**DEVELOPMENT OF AN ADVANCED, CONTINUOUS MILD GASIFICATION PROCESS
FOR THE PRODUCTION OF CO-PRODUCTS**

Quarterly Technical Progress Report
for the Period of October-December 1991

by

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1.0 CONTRACT MODIFICATIONS

The Contract Reporting Requirements Checklist and the Report Distribution Addressee List were changed by Modification No. M020. A change in Key Personnel was made to the contract by Modification No. M021, which named Brian Runge as Project Manager. This modification also extended the period of performance to September 30, 1992. The period of performance for the EERC subcontracts with Xytel-Bechtel, Inc. (XBi), AMAX R&D, and J.E. Sinor Consultants, Inc., were each extended. The Sinor subcontract is now scheduled for completion on February 29, 1992, the XBi subcontract is now scheduled for completion on April 30, 1992, and the AMAX subcontract will be completed on August 31, 1992.

Tables 1 and 2 represent an integrated time line for the completion of the Mild Gasification project. The schedule includes the activities to be conducted by the EERC, XBi, and AMAX, as well as the subcontracts for solid and liquid product upgrading. The selection of the contractor to conduct the product upgrading testing will be discussed at the next project review meeting scheduled for January 21, 1992.

2.0 PROJECT REVIEW MEETINGS

On November 6, 1991, a meeting was held at the AMAX Research and Development Center in Golden, Colorado. Those in attendance at the meeting included Brian Runge and Robert Ness of the EERC, Scott McFeely of XBi, Frank Hogsett and Mahesh Jha of AMAX, and Jerry Sinor and Trevor Ellis of J.E. Sinor Consultants. Items on the agenda included framing the scope of work to be conducted by Sinor on the market assessment for mild gasification products. An attempt was made to draft an integrated time line for the completion of all subcontracts issued under the project. The commercial process flowsheet under development by XBi was presented for review. The goals to be achieved by the technical and economic assessment to be performed by XBi were outlined. Frank Hogsett reported on the progress of the coal cleaning being conducted by AMAX. As soon as sufficient coal has been cleaned, the mild gasification reactors at the EERC will be run to generate sufficient quantities of products to allow testing of product upgrading and utilization methods.

The next project review meeting was held on December 12, 1991, in the Houston, Texas, offices of XBi. The meeting was attended by Brian Runge (EERC), Frank Hogsett (AMAX), and Scott McFeely, Jeannette Fong, Hudson Jayne, Gerald Barta, and Les Cohen (XBi). Les Cohen will now be managing the efforts of the XBi team. The major work conducted during this meeting focused on review of the preliminary process flow diagrams (PFDs) prepared by XBi. Several modifications were discussed and will be reflected in the updated PFDs.

In the course of the discussion of the process flow diagram, a question arose about the mass flow rate of gas through the calciner. It became apparent that an error had occurred in communications between the EERC and XBi

TABLE 1

	December	January	February	March	April	May	June	July	August	September	October	November	December
	2 9 16 23 30 --1 5--	5 12 19 26 --1--	2 9 16 23 --1--	1 8 15 22 29 --1--	5 12 19 26 --1--	3 10 17 24 31 --1--	7 14 21 28 --1--	5 12 19 26 --1--	2 9 16 23 30 --1--	6 13 20 27 --1--	4 11 18 25 --1--	1 8 15 22 29 --1--	6 13 20 27 --1--
MILD GASIFICATION													
Carbonizer Test #1		X											
Carbonizer Test #2			X										
Char Cleaning/Shipping													
Calciner/CFBR Tests			X										
Calciner Tests				X									
Calciner Char Cleaning													
Condensable Upgrading Sub													
Form coke Testing													
Pelletec Testing													
Activated Carbon Testing													

TABLE 2

	December	January	February	March	April	May	June	July	August	September	October	November	December
	2 9 16 23 30	5 12 19 26	2 9 16 23	1 8 15 22 29	5 12 19 26	3 10 17 24 31	7 14 21 28	5 12 19 26	2 9 16 23 30	6 13 20 27	4 11 18 25	1 8 15 22 29	6 13 20 27
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concerning the mass balance around the calciner. XBi was directed to obtain a new solution for their process simulation using a smaller gas input rate. This work will modify the mass balance for the entire system; however, it should not significantly delay further work on the project.

