MASTER

**Coal Technology Program
Progress Report for December 1977**

OAK RIDGE NATIONAL LABORATORY
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COAL TECHNOLOGY PROGRAM
PROGRESS REPORT FOR DECEMBER 1977

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COAL TECHNOLOGY PROGRAM PROGRESS REPORT FOR DECEMBER 1977

ABSTRACT

This report — the forty-first of a series — is a compendium of monthly progress reports for the ORNL research and development programs that are in support of the increased utilization of coal as a source of clean energy. The projects reported this month include those for coal conversion process development, materials engineering, alkali metal vapor topping cycles, a coal equipment test program, an AFB coal combustor for cogeneration (CCC), engineering and support studies, process and program assistance, environmental assessment studies, magnetic beneficiation, AFBC demonstration plant, and AFBC systems analysis and technology assessment.

1. SUMMARY

L. E. McNeese

Highlights of our progress in December are as follows:

- Cleanup and sampling for hydrocarbonization run HC-24 was completed. This run was made using Illinois No. 6 coal that had been treated with Na_2CO_3 . Analytical results from run HC-24 are in preparation. In addition, preparations are underway for the next run (HC-25) which will be made using Wyodak coal at 150 psig reactor pressure.

- In support of in situ gasification, block pyrolysis experiment BP2-41 was conducted at $0.3^\circ\text{C}/\text{min}$, reaching a maximum uniform block temperature of 600°C . This is the latest in a series of bituminous coal block pyrolysis experiments using an H_2 reactor purge gas. Significant H_2 consumption and high thermal efficiency were observed. A thermal efficiency for gas production of 42.4% was calculated.

In our pressure vessel and piping materials work, the report, *Assessment of Materials Technology for Gasifier and Reaction Pressure Vessels and Piping for Second Generation Commercial Coal Conversion Systems* (ORNL-5238), has been submitted for publication and distribution. Impact and tensile testing is underway on 2 1/4 cr-1 Mo steel which has received a simulated quench, temper, and postweld heat treatment.

Two topical reports on coating inspection have gone to reproduction. CoCrAlY material has been received and specimen production has been initiated. We are streamlining our methods for eddy-current design and have developed a new method for material characterization. A penetrant procedure for cermet coatings has been optimized and some interesting observations of

coating behavior were made during the tensile cracking of a cermet specimen.

In our welding and cladding program, experimental gas metal-arc weld-clad deposits of type 320 Cb stainless steel have been made on an intermediate layer of Inconel 82 (primary substrate material is steel). Several microfissures in the clad have been found, but none were revealed by dye penetrant. Submerged-arc clad deposits with Incoflux 6 have been made to alleviate the chromium and nickel depletion noted with "neutral" welding fluxes.

Metallographic and microprobe examination of tubes from the 1500-hr Fluidyne AFBC fireside corrosion test showed mild oxidation on both the I.D. and O.D., no indication of sulfidation attack, and very slight intergranular corrosion. Samples of spalled scale are being analyzed to determine whether some of the protective oxide had been removed from the metal, thereby exposing fresh metal and causing metal wastage. Two new composite 2 1/4 Cr-1 Mo/304 stainless steel tubes have been welded and measured and thermocouples attached. These tubes will be shipped to Fluidyne for evaluation during a preliminary shake-down run during January 1978.

Examination of various valve components and air distributor plates from operating plants is underway in our failure analysis work. Nondestructive evaluation of a lower head section from the Wilsonville, Alabama SRC dissolver tank has been conducted. No indications of radially extended cracks were found. However, an interesting indication that was found was a pattern of high-density inclusions having the appearance of circumferential wires. Efforts to interpret these indications are continuing and we are preparing sketches for destructive examination.

- In the gas-fired potassium boiler experiment, the new bubbler level indicator system, mentioned in last month's report, has been fabricated and installed. This system was required because a small potassium leak occurred at a point where liquid level indicator lines exit the boiler causing corrosion and subsequent breakage of the lead wires. Modification and reinstallation of the secondary containment are presently underway.

- In the Coal Equipment Test Program non-disclosure agreements have been reached with Memphis Light, Gas and Water Division for the U-Gas process information and with Illinois Coal Gasification Group (ICGG), Dravo Co. and Ralph Parsons Co. for COGAS process information. However, discussions are still in progress with COGAS Development Co., Allied Chemical Co., and Ford, Bacon and Davis Co. who are subcontractors to ICGG. In the absence of detailed process information from the demonstration plant contractors, "best estimate" flowsheets have been developed at ORNL and TRW to provide preliminary data for the study.

- Additional background information was obtained on the coal feeder systems recommended for further development by Jet Propulsion Laboratory. Conceptual design of a pilot-scale coal feeder test facility of about 5 T/hr capacity is planned.

- The request for proposal (RFP) and the performance specifications for the combustor in our AFB Coal Combustor for Cogeneration program have been revised in response to comments from DOE-FE. The preliminary market survey to be included with the RFP has been completed. This complete package will be forwarded to DOE-FE for final review in January. Work was begun on installing a coal feed splitter suitable for the AFB CCC in the fluidized bed cold flow model facility for testing.

- The first volume of the Synthetic Fuels Process Research Digest was published and distributed. Articles for the second issue are in progress.

- Technical and economic studies were completed on the study of effluent control technologies for hydrocarbon and carbon monoxide emissions from coal conversion plants. Results indicate that incineration in a coal-fired boiler is the least expensive method considered. A draft report is in progress.

- The Fossil Energy Environmental Project team reviewed the environmental monitoring program for the ICGG plant at the request of DOE. Comments were transmitted to the Corps of Engineers (Huntsville) who coordinated the review.

- A draft report was prepared for an AFBC Systems Analysis and Technology Assessment: Baseline Phase.

2. COAL CONVERSION PROCESS DEVELOPMENT

H. D. Cochran, Jr.

Coal conversion process development activities are carried out in the Chemical Technology Division. This section discusses hydrocarbonization studies in a 20-atm bench-scale facility, and engineering support studies for in situ gasification.

2.1 Hydrocarbonization Research

E. L. Youngblood, J. Beams, and J. C. Rose

2.1.1 Bench-Scale Hydrocarbonization

Work accomplished. In December we completed the cleanup and sampling for run HC-24 which was made using Illinois No. 6 coal that had been treated with Na_2CO_3 . Part of the analytical results from that run have been received and are presented below; however, we do not yet have all the data needed for material balance and yield determinations. Also, during the month we began preparation for future runs. Most of the coal feed has been prepared for the next run (HC-25) which is to be made using Wyodak coal at 150 psig reactor pressure. Run HC-25 will be made using approximately one half the operating pressure used in most previous runs and will provide data on the effect of pressure on yields. We have begun scouting tests to determine if ferric sulfate (the Meyers process) or some other simple treatment can be used to eliminate the caking tendencies of Illinois No. 6 coal without the use of an autoclave. These tests may be useful in determining conditions for preparing treated coal for future runs. The length of the plastic reactor mockup has been increased by 4 ft to study the flow characteristics of a longer reactor, and a section of 4 in. sched 80 pipe has been obtained for lengthening the reactor later in the year.

Analyses of the Illinois No. 6 coal before and after treatment with sodium carbonate for run HC-24 are given in Table 2.1.

As shown in the table only a small amount of the sulfur was removed by the treatment. The treated coal contained 2.9% (maf) sodium and had a higher ash and moisture content than the untreated coal.

The steady state concentration of the gas effluent for run HC-24 is given in Table 2.2. We are also including Tables 2.3 and 2.4 which give corrected values for the steady state gas effluent for run HC-23 and HC-21. Corrections were made to eliminate errors in the H_2S concentration caused by the erroneous use of H_2S calibration data. The corrections give a lower H_2 effluent flow rate which also results in small changes in the percent composition of other components.

Table 2.1. Analyses of Illinois No. 6 coal before and after treatment with sodium carbonate for run HC-24

	Illinois No. 6 coal (before treatment)	Illinois No. 6 coal (after treatment with Na ₂ CO ₃)
Moisture	2.2	4.2
Ash	12.2	16.8
Volatile matter	37.4	33.0
C (maf)	81.0	82.5
N (maf)	1.3	1.4
H (maf)	6.4	6.4
Total S (maf)	4.5	4.2
Organic S (maf)	3.2	3.1
Na (maf)	0.09	2.9

Table 2.2. HC-24 effluent gas composition at steady state
300 psig, 1060°F at 0745 on 11/29/77

Component	Effluent flow rate (scfm)	Composition (%)	H ₂ and N ₂ -free composition (%)
CH ₄	0.177	0.89	60.3
C ₂	0.044	0.22	15.0
C ₃	0.009	0.05	3.1
CO	0.043	0.22	14.7
CO ₂	0.009	0.045	3.1
H ₂ S	0.012	0.060	4.1
H ₂	19.630	98.37	--
N ₂	0.031	0.16	--

Work forecast. Preparations for the next hydrocarbonization run (HC-25) will continue. The run, which will be made using Wyodak coal at a hydrogen pressure of 150 psig, is scheduled to be made near the end of January.

Table 2.3. HC-23 effluent gas composition at steady state
300 psig^a, 1060°F at 1645 on 9/13/77

Component	Effluent flow rate (scfm)	Composition (%)	H ₂ and N ₂ -free composition (%)
CH ₄	0.101	0.52	59.9
C ₂	0.032	0.16	16.6
C ₃	0.003	0.02	2.1
CO	0.047	0.24	24.9
CO ₂	0.004	0.02	2.1
H ₂ S ^b	0.001	0.005	0.5
H ₂	18.505	95.49	--
N ₂	0.687	3.54	--

^aSystem was at 280 psig for part of the experiment. For this condition steady state effluent gas composition was not appreciably different from the above at 300 psig.

