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**Fossil Energy Program
Progress Report for June 1980**

L. E. McNeese

**OPERATED BY
UNION CARBIDE CORPORATION
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DEPARTMENT OF ENERGY**

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FOSSIL ENERGY PROGRAM
PROGRESS REPORT FOR JUNE 1980

L. E. McNeese
Program Director

Date Published: August 1980

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
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FOSSIL ENERGY PROGRAM REPORT FOR JUNE 1980

ABSTRACT

This report - the seventy-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 and other fossil fuel alternatives to oil and gas as sources of clean energy. The projects reported this month include those for coal conversion development, chemical research and development, materials technology, component and process evaluation studies, technical support to major liquefaction projects, process analysis and engineering evaluation, fossil energy environmental analysis, coal preparation and waste utilization, coal preparation plant automation, atmospheric fluidized bed coal combustor for cogeneration, TVA fluidized combustion demonstration plant program technical support, coal cogeneration/district heating plant assessment, performance assurance system support, and international energy technology assessment.

1. Summary

L. E. McNeese

Coal conversion development - A series of pipeline viscometer differential pressure measurements are being made by varying the slurry temperature while the feed rate is held constant. During the month the first rheological characterization run was made with 35 wt % Kentucky No. 9 coal in Wilsonville recycle solvent. The run was made at a slurry feed rate of 0.987 g/s and 13.9 MPa pressure. The results obtained with the Kentucky No. 9 slurry is similar to those obtained with Illinois No. 6 slurry except the magnitude of the gelation peak was substantially higher for the Kentucky No. 9 slurry. The system is being prepared to perform rheological characterization measurements on H-coal PDU reactor effluent samples next month.

In studies of the reaction of coal with phenol, lowering the phenol/Wyodak ratio from 10/1 to 2/1 at the same density reduced the conversion from 79% to 56% when the temperature and reaction time was held constant at 454°C for 15 minutes. Examination of past data indicated that a temperature increase at this density would further increase conversion. An initial run with 10 parts 1,4 dihydroxy benzene to one part Wyodak at 454°C for 15 minutes produced 87% product which passed through a fine precipitate filter when washed with ethanol. The pyridine solubility and 1,4 dihydroxy

benzene uptake is being determined. Adding organo-sulfur compounds to coal before nitric acid oxidation did not significantly improve conversions.

Chemical research and development - Liquid phase thermolysis of 1,3-diphenylpropane at 365°C is more rapid than that of 1,2-diphenylethane (bibenzyl) even though its weakest C-C bond is considerably stronger. This anomaly occurs because the energetics of β -scission of free radicals are favorable only in the former case and allow long chain reactions to occur. Passage of 1-butene in hydrogen over a carburized Fe Fischer-Tropsch catalyst gave 1-2% chain growth to C₅ and C₆ hydrocarbons in the *absence* of added CO.

Materials technology - The investigation of fracture toughness and hydrogen attack of pressure vessel steels was continued. Efforts this month concentrated on the testing of a 305-mm-thick weldment supplied by Chicago Bridge and Iron Company. In the task to develop weld overlay cladding techniques with type 320Cb stainless steel, specimens were prepared for testing in an SRC pilot plant. Efforts in the study of fireside corrosion of AFBC heat exchanger materials continued. The draft report on the 4500-h materials test in the FluidDyne AFBC is nearly complete. In the failure prevention and analysis task, tubing from the light ends column reboiler tube bundle at the Fort Lewis SRC Pilot Plant which experienced severe surface attack is being examined. The investigation of materials performance in liquefaction systems continued. These studies include general corrosion and stress-corrosion cracking in liquefaction environments, corrosion in the fractionation area of SRC plants, and the evaluation of materials proposed for the regeneration and condenser vessels of the Zinc Chloride Hydrocracking Process. In the task for development of modified 9 Cr-1 Mo steel, fabrication of the two 14-Mg heats procured previously into various product forms is proceeding without difficulty. Several long-term creep tests on these heats are continuing. In the ceramic recuperator task, a draft report was prepared on an earlier test in which candidate structural ceramic tubes were exposed to the products of combustion of No. 6 fuel oil at 1200°C for 500 h (CRAF Test 1). Preparations for a second test to expose these materials to the products of combustion of coal-oil mixtures are under way.

Technical support to major liquefaction projects - Oak Ridge National Laboratory and Union Carbide Nuclear Division Engineering provide technical support for the major liquefaction projects being managed by DOE Oak Ridge Operations--SRC-I and SRC-II demonstration plants and H-Coal pilot plant projects. Support is provided in seven broad areas--engineering and design review, technology overview, design data validation, components, materials, environmental and health, and general.

During June an in-depth review was initiated of the design basis and supporting data for the Kerr-McGee CSD process in the SRC-I project. Negotiations are continuing to place an ORNL technical representative on site at the H-Coal plant. Under subcontract, Battelle has initiated a scoping evaluation of wet grinding of coal slurried with recycle solvent. Modeling and experimental feasibility studies are underway on a packed-bed pressure letdown system. Investigations of corrosion in fractionation columns have indicated that a water wash may substantially reduce the corrosive nature of the liquids. The Draft Environmental Impact Statement for SRC-I has been submitted for DOE review prior to public release; the SRC-II Draft Environmental Impact Statement was released early in June, and public hearings were held at the end of the month. Based on earlier evaluations of the H-Coal reactor vessel for a planned two-year operating life, studies have been initiated to assess the vessel acceptability for a possible five-year operating life.

Process and program analysis - A study of environmental protection-related costs for synthesis of methanol and gasoline from coal has been initiated for the DOE Assistant Secretary for the Environment's Office of Technology Impacts. The work will examine the effect of varying degrees of stringency of environmental standards on the economics of the indirect liquefaction process at several plant capacities.

Fossil energy environmental analysis - In the Fossil Energy Environmental Project, review copies of the ICGG and CONOCO Draft EIS's were delivered to DOE for comments. The notice of availability of the Draft EIS for SRC-II was published in the Federal Register on June 2 and hearings were held in Morgantown, West Virginia, on June 30 - July 1.

In the ERA Support Project some delays have occurred due to delays in receipt of information from the utility. A task order for work related to the Northport powerplant on Long Island was received.

The third document in the NEPA Energy Project series was completed. Draft copies of the Tennessee, Ohio and West Virginia volumes of the Environmental Program Compliance Handbooks are nearing completion. The IH/OM Workshop has been rescheduled from August to October at the request of DOE.

Coal preparation and waste utilization - Mr. Ray Vititoe, of Powell Construction Co., presented an interim report on the comparative design study and cost estimate to representatives of ORNL and TVA.

A preliminary circular feed test series was performed with our superconducting magnet operating in the cusp mode. Further investigations were performed with the Frantz Isodynamic Magnetic Separator to find the settings which would achieve maximum separation of the free falling stream of coal.

General Dynamics is now seriously considering open-gradient magnetic separation as a commercial venture. A sample of Brazilian Candiota Coal has been supplied to us, through TVA, by the Companhia Estadual de Energia Electrica in Porto Alegre-Rs, Brazil. This coal contains 50 to 55% ash which makes combustion difficult and shipping prohibitive.

Coal preparation plant automation - The cross-correlator circuit being considered for application in the measurement of mass flow of coal has been fabricated and is undergoing bench testing. An oscillating-sphere viscometer has been received for test and evaluation. A list of operating principles of on-line analytical instruments currently in use or under development in coal-related industries has been prepared from information gathered in the literature survey. It was concluded from an analysis of the froth flotation unit process that this unit operation would be an attractive area for early on-site testing. A review of immediate instrument needs for on-site tests was conducted and recommendations for procurement were prepared. The development of basic mathematical descriptions of parts of the fines coal circuit continues and is about 50% complete. A survey of solid/liquid two-phase flow theory and practice has been completed and a summary of various coal cleaning performance criteria has been written. Work continued on building the data base on coal preparation and instrumentation document. One hundred and forty-three requests for documents, searches, and information were processed. Further review of appropriate systems and software packages for data acquisition equipment was done. Visits were made to one coal preparation plant and two plants which manufacture coal cleaning equipment.

Atmospheric fluidized bed coal combustor for cogeneration (AFBCCC) - The revised cost proposal from Babcock and Wilcox has been received by UCC-ND and Westinghouse for review. An initial planning meeting to discuss plans for work under the Letter of Intent was held at Westinghouse on June 10.

Tennessed Valley Authority (TVA) fluidized bed combustion (FBC) demonstration plant program technical support - In the AFBC modeling and simulation task work continued on the development of the freeboard model and the integration of the limestone-ash elutriation and attrition subcode, coal combustion subcode and the sulfur capture subcode. Modifications were made to the coal combustion subcode which included revising the computational scheme in the slow bubble regime.

In the AFBC bench scale facility task sulfur capture testing was continued during June with limestone from the Lower Fredonia quarry in Fredonia, Kentucky. Thirty-four hours of coal combustion were accumulated during the month. Data were obtained for a superficial velocity of 1.2 m/s (4 ft/s). The Lower Fredonia limestone performs as well as the best stones tested to date.

Nine of fifteen coal limestone feed test runs have been completed. So far we have learned:

- The presence of limestone prevents 8% moisture coal from sticking to the pipe walls and forming impact plugs.
- We are unable to feed 8% moisture coal at rates higher than about 680 kg/h (1500 lb/h) through the 6-in. rotary valve.
- At feed rates greater than 500 kg/h (1100 lb/h), the 8% moisture coal tends to stick in the rotary valve pockets.

In the muffle furnace tests, three 150-h runs at 900°C (1650°F) have been completed in the gas-metal apparatus covering a range of 10^{-8} to 10^{-21} atm P_{O_2} and 10^{-10} to 10^{-4} atm P_S . Examination of the samples, both uncoated and coated with calcium sulfate deposit, is under way. Preliminary observations indicate that sulfidation-oxidation corrosion has occurred with Alloy 600 showing extensive attack. Alloy 800 appears to be the next most attacked while the samples of types 304 and 310 stainless steel were least affected.

Fossil fuel applications assessments - A range of estimates for new emission limits for new industrial boilers has been formulated for use in the industrial applications assessment.

Contractual arrangements with Burns and Roe for the district heating turbine assessment are being finalized.

Performance assurance system support for fossil energy projects - Work on the failure mode and effects analysis (FMEA) for a generic slurry preheater has continued. The analysis of 25 slurry preheater components indicated 15 failures which are considered to be high risk. Technical assistance was provided for an audit of quality assurance activities at the H-Coal pilot plant.

International energy technology assessment - The Oak Ridge National Laboratory is supporting the Lawrence Livermore Laboratory in a broad program funded by the DOE Office of International Affairs. During the month of June a preliminary report on indirect liquefaction processes was completed and submitted for review. The primary emphasis of this report was on those employed in SASOL plants in South Africa. In the area of coal liquefaction materials, information classification is in process and a status review meeting was attended which provided an opportunity to extend our coordination arrangements. The international assessment of atmospheric fluidized bed combustion technology is under way for identifying and describing development work and application of AFBC systems in foreign countries. A literature search is in process, and a detailed questionnaire seeking specific information on projects, developmental activities and goals for the future has been sent to various organizations abroad. Also on file are trip reports covering visits of individuals to AFBC facilities in foreign countries in the past year. The status of the project was presented at the IETA project review meeting at Argonne National Laboratory on June 25-26, 1980.

2. COAL CONVERSION DEVELOPMENT

J. R. Hightower, Jr.

Coal conversion development activities are carried out in the Chemical Technology Division. This section discusses two projects conducted for the Office of Coal Processing -- Physical Properties of Coal Liquids and New Liquefaction Techniques.

2.1 Physical Properties of Coal Liquids

G. E. Oswald, E. L. Youngblood, M. R. Gibson, and L. S. Dickerson

The objective of this project is to measure and correlate physical properties (viscosity, density, thermal conductivity, and heat capacity) of various coal-solvent slurries and solids-free, coal-derived liquids at typical processing conditions, up to 31 MPa (4500 psig) hydrogen pressure and 810 K (1000°F) in a bench-scale, continuous flow system. This system includes a slurry preheater and a hydrogenation reactor to simulate processing conditions prior to physical property measurement. Immediately after physical property measurement, the test fluids will be quenched and sampled for chemical characterization. Physical properties will ultimately be correlated with chemical characteristics of the test liquid to provide information useful to designers.

Results of pipeline viscometer differential pressure measurements on 35 wt % Kentucky No. 9 coal slurry from 400 to 700 K at a constant slurry feed rate are presented. Proposed rheological characterization measurements on the H-Coal PDU reactor effluent sample are discussed.

2.1.1 Work accomplished

As outlined in the last quarterly report,¹ a series of runs are being made in which the slurry feed rate to the system will be held constant, and the slurry will be preheated with incremental increases in preheater discharge temperature. The heated slurry is passed directly through the pipeline viscometer located at the preheater exit. Viscometer temperature is controlled to match the preheater discharge temperature, and the viscometer differential pressure is recorded as a function of temperature from 400 to about 730 K. At each measurement temperature, the preheater is operated with constant heat flux along its length. If possible, this procedure will be repeated over the range of slurry feed rates possible with the positive displacement feed pump (~0.4 - 1.0 g/s). These measurements will characterize the flow behavior of slurry in the gelation region and will provide broad rheological characterization information on slurry outside of this area.

A constant slurry mass rate-variable temperature rheological characterization run was completed on 35 wt % Kentucky No. 9 coal (-170 mesh)/ Kentucky No. 9 Wilsonville recycle solvent slurry at 0.987 g/s slurry feed rate and 13.9 MPa (2000 psig) pressure. Results are presented in Figure 2.1 — a plot of viscometer differential pressure vs slurry temperature. Peak gelation was observed at 650 K; viscometer differential pressure was 6.7 kPa (27 in. H₂O). Minimum differential pressure on heat-up, 1.3 kPa (5.3 in. H₂O) was observed at 500 K. The shape of this curve is similar to those previously reported^{1,2,3} for slurries prepared with Illinois No. 6 coal; the temperatures at which peak gelation and minimum viscometer differential pressure occur are the same as for Illinois No. 6 coal slurry. However, for Kentucky No. 9 coal, the magnitude of the gelation peak is substantially greater than for Illinois No. 6 coal. The largest gelation peak observed for 35 wt % Illinois No. 6 coal slurry was 3.9 kPa at 650 K at 0.665 g/s slurry mass rate.¹ Allowing for the differences in mass flow rate through the viscometer, the peak gelation viscosity for Kentucky No. 9 coal slurry is roughly 70% greater than that observed for Illinois No. 6 coal slurry. This estimate does not take non-Newtonian flow behavior into account. Also, at temperatures outside of the gelation region (400 → 500 K and 700 K) viscometer differential pressure, corrected for differences in slurry mass flow rate, is higher than those observed for Illinois No. 6 coal slurry. Repetitive measurements will be made to confirm this behavior. Since the solvents used to make both slurry mixes have similar rheologies,^{1,3} the higher viscometer differential pressures observed for the Kentucky No. 9 coal slurry are probably due to differences in the two coals, both of which are high volatile bituminous. Particle distribution analyses are in progress on the Illinois No. 6 and Kentucky No. 9 ground coal used to make these slurries to see if there is any substantial difference which would explain the increase in viscometer differential pressure. As mentioned in the last monthly report,³ the Wilsonville recycle solvent used to prepare the Illinois No. 6 coal slurry was derived from Indiana No. 5 coal and the solvent used to prepare the Kentucky No. 9 slurry was derived from Kentucky No. 9 coal. The differences in the ultimate analyses and boiling range for these solvents are small. For comparison, these analyses will be included in the next quarterly report. No hydrogen donor capacity tests have been performed on these solvents.

2.1.2 Future work

The Coal Liquids Flow System has been modified to perform rheological characterization measurements on the H-Coal PDU reactor effluent sample. In preparation for measurements, the sample will be removed from the bomb (7 liter capacity) by heating the surface of the bomb until its contents become molten (350 - 425 K) and then applying helium overpressure to force the material from the bomb. The material will be placed in a special stirred and heated feed tank; this will assure compositional homogeneity of the feed to the system. The mass feed rate of material to the system will be monitored by an electronic load cell. Feed tank temperature will be controlled to keep the material molten so it can

ORNL DWG 80-1024

35 wt % KY. NO. 9 (-170 MESH) COAL/KY. NO. 9

WILSONVILLE RECYCLE SOLVENT

PRESSURE = 13.9 MPa (2000 PSIG)

SLURRY MASS RATE = 0.978 g/s

VISCOMETER DIMENSIONS = 2.77 mm ID x 0.61 m LONG

Fig. 2.1. Pipeline viscometer differential pressure vs slurry temperature.

be circulated by the suction port of the positive displacement feed pump. The feed pump head and its discharge line are heat traced to maintain fluidity of the material as it flows to the preheater inlet. The preheater will be operated with constant heat flux along its length. Pipeline viscometer measurements will be made at the same conditions at which the sample was taken, 726 K (848°F) and 18.1 MPa (2623 psig). Differential pressure will be recorded as a function of flow rate through the viscometer to produce a rheogram (shear stress vs shear rate plot) for the material. The material exiting the viscometer will flow directly into an empty sample bomb piped into the system at the viscometer discharge. This material will be saved for possible recycle through the system for additional measurements.