3.0 UNDEERC PROJECT ACTIVITY

Project efforts early in this quarter were focused on supplying XBi with any data the EERC could gather on the FMC formcoke process. XBi requires mass and energy flow data if they are to include a coke briquetting process in the process flow sheets they are designing.

During the month of December, the distributor plate in the bottom section of the carbonizer was damaged while performing tests on pressurized fluid-bed coal combustion. A new plate and bubble caps were milled out to replace the damaged unit. It was also necessary to replace the bottom 10 inches of refractory. The new refractory was cured during the first week of January.

A shipment of approximately 6.5 tons of cleaned, sized Indiana No. 3 coal was received at the EERC from AMAX in mid-December. The coal has been placed into nitrogen-purged storage bunkers. A run using the cleaned coal has been scheduled for the third week of January. Upon completion of this test, the low volatile char produced will be sent to AMAX in Golden, Colorado, for further cleaning.

4.0 XYTEL-BECHTEL, INC. (XBi) PROJECT ACTIVITY

October activities on the Mild Coal Gasification Project focused on completion of an integrated heat and material balance, based on computer simulation efforts. Also, preparation of process flow diagrams began.

By the third week in October, XBi had completed an integrated simulation of the following units:

- Carbonizer and Fines Removal
- Oil Recovery
- Char Cooling
- Calcining
- Fluidized-Bed Combustion
- Recycle Gas Compression

The integrated simulation confirmed that sufficient chemical energy exists in the carbonizer make-gas to support both the carbonizer and calciner heat demands, including the effects of char cooling between the units.

Continued analysis of the gas quench system has placed the practicality of a second-stage quench loop in doubt. Preliminary numbers do not justify inclusion of a second-stage (light oil) recovery unit, as only about 184 lb/hr of light oil can be recovered.

XBi's simulation efforts, which do not account for sulfur contained in the oil, show that the sulfur (SO₂) content of stack gases is of the same

concentration as might be expected in high-sulfur coal-fired power plants. This suggests that some type of sulfur removal system must be provided prior to releasing the purge gases to atmosphere.

November activities focused on preparation of an initial draft of the project process flow diagrams. A total of five PFDs were drafted, including the following:

- Coal Storage and Preparation
- Carbonization
- Calcination
- Carbonizer Gas Quench System
- AFBC and Flue Gas Treatment

Considerable effort was expended in November estimating the operating pressure profile in the conceptual plant design. Of greatest concern was the pressure drop across the carbonizer and calciner units. In the project review meeting held in Golden, Colorado, on November 6, 1991, XBi outlined technical concerns regarding the physical configuration of the carbonizer unit. XBi requested, and UND agreed to provide, guidance on scaleup of this unit by the end of November. On November 25, XBi was advised to relax the carbonizer residence time in order to allow a reactor L/D ratio of 1:1. XBi has calculated the pressure drop based on this criteria, and revised the heat and material balance to reflect the calculated carbonizer operating pressure.

Following the December 12 meeting, UNDEERC requested that several changes be incorporated into the current design. Changes include:

- Addition of a feed coal drying step (13% AR moisture in, 8% out);
- Addition of a crushing step downstream of dryer (2"x0 to 1/4"x0);
- Consideration of pneumatic conveying instead of screw-feeding to the carbonizer;
- Addition of a mixing/blending device to T-103 and T-304;
- Addition of a Fike or Fenwall fire suppression system on baghouses (estimate only, detail not on PFDs);
- Consideration of multiple feed design for the carbonizer and calciner.