^bNear low limit of sensitivity; accuracy questionable.

Table 2.4. HC-21 effluent gas composition at steady state
300 psig^a, 1035°F at 0500 on 7/13/77

Component	Effluent flow rate (scfm)	Composition (%)	H ₂ and N ₂ -free composition (%)
CH ₄	0.193	1.57	49.9
C ₂	0.045	0.37	11.6
C ₃	0.017	0.14	4.4
CO	0.089	0.72	23.0
CO ₂	0.041	0.33	10.6
H ₂ S ^b	0.002	0.02	0.5
H ₂	11.887	96.60	--
N ₂	0.032	0.26	--

^aSystem pressure was 260 psig for part of the experiment. For this condition steady state effluent gas composition was not appreciably different from the above at 300 psig.

^bNear low limit of sensitivity; accuracy questionable.

2.2 Experimental Engineering Support of In Situ Gasification Processes

P. R. Westmoreland, L. S. Dickerson, and R. L. Andrews

Appropriate pyrolysis data are needed for modeling of in situ coal gasification (underground coal gasification). Earlier data described the pyrolysis of powder samples. By contrast, in situ gasification may react large blocks formed by roof collapse or seam fracturing, or possibly it may react a broad seam cross-section. Heat and mass transfer resistances can potentially affect product yields from block pyrolysis compared to powder pyrolysis.

In experiments which began at ORNL in 1975, 6-in.-diam (16 cm) right circular cylinders of subbituminous and bituminous coal have been pyrolyzed by heating the blocks at 0.3-14 C°/min (surface temperature) from ambient temperature to maximum temperatures of 500-1000°C. Using an argon or hydrogen purge gas, gas and vapor-phase reaction products are continuously swept from the reactor. Water, oils, and tars are collected in a water-cooled condenser and by filters, and the remaining noncondensable gases are metered and periodically sampled. In many of the experiments, block temperature profiles have been measured by internal thermocouples. These tests are designed to support modeling of field in situ gasification experiments at Laramie Energy Research Center, Lawrence Livermore Laboratory, and Morgantown Energy Research Center (MERC).

Effects of heat and mass transfer resistances have been observed in both subbituminous and bituminous coal block pyrolysis. Pyrolysis at 3 C°/min of naturally moist subbituminous blocks produced more gas (especially H₂ and CO) than pyrolysis of powders, dried blocks, or blocks heated at 0.3 C°/min. This increase evidently is caused by self-gasification of the blocks' hot outer surface as H₂O from the damp, shrinking core diffuses outward. In bituminous coal, swelling is decreased and more light hydrocarbons are produced from blocks pyrolyzed at 3 C°/min as compared to 0.3 C°/min pyrolysis. Such differences may result from differences in plasticity distributions within the block.

2.2.1 Recent Experiments

Block pyrolysis experiment BP2-41 was conducted in December at 0.3 C°/min, reaching a maximum uniform block temperature of 600°C. This experiment was the latest in a series of bituminous coal block pyrolysis experiments which have used an H₂ reactor purge gas. Because of the H₂ purge, some effects on gas composition were expected. In addition, any effects of the H₂ purge on amounts or characteristics of tars produced are important. Conditions for these H₂ purged experiments to date are summarized in Table 2.5.

Significant H₂ consumption and high thermal efficiency were observed in experiment BP2-41, as shown in Table 2.6, a summary of BP2-41 gas

Table 2.5. Summary of experimental conditions for bituminous coal
pyrolysis experiments using a hydrogen cover gas

Run number	Date of run	Heating rate (C°/min)	Maximum temperature (°C)	H ₂ cover gas flow rate (Std. liter/min)	Coal block ^a			
					Dimensions (cm)		Weight	
					Height	Diameter	(kg)	(kg maf)
BP2-33	8/13/77	3	600 (640)	2.90	24.0	15.7	6.133	5.810
BP2-34	8/31/77	3	1000	2.95	17.8	15.2	4.564	4.323
BP2-35	9/21/77	3	800	2.95	21.9	15.2	5.384	5.100
BP2-37	10/17/77	3	900 (880)	3.08	18.4	15.1	4.217	3.995
BP2-38	10/31/77	14	900 (890)	2.90	19.7	15.4	4.658	4.413
BP2-39	11/14/77	0.3	900 (925)	3.00	22.5	14.9	5.000	4.737
BP2-41	12/15/77	0.3	600	3.00	21.3	13.5	4.820	4.566

^aCoal blocks were all Pittsburgh seam coal which will be gasified in Morgantown Energy Research Center field tests.

Table 2.6. Summary of gas data from experiment BP2-41
(bituminous coal block pyrolysis to 600°C at 0.3 C°/min, H₂ purge gas)

	Total	H ₂	CH ₄	C ₂ 's	C ₃ 's	CO	CO ₂	H ₂ S
Gas in — H ₂ cover gas (std. liters)	6750	6750	--	--	--	--	--	--
Gas out (std. liters)	6722 ^a 6770 ^b	6312	253.0	45.4	16.88	15.23	12.66	24.2
Net gas from experiment								
Volumetric (std. liters)	~0	-438	253.0	45.4	16.88	15.23	12.66	24.2
Normalized (std. l/kg)	~0	-95.8	55.3	9.93	3.69	3.33	2.77	5.29
Mass (g)	~0	-39.4	181.2	60.0	32.7	19.04	24.9	36.8
Normalized (g/kg maf)	~0	-8.62	39.6	13.13	7.16	4.17	5.44	8.06
Average gas composition (vol %)		93.7	3.75	0.67	0.25	0.23	0.19	0.36
(H ₂ , Ar-free vol %)		--	68.9	12.4	4.60	4.14	3.45	6.59
Elemental composition of gas (g, net)								
Carbon	226.5							
Hydrogen	25.2							
Sulfur	34.6							
Oxygen	29.0							
Gas efficiency (Btu in product gas vs Btu in coal and in consumed H ₂)	42.4%							

^a Integration of flows calculated at 30 min intervals; includes N₂ and residual Ar.

^b Wet test meter total flow recorded at end of run; includes N₂ and residual Ar.

data. Overall, 8.6 g H₂ were consumed per kg of moisture-and-ash-free coal, or 96 std l/kg maf. By comparing combustible heating value of gases produced during the experiment to heating value of the reactants (coal and consumed H₂), a thermal efficiency for gas production of 42.4% was calculated.

As has been observed in previous experiments, more swelling of the block occurred in this pyrolysis at 0.3 C°/min than at higher heating rates. Vertically (along the cylinder axis), up to 25% elongation of the original block was observed. Horizontally (radially from the axis), swelling ranged from 30% at the top of the block to 50% around the bottom half; 50% radial expansion corresponds to the constraint of swelling against the reactor wall.

2.2.2 Bituminous Coal Condensibles and Char Yields

Gross yields of condensible pyrolysis products and of char have been tabulated for comparison (Tables 2.7 and 2.8). Significantly, use of H₂ purge gas was observed to decrease the yield of condensibles and to increase the yield of char in comparison to results with an inert purge gas. Condensibles consist of tars, oils, water (produced by drying or by reaction), and water-soluble organic compounds. Since only 8-9 g H₂O/kg maf coal is present as moisture in the original coal block, less than 7% of the total condensibles would be attributed to drying of the coal. Table 2.9 presents results concerning the effects of H₂, heating rate, and temperature on the yield of condensibles. For a given maximum temperature and heating rate, yield of condensibles in H₂-purged experiments was lower than in Ar-purged experiments. Increasing the reactor heating rate also apparently decreases the yield of condensibles, but effects of increasing the maximum pyrolysis temperature are not clear.

Char yields from Tables 2.7 and 2.8 are similarly compared in Table 2.10. Char yields are reported in g/kg maf coal. While this includes ash content of the char (moisture content is zero), such units permit evaluation of qualitative pyrolysis effects on char yield. Most data confirm that in block pyrolysis, as in powder pyrolysis, char yield decreases with increasing temperature. In Ar-purged experiments, char yield decreased at all temperatures as heating rate increased from 0.3 to 3 C°/min; however, in H₂-purged experiments increases in char yield with increased heating rate were observed at 600 and 900°C. Char yields in H₂ were higher than yields in Ar in each set of comparable 3 C°/min experiments.

2.2.3 Department of Energy In Situ Gasification Program

A technology review paper, "In Situ Gasification: Recovery of Otherwise Inaccessible Coal Reserves," by P. R. Westmoreland, R. C. Forrester III, and A. P. Sikri, was presented on December 7 at the Miami International Conference on Alternative Energy Sources, Fountainbleau Hotel, Miami Beach, Florida. This paper will be submitted for publication in the conference proceedings during January.

Table 2.7. Yield of condensibles and char from pyrolysis of bituminous coal blocks with Ar purge

Experiment	Reactor heating rate (C° min)	Maximum reactor temperature (°C)	Condensibles yield		Char yield	
			(g)	(g/kg maf coal)	(g)	(g/kg maf coal)
BP2-28	0.3	600	762	196.4	3183	820
BP2-31	0.3	800	626.9	160.3	2770	708
BP2-23 ^a	0.3	1000	598	181.8	2372	721
BP2-26	0.3	1000	756	173.8	3235	744
BP2-30	0.3	1000	823	178.9	3237	704
BP2-27	3	600	535	160.5	2410	723
BP2-25	3	800	752	156.0	3335	692
BP2-24	3	1000	542	140.1	2346	606
BP2-32	3	1000	629	164.2	2624	684
BP2-29 ^b	6.1, 1.9	800	686	150.4	3375	740

^aCoal block was dried in Ar before heating.

^bRan 85 min at 6.1 C°/min, then 90 min at 1.9 C°/min.