2.2 New Liquefaction Techniques

B. R. Rodgers, R. K. Hessley,* T. L. Sams, and J. W. Larsen*

The purpose of these research studies is to provide a better understanding of the chemical processes involved in the liquefaction of coal based on recent advances in knowledge of the structure of coal. The technical approach includes exploitation of the chemistry advances to develop new process concepts based on rapid conversion without the addition of external hydrogen.

Present research is aimed at exploring the conversion of subbituminous and bituminous coals by the use of supercritical phenol, including the mechanisms of hydrogen transfer and structural studies of the converted products. Production of phenol from coal is also being explored since this is the necessary step to utilization of the above reaction in a process scheme.

2.2.1 Hydrogen transfer mechanisms

While phenol is instrumental to the conversion of coal by the process discussed previously, it is not known whether its action is due to the vapor or the liquid. During heat-up phenol is a liquid, but at reaction temperatures (460°C) it is above its critical temperature (421.1°C) and exists as a dense gas. If its action is through the gas phase, the density of this phase should effect conversion. Preliminary results reported last month were quite encouraging because of the potential for reducing the amount of phenol required for the conversion. By changing the volume, a 2/1 phenol/Wyodak run was made where the density was held the same as for a 10/1 phenol/Wyodak run. The result was a 55% MAF conversion of Wyodak coal to pyridine soluble products in only 15 minutes at 454°C. This is significantly higher than would have occurred without the density adjustment (previous runs with a 5/1 ratio at 427°C and 482°C gave 8% and 42% conversions respectively. However, it is less than the 79% conversion

*Chemistry Division.

obtained at a 10/1 ratio and 454°C. A repeat of the 2/1, 454°C run gave a 57% MAF conversion run. The gases collected are being analyzed on a gas chromatograph and molecular weights are being determined on the solubles.

Because of the apparent effect of density on conversion, the densities of ten runs made previously for an orthogonal design experiment were calculated. Figure 2.2 shows a definite increase in conversion with density and indicates that the 2/1 phenol/Wyodak conversion should increase with temperature.

2.2.2 Phenols from coal

During production of phenol from coal, a number of multihydroxy benzenes will also be produced. Hydroquinone (1,4-dihydroxy Benzene) is expected to be present in significant quantities. This compound was heated for 15 minutes under typical phenol/coal reaction conditions (10/1 coal, 460°C) to determine its stability. Only 3% of the starting material was converted to pyridine insoluble material under these conditions. A repeat gave 1% insoluble material. A run with Wyodak coal at a ratio of 10 parts Hydroquinone to one part coal, 454°C, and 15 minutes gave essentially complete solubility in ethanol on an MAF basis. This encouraging result is being repeated. Separation of the hydroquinone, a difficult task, is in progress.

2.2.3 Structural studies

Elemental analyses on the silylated product from the phenol/coal reaction are not complete, and thus, complete NMR analyses cannot be made.

Nitric acid oxidations to increase conversion were reported last time to be disappointing. Previous workers had used high sulfur coal and it was thought that the low sulfur coals used in our experiments could account for the discrepancy. Various organo-sulfur compounds (e.g., thianthrene) were added to the coal without any significant increase in conversions.

2.2.4 Future plans

Reactions of coal with multihydroxy benzenes will continue. Pyridine solubility of reaction products will be determined as will the multihydroxy uptake into converted products. Production of colloidal material in the hydroquinone/Wyodak reaction will be determined.

Structural studies will continue to emphasize NMR since the results of current studies of silylated products are encouraging. The HNO_3 oxidations will be discontinued unless new evidence surfaces upon further analyses of the results.

ORNL DWG 80-1043

Fig. 2.2. The effect of phenol gas density on conversion of Wyodak coal to pyridine soluble material. The figures in parentheses are phenol/coal ratio, reaction time (min.), and reaction temperature (°F), respectively.

The OH group was previously shown to be very instrumental in the H-transfer mechanism. Two methods to examine exchange reactions and functionality are to be studied: deuterization of the hydrogen in the OH group and replacing the OH group with an SH group. A mercaptobenzene/Wyodak run is planned in the near future.

The distribution of multihydroxy benzenes produced from coal is needed to determine their relative importance to the phenol/coal reaction. This will be determined as resources permit.

2.3 References for Section 2

1. L. E. McNeese (ed.), Fossil Energy Program Quarterly Progress Report for the Period Ending March 31, 1980, ORNL-5658, Oak Ridge National Laboratory, Oak Ridge, Tennessee (in process).
2. L. E. McNeese (ed.), Fossil Energy Program Monthly Progress Report for the Period Ending April 30, 1980, ORNL/TM-7375, Oak Ridge National Laboratory, Oak Ridge, Tennessee (in process).
3. L. E. McNeese (ed.), Fossil Energy Program Monthly Progress Report for the Period Ending May 31, 1980, ORNL/TM-7414, Oak Ridge National Laboratory, Oak Ridge, Tennessee (in process).

3. CHEMICAL RESEARCH AND DEVELOPMENT

M. L. Poutsma

3.1 Chemistry and Structure of Coal

M. L. Poutsma and C. L. Wolf

Our previous studies and those of others concerning the thermolysis of bibenzyl showed the observed decomposition rate to be fully consistent with rate-limiting homolysis of the $\text{PhCH}_2\text{—CH}_2\text{Ph}$ bond whose dissociation energy is ~ 60 kcal/mol. The weakest C-C bond in the next higher homologue, $\text{PhCH}_2\text{—CH}_2\text{CH}_2\text{Ph}$, is predicted to be ~ 10 kcal/mole stronger. At 365°C , this difference would translate into a ~ 2500 -fold slower rate of homolysis. In actual fact we now find the liquid-phase thermolysis rate of 1,3-diphenylpropane to be some 25-fold faster than that of bibenzyl. A second difference between these hydrocarbons is the nature of the initial products. Bibenzyl gave major amounts of products of greater molecular weight than the starting material, derived from radical coupling reactions of $\text{Ph}\dot{\text{C}}\text{HCH}_2\text{Ph}$ radicals with themselves or $\text{PhCH}_2\cdot$ radicals. In contrast, 1,3-diphenylpropane gave equimolar amounts of toluene and styrene very cleanly with no significant amounts of heavier materials.

These data clearly show that one must compare not only the C-C bond dissociation energies in the parent hydrocarbon but also those in the radicals derived by hydrogen abstraction. Thus the hypothetical β -scission process for bibenzyl:

can be estimated to be endothermic by ~ 50 kcal/mol and is not kinetically accessible at $350\text{--}400^\circ\text{C}$. However, the analogous process:

benefits from the resonance stabilization of the benzyl radical and is endothermic by only ~ 21 kcal/mol. It can occur readily in this temperature range. Hence 1,3-diphenylpropane decomposes by a *long-chain* radical reaction whereas bibenzyl cannot and is restricted to a *nonchain* decomposition.

Against this background, one must therefore consider that trimethylene bridges in coal, in the presence of radicals generated from other bond scissions, are as likely a locus of thermal depolymerization as the more commonly discussed dimethylene bridges.

Thermolysis of 1,3-diphenylpropane in the liquid phase in Pyrex tubes (see above) is reproducible; however, numerous gas-phase runs have shown relatively poor reproducibility of rates. Hence wall effects appear to be involved, a not unlikely occurrence for a long-chain reaction.

3.2 Indirect Liquefaction Chemical Research

R. A. Strehlow and E. C. Douglas

During the previous period the Fischer-Tropsch (F-T) activity of a commercial catalyst (ICI-31-4) was demonstrated and found to be reproducible. It appeared that carburization of the catalyst could be as well accomplished by 1-butene as by carbon monoxide.

We continued the work with a study of the hydrogenation activity of the previously activated catalysts at gas hourly space velocities ranging to 3600 hr^{-1} . During the studies we explored the temperature and pressure effects and found that 1-butene was not only efficiently hydrogenated to butane, but that at higher temperatures a significant amount (up to 1.8%) of C_5 and C_6 hydrocarbons were produced (even though only hydrogenation had been observed at the lower temperature of 200°C). When the injections of 1-butene were made with a hydrogen to 1-butene ratio of about 5:1, the products were almost entirely saturated. At the lower ratio of 1.2:1, however, half or more of the products were unsaturated hydrocarbons.

We attribute this result to the formation of surface carbon atoms which themselves are hydrogenated and can add to the 1-olefin, indicating that for F-T activity the carbon may come from numerous sources. This type of reaction has been inferred previously, especially with ruthenium catalysts, but we are unaware of any demonstration of this reaction type on iron in the absence of carbon monoxide. This reaction, the addition of methylene groups, will be explored in the next period to determine its extents with an iron catalyst and in an attempt to see its more detailed relation to the Fischer-Tropsch reaction itself.

4. MATERIALS TECHNOLOGY

R. A. Bradley

This section describes the research and development performed by the Metals and Ceramics Division on the Fossil Energy Materials Program supported by the Department of Energy's Office of Advanced Research and Technology. It includes tasks on pressure vessels and piping materials, welding and cladding development, corrosion of AFBC materials, failure prevention and analysis, materials research for liquefaction systems, development of modified 9 Cr-1 Mo alloy, and materials for ceramic recuperators.

4.1 Pressure Vessel and Piping Materials

D. A. Canonico, W. J. Stelzman, and L. J. Corsa

The purpose of this task is to investigate the fracture toughness and hydrogen attack of pressure vessel steels. Efforts this month concentrated on testing of the 305-mm-thick (12-in.) weldment supplied to ORNL by Chicago Bridge and Iron Company. Charpy V-notch (C_V) impact properties at the quarter thickness depth location have been determined for the as-received base metal. The thermal history of the as-received plate and weldment is

austenitized at 925 to 955°C (1700-1750°F)
water quenched
tempered at 630°C (1170°F) for 6 3/4 h
welded with 150°C (300°F) minimum preheat
after welding heated to 315°C (600°F) and held at that
temperature for 24 h.

The base metal has good C_V properties at this stage in its processing history. The C_V upper-shelf energy is near 110 J (80 ft/lb) and the 68-J (50 ft/lb) temperature is near 20°C (65°F).

Heat-treating of the "rich" composition of 2 1/4 Cr-1 Mo steel supplied by Lukens Steel Company is continuing. The DATA TRAK has been used to duplicate the cooling rate in 12 × 12 × 125-mm (1/2 × 1/2 × 5-in.) bars that is obtained at the quarter depth location in thick plate.

4.2 Welding and Cladding Development

D. P. Edmonds and G. M. Goodwin

The purpose of this task is to develop techniques for weld overlay cladding of components for coal conversion systems and to characterize weldments in thick-section steels. Specimens from various stainless steel clad metals have been supplied to our Materials Compatibility

Group for inclusion in U-bend corrosion testing in SRC-II. Clad samples will be tested as-welded and postweld heat-treated (40 h at 690°C).

A meeting of the Metal Properties Council, Inc. Task Group on Extra Large Pressure Vessels for Coal Liquefaction was attended. Fabrication and examination problems where additional work is needed were outlined by the group.

4.3 Fireside Corrosion of AFBC Heat Exchanger Materials

T. G. Godfrey and J. H. DeVan

Preparation of the draft report on the 4500-h materials test in the Fluidyne AFBC is continuing with completion expected in July. Other activities involving AFBC materials testing are discussed in Section 12 of this report.

4.4 Failure Prevention and Analysis

R. W. Swindeman

4.4.1 Examination of reboiler tube from Fort Lewis SRC Pilot Plant - J. R. Keiser and M. D. Allen

Two pieces of tubing from the light ends column reboiler tube bundle were sent to ORNL by the metallurgist at the Fort Lewis SRC Pilot Plant for metallographic examination. The tubes had experienced severe surface attack. Although the material had been supplied as Incoloy 825, Fort Lewis personnel questioned the identification since the tubes had experienced corrosion more severe than that found with type 316 stainless steel tubes in the same location. A sample of the tube has been submitted for chemical analysis and other pieces are being examined metallographically.

4.5 Materials Research for Liquefaction Systems

R. W. Swindeman

4.5.1 Materials to resist stress-corrosion cracking in coal liquefaction pilot plants - J. R. Keiser and V. B. Baylor

This work is being performed to assess the resistance of various materials to stress-corrosion cracking in coal liquefaction plants. Efforts this month were directed toward preparing the safety assessment for the laboratory autoclave facility and examining three racks of U-bend specimens which had been exposed in the Fort Lewis separator vessels. Corrosion rates calculated from the weight changes are given in Table 4.1. As can be seen from the results, only Incoloy 800, type 410 stainless steel, and Inconel 600 suffered unacceptably high weight losses.

Table 4.1. Calculated corrosion rates for U-bend specimens exposed in the Fort Lewis separator vessels

Alloy	Corrosion rate	
	(mm/year)	(mils/year)
<u>High-Pressure Flash Drum</u>		
E-Brite 26 Cr-1 Mo	<0.003	<0.1
18 Cr-2 Mo (welded)	0.024	0.9
Incoloy 825	0.036	1.4
Type 347 stainless steel	0.055	2.1
Type 321 stainless steel (welded)	0.095	3.7
Type 304L stainless steel (welded)	0.127	5.0
Incoloy 800	0.265	10.4
Type 410 stainless steel (welded)	0.444	17.5
Type 410 stainless steel	0.451	17.7
Inconel 600 (welded)	1.727	67.9
<u>Intermediate-Pressure Flash Drum</u>		
E-Brite 26 Cr-1 Mo	<0.003	<0.1
18 Cr-2 Mo (welded)	<0.003	<0.1
Incoloy 825	<0.003	<0.1
Type 347 stainless steel	0.014	0.6
Incoloy 800	0.021	0.8
Type 316 stainless steel (welded)	0.023	0.9
Type 321 stainless steel (welded)	0.035	1.4
Type 410 stainless steel	0.061	2.4
Type 410 stainless steel (welded)	0.072	2.8
Inconel 600	1.475	58.0
<u>Recycle Condensate Drum</u>		
Inconel 600 (welded)	<0.0003	<0.01
E-Brite 26 Cr-1 Mo	<0.0003	<0.01
Type 347 stainless steel	<0.0003	<0.01
Type 316 stainless steel (welded)	<0.0003	<0.01
Type 321 stainless steel (welded)	<0.0003	<0.01
Incoloy 825	<0.0003	<0.01
Incoloy 800	<0.0003	<0.01
Hastelloy G-3	0.0003	0.01
Type 410 stainless steel (welded)	0.001	0.03
Type 410 stainless steel	0.001	0.04

The specimens are now being examined metallographically to determine if any cracking has occurred.

4.5.2 Studies of general corrosion in coal liquefaction plants J. R. Keiser, V. B. Baylor, M. Howell, and J. F. Newsome

The purpose of this work is to determine the potential for general corrosion in coal liquefaction pilot plants. The corrosivity of the fluids is measured by exposing corrosion coupons in a number of vessels in the Fort Lewis, Wilsonville, and Catlettsburg plants. During the last month, we have measured the corrosion rates of coupons exposed in the Fort Lewis wash solvent column.

Four racks were removed from the column during the May shutdown and replaced with other racks provided by ORNL. Of the racks removed, three had been exposed since January 1980, and the other had been installed in November 1979. The temperature profile of the column had been changed several times so that the rack exposed since November had seen somewhat different conditions than the others.

The corrosion rates calculated from the weight change measurements are shown in Table 4.2. These results indicate that corrosion around Trays 19 and 20 (the top of the column) was more severe than in the middle of the column. Of the new alloys, Haynes 263, a nickel-base alloy containing Co, Cr, Mo, and Ti, performed very well; and alonized type 304 stainless steel had about half of the corrosion rate of type 304 stainless steel.

The specimens currently being exposed will be replaced at the end of the SRC-I run by racks of specimens now being prepared.

Additional studies on corrosion in the fractionation area of SRC plants are described in Section 6.5.4.

4.5.3 Materials for the Zinc Chloride Hydrocracking Process - V. B. Baylor, J. R. Keiser, and E. H. Lee

The purpose of this work is to evaluate materials for possible use in the regeneration system of the zinc chloride coal liquefaction process. Corrosion coupons are being exposed in a quartz experimental loop to an environment containing HCl, dry air, and $ZnCl_2$ at temperatures ranging from 500 to 1000°C. All materials and equipment were received this month for the next two test runs except for the heaters, which are now scheduled for delivery in July.

4.6 Development of Modified 9 Cr-1 Mo Structural Steel

V. K. Sikka

Large heat fabrication, mechanical property characterization, and weldability studies continued during the last month.

Industrial fabrication of two 14-Mg (15-ton) heats of modified 9 Cr-1 Mo alloy to plate and bar product was completed. The yield on these products approximated 90%, which is considered excellent by Carpenter Technology, the fabricator. They also stated that the fabrication of this alloy can be carried out with existing facilities without any modifications and that this alloy fabricated without any difficulties. Ease of industrial fabrication of this alloy should help in obtaining an earlier approval for its ASTM specifications. The bars and plate are expected at ORNL by the end of July.