UNDEERC confirmed that an error had been made in the calciner gas rate data given to XBi; i.e., the gas rate should be approximately 1/6 of the rate being used up until December 12. According to the EERC, XBi may use anywhere from 1/6 to 1/2 the previous rate to obtain a "reasonable" calciner gas inlet temperature. Per UNDEERC, superficial gas velocity in the calciner will be maintained at 2 fps. XBi is currently rerunning mass and energy balances to establish a suitable gas rate and its effect on process design, and to determine the cost and schedule impact of this change.

Work on the design of the power generation portion (AFBC) of the facility has been started.

5.0 AMAX PROJECT ACTIVITY

AMAX R&D has a commitment to UNDEERC to supply about 25 tons of Indiana No. 3 bituminous coal (AMAX Chinook Mine) that has been cleaned to lower the sulfur and ash content prior to mild gasification tests at UNDEERC. Based on

previous test results, a dry gravity separation technique has been selected to clean the coal.

An air table was purchased from Oliver Manufacturing in Rocky Ford, Colorado, for use in the dry gravity separation processing. The air table has been installed at AMAX R&D, and various process equipment such as feeders, vibrating screens, and a blender have also been assembled into a processing system that has been used to clean the coal.

Approximately 45 tons of Chinook coal has been crushed to minus 1/4 inch and is in storage in preparation for cleaning. Since the coal was mined during extremely wet conditions in late August, the moisture content of the crushed coal was higher than normal and presented some problems in material handling. Approximately 8.5 tons of the wet coal was laid out on the ground and air dried to lower the moisture content. After the drying step, the material was noticeably drier and did not present any material-handling problems.

The 8.5-ton portion of the dried coal was also screened into three size ranges in preparation for cleaning on the air table. The coal, with an initial top size of 1/4 inch, was screened on 10- and 24-mesh screens. This resulted in the desired three screen fractions, plus some fugitive dust that was collected and weighed and then discarded. Results of the screen separations are shown in Table 3.

Samples of the different screen fractions have been submitted for Btu content, proximate and ultimate analysis, and sulfur analysis, including total sulfur, pyritic sulfur, and sulfate sulfur (organic sulfur by difference). Results of these tests can be found in Table 4.

Initial cleaning tests were begun on the air table, and the operator recycled material back through the cleaning step until some measure of reproducibility was achieved. At that time, the actual processing of the coal was begun, one size range at a time. After cleaning, the light fraction from each size range was combined and blended prior to shipment to UNDEERC. The initial coal shipments to UNDEERC were delivered by the middle of December.

TABLE 3
Screen Separation Results

<u>Size Range</u>	<u>Weight Collected, Pounds</u>	<u>% of Feed</u>
1/4 Inch x 10 Mesh	7,070	41.14
10 x 24 Mesh	5,695	33.14
Minus 24 Mesh	4,133	24.05
Fugitive Dust	286	1.66
Total	17,184	99.99