Table 2.8. Yield of condensibles and char from pyrolysis of bituminous coal blocks with H₂ purge

Experiment	Reactor heating rate (C° min)	Maximum reactor temperature (°C)	Condensibles yield		Char yield	
			(g)	(g/kg maf coal)	(g)	(g/kg maf coal)
BP2-41	0.3	600	705.0	154.4	3357	735
BP2-39	0.3	900	775.6	163.7	3149	665
BP2-33	3	640	884.1	152.2	4483	772
BP2-35	3	800	674.2	132.2	3812	747
BP2-37	3	900	564.6	141.3	2820	706
BP2-34	3	1000	637.6	147.5	3213	743
BP2-38	14	900	575.2	130.3	3104	703

Table 2.9. Yield of condensibles from pyrolysis of bituminous coal blocks
(g condensibles/kg maf coal)

Maximum temperature (°C)	Purge gas	Reactor heating rate (C°/min)		
		0.3	3	14
600	Ar	196	161	--
	H ₂	154	152	--
800	Ar	160	156	--
	H ₂	--	132	--
900	Ar	--	--	--
	H ₂	164	141	130
1000	Ar	176	152	--
	H ₂	--	148	--

Table 2.10. Char yield from pyrolysis of bituminous coal blocks
(g char/kg maf coal)

Maximum temperature (°C)	Purge gas	Reactor heating rate (C°/min)		
		0.3	3	14
600	Ar	820	723	--
	H ₂	735	772	--
800	Ar	780	692	--
	H ₂	--	747	--
900	Ar	--	--	--
	H ₂	665	706	703
1000	Ar	724	646	--
	H ₂	--	743	--

A. P. Sikri (DOE Division of Oil, Gas, Shale, and In Situ Technology) visited ORNL on December 9. Details of the block pyrolysis experiment and data were presented, and recent conversations with J. W. Martin of MERC were reviewed. W. C. Ulrich also participated in the meeting, describing recent ORNL work on engineering evaluations of in situ gasification.

T. F. Edgar of the University of Texas at Austin and W. E. Michalke of ALCOA (Rockdale, Texas) have helped provide blocks of Texas lignite

for future pyrolysis tests. The lignite should be shipped to ORNL during January.

2.2.4 Work Forecast

During January, bituminous coal block pyrolysis experiments will continue. Experiments at 0.3 C°/min to 800° and 1000°C are planned. In addition, analysis of recent gas data will be emphasized.

3. MATERIALS ENGINEERING

R. T. King

The materials engineering and associated technology reported here are in support of activities directed by the Materials Branch of the Division of Coal Conversion, DOE, in the Fossil Energy Program. Other related work not funded directly by this division of DOE/FE is included also.

Summary

The report, *Assessment of Materials Technology for Gasifier and Reaction Pressure Vessels and Piping for Second Generation Commercial Coal Conversion Systems* (ORNL-5238), has been submitted for publication and distribution. Impact and tensile testing is underway on 2 1/4 Cr-1 Mo steel which has received a simulated quench, temper, and postweld heat treatment.

Two topical reports on coating inspection have gone to reproduction. CoCrAlY material has been received and specimen production has been initiated. We are streamlining our methods for eddy-current design and have developed a new method for material characterization. A penetrant procedure for cermet coatings has been optimized and some interesting observations of coating behavior were made during the tensile cracking of a cermet specimen.

Experimental gas metal-arc weld-clad deposits of type 320 Cb stainless steel have been made on an intermediate layer of Inconel 82 (primary substrate material is steel). Several microfissures in the clad have been found, but none were revealed by dye-penetrant. Submerged-arc clad deposits with Incoflux 6 have been made to alleviate the chromium and nickel depletion noted with "neutral" welding fluxes.

Metallographic and microprobe examination of tubes from the 1500-hr Fluidyne AFBC test showed mild oxidation on both the I.D. and O.D., no indication of sulfidation attack, and very slight intergranular corrosion. Samples of spalled scale are being analyzed to determine whether some of the protective oxide had been removed from the metal, thereby exposing fresh metal and causing metal wastage. Two new composite 2 1/4 Cr-1 Mo/304 stainless steel tubes have been welded and measured and thermocouples attached. These tubes will be shipped to Fluidyne for evaluation during a preliminary shake-down run during January 1978.

Examination of various valve components and air distributor plates from operating plants is underway. Nondestructive evaluation of a lower head section from the Wilsonville, Alabama SRC dissolver tank has been conducted. No indications of radially extended cracks were found. However, an interesting indication that was found was a pattern of high-density inclusions having the appearance of circumferential wires.

Efforts to interpret these indications are continuing and we are preparing sketches for destructive examination.

3.1 Pressure Vessel and Piping Materials

D. A. Canonico and T. N. Jones

The report, *Assessment of Materials Technology for Gasifier and Reaction Pressure Vessels and Piping for Second Generation Commercial Coal Conversion Systems* (ORNL-5238), has received a final author editing to include revisions of figures and the manuscript has been submitted for formal publication and distribution.

Further Charpy V-notch (C_V) and tensile testing is being conducted on 2 1/4 Cr-1 Mo steel which has received a simulated quench (re-austenitized at 1900°F), temper and post-weld heat treatment in the DATA-TRAK.

3.2 Inspection Techniques for Wear- and Process-Resistant Coatings

R. W. McClung and G. W. Scott

3.2.1 Review and Evaluation (G. W. Scott)

Two reports have been reviewed and have been submitted for reproduction:

- a. ORNL/TM-6176 — *An Arc Discharge System for Nondestructive Detection of Flaws in Thin Ceramic Coatings*
- b. ORNL/TM-6210 — *Nondestructive Inspection of Thin Plasma-Sprayed Ceramic and Cermets Protective Coatings for Coal Conversion and Utilization Equipment*

Abstracts of these reports are included as an Appendix.

3.2.2 Specimens and Standards (G. W. Scott and D. P. Edmonds)

CoCrAlY spray powder has been received and preparation of an experimental free-layer specimen was initiated. We expect some delay in specimen preparation because of the extended absence of a key technician in the Welding and Brazing Laboratory.

3.2.3 Eddy-Current Testing (G. W. Scott and C. V. Dodd)

We are transferring our reflection-coil computer programs from the existing laboratory-wide time-sharing (PDP-10-based) computer system to

a dedicated (Mod-Comp IV-based) system in the NDT Laboratory. Initiation of design calculations for this project will be delayed somewhat by the move. Effects of this delay are likely to be offset by improved access to and increased speed of the dedicated system.

We are writing a new through-transmission program for use in characterizing free-layer specimens. The associated measurement scheme will use measurements at two frequencies to compute resistivity and permeability. The computations will be self-correcting for the effects of lift-off or coil spacing and specimen thickness.

3.2.4 Surface Inspection Materials (S. D. Snyder)

The process for detection of cracks in cermet-coated specimens with post-emulsified fluorescent penetrant by the penetrant reversal method has been optimized. This procedure is as follows:

1. Apply penetrant with a dwell time of 20 min.
2. Strip-wash with a warm (26°C) water spray for 4 min $\pm$ 1 min.
3. Dry with forced air.
4. Emulsify for 4 min $\pm$ 1 min.
5. Dry with forced air.
6. Visual observation should be done immediately after the final dry.

It was also observed that an ultra-high-sensitivity penetrant such as Magnaflux Corporation ZL-20A produces slightly better contrast than the ZL-22A penetrant because of its higher retentive and fluorescence response characteristics.

A redesigned tensile-crack specimen having a minimum throat width of 1.6 cm (5/8 in.) and a throat radius of curvature of 9.6 cm (3 3/4 in.) was coated with a 0.25 mm (0.010 in.) thick layer of 50% ZrO₂ - 50% NiCrAl on a IN-800 substrate. This specimen was subjected to tensile loading to 22.5 kN (5000 lb). The coating surface was observed at 3x magnification during the entire cycle of tensile loading and unloading and no cracks were seen at anytime. However, during the removal of the specimen from the tensile machine holding fixtures, cracks developed across the throat over a length of about 3 cm (1 3/16 in.) in the center portion of the specimen throat. An explanation of the mechanism that produced these cracks will be postponed until consultation with mechanical properties experts can be arranged.

3.3 Fossil Energy Welding and Cladding Program

D. P. Edmonds, J. J. Woodhouse, and J. D. Hudson

We are investigating the effects of welding conditions on soundness and corrosion resistance of type 320 Cb stainless steel cladding deposits. We have performed metallographic analyses of gas metal-arc (GMA) deposits which were made using an intermediate layer of Inconel 82. Dye-penetrant examination of the surfaces had previously revealed no fissuring in these deposits. However, metallographic evaluation revealed fissures in several of them. None of these fissures had propagated to the clad surface. Additional metallographic and chemical analyses are being performed to determine the exact nature of this cracking.

Chemical analyses revealed significant chromium and nickel depletion in submerged-arc (SA) clad deposits made with "neutral" stainless steel welding fluxes. Therefore several deposits have been made using Incoflux 6, which is a more highly alloyed flux commonly used with high nickel alloys. Deposits were made with 4 mm (0.16 in.) diam type 320 Cb wire using voltages around 40 V and currents ranging from 400 to 600 A-dcsp (direct current straight polarity). Dilutions from the base metal of less than 15% were obtained for several of these deposits. Dye-penetrant examination revealed no cracking on the clad surfaces. Metallographic and chemical analyses are presently being performed.

