANNED FUTURE ACTIVITIES

The selected test coals will be ordered for delivery in January for crushing and sampling. None of the test coals are expected to need precleaning. Splits of the test coals will be shipped to Arcanum and CAER as they become available for their Subtasks 4.2 and 6.3 process development and optimization work. Similar laboratory work will also begin at Amax R&D with the initial emphasis placed upon development of the Subtask 4.1 grinding strategy.

Near-term application testing of the Ayrshire and Lady Dunn samples will also begin at Amax R&D, Arcanum, and CAER. Bechtel is scheduled to complete their engineering analyses of the various near-term options and prepare recommendations for the Subtask 3.2 engineering development test plan.

END

DATE
FILMED
6/3/93