Table 4.2. Corrosion rates for coupons exposed in the Fort Lewis wash solvent column (21 trays)

Alloy	Corrosion rate	
	(mm/year)	(mils/year)
<u>Above Tray 20 - Exposed 2156 h</u>		
Titanium	<0.001	<0.01
Hastelloy C-276	<0.001	<0.01
Haynes 263	0.018	0.72
Haynes 20 mod	0.139	5.46
Inconel 625	0.175	6.88
Hastelloy G	0.183	7.20
Type 321 stainless steel	0.264	10.4
Monel 400	0.325	12.8
Inconel 671	0.400	15.8
Incoloy 825	0.489	19.2
Alonized type 304 stainless steel	0.534	21.0
Carpenter 20Cb3	0.536	21.1
Alloy 904L	0.548	21.6
Type 310 stainless steel	0.672	26.4
Type 317LM stainless steel	0.680	26.8
Type 316 stainless steel	0.755	29.7
Type 304 stainless steel	0.998	39.3
Type 410 stainless steel	2.13	83.9
<u>Below Tray 20 - Exposed 2156 h</u>		
Titanium	<0.001	<0.01
Haynes 263	0.003	0.10
Inconel 625	0.012	0.48
Hastelloy G	0.038	1.51
Hastelloy C-276	0.102	4.02
Haynes 20 mod	0.264	10.4
Monel 400	0.276	10.8
Inconel 671	0.345	13.6
Type 321 stainless steel	0.648	25.5
Type 310 stainless steel	0.768	30.2
Incoloy 825	0.967	38.0
Type 410 stainless steel	1.00	39.5
Type 304 stainless steel	1.05	41.3
Type 316 stainless steel	1.07	42.1
Type 317LM stainless steel	1.07	42.1
Alloy 904L	1.07	42.2
Carpenter 20Cb3	1.22	47.9
<u>Below Tray 19 - Exposed 3491 h</u>		
Hastelloy C-276	0.001	0.02
Titanium	0.033	1.31
Hastelloy G-3	0.224	8.82
Hastelloy G	0.250	9.82
Incoloy 825	0.347	13.6
Type 321 stainless steel	0.454	17.9
Type 317 stainless steel	0.685	27.0
Type 317LM stainless steel	0.694	27.3
Type 304 stainless steel	0.913	36.0
Type 316 stainless steel	0.975	38.4
SC-1	2.02	79.4
Type 410 stainless steel	2.18	85.9
26-1 S	3.17	125.0
Carbon steel	4.74	187.0
<u>Above Tray 12 - Exposed 2156 h</u>		
Titanium	<0.001	<0.01
Inconel 625	<0.001	<0.01
Hastelloy C-276	<0.001	<0.01
Hastelloy G	0.003	0.12
Inconel 671	0.004	0.14
Haynes 20 mod	0.010	0.39
Haynes 263	0.018	0.73
Type 321 stainless steel	0.064	2.52
Type 310 stainless steel	0.076	2.98
Alloy 904L	0.081	3.18
Type 317LM stainless steel	0.095	3.73
Incoloy 825	0.168	6.60
Type 316 stainless steel	0.195	7.68
Monel 400	0.231	9.10
Type 304 stainless steel	0.293	11.5
Carpenter 20Cb3	0.352	13.8
Type 410 stainless steel	0.890	35.0

Several long-term creep tests on the two 14-Mg commercial heats continued during the last month and are expected to continue during the next several months.

As a part of the new strategy to obtain an earlier ASME Code case approval of modified 9 Cr-1 Mo, mechanical property testing was started on the tube heats. Tubes from the heat used in making the Tennessee Valley Authority tubing were the first of these heats to be tested. Tensile tests on this heat were completed in February. Three creep tests on this heat are currently in progress. Additional tube heats from Combustion Engineering, Chattanooga, Tennessee, were received during the last month. Testing of these heats will start during the next month.

4.7 Ceramic Recuperators (Heat Exchangers)

V. J. Tennery and G. C. Wei

The objective of this task is to evaluate the behavior of candidate structural ceramic materials for use as recuperators or heat exchangers in fossil fuel combustion environments. In this period, we prepared the draft of a report on the results of CRAF Test 1. This draft report will be subjected to internal review and approval started July 1, 1980, in preparation for issue as a topical report.

Thin specimens of post-test sintered- α SiC were prepared. These thin specimens are for transmission electron microscope analysis of the microstructure of this material. The objective is to identify the mechanisms for the observed large increases in helium permeability and grain size of sintered- α SiC during the high-temperature, long-term exposure to the combustion products of No. 6 fuel oil in CRAF Test 1.

On June 12, 1980, a quantity of coal-oil mixture (COM) fuel (1.89 m^3 or 500 gal) was received. This COM fuel will be used as fuel in firing tests of the CRAF to ensure that its combustion can be adequately controlled in the CRAF. Subsequently, a total quantity of 36 m^3 (9500 gal) of the COM fuel will be delivered in two shipments for CRAF Test 2. To date, the COM fuel has been successfully pumped to the CRAF burner. Preliminary results indicate that combustion of the COM is stable when the furnace has been preheated to about 600°C using an auxiliary gas burner. A maximum temperature of 1400°C was achieved with this fuel in the combustion chamber of the CRAF. Planning is now under way for shipment of the 9500 gal of fuel to be used in CRAF Test 2.

Tubes of α -SiC were received for use in CRAF Test 2 and all tubular specimens for this test have now been received from the vendors. Pre-test characterization of these tubular test specimens is under way.

Discussions were held with the program manager at Pittsburgh Energy Technology Center (PETC) pertaining to initiating a program planning activity on ceramic heat exchanger technology. Additionally, planning was started for design and procurement activities associated with modifying the CRAF to burn coal directly by injecting powdered coal into a relatively clean burner flame. This mode of fuel combustion will be used in CRAF Test 4 to determine the stability of structural ceramics in the combustion of coal above the ash fusion temperature.

5. COMPONENT DEVELOPMENT AND PROCESS EVALUATION

D. M. Eissenberg

The objective of component development and process evaluation activities is to ensure that coal conversion (liquefaction, gasification, pyrolysis) processes, subsystems, and components have satisfactory functional performance, lifetime, reliability, and safety for their intended applications, and that sufficient component and subsystem performance data are available to permit process design optimizations. Activities to be carried out include performance and cost analyses; assessments of operating plants; field tests; operation of test loops; and the development of advanced processes, subsystems, and components.

Present activities are primarily those carried out as part of the technical support to large liquefaction projects. In addition, studies are being initiated aimed at the development of processes, subsystems, and components for more generic coal conversion applications.

5.1 Technical Support to Large Liquefaction Projects

P. K. Carlson, W. A. McAuley, L. F. Parsly, and A. N. Smith

Activities in this area are in support of the H-Coal and SRC Demonstration Projects, and are described in more detail in Chapter 6. Work in support of the H-Coal reactor safety assessment will continue. We have been asked to consider the implications of extending the reactor lifetime from the originally planned two years to five years. An examination of how this will affect the loading histogram used for the original safety analysis is underway. Construction of the slurry pressure letdown loop was completed. Computer modeling runs were made to provide predictions of performance of the letdown valve to compare with the experimental results using water and N₂ gas. A contract was awarded to Battelle Memorial Institute for a techno-economic assessment of wet grinding of coal feed to direct liquefaction plants.

5.2 Component Test Facilities

D. M. Eissenberg

Planning for large component test facilities is deferred pending information from DOE/Washington.

5.3 New Initiatives in Coal Conversion Component Development

D. M. Eissenberg

As part of the Engineering Technology Division strategic planning activities, an assessment is being carried out to identify and propose new initiatives in coal conversion component development.

A rough draft seed money proposal has been completed for the proposed slurry feed/letdown system incorporating the flow work exchanger concept. It is currently being revised to include a more detailed description of the proposed experimental test setup.

6. TECHNICAL SUPPORT TO MAJOR LIQUEFACTION PROJECTS

H. D. Cochran

Support is provided by Oak Ridge National Laboratory and Union Carbide Nuclear Division Engineering for the major liquefaction projects being managed by DOE Oak Ridge Operations--SRC I and SRC II Demonstration Plants and H-Coal Pilot Plant Projects. Activities under twenty-four specific subtasks are reported in seven broad categories--engineering and design review, technology overview, design data validation, components, materials, environmental and health, and general technical support.

6.1 Engineering and Design Review

This section reports on three subtasks whose objectives are focused on review of engineering and design of the SRC-I and SRC-II demonstration plants and the H-Coal pilot plant: engineering design review, SRC/H-Coal process and design review, and solid-liquid separation design review.

6.1.1 Engineering design review - J. J. Kurtz

Objective - This activity consists of providing technical assistance to the DOE-ORO SRC Projects Office on the SRC-I and SRC-II projects. The SRC-I project involves the design, construction, and operation of a coal liquefaction plant for the production of a clean solid boiler fuel. The SRC II project is for the production of a clean liquid boiler fuel. The government-funded preliminary design of the SRC-I project is contracted with the Southern Company Services (SCS), Inc., and the SRC-II project contract is with the Pittsburg and Midway (P&M) Coal Mining Company.

The principal purposes of the SRC projects review and evaluation activities are to provide objective assessments of the contractors' technical progress, identification of potential problems, and critiques of project deliverables.

Status summary - The SRC-I Project Technical Status Review meeting in Allentown, PA was attended. Texaco and Koppers-Totzek gasifier capital and operating economics, pertinent to the selection decision, were presented. The corrosion effects of inorganic chlorides originating from feed coal were also discussed and mitigating measures will be studied. The SRC-II Project Technical Status Review meeting in Cambridge, MA was also attended. The status of the overall project schedule was discussed, and the plans for integration of process area design, supporting R&D, and detailed design schedules was stressed.

The 4th annual symposium on Instrumentation and Control for Fossil Energy Processes was attended by an I&C representative from UCC-ND Engineering. The majority of the papers addressed topics related to requirements in the SRC demo plants. Of immediate interest was an Exxon paper on a letdown valve of proprietary trim design which, to the time of the meeting, had operated successfully for two weeks.

The DBM for the SRC-I Processing and Deashing Area - Revision 1 was reviewed and the comments were submitted to the ORO SRC Project office.

A study request was submitted to the ORO SRC Projects Office addressing engineering issues and benefits assessments related to the use of layered pressure vessels in the SRC-I demo plant. ORO responded with a request for a broader proposal addressing program benefits of multilayered pressure vessels to the overall synfuels commercialization program.

Actions were initiated to expedite the security of bilateral and trilateral nondisclosure agreements with commercial entities providing proprietary process information to the SRC projects. Bilateral agreements with essentially all major process licensors are in place. Trilateral agreements with key licensors, including Texaco, Lummus, Kerr-McGee, Chempro, Benfield, and Gore, Arrington & Associates have also been executed.

6.1.2 SRC-H-Coal process and design review - A. R. Irvine, J. F. Fisher, W. R. Gambill, H. F. Soard

Objective - The objective of this activity is to provide review and analysis of key process areas of the SRC demonstration plants and those aspects of the H-Coal pilot plant that will provide information useful in the design and evaluation of the SRC-I and SRC-II demonstration plants.

Status summary - A draft report entitled "Selection of SRC Demonstration Plant Feed Coals" was revised to provide an abstract, enlarge the scope of information provided concerning major deposits of high sulfur bituminous coal, and a map showing the counties in which these major deposits are located.

Additional reports dealing with the effects of feed coal character and process conditions on product yield were reviewed. Some of this work was done in connection with review of reports from the direct liquefaction development centers for preparation of a digest of direct liquefaction development (Subtask 12). Study of these reports has led to the following observations.

1. Coal character changes from point to point in a seam.
2. Optimal operating conditions are probably different for even slightly different coals.

3. An important parameter of process conditions is solvent quality. It appears that the "elements" of solvent quality have not yet been properly defined, and overall solvent quality cannot be measured except in an empirical fashion. (Exxon has a measure of solvent quality, but they have not published how the determination is made.) In addition, virtually no information is available pertaining to how to manipulate solvent quality.
4. Deviation from actual optimal conditions (as opposed to pre-determined operating conditions) cannot be sensed by any known plant instrumentation or analytical inspection of process streams.
5. Optimal conditions for a given coal can be determined only by time consuming trial and error tests in small scale coal liquefaction devices.
6. The elements of coal composition which influence liquefaction yield and optimal process conditions are not identified in any way that would be usable in operation of a coal conversion facility.

6.1.3 Solid liquid separations design review — B. R. Rodgers and J. R. Hightower

Objective - The objective of this project is to provide technical support to DOE-ORO in the area of solids/liquid separations. The first request was to determine to the extent possible in the laboratory, the fate of the Kerr-McGee solvent lost in their deashing process, or at least if it was chemically reacted. The time frame was to be two months.

Status summary - At the request of EPRI, a work plan was formulated to examine Kerr-McGee process solvent losses using a radioactive tagged mixed solvent. This will be a follow-on to the work completed on the single solvent, reported in May. This work could begin by the end of July and will take approximately three months to complete.

At the request of Mike Eastman, DOE-ORO, an effort has been initiated to examine the data base which supports the Kerr-McGee critical solvent deashing process. A meeting has been set for July 25th at Wilsonville, Alabama, with Kerr-McGee, Catalytic, Inc., and EPRI to discuss the Wilsonville data in support of the Kerr-McGee demonstration plant product recovery design basis of 82.7%. A letter report will be transmitted to DOE by August 1. A second effort of this assessment will consist of detailed examination of the preliminary Kerr-McGee Demonstration Plant Process Design which is scheduled to be transmitted to DOE-ORO on August 1.

6.2 Technology Overview

This section reports on five tasks whose objectives are to provide a broad overview of direct liquefaction technology — Direct Liquefaction Technology Overview and four technical field representation tasks.

6.2.1 Direct liquefaction technology overview — R. W. Glass, K. H. Lin, A. R. Irvine, J. P. Belk, J. F. Fisher, J. R. Horton, J. K. Huffstetler, B. Niemann, W. R. Reed, and B. T. Thompson

Objectives — The objectives of this task are:

1. To keep abreast of significant developments in coal conversion R&D activities, to monitor progress in coal liquefaction facilities, and to derive and document technical data of importance to design and operation of pilot, demonstration, and commercial plants. This will also assist in preventing duplication of efforts at various facilities.

2. To prepare a source book of data base and technical information for DOE management and other participants in DOE-funded programs.

3. To conduct short- to intermediate-term studies on subjects which could have major impact on coal liquefaction technology and economics.

Scope — The role of this task is to provide an overview of a wide range of activities relevant to coal liquefaction technology. The major emphasis will be directed toward the following areas of activities and types of information:

1. R&D activities relevant to (a) modification and improvement of key unit processes and associated equipment, (b) determination of physical and chemical properties of major process streams and products and other process data, and (c) defining necessary processes for upgrading liquefaction products.

2. Plant experience data from pilot plants and PDUs that are crucial to design and operations, including (a) significant operation and maintenance experiences, (b) technical problems encountered due to deficiency in the design or to abnormal process conditions, and (c) specific solutions to the problems.

Status summary - An action plan describing specific activities and the schedule for the remainder of FY-1980 was completed. Also completed was the tentative outline for the digest entitled "Progress in Major Coal Liquefaction Facilities." The outline consists of the following items:

- A. Pilot Plant Operations
 - Plant test runs
 - Test runs for critical components and systems
 - Characterization of process streams
 - Future plans and projects
- B. Significant Operation and Maintenance Experiences
 - Operating and equipment problems
 - Useful observations and experiences
- C. R&D Activities in Direct Support of Liquefaction Pilot Plants and of Demo Plant Design
 - R&D subject
 - Objectives and scope
 - Progress and result
 - Relation to similar studies at other sites
 - Plans for immediate future

A comprehensive review of the progress reports from pilot plants and PDUs is in progress for the purpose of preparing the first issue of the digest.

Effort has been initiated to establish and index an information and literature file on direct liquefaction technology.

Lists of test program plans and capital cost items proposed by the H-Coal pilot plant project were reviewed. Although many of the tests to be carried out appear to be of critical importance based on the subject titles alone, the information provided was not sufficient to permit evaluation. Some of the tests may be related to or possibly duplicate those at other sites.

The work on the source book continued on schedule by individual members assigned to different subject areas. In addition to studies on pertinent literature, the maximum use is made of the information derived from other activities such as the design data base review and review of designs and analyses undertaken by the contractors. Brief reports of progress were delivered by the source book participants at the recent Fossil Energy Program/Engineering Monthly Meeting. Specific subjects discussed included sections on coal preparation, coal slurry mixing, and preheater units of direct coal liquefaction processes. Other subjects discussed included additional items of equipment under study as well as broader studies of process simulation, process control, materials, and safety reliability.

6.2.2 Technical representation at field sites — R. W. Glass

Objective — The objectives is to place a UCC-ND technical representative at each of the major development sites — H-Coal, Exxon Coal Liquefaction Plant, Harmarville, Ft. Lewis, and Wilsonville. The purpose is to facilitate the flow of information between the above-mentioned sites, DOE, and ORNL.