3.4 Fireside Corrosion of Atmospheric-Fluidized-Bed Combustor Tubes

T. G. Godfrey and J. H. DeVan

Metallographic and microprobe examination of the three most important specimen tubes from the 1500-hr test in the AFBC at Fluidyne is continuing. The materials involved are 310 and 316 stainless steel, Incoloy 800, and Alonized 310 and 800. Cross sections show mild oxidation on both the I.D. and O.D., no indication of sulfidation attack, and very slight intergranular corrosion. The Alonized samples show complete failure of the outer layer (which was highly porous at the start of test), but an encouraging solidarity of the diffusion zone.

As noted previously, a significant fraction of the outermost scale spalled soon after the tubes were removed from the AFBC at Fluidyne. Samples of the spalled scale are being analyzed to determine whether some of the protective oxide was simultaneously removed, thereby exposing fresh metal and causing metal wastage. Metallographic examination is not conclusive on this point since one cannot be certain whether or not cracks in the oxide layer were caused by the scale or by the metallographic mounting epoxy.

All tube-wall measurements on the two new 2 1/4 Cr-1 Mo/304 stainless steel composite low temperature (510°C, 950°F) tubes have been completed, the tube sections have been welded together, and the sheathed

thermocouples have been weld-brazed in the tube walls. These tubes will be shipped to Fluidyne for evaluation during a preliminary shake-down run during January 1978. If they prove to be satisfactory, four similar new tubes will be prepared together with eight new high-temperature (870°C, 1600°F) tubes for inclusion in the forthcoming 3000-hr test in the AFBC.

3.5 Failure Analysis and Prevention

R. T. King

3.5.1 Valve and Air Distributor Components (R. T. King)

Examination of a failed valve and a failed valve spring from the hydrogen compressor at the Tacoma, Washington SRC plant was started. Examination of the air distributor plates from the atmospheric fluidized combustors at Rivesville, West Virginia and Alexandria, Virginia continued.

3.5.2 Inspection Assistance to SRC, Wilsonville, Alabama (G. W. Scott and B. E. Foster)

The "old" lower head section from the SRC dissolver tank has been radiographed. Available source energies and intensities dictated the use of an Iridium-192 source located on the cylindrical axis of the part with film placed on the O.D. [21.6 cm (8.5 in.) radius]. We were able to achieve 1-2T image quality, but resolution was poor because of the high geometric unsharpness factor [largest source dimension 3 mm (.12 in.)].

No indications of radially-extended cracks with either axial or circumferential orientation were found. However, it is unlikely that the exposure geometry would have allowed imaging of even favorably-oriented tight cracks.

The most interesting indication found was a pattern of high-density inclusions having the appearance of circumferential wires. These indications are regularly spaced in the axial direction with separation of approximately 5 cm (2 in.) and individual widths (or diameters) of approximately 6 mm (.25 in.) (as measured on the film). These indications did not appear on test radiographs where the film was placed on the I.D. and the source outside the part. Therefore, they seem to originate from some artifact near the O.D. of the part. We are attempting to contact SRC personnel to see if they have any background data on the fabrication of the vessel which may assist the interpretation of these indications.

We are preparing sketches for sawing the head section into segments for metallography, mechanical properties, and the ultrasonic calibration block requested by SRC.

APPENDIX

(Abstracts Referenced in Section 3.2.1)

1. G. W. Scott and E. V. Davis, *An Arc-Discharge System for Nondestructive Detection of Flaws in Thin Ceramic Coatings*, ORNL/TM-6176, in publication.

The feasibility of nondestructively detecting small cracks or holes in plasma-sprayed ceramic coatings with an electric arc-discharge system was studied. We inspected ZrO_2 coatings 0.46 mm (0.018 in.) thick on Incoloy alloy 800 substrates. Cracks were artificially induced in controlled areas of the specimens by straining the substrates in tension. We designed and built a system to scan the specimen surface at approximately 50 μm (0.002 in.) clearance with a sharp-pointed metal-tipped probe at high dc potential. The system measures the arc currents occurring at flaws or plots a map of the scanned area showing points where the arc current exceeds a preset threshold. A theoretical model of the probe-specimen circuit shows constant dc potential to be the best choice for arc-discharge inspection of insulating coatings. Experimental observations and analysis of the data disclosed some potential for flaw description.

2. G. W. Scott, et al., *Nondestructive Inspection of Thin Plasma-Sprayed Ceramic and Cermet Protective Coatings for Coal Conversion and Utilization Equipment*, ORNL/TM-6210, in publication.

This report described the results of a project to develop nondestructive inspection techniques for ceramic and cermet wear- and process-resistant coatings used in coal system components. The general inspection problem has been analyzed, and the difficulties peculiar to plasma-sprayed coatings are discussed. Physical properties, especially porosity, and the nominal 0.25 mm (0.010 in.) thickness make the inspection of these coatings difficult. The literature has been reviewed for inspection methods and technology adaptable to coating inspection. Several inspection methods have been evaluated for feasibility by laboratory experiments. The basic coating defect conditions considered are cracks or holes, variations in thickness, lamellar separations, and inhomogeneities. Materials examined were ceramics and cermets. Assessment of current technology indicates that a few NDT methods can be applied directly to the inspection of coatings with very little development; in most cases, however, considerable development is required.

4. ALKALI METAL VAPOR TOPPING CYCLES

R. S. Holcomb

4.1 Gas-Fired Potassium Boiler

R. S. Holcomb, D. B. Lloyd, and R. H. Guymon

4.1.1 Contract Objective

Design, construction, and testing of a full-scale potassium boiler tube bundle and burner module on water and then potassium to determine the performance and operating characteristics.

4.1.2 Status Summary

1. The argon bubbler tubes to be used to obtain the potassium liquid level have been fabricated and installed in the boiler drum. A cap was welded over the cutoff indicator sheath tubes to seal the area where the potassium leak occurred.

2. A differential pressure transmitter has been installed, calibrated and connected to the argon bubbler level indicator system.

3. Electric heaters and thermocouples have been installed on the argon bubbler tubing. The thermal insulation has been reinstalled, and the system will be ready for operation when installation of the secondary containment is completed.

4.1.3 Plans for Next Month

The secondary containment on the potassium liquid return line will be reinstalled, and shakedown testing of the system will be resumed. If the shakedown test is successfully completed, performance tests will be initiated.

4.1.4 Technical Progress

The bubbler level indicator system, mentioned in last month's report, has been fabricated and installed. Argon lines have been run from the control room and connected to the system. A differential pressure transmitter has also been installed, calibrated, and connected to the system. Several new heaters and thermocouples have been installed on the new piping and connected appropriately in the control room. The thermal insulation has been replaced, and modification and reinstallation of the secondary containment are presently underway.

Prior to installation of the combined level bubbler tube-thermowell, the level element sheaths and the old thermowell were flushed with a dilute (10%) solution of nitric acid and flushed with distilled water and then alcohol in an effort to remove any remaining potassium oxide or potassium hydroxide from the system. These were then dried out by evacuating them for several days. When the pressure reached 15 torr, the furnace preheater temperature was set at 400°F and evacuation was continued for an additional 24 hours.

5. COAL EQUIPMENT TEST PROGRAM

J. M. Holmes and R. E. MacPherson

Work under the Coal Equipment Test Program (CETP) is currently divided into two sections:

- Critical Equipment for Demonstration Plants
- Coal Feeder Test Program

5.1 Critical Equipment for Demonstration Plants

J. M. Holmes, D. E. Reagan, J. W. Wells, and H. F. Hartman

Negotiations continued with two DOE Demonstration Plant contractors and their subcontractors concerning nondisclosure agreements for use by TRW in the ORNL CETP study. Agreements have been reached with Memphis Light Gas & Water Division for the U-Gas process information and with Illinois Coal Gasification Group (ICGG), Dravo Company, and Ralph Parsons Company for COGAS process information. However, negotiations are still in progress with COGAS Development Company, Allied Chemical Company, and Ford, Bacon & Davis, who are subcontractors to ICGG. The information required will not be available from ICGG until these agreements are reached. The Union Carbide Corporation Legal Department is proceeding with these negotiations.

In the absence of detailed process information from the demonstration plant contractors, "best estimate" flowsheets have been developed at ORNL and TRW to provide preliminary data for the study. ORNL has prepared a set of COGAS flowsheets developed from information available in the literature. The flowsheets identify the major equipment, piping, process conditions and instrumentation for seven areas of the plant. These flowsheets include (in addition to the overall block flow diagram):

- Coal Preparation
- Pyrolysis and Gasification
- Product Recovery
- Compression and Gas Purification
- CO Combustion, Heat and Power Recovery
- SO₂ Removal

A flowsheet for the shift, methanation, and CO removal areas is currently in preparation. An overall material balance for the coal capacity of the demonstration plant has been prepared.

Results of this material balance are being used to define the process flows and compositions for approximately 30 items that have been identified as potential critical equipment in the COGAS process. This material balance information is being utilized by TRW to prepare questionnaires for equipment vendors.

Flowsheets for the U-Gas process have been prepared by TRW and are being used in the same manner as the COGAS flowsheets.

The identification of potential sites for installation and testing of critical components has been initiated by TRW. DOE has identified seven government installations for consideration, and contacts are underway to obtain information about the capabilities that presently exist at these sites. In addition, other sites, including several coal conversion pilot plants, are under consideration.

5.2 Coal Feeder Test Program

J. M. Holmes, B. T. Thompson, and H. F. Hartman

ORNL is undertaking a program for testing coal feeders currently under development by DOE. Jet Propulsion Laboratory (JPL), the coordinator for DOE feeder development, has recommended five feeders for testing.

Additional background information was obtained and reviewed on the feeder systems recommended for further development by the Jet Propulsion Laboratory. This review is directed toward the conceptual design of a pilot-scale feeder test facility of about 5 T/hr coal capacity. A December 1 and 2 visit was made to the Foster-Miller Company in Waltham, Massachusetts, to review progress on their feeder development program (performed under DOE contract) and to meet with representatives of JPL.