Table 4

Results of Air Table Cleaning, Test for Chimook Coal Sent to UNDEERC

	Screened Analysis			Reject Analysis			Dust Analysis			Reject and Dust			Cleaned Sample, Clean Blended Product			
	Composite Head Sample			Composite Heavies			Composite Dust			Analysis Total Reject			As- Received	Dry Basis	Screen Analysis	
	As- Received	Dry Basis		As- Received	Dry Basis		As- Received	Dry Basis		As- Received	Dry Basis	Mesh			%	
Moisture, %	5.80	-		3.69	-		4.34	-		3.92	-		4.57	-	1/4 Inch	0.03
Proximate Analysis, %																
Ash	12.17	12.92		26.68	27.71		22.48	23.50		25.19	26.22		9.84	10.31	10	32.1
Volatiles	35.91	38.12		32.51	33.76		33.36	34.88		32.82	34.16		37.33	39.12	16	20.1
Fixed Carbon	46.12	48.96		37.11	38.53		39.82	41.63		38.07	39.63		48.26	50.57	28	17.9
Sulfur Analysis, %															48	15.7
S (Total)	4.52	4.80		6.89	7.16		5.26	5.50		6.31	6.57		3.88	4.07	65	4.9
S (Pyrite)	1.54	1.64		3.72	3.86		1.11	1.16		2.79	2.81		1.19	1.25	100	1.8
S (Sulfate)	0.88	0.72		0.76	0.79		2.16	2.25		1.26	1.31		0.55	0.57	-100	2
S (Organic)	2.30	2.45		2.41	2.50		1.99	2.08		2.26	2.35		2.14	2.25		
Btu/lb	11,570	12,282		9,597	9,965		9,315	9,738		9,497	9,885		12,474	13,071		
MAF Btu/lb	-	14,105		-	13,785		-	12,729		-	13,397		-	14,574		
Weight Collected, Pounds	17,308	16,304		2,562	2,467		1,416	1,355		3,978	3,822		13,329	12,779		
Percentage by Class	100.00	100.00		100.00	100.00		100.00	100.00		100.00	100.00		100.00	100.00		
Overall																
Weight Distribution	100.00	100.00		14.80	15.13		8.18	8.31		22.88	23.44		77.01	78.38		
Ash Distribution	100.00	100.00			32.45			15.11			47.56			62.53		
Sulfur Distribution	100.00	100.00			22.55			9.51			32.06			66.34		
Btu Distribution	100.00	100.00			12.28			6.59			18.87			83.42		
Ultimate Analysis, %																
C	63.79	67.72		54.93	57.03		55.09	57.59		54.99	57.23		68.07	71.33		
H	4.05	4.30		3.68	3.82		3.86	3.83		3.67	3.82		4.87	4.87		
N	1.53	1.62		1.18	1.22		1.18	1.24		1.18	1.23		1.95	2.04		
S	4.04	4.29		6.13	6.36		4.72	4.94		5.63	5.86		4.05	4.24		
O*	8.26	8.77		7.38	7.68		9.36	9.79		8.08	8.41		6.75	7.07		
O*	8.60	9.13		3.71	3.85		8.52	8.91		5.42	5.64		6.56	7.41		

* Measured.

* By difference.

On a weight basis, 77.6 percent of the coal was recovered in the cleaned product. Ash rejection was fair with only 63.9 percent of the ash in the feed reporting to the product, but sulfur rejection was poor with 73.4 percent of the sulfur reporting to the product. These results are typical of those obtained in the bench-scale testing and indicate that the sulfur is uniformly distributed throughout the coal, which makes cleaning very difficult at acceptable recovery rates.

Preliminary analysis of the data available on the cleaned coal shows the distribution of ash and sulfur as follows.

1. The feed stream was 17,184 pounds at 5.81 percent moisture, 12.12 percent ash, and 4.52 percent sulfur (ash and sulfur on as-received basis).
2. The cleaned product was 13,329 pounds at 4.12 percent moisture, 9.99 percent ash, and 4.28 percent sulfur.
3. The reject streams, including dust, weighed 3,855 pounds at 19.48 percent ash and 5.35 percent sulfur.

Compared to the 22 percent weight loss from the starting material, about 38 percent of the ash and 34 percent of the sulfur were rejected during the cleaning operation. Btu rejection was less at 17 percent, which shows that the cleaning step was effective in improving the coal quality. Final cleaned product quality on an as-received basis was 4.57 percent moisture, 3.88 percent sulfur, 9.84 percent ash, and a Btu content of 12,474 Btu/pound. This compares to the respective head assay values of 5.80 percent moisture, 4.52 percent sulfur, 12.17 percent ash, and 11,570 Btu/pound. The resultant 6.5 tons of clean coal will be processed through the mild gasification reactor at UNDEERC and returned to AMAX for screening and additional beneficiation using a magnetic separation technique.

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