Status summary — Discussions were held with DOE/ORO, ASFI, and the DOE H-Coal pilot plant site representative to define the role of the ORNL/ORO technical site representative at the H-Coal pilot plant. Different signals were received from the above three parties regarding the technical representative's function at the pilot plant. We are continuing to resolve the differences and, thereby, to enable the ORNL/ORO technical representative to assume his duties at the H-Coal pilot plant.

Activities to outfit the Health and Environmental Monitoring (H&EM) trailer are underway in the Analytical Chemistry Division. Efforts are also being made by the Environmental Sciences Division to establish the H&EM program at the pilot plant.

6.3 Design Data Validation

This section reports on three subtasks whose objectives are aimed at providing experimental measurements to answer questions which have arisen in designing the SRC demonstration plants. These subtasks are: Coal Slurry Mixing Tests, Wet Grinding for SRC Processes, and Vacuum Bottoms Viscosity Measurement.

6.3.1 Coal slurry mixing tests — E. L. Youngblood, L. S. Dickerson, and J. R. Hightower

Objective — The objective of this project is to study the changes that occur in physical properties (particularly viscosity) in coal slurries during mixing at temperatures up to 533 K (500°F). The system includes a small scale mix tank with an agitator and slurry circulation system of the type used for feed makeup in the SRC processes. Continuous viscosity measurements will be made with an on-line pipeline viscometer. The ultimate objective of the study is to establish conditions that will permit the slurry preparation system in the SRC demonstration plants to be operated at increased temperature thereby improving the overall process thermal efficiency and cost.

Status summary — During the month, craft work continued on the construction of the equipment for the slurry mixing tests. The mixing vessel was installed in the system and the supports for the circulation piping and pipeline viscometers were installed. Lines for the instrument air, nitrogen purge gas, vessel vent, and signal lines from the pressure differential transmitters for the viscometers were installed. The

electrical power supply for the heaters and pumps has been run to the panelboard from the main building transformer. Electrical heaters have been installed on the mixing vessel. Electrical circuits and thermocouples have been run from the panelboard to plug-in terminal boxes near the experimental equipment.

Completion of the piping and line heating cannot be done until the circulation pump, heating tape and high temperature ball valves which have been ordered are received. During this period, we will calibrate equipment and test the pipeline viscometers with fluids of known viscosities in the range expected in the first slurry tests. A safety summary and quality assurance assessment have been prepared and submitted for approval in preparation for operation of the system. The current plan is to use pipeline viscometers with a viscosity range suitable for SRC-I slurry for the initial runs.

During the next month, we plan to install the pipeline viscometers and begin calibration with fluids of known viscosity. During this period check-out of equipment and instruments such as temperature and pressure recorder, heating circuits, and pumps will be started.

6.3.2 Wet grinding for the SRC II process - D. M. Eissenberg and W. A. McAuley

Objective - This study will investigate the feasibility of incorporating a wet grinding process into the SRC II Demonstration Plant. The presently proposed dry grinding/mixing system has encountered problems such as coal swelling and gel formation.

Status summary - Blanket CPFF Subcontract Letter Release No. X04 was sent to Battelle Memorial Institute on June 17, 1980. The total amount of the letter release was \$34,252.00.

A "kick-off" meeting to discuss ORNL's expectations of how the wet grinding feasibility study is to be implemented and the general format of the final report has been scheduled for July 10, 1980, at the conference room of Battelle's Oak Ridge Office. Representing Battelle at the 8:30 a.m. meeting will be W. G. Steedman, B. K. Parekh, and J. S. Lawson, Jr; W. A. McAuley, L. F. Parsly, Jr., and D. M. Eissenberg will represent ORNL.

6.3.3 Vacuum bottoms viscosity measurement - J. H. Wilson, B. R. Rodgers, and J. R. Hightower

Objective - The objective of this project is to provide a tested and calibrated instrument for installation at the Ft. Lewis SRC pilot plant or other suitable site which is capable of providing on-line viscosity measurement of residuals obtained from the vacuum still of the SRC I and II processes. This type instrument is necessary to provide indication of the onset of irreversible polymerization or coking problems which would interfere with controlled feeding of vacuum still bottoms to a gasifier.

Status summary - In order to simplify the operation as well as reduce the cost of the vacuum still bottoms (VSB) viscometer, the let-down tank, shown on the flow sheet in last month's report,¹ has been eliminated. For calibration of the Bran and Lubbe pump, the VSB sample now will be discharged directly into the sample receiver through a back-pressure control valve. Erosion of the valve trim should not be a significant problem since the pressure drop will be less than 100 psi. Furthermore, the valve probably will be used relatively infrequently.

A cost estimate for design and fabrication of the VSB viscometer will be provided by UCC Engineering by the middle of July. A detailed description of the operations to be performed by the process control computer has been prepared and submitted to the Instrumentation and Controls Division. This will be used for their estimate of the instrumentation and the control system required for the VSB viscometer.

One drum each of heavy distillate and of VSB is being sent by Gulf Science and Technology Company (GS&TC). The samples were produced on the P-99 SRC-II pilot plant. The heavy distillate will be used as a flush solvent during testing of the VSB viscometer before shipment of the instrument to Ft. Lewis.

A visit was made to GS&TC in Harnarville, Pennsylvania, to discuss their experience with SRC-II VSB. In their operation, VSB is drained periodically from the vacuum still into a hold tank. The hold tank is isolated from the still and pressured with nitrogen to slightly above atmospheric pressure. VSB is then drained into a five-gallon can. After withdrawing the VSB from the hold tank, the operator runs a drill bit up through the drain line to prevent plugging, which tends to occur in this area. A consideration of the probability of similar plugging problems in the VSB viscometer led to the replacement of the let-down tank by a pressure control valve.

GS&TC uses high temperature Hills-McKenna ball valves for the VSB service. An asbestos-filled teflon packing is used. Graphite-filled Kevlar and solid Kevlar packings had been evaluated, but did not perform satisfactorily.

6.4 Components

This section reports on three subtasks which focus on critical components for service in liquefaction plants--a Components and Technology Workshop, SRC Components Design Review, and a Packed Bed Pressure Letdown Study.

6.4.1 Components and technology workshop - M. Siman-Tov

At the request of DOE, effort has been suspended on this subtask.

6.4.2 Component design review - D. M. Eissenberg

Objective - The objective of the component design review is to identify critical components in the SRC I and SRC II Demonstration Plants and to provide assessments as to their expected performance based on Phase I design specifications and analysis of similar components utilized in pilot plants or other comparable service. Where appropriate, recommendations will be proposed for alternate specifications, alternate component selection or development and testing programs which would lead to improved components.

Status summary - Design basis memoranda were reviewed as requested by DOE. A visit to the Wilsonville SRC Pilot Plant is planned for early July.

6.4.3 Packed bed pressure letdown study - D. M. Eissenberg and P. K. Carlson

Objective - The objective of this study is to develop an improved slurry pressure letdown system for possible application to the SRC I and II Demonstration Plants. The improved system utilized a packed bed for pressure drop, with flow control provided by addition of clean liquid which volatilizes at the temperature/pressure conditions within the packed bed.

Slurry test loop - Construction of the test loop has been completed. Detailed engineering drawings are complete and a high pressure review is underway.

The initial series of loop runs, to begin in July, will be to verify the two-phase correlations being used in analytical determinations. The run conditions will be in most cases outside the experimentally verified range for the correlations being used, so that another purpose of the loop runs will be to extend the validity of the correlations. The test parameters and their corresponding ranges of variation are as follows:

Liquid flow rates:	0 to $4.42 \times 10^{-4} \text{ m}^3/\text{s}$
Liquid superficial velocity:	0.952 m/s (max)
Gas flow rate:	0 to 5.41 g/s
Gas superficial velocity:	10.2 m/s (max)
Liquid viscosity:	approx. $1-10 \times 10^{-3} \text{ Pa.s}$

Modeling studies - During June, computer modeling of the bench scale packed bed was done to prepare for actual test runs with water and N_2 gas. Some of the results of this work are plotted in Fig. 6.1. Here, the volumetric input flow combinations required to produce given pressure drops are shown. The device being modeled is a 2.43 cm I.D. (1" Schedule 80) pipe of 1.83 m length filled with 0.635 cm steel spheres. Single-phase correlations by Ergun and two-phase correlations developed by Larkins, White, and Jeffreys were used to develop the plots.

Fig. 6.1. Input volumetric flow rates required to give constant pressure drops (to atmospheric) across bench scale packed bed.

In the calculations, the single-phase friction loss equation of Ergun is used first to determine δ (pressure drop per unit distance) for each phase separately. This equation is:

$$\delta = N_{Re}(\alpha + \beta N_{Re}) / \frac{G_c \rho D_p^3}{\mu^2} \frac{\epsilon}{1 - \epsilon}^3$$

where

- α = empirical constant = 118.2 for spherical packing
- β = empirical constant = 1.0 for spherical packing
- ϵ = Bed void fraction
- μ = Fluid viscosity
- D_p = Packing diameter
- ρ = Fluid density
- G_c = Gravitation constant
- N_{Re} = Reynolds number = $\rho u D_p / \mu (1 - \epsilon)$
- u = Superficial velocity

The following correlations (Fig. 6.2) developed by Larkins, White, and Jeffreys² are applied to give two-phase pressure drop per unit distance and liquid saturation.

This correlation has been found to hold for the following range of variables (Table 6.1) with a standard deviation of 13% for the pressure drop curve and 16% for the saturation curve.

The constant length packed bed pressure drop calculation consists of numerically integrating the quantity $(1/\delta_{lg})$, a function of pressure, between the bed outlet pressure and progressively higher inlet pressures, until the result is the desired length, in this case 1.83 m.

6.5 Materials

This section reports on four subtasks in the area of materials technology--Materials Design Review and Coordination of Materials R&D for SRC Projects, Quality Assurance Support for H-Coal Pilot Plant Welding, H-Coal Materials Testing and Failure Analysis, and Investigation of Corrosion in Fraction Areas of Liquefaction Plants.

R_l = liquid saturation

δ_l = liquid pressure drop per unit distance

δ_g = gas pressure drop per unit distance

δ_{lg} = two phase pressure drop per unit distance

Fig. 6.2. Two-phase concurrent-flow pressure drop through packed beds.

Table 6.1. Range of experimental variables.

<u>Variable</u>	<u>Minimum</u>	<u>Maximum</u>
Column size, m	5.08×10^{-2}	$10.2 \times 10^{-2}{}^a$
Packing diameter, m	$.3175 \times 10^{-2}$	$.9525 \times 10^{-2}$
Packing porosity	0.357	0.520
Superficial gas velocity, m/sec	0	8.04
Superficial liquid velocity, m/sec	0	.265
Viscosity of gas, Paschal-s	1.2×10^{-5}	1.9×10^{-5}
Viscosity of liquid, Paschal-s	3.29×10^{-4}	4.10×10^{-2}
Reynolds number for gas	0	6200
Reynolds number for liquid	0	3405
Two-phase pressure drop, Paschal/m	5.42×10^3	3.12×10^5
Column pressure, MPa	.12	.68 ^b
Fraction liquid	0	1.0

6.5.1 Materials design review and coordination of materials R&D for SRC projects - R. R. Judkins and A. R. Olsen

Objective - The objectives of this task are to assist in the review of contractor documents for materials selection, to review and provide input to materials testing and failure analysis plans, and to coordinate materials research and development for SRC projects.

Status summary - A schedule for the release of documents containing materials selections for SRC-II was provided by the Pittsburgh and Midway Coal Mining Company in the minutes of the meeting held at Englewood on May 22. That company also provided a list of items that are critical with respect to materials selection. The information provided by P&M is presented in Tables 6.2 and 6.3.

During the May 30, 1980, meeting at the International Coal Refining Company in Allentown, Pennsylvania, we were asked to provide ICRC with comments on the materials selection contained in Phase 0 documents for the SRC-I Demonstration Plant. We have identified documents that contain materials information and have initiated the review. Minutes of the May 30, 1980, meeting were received.

6.5.2 Quality assurance support for H-Coal pilot plant welding - K. K. Klindt

Objective - The objective of this activity is to provide technical support to DOE-ORO in the resolution of weld quality problems in the piping system at the H-Coal pilot plant.

Status summary - No support was needed during the month of June 1980.

6.5.3 H-Coal materials testing and failure analysis - A. R. Olsen, J. R. Keiser, V. B. Baylor, and R. W. Swindeman

Objective - The objective of this task is to provide assistance to the Ashland Synthetic Fuels, Inc. (ASFI) in developing and implementing a materials testing, surveillance, and failure analysis plan for the H-Coal Pilot Plant at Catlettsburg, Kentucky. The scope of work involves the review of the materials of construction, participation in the materials testing effort, the preparation of a failure analysis plan acceptable to the participants of the H-Coal Project, and the provision of failure analysis service to the H-Coal Pilot Plant on request.

Table 6.2. Materials selection documents

Unit	Technology Source	Proven Technology	Document Availability ^a
Dissolver System	Gulf	No	4th Qtr '80-1st Qtr '81
Hydrogen Treatment and Recovery System	Not selected	No	1st-2nd Qtrs '81
Hydrodesulfurization	Gulf	Yes ^b	1st-2nd Qtrs '81
Gasifier	Texaco	No	1st-2nd Qtrs '81
Shift Conversion System	Not selected	Yes	1st-2nd Qtrs '81
Hydrogen Purification and Compression System	Not selected	Yes	1st-2nd Qtrs '81
Syngas Purification System	Not selected	Yes	1st-2nd Qtrs '81
Methanation System	Not selected	No	1st-2nd Qtrs '81
LP Gas Treatment System	Not identified	Yes	1st-2nd Qtrs '81
Production Gas System	Not identified	Yes	1st-2nd Qtrs '81
Sulfur Recovery System	Not selected	Yes	1st-2nd Qtrs '81
Fractionation System	Not identified	c	4th Qtr '80-2nd Qtr '81
Ammonia Recovery System	Not selected	Yes ^d	2nd-3rd Qtrs '81
Tar Acid Recovery System	Not selected	Yes	2nd-3rd Qtrs '81
Oxygen Production System	Not selected	Yes	2nd-3rd Qtrs '81
Steam Generation	Not identified	Yes	2nd-3rd Qtrs '81
Water Supply, Treating, Intake	Not identified	Yes	2nd-3rd Qtrs '81
Water Reclamation System	Not identified	e	2nd-4th Qtrs '81
Cooling Water System	Not identified	Yes	2nd-3rd Qtrs '81
Miscellaneous Utilities (Plant Air, Instrument Air, Nitrogen)	Not identified	Yes	2nd-3rd Qtrs '81
Fuel and Flare	Not identified	Yes	2nd-3rd Qtrs '81
Electrical Supply and Distribution	Not identified	Yes	2nd-3rd Qtrs '81
Coal Supply Systems	Stearns-Roger	Yes	
Coal Crushing Systems	Stearns-Roger	Yes	
Fine Coal Handling Systems	Stearns-Roger	Yes	
Plant Ash Handling Systems	Stearns-Roger	Yes	
Ash Disposal System	Stearns-Roger	Yes	
Site Development, Improvements, Roads, Railroads	Constructor	Yes	
General Plant Buildings, Mobile Equipment	Constructor	Yes	
Receiving, Storage, Shipping	Constructor	Yes	
Interconnecting Piping (Offsite Piping, Pipe Racks)	Constructor	Yes	
Plant Fire Protection, Sewers, Drainage	Constructor	Yes	
Central Process Control, Communication	Constructor	Yes	

^a Dates documents containing material selections available, according to schedules published since May 21, 1980, meeting.

^b Conventional practice if feed is chloride free.

^c Conventional process scheme, but there are metallurgical problems associated with atmospheric distillation in processing coal derived liquids.

^d Conventional unit that operates with unconventional feedstock. Materials problems may exist in stripping column.

^e No problems expected; however, design is very preliminary.

Table 6.3. Critical items for materials selection

Component	Problems
Letdown valves	Special design criteria may be required, but special materials may be needed to resist the erosive wear.
Gasifier refractory	Only limited test information is available until licensing agreements are signed.
Wash solvent columns	Chloride attack with superimposed effects of oxygen and water is of concern.
Charge heater	Erosion-corrosion and coking are problems.
Pumps	Liners and seals to resist abrasive wear are needed.
Vacuum bottoms	Performance of pumps is a concern.
Process heat exchangers in slurry service	Fouling factors and corrosion may be of consequence.
Dissolver	High strength structural alloys are needed with better resistance to hydrogen attack so that process pressure can be increased. Increasing chromium content from 2.25 to 3.0% would be expected to help.

Status summary - As a result of our review of the materials of construction we have identified the need for more materials information regarding the mechanical properties, stress-corrosion, and corrosion-fatigue resistance of type 347 stainless steel cladding. Efforts are underway to procure material for evaluation and to recommend testing programs that will produce needed information. We are also evaluating the availability of data for several alternate alloys of interest for H-Coal pressure vessel applications. Alloys of interest include the modified 2 1/4 Cr-1 Mo steel produced by Japan Steel Works, 3 Cr-1 Mo steel, and 9 Cr-1 Mo steel. Efforts will be made to include these materials in the H-Coal materials testing program.