A visit to JPL is planned for January to review work of the three feeder developers — Foster-Miller, Ingersoll Rand, and Lockheed. Feeder test facility criteria and pilot feeder delivery times are topics to be included in the discussions. A list of additional information required for the detailed design of a feeder test was forwarded to JPL for discussion at the meeting.

Additional review was done on coal feeder requirements associated with gasification processes. Gasifier pressure and temperature, coal size (lump, crushed, pulverized) and moisture were the requirements of most interest. Several sources of process data were reviewed. Coal feed requirements will be compared with the anticipated operating capabilities of the recommended coal feeders.

6. ATMOSPHERIC FLUIDIZED BED COAL COMBUSTOR FOR COGENERATION (AFB CCC)

R. S. Holcomb

The request for proposal and the performance specifications for the combustor have been revised as requested by DOE at a meeting in Washington on November 28. The abbreviated assessment study and market survey to be included with the request for proposal has been completed and is ready for internal review. The complete package should be ready before January 15 and will be sent to DOE-FE for final review at that time.

Work on the application assessment study is continuing. Additional sources of data on industrial energy use will be reviewed and compiled for the study. Additional examples of process applications will be done for the petroleum, chemical, and food industries. It is planned to complete the sections of the study on industrial energy use and analysis of typical process applications by the end of January. Work has begun on the conceptual design of CCC systems for industrial applications. This work will be completed in February as the last phase of the study.

The layout drawings for installation of the system in Building 9731 have been completed. The layout indicates that there is very ample space for the system in the building. The only area of concern that has been brought to attention is that the present roll-up doors in the building are only 12 ft wide, and one of these might have to be removed and the opening enlarged in the event that the combustor design selected for the test has any parts that are too large to pass through the present doors. One alternative would be to fabricate the largest parts of the combustor in sections that would go through the door opening and assemble the sections inside the building. Another alternative is to cut an opening in the roof and set the combustor parts into the building through the opening with a mobile crane. A roof opening and/or a penthouse may be required anyway for combustor designs that are very tall.

The system layout drawings will be reviewed and revisions made where the layout can be improved.

6.1 Supplemental Studies

Work was begun this month on installing the coal feed system in the fluidized bed cold flow model test facility. The limestone was removed from the bed, and the reference design coal feed nozzles were installed in the distributor plate. The existing coal feed lines in the lower air plenum that had not been in use were uncapped at the point where they had been terminated at the plenum housing, and the limestone that had settled in them from earlier test runs was removed from them. Installation of the components of the coal feed system is in progress.

Metallographic examination of samples from the tubes run in the 1000-hr corrosion test has continued. The results appear to be very similar to those obtained in the 500 hr test. The thickness of the oxide layer is about the same for both tests, and the depth of intergranular attack in Incoloy 800 is also about the same. These results are encouraging in that they indicate that the oxidation attack does not progress with time, but that the oxide layer formed early in the exposure tends to be protective. Likewise, the intergranular attack of the Incoloy 800 does not appear to continue to penetrate with time, but extends only to a depth of about 0.0015 in. as was found in the 500 hr test. The examination is continuing, and precise optical measurement of the sound metal wall thickness will be made as well as microprobe scans to determine the relative elemental composition of the corrosion layer and in the intergranular attack zone in the Incoloy 800.

7. ENGINEERING STUDIES AND TECHNICAL SUPPORT

J. R. McWherter

Engineering studies and technical support are provided primarily for the DOE/FE Division of Coal Conversion. The effort includes: the development of analytical tools for use in the evaluation of processes and equipment; the technical and economic evaluation and comparison of coal conversion processes and subprocesses on a uniform basis; surveys of the need for coal conversion equipment and the capability of industry to provide such equipment; and studies of the magnitude and control of coal conversion plant emissions.

7.1 Process Modeling

R. Salmon, D. M. Lister, O. L. Culberson, and D. Sellinger

7.1.1 Contract Objective

The objective is to assist DOE/FE in its plan for computer analysis and computer support for coal conversion studies. This includes assistance to Purdue and Lehigh Universities in the development of computer programs for this plan. Physical property data are being collected and computerized primarily by Purdue and will be used in support of programs prepared by both universities. Purdue's general design program will aim at material and energy balances, equipment size and costing, plant capacity, and general economics. Lehigh's dynamic simulation programs will address plant design primarily from the standpoint of process performance during transient operations, but can also be used for steady-state conditions. A single flowsheet will be selected to assess the operability and complementary utility of both design programs.

7.1.2 Status Summary

Work on the HDC heat exchanger design and cost program continued. An external flange design routine was written and was used to design flanges with diameters ranging from 8 to 120 in. and with pressure ratings ranging from 150 to 2500 psi. The results were incorporated into HDC as a sub-routine which calculates flange dimensions as a function of diameter, design pressure, and flange type. The materials of construction data array has been expanded from 5 to 40 alloys. Work is continuing on the collection of current materials costs for this array.

Work continued on the editing of the Purdue material balance and physical properties routines for compilation on the Fortran compiler used by the ORNL IBM-360 system. The initial phase of this work has been completed, and the second phase is under way. About 75% of the routines have been copied into the master file of the editing routine and work has commenced on the conversion process.

7.2 Synthetic Fuels Process Research Digest

F. M. O'Hara, Jr. and R. W. Glass

7.2.1 Contract Objective

The objective is to provide continuing technical assistance to DOE/FE by preparing digest reviews of current or potential subjects relating to coal conversion technology.

7.2.2 Status Summary

The first volume of the Digest was published and distributed. Articles contained in the first volume are: (1) Coal Gasification with Chemically Incorporated Catalysts, (2) Flash Hydropyrolysis of Coal, (3) Zinc Chloride Hydrocracking of Coal and Coal Extracts, and (4) Conversion of Methanol to High Octane Gasoline.

Articles for the second issue are progressing as follows: The article on the Consol Synthetic Fuel Process is awaiting final in-house review. The article on SRC-II has been largely rewritten and requires only polishing to complete the draft. A history of the development of the chemistry that underlies the CSF, SRC, and Fischer-Tropsch processes was researched and written as an introduction to the SRC-II article. The material will also serve as introductory matter for the entire second issue of the Digest. Research on the Fischer-Tropsch process is continuing.

7.3 Survey of Industrial Coal Conversion Equipment Capabilities

W. R. Williams, W. F. Boudreau, W. A. Bush,
W. R. Gambill, J. R. Horton, J. P. Meyer, and W. R. Reed

7.3.1 Contract Objective

The objective of this project is to conduct surveys of industrial equipment capabilities that will identify the present ability of industry to supply the equipment needed. The project will also determine research and development needs, including lead time requirements, for producing equipment of advanced design for the various unit operations of critical importance to the Division of Coal Conversion (CC) programs.

7.3.2 Status Summary

The additional tasks requested by T. K. Lau of DOE/FE-CC on November 29 were incorporated into a revised work statement which also reflects shifted priorities. Changes to the budget and schedule distribution within the project were also made.

All DOE comments on the FY 1977 draft reports have been received and are now being incorporated. These reports should be ready for editing before the end of January.

Eight coal conversion pilot plants have been tentatively selected to be contacted concerning their experience in operating coal conversion equipment. Methods for presenting equipment costs are being reviewed prior to requesting such information from manufacturers.

All tasks planned for FY 1978 are to be initiated by early January. These tasks include availability surveys of let-down valves, mechanical connectors and expansion joints, surveys of equipment costs and of equipment development programs, and a survey of equipment operating experience in coal conversion pilot plants. A review of the availability of equipment for the DOE demonstration plants is to be made based on the results of the FY 1977 surveys.

7.3.3 Problem Areas

Proprietary information restrictions on demonstration plant designs may hinder equipment availability reviews. Attempts to gain access to the necessary information are being coordinated with several other ORNL projects also needing access to design information.

7.3.4 Open Items

Approval of the FY 1978 work statement.

7.4 Flash Hydropyrolysis

S. P. N. Singh

7.4.1 Contract Objective

The objectives are to perform a preliminary technical and economic assessment of the Cities Service and the Schroeder-Spencer Chemical Company flash hydropyrolysis processes and to determine whether a more detailed engineering evaluation is justified.

7.4.2 Status Summary

A draft final report titled "Scoping Study on Two Flash Hydropyrolysis Processes" was completed in September and forwarded to DOE for review and comment. The report gives the results of technical and economic evaluations of the Cities Service and Schroeder-Spencer Chemical Company flash hydropyrolysis processes.

Comments received from DOE on the draft report have been reviewed and appropriate revisions have been made. The revised version of the draft report is being internally reviewed. Following this review, the report will be sent to DOE for final approval prior to publication.

7.5 Hot Gas Purification Processes

M. S. Edwards and J. P. Meyer

7.5.1 Contract Objective

The objective of this project is to investigate the present state-of-the-art hot gas cleanup processes. The application of most interest is the removal of contaminants from coal-derived fuel gas prior to firing combined cycle turbines.

In this work, a survey of the available and developmental processes for the removal at high temperature of various contaminant materials (particulate, sulfur, nitrogen, and alkali metal compounds) has been conducted. Based on the data obtained in this work, from a variety of sources, an analysis has been performed to evaluate the performance of a number of potential cleanup processes in light of the overall system needs.

7.5.2 Status Summary

A draft of the final report has been completed and is being circulated for internal ORNL review. The report, ORNL/TM-6178, is titled *A Survey of Processes for High Temperature-High Pressure Gas Purification*. It includes a review of the available systems for the removal of particulates and sulfur and nitrogen compounds to levels compatible with high temperature-high pressure turbine operation. It is expected that the draft report will be ready for transmittal to DOE by December 31, 1977.

7.6 State-of-the-Art Review of Heat Recovery Processes

W. R. Gambill and W. R. Reed

7.6.1 Contract Objective

The objective of this review is to survey, appraise, and catalog the processes for heat recovery which industry offers or plans to offer or may logically be expected to offer. These processes will be applicable to the recovery of heat in process streams from primary exothermic coal conversion and combustion process steps. Simple unaugmented application of conventional heat transfer equipment will not be included. The review will distinguish between presently installable technology, near term developable technology, and future prospects. Consideration will be given to possible transfer of technology from other industries.

7.6.2 Status Summary

Additional descriptive material was evaluated. Items included flue-gas heat recovery, behavior of heat-exchanger tubes in a fluidized bed combustor, dry cooling of hot coke, industrial heat pumping, laminar-flow heat transfer in industrial heat exchangers, ceramic thermal regenerators (heat wheels), heat-transfer fluids for high-temperature systems, and high-temperature heat-recovery steam generators and transfer line exchangers.

Preparation of the final (draft) report was essentially completed. This report describes our survey and appraisal of current and anticipated heat-recovery processes and associated equipment which should be applicable to the recovery of heat in process streams from primary exothermic coal conversion and combustion process steps.

7.7 Assessment of a Moving Bed System for Cleanup of Raw Gasifier Gas

R. W. Glass, W. R. Gambill, and R. H. Lamb*

7.7.1 Contract Objective

The objective is to evaluate the feasibility of a proposed moving bed system for removal of sulfur and particulates from raw gasifier gas.

The assessment considers two basic hot gas treatment systems, with each system specifically addressing sulfur and particulate removal. The reference system incorporates a panel filter for dust removal and fixed bed adsorber/regenerator units. The project system incorporates a moving bed filter/adsorber unit, with fluid bed regeneration of the recycled filter/adsorber media. Both systems produce high pressure steam (waste heat boiler) from the regeneration off-gases. The assessment includes simple equipment flowsheets and material balances for both systems, and comparative economics are developed.

7.7.2 Status Summary

A final project review will be held early next month with all prime participants to review the final draft report before publication. Comments collected to date have been incorporated and no substantive changes are anticipated.

* Consultant

7.8 Technical/Economic Assessment of Hydrogen Production by the Steam/Molten Iron Process

R. W. Glass and L. Seglin*

7.8.1 Contract Objective

The objective is to determine whether there is sufficient incentive to develop the subject process for production of hydrogen from coal. The project considers specifically the comparison of the subject process (a molten-iron/steam concept) to the more conventional concepts employed in the Koppers-Totzek and Bi-Gas processes. All three processes are considered as part of an overall integrated SRC-II system. Process flowsheets, system costs, and product distributions will be described for each case and comparative economics developed. A development program for bringing the molten-iron process to the state of commercial availability will be addressed.

7.8.2 Status Summary

A final project review will be held early next month with all prime participants to review the final draft report before publication. Comments collected to date have been incorporated and no substantive changes are anticipated.

7.9 A Study of Effluent Control Technologies for Hydrocarbon and Carbon Monoxide Emissions from Coal Conversion Plants

J. Fisher and G. R. Peterson

7.9.1 Contract Objective

The objective of this project is to provide a technical and economic comparison of processes available for the control of gaseous hydrocarbon (HC) and carbon monoxide (CO) emissions. The Lurgi gasification process is considered as the reference emission source, and comparisons of control technologies consider incineration as the reference control system.

7.9.2 Status Summary

Technical and economic studies were completed and the results were transmitted to DOE in draft form on December 20, 1977. The results indicate that incineration in a coal-fired boiler is the least expensive of the methods considered.

* Consultant

Preparation of a draft final report has begun. It is expected that the draft will be ready for DOE review by the end of February 1978.

7.10 Environmental Controls for Low-Btu Gasification

S. P. N. Singh, M. S. Edwards, G. R. Peterson,
J. F. Fisher and R. Salmon

7.10.1 Contract Objective

The objective of this project is to evaluate the various environmental control processes that might be used in connection with low-Btu gasification facilities. This includes considerations of economic trade-offs for various processes and levels of control.

7.10.2 Status Summary

A meeting was held with DOE/ESP representatives on December 7, 1977, in Washington, D.C., to present to them the results of Phase I of the study. Phase I consists of Tasks 1 through 4 of the work statement, and covers the preparation of a detailed work plan and the selection of gasification processes and environmental control processes for use in the study. Plans for the completion of Phase II were also presented at the above meeting. Phase II consists of Tasks 6 through 8 in the work statement, and covers the collection and analysis of technical and economic data on the various environmental control processes and the preparation and analysis of flowsheets showing overall systems of environmental control processes used with various gasifiers.

At DOE/ESP's suggestion, we have reviewed potential waste water treatment processes with the objective of selecting four additional processes. These four additional waste water treatment processes will be used to compensate for a reduction of four effluent gas treating processes. This action is being taken to provide a better balance in the overall effluent controls for low-Btu gasification processes.

Four coals have tentatively been selected as a basis for the low-Btu gasification evaluation. A fifth coal (a Texas lignite from the Wilcox formation) is proposed to be added to the list as soon as an analysis can be obtained.

7.10.3 Changes

For Task 8, DOE/ESP requested that we consider whether three gasification processes with three environmental control schemes for each would provide more useful information than four gasification processes with two environmental control schemes each. This is presently under review.

7.10.4 Open Items

We have not yet received written approval from DOE/ESP to proceed with Phase II of the study. The project work statement required DOE consent to proceed with Phase II. Verbal approval was given at the December 7 meeting and written confirmation was to follow.

7.11 Support of the Office of Initial Operations (OIO)

B. Niemann, T. W. Pickel, J. F. Fisher,
H. F. Hartman, and W. R. Reed

7.11.1 Contract Objectives

The objectives of this project are: (1) to perform rapid reaction reviews and analyses of documents provided by DOE on Coal Conversion Demonstration Plant projects with appropriate follow-up as requested; (2) to conduct requested evaluations in the areas of start-up, safety, environmental protection, maintainability, and reliability; and (3) to develop guidelines for the preparation of safety, operation, and maintenance manuals.

7.11.2 Status Summary

No reviews of design documents were requested during the reporting period. The Support Team is continuing the effort of preparation and of establishing the methodology for the rapid review responses.

7.11.3 Problem Areas

Efforts by UCC-ND Legal Department are underway to execute the necessary agreements to allow appropriate personnel to receive proprietary information relevant to the documents to be reviewed. Effective accomplishment of the task assignments will depend heavily on securing all available source material.

8. PROCESS AND PROGRAM ANALYSIS

J. R. McWherter

Process and program analysis studies are being conducted for the DOE Fossil Energy Office of Program Planning and Analysis. This effort includes research studies on most of the coal conversion and utilization processes. The program objective is to provide, on a consistent basis, technical and economic evaluations of competing processes and systems for coal conversion and utilization.

8.1 Low-Btu Coal Gasification

H. F. Hartman and J. P. Belk

8.1.1 Contract Objectives

The objectives of this study are to survey the low-Btu coal gasification processes, select the most promising processes, and provide technical and economic information on the competing processes.

8.1.2 Status Summary

Additional comments on the September 1977 draft report were received and reviewed. A majority of the reviews of 14 briefly described processes were received from the process proponents. Reviews have now been received from 17 of the 21 representatives of processes that were described in more detail in the report's process data section. Requests were again made to the remaining four process representatives who have not yet submitted their comments. The reviews and comments will be used in preparing the second draft of the report.

8.2 Direct Combustion

E. C. Fox and T. D. Anderson

8.2.1 Contract Objectives

The purpose of this study program is to assist DOE/FE in their effort to develop a national strategy to increase the near-term use of coal through direct combustion; the applications of interest in this study are the small-to-moderate industrial user and the large residential/commercial user. The following objectives will be accomplished:

1. Identify and quantify the important factors restricting the use of coal in the sectors of interest.
2. Evaluate potential technological and institutional solutions to the problems identified in (1) above.

3. Make recommendations to DOE/FE relative to the most promising approaches for increasing the near-term use of coal.

8.2.2 Status Summary

A considerable amount of effort has been spent accumulating data on energy transport technology to be used for evaluation of the central steam generation and coal depot concepts. Pipeline costs are being developed for central steam distribution systems. These costs are being formulated in a building block manner so that various system configurations can be costed and specific regional sites can be modeled.

Additionally, two specific coal distribution systems are being investigated in conjunction with the area coal depot. These are pneumatic and hydraulic coal pipelines which would transport the coal from a central processing depot to the user's site. The delivery systems will be compared to rail and truck distribution and the overall concepts to the on-site systems developed earlier in this project.

8.3 Advanced Power Conversion Systems

G. Samuels and A. P. Fraas^{*}

8.3.1 Contract Objective

The objectives of this project are to review selected major advanced power conversion systems and to assess these systems with respect to their basic R&D status.

8.3.2 Status Summary

Twelve draft reports have been prepared and distributed widely for comment. They are currently undergoing review and revision based on comments and additional input from reviews.

8.4 In Situ Coal Gasification

W. C. Ulrich and M. S. Edwards

8.4.1 Contract Objective

The objective of this program is to provide technical and economic evaluations of candidate processes for the conversion of coal in situ to fluid products presently of interest. During FY 1977, technical and economic evaluations of the linked vertical well process applied to sub-bituminous coal were addressed. Three alternative end product configurations were considered — electricity, SNG, and syngas.

^{*} Consultant

8.4.2 Status Summary

Based on comments from DOE/FE representatives in November, a revised work statement for FY 1978 in situ evaluations was prepared. The revision emphasizes the detailed design of an in situ facility for producing gasoline from methanol via the Mobil-M process. The revised work statement was transmitted to DOE on December 9, 1977.