The latest version of the ASFI Materials Testing and Failure Analysis Plan has been sent to the National Bureau of Standards Failure Data Information and Dissemination Center for comments.

6.5.4 Investigation of corrosion in fractionation areas of liquefaction plants - J. R. Keiser, D. C. Canada, V. B. Baylor, M. Howell, and R. W. Swindeman

Objective - Severe corrosion has been observed in the fractionation area of the SRC pilot plants. A concentrated effort is being made at ORNL to discover both the corrosion mechanism and a means to control the corrosion.

Status summary - During the past month, our efforts have been directed toward analyses of liquids from the pilot plants and operation of laboratory experiments.

The liquids analyzed were supplied by the Fort Lewis SRC Pilot Plant. Samples were collected from 15 different locations to permit measurement of the Cl, N, O, and S contents through the plant. Results of the analyses are given in Table 6.4, and the sampling locations are shown in Fig. 6.3. The most significant results indicate that

- (1) the recycle process tank water removes a large portion of the chlorine and acidic components from the oil that comes through the high pressure flash overhead, and
- (2) the chlorine and neutralization number (in oils) are highest in the areas where corrosion is the greatest (tray 21 and middle distillate).

The oxygen content is highest in the area of greatest corrosion while nitrogen and sulfur have not shown significant patterns.

Two laboratory experiments of special relevance were performed this month. One was a repeat of the experiment in which an iron tube that was welded shut was exposed at 200°C to corrosive material from Fort Lewis. The inside of the tube was purged with argon before the exposure started, then after exposure a sample of the gas in the tube was

collected and analyzed. Results indicate the gas was 43 vol % hydrogen, confirming our theory that one step in the corrosion process involves the reaction

The other experiment, which was suggested by Dennis Canfield of the Fort Lewis Pilot Plant, consisted of a determination of the effect of water washing on the corrosivity of Fort Lewis middle distillate. These experiments were performed by exposing carbon steel and type 304 stainless steel specimens to the middle distillate product collected at Fort Lewis on April 23 and 24, 1980. Middle distillate was used because it was the product from the area of greatest corrosion during this operating period. The specimens were exposed 5 h at an average temperature around 215°C (420°F). In one case, specimens were exposed to as-received middle distillate. The second experimental condition used middle distillate that had been mixed with an equal volume of water, then centrifuged to break the emulsion, and finally filtered to further separate the oil and water portions. The oil retained enough water to require heating to drive it off before the experiment could be run. In the second set of experiments the as-received oil was given the same heating treatment as the water-washed oil.

Calculated corrosion rates for these experiments are shown in Table 6.5. Clearly, water washing significantly reduced the corrosion.

Corrosion rates are based on the assumption that corrosion occurred at a constant rate during the entire 5-h experiment. We suspect that corrosion was greatest during the first few hours and, consequently, corrosion rates were higher than the values calculated. For the second set of the as-received oil, about 50% more oil was used, and the weight loss was greater. This indicates the corrodent may have been consumed early in the first test.

Liquids used in these experiments are being analyzed, and partial results are given in Table 6.6. These analyses show that the two samples of as-received oil had similar chloride contents but different neutralization numbers. The water wash removed more than 75% of the chlorine from the oil and greatly reduced the acidity, and we suspect this is the most significant aspect of the water wash. Analyses for nitrogen and sulfur are being performed, and the results could provide vital information regarding transport of critical components through the column.

Although a complete description of what is removed by water washing will not be available until the chemical analyses are completed, it is clear that the chloride content of the oil is greatly reduced. Of perhaps greater importance is the reduction in corrosion which we've observed with the water washing of the oil. If this means of corrosion control can be demonstrated successfully on the pilot plant level, it would offer an alternative to removal of phenols or construction of the column from very expensive alloys.

Table 6.4. Results of chemical analysis of Fort Lewis liquids collected on April 23, 1980

Neutralization number, mg KOH/g	Total Cl, ppm	H ₂ O-soluble Cl, ppm	Total N, %	Total S, %	Total O, %	H ₂ O, %	Stream identification number ^a
0.87	80.7	93.4	0.54	0.36	2.56	0.60	Recycle process tank, oil (1)
57.8	710	--	--	--	--	--	Recycle process tank, water (2)
0.34	261	232	1.12	0.57	1.73	0.10	Vacuum flash con- densate drum (3)
0.40	173	205	1.01	0.50	2.35	0.18	Light ends column, feed (4)
0.10	87.0	110	0.30	0.38	--	0.20	Light ends column over- head, naphtha (5)
0.53	66.3	--	--	--	--	--	Light ends column over- head, water (6)
0.29	203	262	1.07	0.44	3.0	0.06	Wash solvent column, feed (7)
0.12	90.5	93	0.76	0.383	2.8	0.06	Wash solvent column, tray 13 (8)
0.12	86.4	90	0.71	0.391	2.2	0.09	Wash solvent column, tray 15 (9)
0.36	204	225	0.79	0.340	3.0	0.05	Wash solvent column, tray 16 (10)
0.14	98	117	0.92	0.149	2.4	0.03	Wash solvent column, tray 17 (11)
0.31	166	203	1.00	0.224	2.9	0.04	Wash solvent column, tray 19 (12)
0.76	489	520	0.92	0.246	3.7	0.05	Wash solvent column, tray 21 (13)
0.81	417	574	0.81	0.299	4.5	0.08	Middle distillate (14)
0.13	117	99	0.99	0.591	1.7	0.06	Heavy distillate (15)

^aNumber in parentheses refers to location shown in Fig. 6.1.

Fig. 6.3. Process flow diagram of solvent recovery area of Fort Lewis SRC Pilot Plant.

Table 6.5. Corrosion rates calculated from weight changes of specimens exposed in the middle distillate product from the Fort Lewis SRC Pilot Plant

Specimen	As-received middle distillate		Water-washed middle distillate	
	(mm/year)	(mils/year)	(mm/year)	(mils/year)
<u>First Experiment^a</u>				
Carbon steel	4.42	174	0.56	22
Type 304 stainless steel	3.92	154	0	0
<u>Second Experiment^b</u>				
Carbon steel	8.80	345	0 ^c	0
Type 304 stainless steel	6.79	267	0 ^c	0

^aSingle water wash used; water removal heating cycle used only on washed oil.

^bDouble water wash; water removal heating cycle used on both as-received and water-washed oil.

^cSlight weight gain.

Table 6.6. Partial analyses of liquids used in experiments exposing specimens in the middle distillate product from the Fort Lewis SRC Pilot Plant

Liquid	Neutralization number, mg KOH/g	Total Cl, ppm	Total S, %	Total N, %
<u>First Experiment</u>				
As received oil	0.81	417	0.299	0.99
Water after washing oil	1.21	310	--	--
<u>Second Experiment</u>				
As received oil	1.24	432		
Post test oil	1.10			
Pretest water washed oil	0.10	5	0.24	0.575
Water after washing oil	1.45	492		

6.6 Environmental and Health

The objectives of this task are: (1) to assist DOE in the preparation of the NEPA-required Environmental Impact Statements for the SRC-I and SRC-II demonstration plants; (2) to provide environmental technical assistance to DOE in support of these projects; (3) to assist DOE in the review of plans for landfilling of solid wastes from H-Coal operations; (4) to provide support to DOE in the accumulation, synthesis, and interpretation of environmental and health data related to direct coal liquefaction technologies, especially SRC and H-Coal processes.

6.6.1 SRC I and SRC II environmental impact statements - C. R. Boston and S. G. DeCicco

SRC I demonstration project - On May 5, 1980 the preliminary Draft Environmental Impact Statement (PDES) was sent to DOE for review. DOE, in turn, distributed the document to Southern Company Services, the International Coal Refining Company, and others for review. A lengthy nine week comment period was allowed by DOE. During the month of June, ORNL issued two supplements to the PDES to respond to early comments and incorporate resolutions reached in preparing the SRC II Draft EIS. These supplements were issued on June 6 and 20. The Draft Environmental Impact Statement is expected to be completed by early August.

SRC II demonstration project - On June 2, 1980 the Federal Register announced the Notice of Availability of the SRC II Draft Environmental Impact Statement (DES), marking the beginning of the 45-day public comment period. Public Hearings were held on the DES in Morgantown, West Virginia on June 30 and July 1. Several hundred persons attended and presented written and oral comments on the DES. The majority of the speakers were opposed to the project based on health risks, social and economic impacts that would be imposed on the surrounding area, the fact that the DES was not based on a final detailed design, and the consumptive use of water from the Monongahela River. These comments and others received prior to July 19 will be used to prepare the Final Environmental Impact Statement.

6.6.2 Environmental review for H-Coal landfill - T. H. Row

No effort was requested in this area during June.

6.6.3 Environmental and health status of SRC and H-Coal processes - R. F. Kimball, N. B. Munro, C. J. Oen, and L. W. Rickert

The literature search for pertinent information was essentially completed this month with the exception of the search of the EMIC files for information about type compounds. Individuals in a number of other institutions have been contacted and have been very helpful in supplying hard copies of available publications and preprints. A

file of information on principal investigators has been set up as a basis for an eventual directory of research in progress in the topic area.

A computer file has been set up of information on compounds that have been identified by chemical analysis of coal liquefaction materials and materials from related technologies. A selected set of tables from various publications formed the basis of this file. This computer list has been used to search the EMIC files for documents containing pertinent information on mutagenesis of these compounds. The next step is to identify and obtain hard copies of a subset of these documents, including reviews and the most recent research publications. This set will provide an essential source for the "Type Compound" portion of the review.

A draft of the section on Mutagenesis Test Protocols (Section III of the report outline) has been completed. Material for Section IV, Results for Coal-Derived Liquid Products and By-Products, is being organized preparatory to writing this central section of the review.

6.7 General Technical Support

General technical support is provided for the SRC I and SRC II projects and for the H-Coal project as requested.

6.7.1 SRC I and SRC II general technical assistance - H. D. Cochran

There is no current activity in this area.

6.7.2 H-Coal pilot plant general technical assistance - H. D. Cochran

The following activity on H-Coal reactor safety assessment (headed by H. A. Mitchell) is in progress in this area.

Objectives - The purpose of the reactor safety assessment is to determine the adequacy of the vessel for the two-year duration of the H-Coal project, to identify any significant failures which could affect reactor operation, and to determine the adequacy of systems to limit or control those effects. The safety assessment encompasses the major reactor components and subsystems, the instrumentation directly associated with the reactor and normal, upset, and emergency procedures.

Status Summary - The draft report of the assessment submitted to DOE on May 12 was summarized in a presentation to the H-Coal Management Advisory Committee (MAC) at the pilot plant on June 12, 1980. There was considerable discussion on the method of analysis, materials data and the loading histograms that were used. DOE requested that comments from the MAC be transmitted in writing so the draft report could be finalized.

The conclusion presented at the meeting was that the vessel is adequate for 2 years operation of the pilot plant. However, DOE is considering extending operation of the pilot plant for a total life of 5 years at the request of the pilot plant operators. Consequently, DOE has asked if the vessel is adequate for the projected 5 year life. The response to this question is being developed.

6.8 References for Section 6

1. L. E. McNeese (ed.), Fossil Energy Program Monthly Progress Report for the Period Ending May 31, 1980, ORNL/TM-7414, Oak Ridge National Laboratory, Oak Ridge, Tennessee (in process).
2. R. P. Larkins and R. R. White, University of Michigan, Ann Arbor, MI; D. W. Jeffreys, Humble Oil & Refining Company, Baytown, TX; "Two-Phase Concurrent Flow in Packed Beds", A. I. Ch. E. Journal, Vol. 1, No. 2, June 1961.

7. PROCESS ANALYSIS AND ENGINEERING EVALUATIONS

R. W. Glass

Process analysis and engineering evaluations studies are being conducted for DOE/FE to provide on a consistent basis, technical and economic assessments and evaluations of processes and systems for coal conversion and utilization.

7.1 Liquefaction Technology Assessment (LTAS)

R. C. Forrester III, R. Salmon, S. P. N. Singh, J. F. Fisher,
R. M. Wham, W. C. Ulrich, and P. J. Johnson

7.1.1 Objective

The objective of the Liquefaction Technology Assessment is to provide technical information, cost information, and economic evaluations needed by the Department of Energy (DOE) to compare, on a consistent basis, coal liquefaction processes. The assessment will be carried out in several phases, starting with processes employing available technology and progressing to those which are in earlier stages of development. Technical and cost information will be provided by Fluor Engineers and Constructors through a contractual agreement with the Oak Ridge National Laboratory (ORNL). ORNL will provide the process design bases, conceptual design philosophy guidance, and economic evaluations based on the cost information provided by Fluor.

7.1.2 Status summary

Revision of the Phase 0 draft report is complete and the manuscript has been submitted for final editing. Publication has been delayed slightly but is expected during the next quarter.

Phase I continued to proceed with issuance by ORNL of the Phase I draft final report for a limited proponent review. The publication process will begin following incorporation of DOE and proponent comments into the Phase I draft final report.

In addition to the Phase I and Phase II Studies, work has begun on an environmental study for the Assistant Secretary for the Environment (ASEV) through the Office of Technology Impacts of DOE. The objective of this study is to examine the effect of varying degrees of stringency of environmental standards on the economics of an indirect liquefaction process at several plant capacities. Fluor will use the Phase I designs as a starting point and develop a total of twelve designs. Four different levels of environmental standards will be examined for three different plant sizes.

The subcontract procurement package prepared for Fluor Engineers and Constructors has been approved by DOE. ORNL has begun developing the standards for the four levels of environmental control. Fluor will begin work on process designs after the environmental control levels have been established.

7.2 Direct Combustion

E. C. Fox and T. D. Anderson

7.2.1 Objective

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 to increasing the near-term use of coal.

7.2.2 Status summary

The main report, "Conversion to Direct Coal Combustion in the Industrial and Commercial/Residential Sectors - A Study of the Barriers to Implementation in the Near Term," ORNL/TM-6139, is being prepared for final publication.

7.3 Advanced Power Conversion Systems

J. E. Jones Jr. and A. P. Fraas^a

7.3.1 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.

^aConsultant

7.3.2 Status summary

A total of eleven systems or components of systems were evaluated. Draft reports covering all of these topics, an overall summary report, and an executive summary report have been completed and are undergoing final review. The reports entitled "Summary of the Research and Development Effort on Open-Cycle Coal-Fired Gas Turbines," ORNL/TM-6253, and "Summary of Research and Development Effort on Air and Water Cooling of Gas Turbine Blades," ORNL/TM-6254, have now been published.

7.4 Process Modeling

R. Salmon, P. J. Johnson, and W. C. Ulrich

7.4.1 Objective

The objective is to assist DOE/FE in its plan for computer analysis and computer support of coal conversion studies. Past work included assistance to Purdue and Lehigh Universities in the development of computer programs for this plan. Physical property data were collected and computerized primarily by Purdue and will be used in support of future process modeling efforts. Purdue's general design program was aimed at material and energy balances, equipment sizing and costing, plant capacity, and general economics. Lehigh's dynamic simulation programs addressed plant design primarily from the standpoint of process performance during transient operations, but can also be used for steady-state conditions. Current work includes process modeling and systems engineering support to Morgantown Energy Technology Center (METC). This comprises implementation of codes delivered by Purdue and Lehigh Universities onto the computer system at METC and development, testing, implementation, and use of new process models. The project is funded by Morgantown Energy Technology Center.

7.4.2 Status summary

Evaluation of Physical Property Package PPROP

A draft report on the evaluation of the physical property package PPROP is being reviewed internally prior to transmittal to METC.

Addition of Solids Handling Capability to PPROP

Work on this task continued. Representative properties (ultimate, proximate, and ash analyses; heating values; etc.) were selected for typical eastern (Illinois No. 6) and western (Wyodak) coals. Representative chemical compositions for typical limestone (Chaney) and dolomite (Tymochtee) were also selected. This information will be used for testing the routines which are being developed for handling solids and in checking the validity of the resulting physical properties program.

Three sample problems were also devised to provide means for validating results which we expect to obtain when this portion of the code is completed.

Evaluation of Rajan-Wen-Krishnan FBC Computer Program

Review and evaluation of the fluid bed combustor portion of the program continued. A number of deficiencies were found:

- The material balance convergence routine equates two quantities that cannot be stoichiometrically equal
- Overall material balance is not achieved
- Bed composition is inconsistent with input from elutriation-attrition model
- Amitin expression for transport disengaging height was modified with no justification
- Calculated carbon content of bed (0.2%) is much lower than experiments indicate.

Evaluation of the combustor section of the program should be completed next month.

7.5 Coal Liquefaction Advanced Research Digest

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

7.5.1 Objective

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

7.5.2 Status summary

Researching and writing were completed on the article "Chemical Reactions of Coal Liquefaction" for the third issue of the Digest. The manuscript has been submitted for typing, and when that is complete it will be circulated for internal review. Writing was completed on the "Foreword," and writing continues on the article "Chemical Characterization of Coal-Derived Liquids" for the same issue of the Digest.

The article "Coal Depolymerization" was submitted for final editorial review and typesetting for the fourth issue of the Digest. Writing continues on the article "Free-Radical Chemistry of Coal Liquefaction" for that same issue.

8. FOSSIL ENERGY ENVIRONMENTAL ANALYSIS

C. R. Boston, T. H. Row

Environmental support is provided to DOE/Fossil Energy and DOE/Economic Regulatory Administration. The effort includes: (1) preparation of NEPA-required assessments and statements related to synfuels demonstration programs and fuel conversion implementation; (2) programmatic environmental studies that are critical to the early realization of advanced fossil technologies and minimization of the use of petroleum and natural gas; and (3) general environmental technical assistance.

8.1 Fossil Energy Environmental Project

C. R. Boston

The Fossil Energy Environmental Project provides DOE with program assistance in the performance of environmental assessment functions related to the expansion of fossil energy conversion technologies, performs assigned technical assistance tasks, and conducts programmatic environmental investigations that are critical to the early realization of advanced fossil energy technologies.

8.1.1 Stored solids study - W. J. Boegly, Jr., F. S. Brinkley, E. C. Davis, C. W. Francis and H. W. Wilson, Jr.

The EPA extraction procedure and the two proposed ASTM leaching tests have been performed on all wastes currently in storage at ORNL. Four site soils have been sent to analytical chemistry for elemental analysis, and the remaining two site soils will be analyzed when received. Preparations are underway to initiate measurement of the absorption properties of the site soils for use in the lysimeter experiments and modeling studies.

Analysis of the column leaching data indicates that certain of the constituents listed in the Secondary Drinking Water Standards will be exceeded in the initial leachates produced. Since these Standards may be included in the RCRA criteria for nonhazardous waste disposal as the maximum contaminant levels (MCL) allowed in the groundwater at the disposal site, certain mitigation measures may be required in the landfill design (liners, etc.).

Evaluation of the new RCRA hazardous waste regulations indicates that there will be no change in the initial finding that the mineral residues from the gasifiers being studied will be classified as nonhazardous. In fact, it appears that the regulations exempt solid wastes resulting from the combustion of coal. It is not clear whether EPA will consider gasification as combustion in applying RCRA to ash

landfills. Phase II and III regulations will be published in the future which may clarify this exception.

8.1.2 Coal conversion demonstration projects

Liquefaction projects - S. G. DeCicco

This activity is reported in Chapter 6.

Gasification projects - A. J. Witten

MLGW - A DES review draft was provided to DOE on May 9. Representatives of DOE met with the ORNL team on June 19 and 20 to discuss comments on this draft. Revisions to the document were incorporated and this document was approved by DOE project management on June 30. ORNL is awaiting DOE's revisions of the programmatic sections before completing the final DES mats.

ICGG - A DES review draft was delivered to DOE on June 18. We are awaiting comments.

CONOCO - A DES review draft was delivered to DOE on June 11. We are awaiting comments.

8.1.3 Communications

a. Triegel attended the National Conference on Hazardous and Toxic Wastes Management, Newark, N.J., June 2-5.

b. A review meeting to discuss DOE comments on the MLGW revised PDES was held at ORNL on June 19-20.

c. Witten attended a meeting in Germantown on June 30 to discuss finalization of the Draft EIS for MLGW.

d. Boston, DeCicco, DeVault, Kornegay, Martin and Row attended the SRC-II hearings in Morgantown on June 30, July 1.

8.2 Economic Regulatory Administration Support Project

R. C. Martin

The purpose of this project is to provide technical assistance to the Economic Regulatory Administration (ERA) of the Department of Energy in its implementation of the Powerplant and Industrial Fuel Use Act of 1978 (FUA). This act has as a general purpose the minimization of the use of petroleum and natural gas as a primary energy source in a manner consistent with applicable environmental requirements. The

scope of FUA includes both new and existing electric powerplants and new and existing major fuel burning installations. Within ERA the Office of Fuels Conversion (OFC) is responsible for implementing FUA and meeting the requirements of the National Environmental Policy Act. The Fuels Conversion Analysis Division supplies the technical support for OFC.

The initial assignment for this project relates to the conversion of two existing powerplants in the New York City area (Arthur Kill and Ravenswood) from oil as the primary fuel to coal or other alternate fuel.

The task order for work on the Northport powerplant on Long Island was received at the end of June.

The second 1980 Fuel Use Act Quarterly Conference was held in Hinsdale, Illinois on June 3 and 4. The following ORNL project personnel attended this meeting: Hartman, Kornegay, Loeb1, Martin, Wilkes and Zittel.

Martin and Wilkes attended a pre-prohibition order meeting on June 12 with LILCO officials and EPA personnel regarding the Barrett powerplant. Martin attended a analysis kickoff meeting on June 24 with New England Power Company officials regarding the Salem Harbor powerplant.

8.2.1 Environmental analysis section - N. E. Hinkle

The latest draft of the EIS Implementation Plan for the coal conversion of the Arthur Kill 2 and 3 powerplants was sent to ERA. A very similar plan for the Ravenswood 3 unit was also prepared and sent to ERA.

Completion of reports on fuel supply, transportation, and engineering (including emissions, effluents, and solid wastes) have been delayed. The Con Ed transportation and solid waste disposal studies have not been received. Draft copies of the Northeast Regional EIS task reports will not be available until August. As a result, the schedules for delivery of the PDEIR for both powerplants were delayed until November 1 for Arthur Kill and December 1 for Ravenswood.

Con Ed rejected Annetta Watson's request for additional in-plant noise data. Con Ed officials did supply copies of open-literature reports about their employee hearing conservation programs. Based on these reports, Ms. Watson has requested identification of high noise areas that have been posted within the plants, an identification of the potential source of the noise in each case, and potential

personnel exposures to noise at work stations nearby. We are also requesting copies of periodic reports prepared for OSHA outlining occupational accidents, injuries and noise exposure, or alternatively, the OSHA office charged with oversight responsibility for these Con Ed powerplants.

Ms. Watson intends to visit TVA offices on July 14 to review occupational exposure data, particularly noise, for typical coal-fired plants. This information will be used to compare with whatever information is obtained from Con Ed for the existing oil-fired plants to derive a differential impact.

8.2.2 Air quality analysis section - F. C. Kornegay

A subcontract has been entered into with HDR, Inc., for assistance with the air quality modeling for the Arthur Kill and Ravenswood powerplants. This work is underway and will accelerate in the near future.

8.2.3 Engineering analysis section - W. L. Greenstreet

A representative of the Engineering Section attended the quarterly EPA Program Conference in Hinsdale, Illinois, on June 3-4, 1980. At that conference, a working group of DOE/ERA and ORNL personnel identified transportation modes to be examined for the Arthur Kill and Ravenswood powerplants. These modes are for FGD sorbents, wastes, and all except one fuel (COM). The transportation method plus alternatives were later determined for COM, and the transportation mode information was given to UE&C. See Table 8.1 for a listing.

In addition to transportation mode information, other information required for the engineering studies, such as methods for handling and storage of ash, sorbent, and pyrites, and capacity factors for converted units, were transmitted to UE&C. A formal transmittal of the latest report outline and list of fuels was also made. Although publication of the engineering analysis reports depends on having all needed information available, the following estimates were made for delivery of reports on the two plants. The Arthur Kill report will be available on August 15, 1980, and the Ravenswood report will be available about September 1, 1980.

Comments were sent to UE&C on draft reports submitted in May. These reports covered noise impacts, occupational hazards, and plant emissions and discharges. It is expected that revised versions of these reports will be issued in July, and they will address both the Arthur Kill and the Ravenswood plants. In the case of noise impacts, the coverage, in this case, will be only for locations exterior to the plants. The strategy for dealing with the in-plant noise assessment has not been finalized.

Table 8.1 Transportation modes for Arthur Kill and Ravenswood powerplant investigations

<u>Plant</u>	<u>Fuel</u>	<u>Sorbent</u>	<u>Ash</u>	<u>Spent Sorbent</u>
Arthur Kill	Coal ^a : Rail (non-unit train)	Rail	Truck (No FGD)	
			Barge (With FGD)	Barge
	RDF: Truck			
	COM ^{b,c} : Barge			
Ravenswood	Coal: Barge	Barge	Barge	Barge
	RDF: Truck			
	COM ^{b,c} : Barge			

^aCoal to be shipped by barge from Arthur Kill to Ravenswood in emergencies.

^bTo be mixed off-site.

^cPreparation plant could be located at Arthur Kill Power Plant or in vicinity. COM could be barged from Arthur Kill to Ravenswood.

To aid in understanding the roles and importance of various characteristics in the handling and use of coal, a brief write-up was prepared by UE&C. In addition, a paper is being written at ORNL, which discusses factors influencing selection of coals for fuels in reconverted powerplants. This paper is to place in perspective the many considerations that come into play. Therefore, the specific objectives are:

1. To identify and describe factors that influence the selection and availability of a coal source and its mode of transport, and to develop a methodology for source selection.
2. To describe the role that coal preparation processes might play in improving the quality of steam coals.
3. To identify those properties of coals most critical in reversion to coal of an existing powerplant and to indicate why they are important. This includes describing the roles and effects of different coal properties on steam raising, steam generator designs and performance, flue gas clean-up systems, and waste disposal.

A write-up on the fuel scenario evaluation for Arthur Kill and Ravenswood was prepared according to the format given in Enclosure B of the letter from M. E. Carosella to R. M. Rush, dated April 8, 1980. In addition, an investigation into sulfur variability in a given coal and FGD system operating experience was made to determine the potential of present system designs to meet new EPA compliance requirements (NSPS). This investigation indicated that with positive management attitudes, proper operating and maintenance personnel training, and acceptable system design, the high operating efficiencies required could be attained.

Reproducibility of coal analysis results is within about 3% when ASTM standard procedures are used. While this accuracy is acceptable, there is a need for improved sampling and more rapid test reporting to provide the FGD system operator with information needed on changing fuel characteristics. Currently, emission compliance and fuel monitoring are not well-matched from an operator viewpoint.

In the case of stack gas bypass being used for reheat, that is, for partial scrubbing, problems of duct corrosion when flow is stopped are reported. However, stack failure appears most likely.

Pyrite handling was examined for cases where the pyrite is not rejected at the pulverizer. Manufacturers indicate that complete grinding with the coal occurs in ball mill type pulverizers. The amount of pyrite, in any case, is probably on the order of 1%, or less, by weight of the total coal pulverized.

Other activities included a review of the Radian study on problems imposed on small utility systems by compliance with the Fuel Use Act. Cost test calculations for Arthur Kill and Ravenswood are being reviewed for changes associated with engineering analyses now underway, and information on the Northport and Barrett powerplants is being collected.

8.2.5 Northeast regional analysis

Air quality - F. C. Kornegay

Air quality modeling for two scenarios is complete at both ANL and ORNL. The ORNL results were presented at the Quarterly Meeting on June 4. The ANL results were received at ORNL on June 24.

8.2.6 Electric utility dispatch analysis - C. R. Hudson

Preparation of the PRODCOST input data for the New England Power Pool has been completed. Conversion of REUOM input data to PRODCOST format for the New York pool is nearly complete. Simulation of these two regions will take place as soon as a review of the PRODCOST code has been completed. It is expected that the simulations will be made in mid-July.

As we are awaiting the outcome of discussions between DOE and the PJM pool regarding data availability, there was no activity in June on modeling the PJM system.

8.2.7 Milestones

The following dates have been established for delivery of the first draft of the indicated reports to ERA. Unless otherwise noted, work on these reports is on schedule.

Arthur Kill Powerplant

Fuel Scenario Evaluation Environmental Regulations Technical Report	March 20, 1980	delivered
Fuel and Waste Technical Report	March 25, 1980	delivered
	May 31, 1980	parts delivered parts delayed
Engineering Analysis Technical Report	August 15, 1980	
Environmental Impact Report	November 1, 1980	

Ravenswood Powerplant

Fuel Scenario Evaluation Environmental Regulations Technical Report	March 20, 1980	delivered
Fuel and Waste Technical Report	March 25, 1980	delivered
	May 31, 1980	parts delivered parts delayed
Engineering Analysis Technical Report	September 1, 1980	
Environmental Impact Report	December 1, 1980	

Northeast Regional Study

Air Quality Technical Report	September 15, 1980
Health Effects Report	September 1, 1980

Electric Utility Dispatch Study

New York Power Pool	April 14, 1980	delivered
New England Power Pool	June 1, 1980	delayed
PA-MD-NJ Interconnection	June 1, 1980	delayed

Annual Reports Preparation

Draft FUA Annual Report	January 28, 1980	delivered
Final FUA Annual Report	February 29, 1980	delivered
Draft Federal Facilities Annual Report	March 15, 1980	delivered
Final Federal Facilities Annual Report	May 15, 1980	delivered

Small Utilities Study

Draft Report	July 31, 1980
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8.3 Fossil Energy Program Support

T. H. Row

This program was initiated with a series of visits to the Energy Technology Centers (ETC) and various Operations Offices to discuss the environmental requirements and projects of Fossil Energy Programs. These discussions resulted in a consistent set of suggested activities designed to provide the environmental effort necessary to assure commercialization of the major coal conversion programs. The ideas generated from these contacts coupled with the defined responsibilities of the Environmental Activities Branch resulted in five specific work areas:

Research planning - Provides for ongoing review of projects coupled with close project interaction to provide the insight needed to assure that all necessary environmental work is initiated.

Critical issues - Provides a detailed critical review of identified environmental problem areas with documentation of findings.

NEPA coordination - Provides assistance in scheduling required NEPA activities in support of major programs or projects.

Regulatory and legislative reviews - Provides a continuing review of all regulatory and legislative items, present and planned, and their effects on fossil energy programs.

Consultation assistance - Provides for identification of a team of experts in the environmental field available to respond rapidly to requests for assistance from the Environmental Activities Branch.

During the month the third document in the NEPA Energy Project series was completed. Draft copies of the Tennessee, Ohio, and West Virginia volumes of the Environmental Program Compliance Handbooks are nearing completion. The IH/OM Workshop has been rescheduled from August to October at the request of DOE.

8.3.1 NEPA compliance coordination - W. W. Goolsby

During this reporting period the third document for the NEPA energy projects was completed. It is expected that this document entitled, "NEPA Energy Projects - Solar, Geothermal, and Small Hydro-electric" dated June 1980, when approved will be distributed by DOE to project personnel, project managers, and other interested DOE and ORNL personnel. Projects included in this document involved the following

technologies: Solar Energy Systems - wind, ocean, photovoltaic, solar thermal, and biomass; Geothermal - geopressure, hot dry rock, and geothermal; and Small Hydroelectric Demonstrations.

Data sheets were developed on each project to provide basic information such as project title, project location, estimated project cost, technology involved, and names and location of responsible project personnel. The schedules define project milestones with respect to conceptual design, detailed design, procurement, and construction. The environmental schedule depicts NEPA activities past, present and future. The information provides an inventory and data base of energy research and development projects in operation, under proposal for funding, or funded in part or whole by DOE. The inventory includes projects large enough for process development, pilot demonstration, or commercial application which require(d) environmental assessments and/or environmental impact statements. Verification and documentation of project data and schedules were confirmed through numerous reference and source documents and by personal contact, phone conversation, and visits to DOE Headquarters, DOE Energy Technology Centers, and other involved agencies and personnel.

Also, during this report period progress was made on a fourth document being developed for other non-fossil energy projects funded in part or whole by DOE with potential NEPA requirements. The technologies involved include Conversion Facilities, Conservation, Energy Storage, Waste Energy, Energy Transmission, Power Marketing, RA and ERA. At this point the total number of projects that will be included is uncertain. Work is also underway in establishing a computerized data base for all NEPA projects for updating and reporting utilizing the 1022 Data Base Management System and RECON. This will provide quick and efficient access to all project data with numerous options for selecting particular information, data by individual project and/or total project retrieval.

8.3.2 Regulatory and legislative review - J. K. Huffstetler and C. J. Oen

Funding for the completion of this project has been approved. A revised schedule was prepared and transmitted, through appropriate channels, to DOE Headquarters for approval. The revised schedule calls for completion of final copies of the applicable federal and state laws and regulations by March 31, 1981.

The Commonwealth of Kentucky promulgated new hazardous waste regulations on June 5, 1980. Notices of this action have been sent to holders of the Kentucky draft volumes. When copies of the new regulations are received they will be abstracted, added to the data base and sent out. Appropriate time-lines, etc., will also be provided.

Draft copies of the volumes for Tennessee, Ohio, and West Virginia are nearing completion. There are now 699 citations in the data base with an additional 97 in process. Indexes for Kentucky and Illinois have been ordered. Final corrections will be made before the publication process for the final edition begins.

8.3.3 Industrial Hygiene/Occupational Medicine Workshop - T. H. Row

All speakers for the IH/OM Workshop were contacted by telephone and later by follow-up letter to confirm their invitation to participate. Acceptance responses were received from the majority of those invited.