Contacts have been made with many of the organizations involved with methanol production and the Mobil-M process, particularly those under DOE contract. Mobil Research and Development, Badger Company, Davy Powergas, American Lurgi, Imperial Chemical Industries, and United Catalysts, Inc., are among those contacted for information and assistance.

Mobil R&D will complete a conceptual design report on gasoline from coal in the near future under DOE/FE contract. DOE/FE was contacted to request a copy of this report as soon as it becomes available. In the interim, Mobil will supply ORNL a copy of the design package which was provided to Badger and R. M. Parsons for other evaluations of the Mobil-M process.

Badger Company will provide ORNL with the most recent quarterly reports on their ongoing evaluation of methanol from coal, expanded to include the Mobil-M process.

A preliminary overall flowsheet has been established to allow the determination of an approximate energy balance. When the energy balance has been estimated, the appropriate split of raw gas can be made between fuel gas requirements and process feedstock. The approximate energy requirements of various plants in the facility are now being determined.

8.4.3 Open Items

External review of the draft evaluation report, *Process Designs and Economic Evaluations for the Linked Vertical Well In Situ Coal Gasification Process* (ORNL-5341), is continuing. The report represents the culmination of our FY 1977 in situ coal gasification analyses studies. The report describes three conceptual plants designed for utilizing gas produced from a linked vertical well in situ coal gasification process and gives results of economic evaluations based on the designs. Final preparation will be concluded following receipt of DOE comments.

8.5 Coal Beneficiation

S. P. N. Singh and G. R. Peterson

8.5.1 Contract Objective

The objective of this study is to provide technical and economic evaluations of currently used and potential coal beneficiation processes,

8.5.2 Status Summary

Project efforts culminated in a draft final report titled *Survey and Evaluation of Current and Potential Coal Beneficiation Processes* (ORNL/TM-5953) which was completed in October and forwarded to DOE for review and comments. The report summarizes the technical evaluations of currently used and several novel coal beneficiation techniques.

Comments received from DOE on the draft of the final report have been studied. A meeting with DOE representatives will be arranged to resolve the comments in preparation for the final publication of the report.

8.6 Gas Cleanup Studies

M. S. Edwards

8.6.1 Contract Objective

The objective of the gas cleanup study is to collect information on the technology and economics of processes for the removal of impurities (principally hydrogen sulfide) from fuel gas streams. High- and low-temperature cleanup processes will be reviewed.

8.6.2 Status Summary

We are awaiting comments on the draft report ORNL/TM-6077, *Selection of Candidate H₂S-Removal Processes Applied to Low-Btu Coal Gas*, which was sent to the Department of Energy on October 3, 1977. The report gives detailed process descriptions and cost data for seven methods of removing H₂S from a low-Btu coal-derived gas: MDEA, Bentiold, Scleroxol, Sulfinol, Stretford, MERC Iron Oxide, and Molecular Sieve. Each of these processes was selected as representing a particular category of gas treating.

8.7 HYGAS Modeling

J. P. Meyer, G. C. Frazier, J. W. Wells, and J. P. Belk

8.7.1 Contract Objective

The objective of this project is to develop a computer model of the HYGAS gasifier.

8.7.2 Status Summary

Efforts are being devoted to developing a reaction kinetics gasification model applicable to the temperature and pressure range of the HYGAS gasifier. Literature reviews are in progress with emphasis on identifying the underlying assumptions and restrictions implicit in the current gasification models; the extent to which these models may or may not be applicable to the HYGAS conditions can then be evaluated.

Initial emphasis has been placed on the development of a computer program for the IGT gasifier model. A preliminary plan for the calculation has been developed and implementation efforts are currently underway.

Using available information, analysis of the HYGAS process has been undertaken. As a result of this work, the HYGAS reactor will initially be modeled as a series of linked fluidized beds which operate at constant temperature and exhibit ideal behavior.

It will be assumed that each stage is in thermal equilibrium and that kinetically only the steam-carbon reaction is rate controlling. This simple model will serve as a basis for future refinements which will offer greater levels of sophistication and complexity.

By developing a simple model, the basic structure of the overall program will be established and problems concerning the mathematical selection of independent variables to assure numerical convergence can be resolved.

8.7.3 Problem Areas

It is important that we obtain operating data and other information on the HYGAS process from Scientific Design as soon as possible. A letter indicating the types of data needed was sent to DOE on November 28, 1977.

8.7.4 Open Items

Authorization for ORNL to discuss the project with Scientific Design and to visit the HYGAS pilot plant was requested during a meeting with DOE representatives on November 22, 1977.

8.8 Liquefaction

J. R. McWherter

8.8.1 Contract Objective

The objective of this project is to provide technical and economic evaluation of coal conversion liquefaction processes. Ralph M. Parsons Company is working under subcontract on the project with J. B. O'Hara as Project Manager. Major tasks included in the subcontract are: (1) a Survey of Liquefaction Processes, and (2) a Detailed Review of High Potential Liquefaction Processes.

8.8.2 Status Summary

Task 1. The preliminary report (Data Source Book) was completed for internal review prior to publication. This report summarizes the characteristics of 32 liquefaction processes reviewed during the screening survey.

Task 2. The fixed capital investment estimates were completed for four of the five high potential processes selected; estimates for the CSF process are not yet complete. The Fischer-Tropsch process cost estimate was revised to reflect zero power import/export. Economic analyses were performed for the H-Coal and Mobil-M processes and the revised Fischer-Tropsch process. Process flow diagrams were completed for all of the high potential processes except the CSF process, which is being prepared.

8.9 High Btu Gas

J. R. McWherter

8.9.1 Contract Objective

This subprogram is being analyzed under subcontract by the Scientific Design Company, Incorporated (SD) with A. S. West as Project Manager. The present work is divided into three phases as follows:

1. The objective of Phase I is to provide technical and economic evaluations of competing processes, concepts and systems for the production of high Btu gas from coal.
2. The objective of Phase II is to monitor and analyze data from the HYGAS Pilot Plant.
3. The objective of Phase III is to perform a technical and economical evaluation of the Battelle Agglomerating Ash Burner Process for the production of medium Btu fuel gas, synthesis gas and hydrogen from coal.

8.9.2 Status Summary

Phase I. A report was completed on the Battelle Agglomerating Ash Burner Process Evaluation for the production of high Btu gas.

Phase II. SD engineers continue to monitor the operation of the HYGAS Pilot Plant in Chicago. The Test No. 67 debriefing meeting was held on December 8, 1977, and was attended by SD. The startup of Test No. 68 was repeatedly delayed because of problems in completing maintenance work, a number of steam leaks, and adverse weather conditions. Test No. 68 was initiated on December 29, 1977.

Phase III. Work continues to firm up the design basis for the fuel gas case. On December 8, 1977, SD met with L. M. Joseph of DOE/FE to discuss and review the status of the design basis for the Battelle Evaluation. SD has had numerous telephone conversations with Battelle.

8.10 Comparative Cost Estimates of Five Coal Utilization Processes

J. R. McWherter

8.10.1 Contract Objective

The objective of this study is to determine consistent investment costs for four different coal utilization processes plus a conventional coal-fired power plant. The study will consider a high sulfur bituminous coal, such as an Illinois No. 6 used for a 500 MW power plant. Of the four coal conversion processes, two will consider scrubbing sulfur from the flue gases, the third will consider atmospheric fluidized bed combustion with simultaneous entrainment of sulfur by injection of lime, and the fourth will consider a coal beneficiation process coupled with flue gas scrubbing. This study is being conducted under subcontract by Chem Systems, Inc., with L. H. Weiss as Project Manager.

8.10.2 Status Summary

The cost estimates for the five processes are being completed. The period of the contract is being extended to permit completion of the required report of this work.

9. FOSSIL ENERGY ENVIRONMENTAL PROJECT

C. R. Boston

9.1 Stored Solids Study

W. J. Boegly, Jr.

One 55-gallon drum of Bi-Gas waste was received during the month, along with a 55-gallon drum of the feed coal used during the run. This may be the first representative sample from this pilot plant during a continuous operation. Negotiations continue with the Cogas and Slagging Lurgi operators in England and Scotland about obtaining 36 55-gallon drums of their waste as soon as possible (request for at least one drum of each was made first priority). ORNL now has samples of Hygas, CO₂ Acceptor, Westinghouse-Walz Mills, and a limited amount of Slagging Lurgi waste on hand. Hygas and Slagging Lurgi are being given highest priority due to the absence of Cogas solid waste. If and when Cogas waste is received it will be added to the priority listing.

A request for preliminary estimates for the cost of lysimeters received no replies. Thus a purchase order has been issued to determine if any company is interested in supplying this order at a fixed price. Apparently most companies are not willing to indicate in advance whether they will bid, and will not provide rough estimates of cost. Until the lysimeters are available, smaller 55-gallon stainless steel drums will be used for studies to determine the characteristics of leachate from coal storage piles. These lysimeters may not be of great value for computer modeling studies, but will allow the collection of fairly large quantities of leachate.

The review of available literature on coal pile leachate has been completed and is currently undergoing internal review for its publication as an ORNL/TM report. A quarterly report has been drafted and is undergoing review and editing prior to submission to DOE.

9.2 Environmental Monitoring Handbook

S. G. DeCicco

On December 15, Radian mailed their "Environmental Characterization Plan Development for Demo Coal Conversion Facilities" to ORNL for inclusion in the Operational Monitoring chapter of the Handbook.