Coordination of workshop details continued with the Boars Head Inn in Charlottesville, and all necessary brochure materials were obtained from them.

Art work was completed for all program materials required for the workshop.

A meeting was held at DOE Headquarters with project management to discuss the final planning. At that meeting, it was determined that an August date for the workshop was not appropriate in light of current DOE travel restrictions. For this reason it was decided to re-schedule the workshop for mid-October.

A survey was made of possible meeting sites having accommodations available in the desired time frame. A decision was made to hold the workshop at the Sheraton Inn/International Conference Center in Reston, Virginia and reservations were made for October 23-24 at that location.

All planning and materials are being revised for this change in date and location.

8.3.4 Milestones

A trip was made to Washington by R. A. Church to coordinate the IH/OM Workshop planning.

9. COAL PREPARATION AND WASTE UTILIZATION

E. C. Hise

The objectives of this program are: to develop, demonstrate, and bring to commercial viability, processes and equipment for the removal of pyrite and ash-forming minerals from dry crushed coal by either or both processes of high-gradient magnetic separation (HGMS) and open-gradient magnetic separation (OGMS); to integrate the magnetic process into the coal preparation system to achieve the most effective and economic preparation of the raw coal; and to develop processes to minimize the refuse disposal by efficiently utilizing the heating value and concentrated mineral resources in that refuse.

9.1 High-Gradient Magnetic Separation

E. C. Hise, M. T. McFee, and D. L. Mailen

Mr. Ray Vititoe, of Powell Construction Co., presented an interim report on the comparative design study and cost estimate to representatives of ORNL and TVA. They have now obtained detailed estimates for the feed classification equipment from vendors and anticipate being able to complete the design and their report by the end of June.

9.2 Open-Gradient Magnetic Separation

A. S. Holman, M. T. McFee, and D. L. Mailen

A preliminary circular feed test series was performed with our superconducting magnet operating in the cusp mode. The results of this test series are being analyzed on the basis of weight percent reporting as magnetic, to determine trends as a function of throughput (feed rate), ring location (pour point), splitter location, and initial trajectory.

Based on the tests run, the following conclusions can be drawn:

1. Separation efficiency declined with increasing feed rate,
2. Maximum diameter pour point produced the best separation, and
3. Diamagnetic separation produced the best results.

The effects of initial trajectory were not obvious during this test but will be explored again in more detail.

The highest feed rate attained was 300 kg/h (1/3 tons/h), which is the maximum throughput of our feed device. A detailed test series will

be run in early July utilizing the information gained from this initial test series. The results of this test series will be reported after analysis has been completed by analytical chemistry.

During the month, further investigations were performed with the Frantz Isodynamic Magnetic Separator to find the settings which would achieve maximum separation of the free falling stream of coal when using the machine in the free-fall mode. Exploratory investigations with the multisplitter showed that a feed location of 14 mm from the back of the pole pieces and a $1^{\circ}20'$ transverse angle, achieves a better separation than the $2^{\circ}20'$ which had been mathematically calculated when the Frantz was originally used in the free-fall mode. Figures 9.1 and 9.2 show the results of this investigation. This test series will be re-run at a later date with the single-edge splitter to obtain more precise and accurate separations.

9.3 Industrial Contacts and Cooperation

E. C. Hise and A. S. Holman

We have received a letter from General Dynamics expressing their appreciation for the technological information on the open-gradient magnetic separation process and stating that General Dynamics is now seriously considering open-gradient magnetic separation as a commercial venture.

A sample of Brazilian Candiota Coal has been supplied to us, through TVA, by the Companhia Estadual de Energia Electrica in Porto Alegre-Rs, Brazil. This coal contains 50 to 55% ash which makes combustion difficult and shipping prohibitive. It is reported that conventional cleaning methods have not been successful with this coal. Microscopic examination of the coarse coal reveals that it is composed of thin layers of coal and minerals. A portion of the sample was crushed and screened, magnetically separated (at an exploratory level) and the fractions submitted for chemical analysis. Microscopic examination of the crushed coal and separated fractions indicate that the crushing had achieved some liberation of the macerals and that the product fraction appeared to be enriched in the maceral component. It would also appear that considerable attention to feed preparation and separation techniques will be required to obtain a good separation.

Mr. Graydon K. Anderson, from Los Alamos Scientific Laboratory, visited our laboratory on June 17 to discuss magnetic separation technology.

Fig. 9.1. Graph of separations achieved at a transverse angle of 2°20' at the 14, 16, and 18 mm feed locations.

Fig. 9.2. Graph of separations achieved at a transverse angle of 1°18' at the 14, 16, and 18 mm feed locations.

10. COAL PREPARATION PLANT AUTOMATION

K. R. Carr

The Coal Preparation Plant Automation Program is being conducted by Oak Ridge National Laboratory for the DOE Pittsburgh Mining Technology Center (PMTc). The objectives of this program are to develop instrumentation for the automatic control of coal preparation processes and to demonstrate overall plant automation in typical coal cleaning plant.

10.1 Physical Measurements

R. L. Andercon, W. H. Andrews, and M. J. Roberts

10.1.1 Objectives

The objectives of this work area are to define deficiencies of existing on-line and laboratory instrumentation for physical measurements and to develop instruments needed to accomplish the physical measurements required for automation of coal preparation plants. Physical measurements include all measurements in the plant except those in the analytical instruments category described below. Examples of plant physical measurements are particle size, mass flow, viscosity, and density.

10.1.2 Status summary

Fabrication of the prototype hardware correlator circuitry is complete and bench testing is underway. The system performs as expected on highly coherent, computer-generated pseudo-random waveforms, giving a clear indication of the amount of delay between the two input signals. Additional tests in the laboratory will use signals from perturbation sensors in flow streams, more closely simulating operation in coal preparation plant processes. These signals are expected to have reduced coherence and it is anticipated that signal averaging techniques may have to be employed in order to obtain reliable transit time data. This circuitry is intended to provide velocity information needed for mass flow measurements to be used initially in characterizing plant processes and perhaps eventually as components in a distributed control system.

The oscillating-sphere viscometer, which had earlier been placed on order, has been received and evaluation testing will begin in the near future.

10.2 Analytical Instruments

L. H. Thacker, L. N. Klatt, D. D. McCue, and D. S. Walia^a

10.2.1 Objectives

The objectives of this work area are to define deficiencies of existing on-line and laboratory analytical instrumentation and to develop instruments needed to accomplish the analytical measurements required for automation of coal preparation plants. Analytical instruments are defined as those instruments that provide information on the chemical constituents of the coal or have a principle of operation based on nuclear methods; examples of analytical instruments are ash monitors, sulfur monitors, and nuclear density gages.

10.2.2 Status summary

Results of the state-of-the-art literature survey to date show that on-line analytical instruments currently in use and under development in the coal and other mineral industries are based on the following principles:

1. Gamma and X-ray Scattering - Ash analyzers based on this principle are commercially available from Gunson's Sortex (England) and KHD Humboldt (Germany). Similar systems are under development in Australia, Poland, and Czechoslovakia. A prototype sulfur analyzer is currently under test in England by Gunson's Sortex.

2. Prompt Gamma Spectroscopy - This technique was originally developed at the Morgantown Energy Technology Center (METC) for ash, sulfur, carbon, hydrogen, and BTU (deduced) measurements. It is now being commercially developed by MDH Industries, Inc., and by Science Applications, Inc., under sponsorship of the Electric Power Research Institute (EPRI).

3. X-ray Diffraction - Development of this technique has been proposed to the Department of Energy by Iowa State University (Ames Laboratory). It is expected to determine the pyrite content and, hopefully, information on ash content and rank.

4. Beta-ray Backscatter - An on-line ash analyzer was reported in Japan in 1961-62. The present state of development of the device is unknown, but correspondence has been initiated to determine this.

5. X-ray Fluorescence - Elemental analyzers, primarily used in the cement and non-ferrous mineral industries, are commercially available from the Diano Corporation and ARL Corporation. These instruments have potential for application as sulfur and ash analyzers in the coal industry.

^aOak Ridge Associated Universities

6. Mössbauer Spectroscopy - Work has recently been done by the General Electric Co. for EPRI to adapt this technique for measuring the amount of pyritic sulfur in coal. The Mössbauer technique is non-destructive and reportedly is rapid and suitable for automation.

7. Laser Vaporization Spectroscopy - This technique is in initial laboratory development for on-line coal analysis at Battelle Columbus Laboratories.

A computer search of selected data bases has been initiated to provide additional information on sulfur, ash, and moisture measurements for the state-of-the-art report. A preliminary outline has been prepared for that report.

The review was completed for PMTC of the Iowa State University proposal on "Rapid Analysis of Mineral Content of Coals (On-Line Monitoring)."

Laboratory testing is planned to evaluate the variation of density of coal with varying amounts of ash in samples from a given seam of coal. This relationship may provide the basis for inferring the ash content on-line via simpler and relatively inexpensive density measurement together with one other auxiliary measurement, such as percent solids. This type of measurement system might be used as a trend indicator and has potential for incorporation in a given coal washing circuit for process control.

10.3 Systems Application

R. L. Moore, L. E. Ottinger, and G. R. Wetherington, Jr.

10.3.1 Objectives

The objectives of this work area are to acquire and maintain an in-depth knowledge of the features of the coal preparation plant environment and overall operation which affect the selection and application of instrumentation and controls, to evaluate the suitability of commercial and developmental devices for installation in coal preparation plants, and to provide the coordination to ensure compatibility and proper interfacing of the various systems and devices to be installed for demonstration in operating coal preparation plants.

10.3.2 Status summary

During this reporting period, an analysis was made of the froth flotation unit process based on information gathered during several plant trips and from available literature. It was concluded that this particular unit operation could readily be instrumented on a short term basis because of the open design characteristics, the homogeneous and less violent operation, and the availability of most of the required instruments.

Members also participated in an Instrument Review Meeting to determine and recommend instruments which could be profitably purchased on a short term basis for testing or installation in the field. Again, it was felt that the fine coal circuit, the froth flotation cell in particular, should be the target for our initial thrust of effort.

10.4 Mathematical Methods

W. R. Hamel, G. O. Allgood, C. H. Brown, and G. S. Canright

10.4.1 Objectives

The objectives of this work area are to utilize mathematical analysis as a tool to study processes, develop control models, and evaluate the technical and economic merit of existing and potential instrumentation devices and systems in the coal preparation plant application. This work area includes the evaluation of existing computer models of coal preparation plants, modification of existing computer programs as required for use, and development of programs and techniques needed to support the coal preparation plant automation effect.

10.4.2 Status summary

The development of basic mathematical descriptions for various areas of a typical fines coal circuit was continued and is now about 50% complete. Froth flotation cells are being modeled using a continuously stirred tank reactor (CSTR) analogy with component balances maintained for water, coal, and refuse in all streams. Frothing kinetics are lumped into a single reaction rate constant where it is hoped that the relationship between rank, oxidation, particle size, etc., and frothing reagents can be included. The vacuum filtration process appears to be somewhat more complex and is being modeled through a CSTR analogy for the slurry vat and porous media laminar flow for movement of water through the filter cake.

For general background information, a survey of solid/liquid two-phase flow theory and practice has been completed. Also, a summary of various coal cleaning performance criteria has been written. Drafts of both reports have been written and final typing is in progress.

A training session on wet concentrating tables was prepared and presented at a general project meeting (W. R. Hamel).

10.5 Information and Reports

G. M. Caton and E. R. Rohrer

10.5.1 Objectives

The objectives of this work area are to compile information related to coal preparation plant design and operation, to develop a system for making information readily available to members of the project team, and to assist in the preparation of reports describing work in progress, technical developments, and milestone achievements.

10.5.2 Status summary

The computer data base on coal preparation and instrumentation documents was expanded and improved. The data base was in three separate parts. In June, the format of Part 1 was converted and Parts 1 and 3 were merged into a new Part 1 with 488 references. Part 2 now has 220 references from continuing computer searches. IBM cards with reference information on beneficiation processes and instrumentation documents, arranged in order by category and reference number, were generated. Listing of the coal preparation and instrumentation documents in the CPPA files, arranged by category and containing abstracts and indexes, are being generated and will be circulated.

Information acquisition and dissemination activities included the following:

1. One hundred forty-three requests for documents, searches, and information were processed.
2. Seventy-eight articles, reports, and books were ordered.
3. Nine current contents routings and six selective routings of the coal preparation search, journals' table of contents, articles, and newsletters were circulated to team members.
4. The CPPA staff presentations on beneficiation are being added to the CPPA files and data base individually and are also being kept collectively in a CPPA Project Seminar notebook.
5. A subscription to World Coal has started and this periodical will be routinely circulated.

10.6 Data Acquisition

J. M. Jansen and J. T. Hutton

10.6.1 Objectives

The objectives of this work area are to determine, select, and apply the appropriate data acquisition and processing equipment consistent with the needs for automation and compatible with the physical environment of coal preparation plants. Support activities leading to the implementation of the full-scale demonstration of an automated plant will include assistance in the selection of data acquisition equipment and techniques for use at coal plants and ORNL in the study of processes, the evaluation of installed instruments, and the development of control methods.

10.6.2 Status summary

Further review was made of the tentative selection of data acquisition equipment for use in on-site tests. Contacts with various suppliers were established to answer specific questions on the remote serial input/output protocol. A survey of appropriate systems and software packages was initiated. Several important questions remain to be answered for the remote serial highway capability with one of the major contending packages. Complete documentation of the remote multiplexer equipment, the serial input/output interfaces, and the potential software packages have been requested for detailed evaluation. Further discussion with vendors may be required to resolve the input/output communication software requirements. The software package will provide both data acquisition and control capabilities for testing. Hardware procurement has been delayed to ensure that the proposed hardware/software combination will work as an integrated unit.

10.7 Visitors, Conferences, and Plant Visits

10.7.1 Visitors

M. Sheih of the Jeffrey Manufacturing Division of Dresser Industries visited ORNL to obtain information on the possible use of a nuclear density gage to replace the aluminum float in their jig coal washing equipment.

10.7.2 Conferences

G. M. Caton attended the Conference on the Chemistry and Physics of Coal Utilization at Morgantown, West Virginia, June 2 - 4.

K. R. Carr attended the 1980 Symposium on Instrumentation and Control for Fossil Energy Processes at Virginia Beach, Virginia, June 9 - 11, and presented a paper "Coal Preparation Plant Automation: Worldwide State-of-the-Art and Future Directions." G. O. Allgood also attended this meeting.

10.7.3 Plant visits

G. O. Allgood, N. C. Bradley, G. S. Canright, K. R. Carr, B. G. Eads, and J. M. Googe visited the New River Coal Preparation Plant near Devonia, Tennessee, operated by the Industrial Processing Company, on June 5, escorted by B. Wagner of Jeffrey Manufacturing to observe the new Jeffrey "CONSEP 2" jig controller in operation.

C. H. Brown, G. S. Canright, and W. R. Hamel visited the Daniels Company, manufacturers of heavy media washers, and the Tabor Machine Company, a leading manufacturer of preparation vibratory screen equipment, in Beckley, West Virginia, on June 17. At Daniels, discussions covered cursory review of proprietary distribution curve data used in designing preparation plants. A few performance and capacity data were obtained for Daniels' washers. Contacts there were Leo Haanskorph, President, and E. C. Stephenson, Vice President - Sales. At Tabor, we had general discussion and a short plant tour with the Chief Engineer, Marvin Shields. Because Fred Turner, apparently the only one at Tabor with all of the equipment mixing and performance expertise, was on a foreign assignment, a follow-up trip will be necessary to get specific data.

11. ATMOSPHERIC FLUIDIZED BED COAL COMBUSTOR FOR COGENERATION (AFBCCC)

R. S. Holcomb

11.1 Objective

The Coal Combustor for Cogeneration (CCC) Program is directed at the development of a fluidized-bed coal combustion system heating air inside tubes to provide high temperature clean air to drive a gas turbine to generate electricity. The heat in the air leaving the turbine exhaust would be recovered to supply industrial process heat. The gas turbine is very well suited for cogeneration since the ratio of thermal to electrical energy is about 3 to 1 for the gas turbine cycle as compared to a ratio of 5 to 1 for a back-pressure steam turbine, and the exhaust heat from the gas turbine is available at a higher temperature. The scope of the program includes the study of industrial cogeneration plants in the size range from 5 to 50 MW(e) and the construction and testing of a 0.3 MW(e) technology test unit.

11.2 Status Summary

R. S. Holcomb, R. H. Guymon, N. W. Durfee, and W. A. Hartman

A meeting was held at Westinghouse on June 10, to discuss plans for work on the CCC program under the Letter of Intent.

On Task 1, Reference Plant Design, Stone and Webster agreed to begin gathering information by telephone and letter from potential industrial users who had expressed interest in cogeneration to characterize the general requirements and the electrical and thermal energy loads of each user. These data would be used to recommend the requirements that would serve as a basis for the Reference Plant Design. Stone and Webster indicated that they should have significant results from their inquiries in about four weeks, and have recommendations in six to eight weeks.