The section was well written, but a difference in emphasis made it unsuitable for direct inclusion in the Handbook. A meeting is scheduled for January 12, 1978, with Stan Dzierlinga of Radian to do the necessary editing. Radian has estimated that their section can be edited and returned to ORNL by the end of January 1978. Except for parts of the groundwater monitoring sections, all ORNL sections went out for full review and are expected to be returned to the editor by January 11, 1978.

When Radian's approved, final draft is submitted, an additional four weeks will be necessary for publishing, resulting in a projected completion date of February 28, 1978.

9.3 Technical Assistance

9.3.1 Interaction with Demonstration Plant Contractors (S. G. DeCicco)

At the request of Jim Malcolm (DOE) on December 1, 1977, the FEEP team reviewed all sections of the environmental monitoring program for the ICGG plant. The Corps of Engineers (COE), Huntsville, coordinated the review. On December 6 and 7 we transmitted our comments to Haven Johnson, COE. The sections reviewed included surface water quality, terrestrial ecology, aquatic ecology, and air quality/meteorology. Socioeconomics, groundwater hydrology/quality, and erosion/sedimentation were not included in the package for review.

Gibbs and Hill submitted some autumnal terrestrial sampling data for our inspection, and discussed preliminary results of the groundwater program over the telephone.

In a telephone conversation with Ed Berkey (WESD) on December 21, ORNL's comments to their expanded monitoring program of October 27 were discussed.

9.3.2 Other Activities

Reviews are now complete for the first document prepared by FEEP, "Environmental Inclusions in Requests for Proposals (RFP's)," Draft, December 1976. David Jones (DOE) would like to reference this document in Program Opportunity Notices (PON's) as well as RFP's and, therefore, would like to see it finalized and assigned an ORNL document number. Since only minor changes are necessary, the final document should be completed in January.

9.4 Carryover Activities from FY 1977

9.4.1 Environmental and Health Aspects of Disposal of Solid Wastes from Coal Conversion: An Information Assessment (H. M. Braunstein)

This document is receiving final in-house review and is now scheduled to go to the printer on February 15, 1978. The original target date was missed because the required in-depth review was not completed on schedule and because of higher priority assignments.

9.4.2 American Chemical Society (ACS) Symposium Paper: "Studies for Design of a Solid Waste Management Program" (H. M. Braunstein)

This paper is to be coauthored by H. T. Jones, DOE, H. M. Braunstein, and W. J. Boegly, Jr., and presented at the 175th National American Chemical Society Symposium, Anaheim, California, March 12-17, 1978. Considerable effort was expended on this highest priority task. The fourth and final draft was sent to the ACS on December 23, 1978. Copies were sent to David Jones (for delivery to H. T. Jones) on that same date.

10. MAGNETIC BENEFICIATION OF DRY PULVERIZED COAL

D. M. Eissenberg, E. C. Hise, and M. D. Silverman

This program was initiated during FY 1977, using Advanced Power Systems Program Development funds.

10.1 Objective

The objective of this project is to develop and demonstrate a novel process for coal beneficiation by magnetic separation of pyrites and ash from dry pulverized coal.

10.2 Status Summary

10.2.1. A comparative study of the potential of magnetic versus heavy media separation of high sulfur eastern steam coals (using a Frantz Isodynamic separator and a float-sink separator) is nearing completion of its first phase. Fractions of three Eastern coals separated by each method and then refractionated by the other method have been analyzed for Btu content, total and pyritic sulfur and ash. The results are currently being analyzed in order to determine whether there are differences in the separability by each method which could lead to an advantage of one over the other or of a combined separation system.

10.2.2. A feasibility study of magnetic separation of dry pulverized coal in a high gradient magnetic separator (HGMS) system has been completed at Auburn University under subcontract to ORNL. The experiments, in which several eastern coals were separated in a batch-wise mode by fluidization within the HGMS, yielded separations of pyrite and ash and Btu recovery of cleaned coal which were attractive commercially compared to results obtained by heavy media or froth flotation separation of similar coals. A patent disclosure for this process is being prepared.

10.3 Plans for Next Month

The preliminary magnetic separability study currently in progress will be completed and a draft report prepared. This is an evaluation of magnetic separability for three coals including Lower Kittanning, Illinois No. 6, and Upper Freeport.

A final report of the Auburn University feasibility study will be completed and issued.

A review of coal handling requirements and flexibilities of pulverized coal (PC) fired boilers will be conducted in order to determine how best to integrate the proposed dry PC magnetic separator system in existing boilers with minimum retrofit.

Experimental plans for the remainder of FY 1978 and for FY 1979 and 1980 are being prepared and will be submitted to the Division of Solid Fuels, Mining and Preparation.

11. ATMOSPHERIC FLUIDIZED BED COMBUSTION DEMONSTRATION PLANT

C. B. Smith and J. E. Jones Jr.

11.1 Demonstration Plant Management Support

11.1.1 Project Status

This project is proceeding on a low level pending resolution of technical and economic issues that have been raised by the Office of Management and Budget (OMB). The proposed New Source Performance Standards of the Environmental Protection Agency and the recent commercial-scale plant cost estimates have caused concerns of the economic potential of AFBC for utility-size plants. ORNL has been asked to assist Fossil Energy in resolving these issues.

11.1.2 Program Opportunity Notice (PON) Preparation

No additional work is being done on the PON pending resolution of the project status.

11.1.3 Support Studies

Technical support studies are devoted to obtaining AFBC process data, in conjunction with the Technology Assessment task activities, and using this data to develop proposal evaluation techniques. This data is being used in development of computer codes for rapid evaluation of technical data in proposals. The computer code for energy and mass balance calculations on the combustion side of the boiler is essentially complete with some minor format changes remaining to be completed. Work has started on the code for heat transfer surface calculations. Preliminary use of the codes has involved analyzing the boiler designs that are being submitted to TVA in the Demonstration Plant studies.

Several project members attended the Fifth International Conference on Fluidized Bed Combustion held in Washington, D.C., on December 12-14, 1977.

11.2 Technology Assessment

M. Siman-Tov, H. D. Cochran, T. G. Godfrey,
R. E. Kuhlman, M. E. Lackey, and G. Samuels

The technology assessment activities were slowed down this month to assist with the preparation of a report entitled *Systems Assessment of Atmospheric Fluidized Bed Combustion: Baseline Study*. During this month:

1. The literature search effort has been almost completed and an "AFBC Library" was established. A complete indexed list of documents with abstracts has been prepared and can be retrieved through a computerized system.

2. A comprehensive list of current AFBC projects and test facilities was prepared outlining their scope, activities and issues being investigated.

3. A listing and a preliminary discussion of major problems in AFBC activities has been initiated.

4. The team has participated in the "Fifth International Conference on Fluidized Bed Combustion" in Washington, D.C., during December 12-14, 1977.

12. ATMOSPHERIC FLUIDIZED BED COMBUSTION SYSTEMS ANALYSIS AND TECHNOLOGY ASSESSMENT

J. E. Jones Jr., L. E. McNeese, G. Samuels, H. D. Cochran,
T. G. Godfrey, and R. E. Kuhlmann

12.1 Objectives

Early in December 1977 ORNL was asked by DOE to undertake a systems analysis and technology assessment of the entire atmospheric fluidized bed combustion (AFBC) technology program with specific emphasis on market potential, comparative economics, technical issues, and impact of environmental control requirements.

The assessment is to be completed in three phases: (1) base-line phase, (2) execution phase, and (3) follow-on phase. The base-line phase is short-term phase addressed to the identification of the major issues and questions regarding AFBC, survey of available literature, and work plan proposal for the execution phase. The execution phase provides detailed analyses and discussion of the AFBC systems analysis and technology assessment. The scope for the subsequent follow-on phase will be defined in the first three months of the execution phase. This project will evaluate the state-of-the-art in AFBC, assess the technology in the light of emerging environmental guidelines and competing systems, and identify R&D needs.

12.2 Results

A team of scientists and engineers from various divisions of ORNL and UCC-ND Engineering was formed. The principal areas for the base-line phase were assigned to the various team members to obtain most efficient usage of the limited time for developing the report.

The major issues and questions regarding AFBC were developed by the team through discussion and review of the specific areas of emphasis; market potential, comparative economics, technical issues, and impact of environmental control requirements.

The literature survey and review was obtained through the use of RECON, the Coal Technology library, and input from MITRE Corporation. The bibliography was reviewed by the team members and 16 key documents were selected for the base-line report. A more complete listing is to be included in the execution phase of this study.

The listing of current AFBC projects and test facilities and the issues addressed by each was accomplished through the use of Fossil Energy Program reports, individual contacts, and industrial surveys. The listing is an initial attempt and will be thoroughly revised and updated to provide a complete listing and description to be included in the final execution phase report.

The work plan for the execution phase during the next six months was detailed and an outline and schedule for the final report were presented.

The above activities were part of the base-line phase of this study which were performed during December and culminated in a draft report (ORNL/TM-6208) on December 30, 1977.

The draft report contained the major issues and questions regarding AFBC systems. It provided a plan for evaluation of the market potential of AFBC, economics relative to competitive systems, the impact of environmental control requirements, and major technical issues.

12.3 Future Work

No future work is anticipated. Portions of the proposed work will be conducted through existing Fossil Energy contracts with MITRE, Gilbert Associates, Burns and Roe, and Stone and Webster. A comprehensive AFBC Systems Analysis and Technology Assessment, as proposed in the ORNL report, will not be pursued at this time.

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- 167-178. ERDA Pittsburgh Energy Research Center, U.S. Energy Research
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- 179-184. The Director, Morgantown Energy Research Center, P.O. Box 800,
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- 185. Tetra Tech, Inc., 1911 N. Ft. Myer Drive, Suite 601, Arlington,
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- 186. Cameron Engineers, Attn: Gary L. Baughman, 1315 South
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