Westinghouse will begin work on the conceptual design of the Reference Plant tentatively using the general considerations from the proposal. They believe that they have selected the turbine that is likely to be the best choice, so they know the nominal electric power rating and turbine air flow rate. They will assume an "average" steam load initially for preliminary design work until the Reference Plant steam load is defined by input from Stone and Webster.

Babcock and Wilcox will use the Reference Plant conditions for the proposal for preliminary design work. They will review the design concepts for the combustor and confirm or modify them, and arrive at a firm

conceptual design for the Reference Plant as quickly as possible. They will take advantage of their experience with the 6 x 6 test unit in arriving at the Reference Plant design. Once they have made their design choices, they will discuss these with Westinghouse and ORNL. When a design concept is agreed upon, this will provide a basis for the design of the test unit and they will initiate work on it.

A meeting is planned to be held in Oak Ridge on July 17, on the status and plans for the program.

Babcock and Wilcox has submitted its revised cost proposal, and this is being reviewed by UCC-ND and Westinghouse. It is expected that this can be incorporated into the final version of the summary proposal from Westinghouse within a few days and the contract package can be completed for signature.

12. TENNESSEE VALLEY AUTHORITY (TVA) FLUIDIZED BED
COMBUSTION (FBC) DEMONSTRATION PLANT PROGRAM
TECHNICAL SUPPORT

E. C. Fox

Tennessee Valley Authority has assumed a lead role in the demonstration of FBC technology for application in large utility boilers. ORNL will provide technical support and services to TVA in FBC systems. This work is to support TVA's objective to develop FBC systems for utility electric power generation which will burn high-sulfur coal and meet environmental emission standards.

TVA will be the lead agency in this work and will reimburse DOE for the work to be performed by ORNL. This work is to be conducted by ORNL under the terms and conditions of the Interagency Agreement between TVA, DOE, and ORNL regarding support for FBC research (reference: Agreement TV-48296A, Subagreement 5).

12.1 AFBC Technology Support - Task 2

M. Siman-Tov and E. C. Fox

12.1.1 Objective

The objective of this program is to provide technical support of a general nature in FBC systems and respond to specific requests from TVA personnel. Such requests may include reviews, assessments, participation in TVA tasks, and similar activities.

12.1.2 Status summary

There was no activity under this task during this month.

12.2 4 x 4 Cold Flow Model - Task 3

M. E. Lackey and R. S. Holcomb

12.2.1 Objective

The objective of this task is to experimentally investigate slumping of a portion of a fluidized bed using a sub-scale cold flow model. The scope of work includes design and minor modification of the 4 x 4 cold flow model for slumping and refluidization tests and conducting bed slumping tests.

12.2.2 Status summary

The 1/4 scale test report by M. E. Lackey entitled "Cold Slumping Characteristics of a Fluidized Bed," has been approved for publication by TVA.

12.3 AFBC Modeling and Simulation - Task 4a

J. W. Wells, M. H. Culver, A. A. Khan, and R. P. Krishnan

12.3.1 Objective

The objectives of this program are to develop a simple steady-state model for conceptual design of the main cell and carbon burnup cell and to incorporate in this model the ability to predict trends in bed performance under various feed and operating parameters.

12.3.2 Status summary

Overview - During this month, work continued on the development of the freeboard model and the integration of the limestone-ash elutriation and attrition subcode, coal combustion subcode and the sulfur capture subcode. Modifications were made to the coal combustion subcode which included revising the computational scheme in the slow bubble regime. Also this month, a meeting was held at the B&W Research Center at Alliance, Ohio on June 18, 1980. In this meeting, the progress on the steady-state modeling effort was reviewed for B&W personnel by J. W. Wells. The presentation was well received.

Freeboard Model - During this month, work continued on the freeboard modeling effort. Simplifications have been made to the solid concentration subcode of the freeboard model to decrease the program size and computer run time. The computational procedure to calculate freeboard solid concentrations has not been altered.

Modification to the subcode is being made by inclusion of an empirical expression for the solids flux in the freeboard as given by Wen and Chen¹

$$F = F_{\infty} + (F_0 - F_{\infty}) \exp(-ah) \quad (1)$$

where

F is the solid flux in the freeboard ($\text{g}/\text{cm}^2 \text{ s}$),

F_{∞} is the solid entrainment rate (particle solid loading in exit flue gas),

F_0 is the initial solids flux at the bed surface ($\text{g}/\text{cm}^2 \text{ s}$),

a is a system constant (cm^{-1}), and

h is the height above the bed surface (cm).

A correlation for solids flux at the bed surface (F_0) given by Wen and Chen¹ yields an initial solids flux close to the value assumed by the present code. The equation is given by:

$$\frac{F_0}{A D_\beta} = 3.07 \times 10^{-6} \frac{\rho_g^{3.5} g^{.5}}{\mu^{2.5}} (U_0 - U_{mf})^{2.5} \text{ (g/cm}^5 \text{ s)}$$

where

F_0 is the initial solids flux ($\text{g/cm}^2 \text{ s}$),

A is the cross sectional area of the column (cm^2),

D_β is the bubble diameter at the bed surface (cm),

ρ_g is gas density (g/cm^3)

μ_g is gas viscosity (g/cm s),

g is gravitational constant ($= 980 \text{ cm/s}^2$),

U_0 is superficial gas velocity (cm/s),

U_{mf} is minimum fluidization velocity (cm/s).

This correlation relates the solids ejection into the freeboard to the bubbles regardless of the mechanism of particle ejection.

A routine to calculate terminal velocities of particles was incorporated into the code to predict the solids entrainment rate (F_∞). The fine particles which are entrained immediately in the freeboard are included in the solids flux profile.

In the future, the model will predict the solids flux (F) as a function of freeboard height and the entrainment rate (F_∞) based on an initial solids flux (F_0). The parameter "a" in equation (1) can be estimated using a curve fitting routine. The solid subcode will predict profiles for coal, limestone and coal ash in the form of equation (1) and these mathematical models will be used by the gas phase subcode of the freeboard model.

Combined Code - Work continued on the integration of the limestone-ash elutriation and attrition subcode, coal combustion subcode and SO_2 capture subcode. Specifically, the elutriation-attrition subcode was modified to calculate limestone particle residence times in the bed. The coal combustion code was also modified. These modifications included

revising the computation scheme in the slow bubble regime. Previously, this reason had been considered perfectly mixed. In the revised code, this region is broken down into increment of height ΔZ . In each increment, two phases are assumed: bubble and emulsion. Because of the nature of slow bubbles, no lateral transfer of gas between the two phases occurs in the low bubble region. All gas transfer occurs vertically to the next increment. Equations describing this phenomenon have been derived and incorporated into the present combustion code. In addition, the mass balance equations in the slow and fast bubble regions have been modified to incorporate the change in the bubble phase gas flow rate as a function of height. Cranfield and Geldart² have experimentally observed that the amount of gas in the bubble phase is a function of height. They observed that the amount of gas in the bubble phase increases as the height above distributor plate increases. The code, as modified, is capable of running both with variable bubble gas flow and constant bubble gas flow. During the next month, the elutriation and attrition code and coal combustion code will be combined. At this point, the sulfur balance will be added to the combustion code.

12.4 Analytical Support and Alternative Design Concepts Evaluation - Task 4b

C. S. Daw, W. K. Kahl, and E. C. Fox

12.4.1 Objective

The objectives of this task are to assist TVA in determining the design parameters which are critical to an effective AFBC system from the standpoints of efficiency and cost and to provide direction as to better design options.

12.4.2 Status summary

With the resolution of some previously encountered discrepancies in combustion efficiency and sulfur capture correlations, the final results of the parametric study are being evaluated. The draft report detailing the trade-offs in design characteristics and appraising the economics of various design options is being prepared.

12.5 AFBC Bench Scale Facility - Task 5

G. P. Zimmerman, R. H. Guymon, and R. S. Holcomb

12.5.1 Objective

The objective of this task is to experimentally investigate heat transfer, sulfur capture, carbon loss, and combustion of recycle carbon using the ORNL AFBC bench scale combustor.

12.5.2 Status summary

TVA sulfur capture testing was continued during June with limestone from the Lower Fredonia quarry in Fredonia, Kentucky. Thirty-four hours of coal combustion were accumulated during the month. Data were obtained for a superficial velocity of 1.2 m/s (4 ft/s). The Lower Fredonia limestone performs just as well as the best stones tested to date.

The Lower Fredonia limestone was prepared by drying and sizing to 6 × 100 mesh. Twenty-two percent of the material weight was smaller than 100 mesh before screening. The chemical analysis of this stone is shown in Table 12.1.

The limestone was added to the combustor and fluidized at 1.5 m/s (5 ft/s) for two hours. The minimum fluidization velocity after elutriation of fines was 0.32 m/s (1.05 ft/s).

Twenty hours of coal combustion were required to bring the bed to the well-sulfated state. Sulfur capture testing was completed during an additional 14 hours. The combustion fuel was a Kentucky #9 coal with about 4% sulfur.

A set of sulfur capture data was obtained for a superficial velocity of 1.2 m/s (4 ft/s) and bed temperatures near 820°C (1510°F). These results are presented in Table 12.2. The sulfur capture characteristics of the Lower Fredonia limestone (based on Table 12.2) appear in Fig. 12.1. Figure 12.2 is a semi-logarithmic plot of the sulfur capture data. These sulfur capture characteristics are identical to those of the Fredonia Valley limestone tested in February. Because of the similarity of these two limestone behaviors, sulfur capture testing was discontinued; no data were obtained for higher superficial velocities.

This series of limestone testing completes the first portion of the TVA sulfur capture program. Three-hundred and twenty hours of combustion have been accumulated with the six different TVA limestones and Kentucky #9 coal. The combustor will now be modified for operation in the recycle mode, and the second portion of the test program will begin.

In preparation for the addition of recycle capability, a full-scale (25 cm diameter) plexiglas model of the ORNL combustor was constructed to allow visual observation of the recycle system. The system included a cyclone separator in the fluidized bed exhaust line and a screw feeder to modulate the flow of recycled solids back into the bed. The system was operated with spent bed material from the bench scale combustor in order to simulate the pressure gradients that exist during combustion. Fly ash which had been accumulated from the hot cyclone bottoms was used to charge the plexiglas model.

The cold recycle system was operated at superficial velocities of 1.2 m/s (4 ft/s) and 1.8 m/s (6 ft/s) which cover the operating range of the bench scale combustor. At both of these superficial velocities, the recycle rate was determined as a function of the screw feeder speed. The

Table 12.1. Chemical analysis of
Lower Fredonia limestone

Calcium carbonate (CaCO_3), %	94.25
Magnesium carbonate (MgCO_3), %	3.91
Silica (SiO_2), %	1.70
Sulfur (SO_3), %	0.144
Aluminum (Al), %	0.13
Iron (Fe), %	0.13
Moisture (H_2O), %	0.04
Potassium (K), %	0.08
Sodium (Na), ppm	207
Chlorine (Cl), $\mu\text{g/g}$	156

Table 12.2. AFBC sulfur capture results for Lower Fredonia limestone

	Date and time						
	6-16-80 11:45	6-16-80 13:10	6-16-80 15:00	6-24-80 11:40	6-24-80 12:45	6-24-80 13:48	6-24-80 14:45
Bed temperature, °C (°F)	822 (1512)	818 (1505)	822 (1511)	819 (1507)	819 (1507)	825 (1517)	823 (1513)
Superficial velocity, m/s (ft/s)	1.2 (4.1)	1.2 (4.0)	1.2 (4.1)	1.2 (4.0)	1.2 (4.0)	1.2 (4.0)	1.2 (4.0)
Static bed depth, m (in.)	0.76 (30.0)	0.86 (34.0)	0.90 (35.5)	0.69 (27.0)	0.76 (30.0)	0.80 (31.5)	0.86 (34.0)
Gas residence time (H/V ₀), s	0.62	0.71	0.73	0.57	0.62	0.66	0.70
Coal feed rate, kg/h (lb/h)	8.7 (19.1)	7.5 (16.6)	8.4 (18.5)	8.4 (18.6)	8.4 (18.6)	8.1 (17.8)	8.1 (17.8)
Limestone feed rate, kg/h (lb/h)	3.7 (8.2)	4.8 (10.6)	3.2 (7.0)	2.4 (5.3)	3.1 (6.9)	4.0 (8.9)	4.9 (10.7)
Calcium to sulfur mole ratio	3.2	4.7	2.8	2.1 ^a	2.7 ^a	3.7 ^a	4.4 ^a
Combustion air flow, kg/h (lb/h)	71.3 (157)	71.3 (157)	71.3 (157)	69.9 (154)	69.7 (154)	70.2 (155)	70.5 (156)
Flue gas components:							
Oxygen, %	3.6	3.5	3.5	3.7	3.0	3.4	3.5
Sulfur dioxide, ppm	535	200	445	890	565	275	160
Oxides of nitrogen (NO _x), ppm	740	820	740	660	670	720	750
Carbon monoxide, ppm	885	460	560	750	600	650	460
Sulfur in coal, wt %	4.08	4.08	4.08	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
Sulfur capture, %	84.1	94.0	86.8	75 ^a	85 ^a	92 ^a	95 ^a

^aThese numbers are based on a typical 4% sulfur coal.^bCoal analysis not yet received.

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Fig. 12.1. Sulfur capture characteristics of Lower Fredonia limestone.

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Fig. 12.2. Sulfur capture characteristics of Lower Fredonia limestone.

results of the calibration are shown in Fig. 12.3. As can be seen from the figure, the recycled solids feed rate is essentially independent of bed superficial velocity and is a smooth function of the screw feeder speed.

During the month of July the recycle system will be installed on the bench scale combustor. Once the construction and shakedown testing are complete, the TVA sulfur capture program will resume with selected candidate limestones.

12.6 Assessment of the State-of-the-Art of PFBC Systems - Task 6

R. L. Graves, M. E. Lackey, and A. P. Fraas^a

12.6.1 Objective

The purpose of this program is to provide TVA with an assessment and overview of the state-of-the-art for PFBC systems and their associated components.

12.6.2 Status summary

The final report for Task 6, "State-of-the-Art of Pressurized Fluidized Bed Combustion Systems," is in the process of being published as an ORNL Technical Memorandum.

12.7 AFBC Technical Source Book and R&D Evaluation - Task 8

M. Siman-Tov and A. A. Kahn

12.7.1 Objective

The objectives of this program are: (1) to develop a single comprehensive source book of technical data for design procedures and evaluation of AFBC facilities and programs, (2) to review and evaluate existing and proposed AFBC facilities to perform research and development for TVA, and (3) to interpret and translate results of test studies performed for TVA and further the knowledge in AFBC research and development activities.

12.7.2 Status summary

The effort in this task is limited to keeping up to date with the state-of-the-art.

^aConsultant

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Fig. 12.3. The effects of superficial velocity upon the recycle feed rate with a 1.68 m head of recycle solids at the feeder inlet.

12.8 Materials Support for TVA Pilot and Demonstration AFBC Plants - Task 9

R. H. Cooper, Jr., T. G. Godfrey, P. L. Rittenhouse,
J. H. DeVan, M. D. Allen, and R. A. Bradley

12.8.1 Contract objective

The objective of this task is to provide TVA technical assistance in the materials area as needed. The principal focus of the work is the area of in-bed heat exchanger tubes and hangers, air distributors, side walls, coal feed lines and nozzles, spent bed removal hardware, and cyclones for separating elutriated materials. Two areas of this task have been and/or continue to be active. The first is the review of recommendations for the materials of construction for the pilot and demonstration plants as made to TVA in proposals, contracts, and vendor designs. The second area involves the metallographic analysis of an array of alloys exposed in an AFBC located in Leatherhead, England, and is part of a joint TVA-EPRI materials program.

12.8.2 Status summary

A draft of a technical assessment of issues related to candidate structural alloys for AFBC has been submitted to the TVA project manager for review and comment. This report deals with short- and long-term mechanical properties and corrosion data and assesses the relative risk associated with various design approaches and the material selection alternatives that are available for uncooled in-bed structural applications.

Several specimens of alloys exposed for the second 1000 h and for the full 2000 h in the Leatherhead AFBC have been examined metallographically with the results presented in the June quarterly report. In general, the alloys showed no unusual or significant corrosion response to the AFBC in-bed environment. Intergranular sulfidation-oxidation attack and sulfide inclusions reached depths of about 40 μm in the worst cases for alloys containing nickel. The chromium-molybdenum steels showed almost no attack and few subsurface sulfides. Measurements of corrosion penetrations have not yet been made around the circumference of these samples. The analysis of the surface deposit, primarily calcium sulfate, continues to be a problem.

12.9 Coal Feed Tests - Task 11

C. S. Daw, J. F. Thomas, and V. R. Brantley

12.9.1 Objective

The objective of this task is to experimentally investigate feeding techniques and equipment for AFBC application. Fundamental tests will be conducted in order to establish the key operating variables over which reliable coal and limestone pneumatic feeding can be achieved.

12.9.2 Status summary

Nine of fifteen test runs have been completed. Pressure drop data are still being analyzed, but so far we have learned:

- The presence of limestone prevents 8% moisture coal from sticking to the pipe walls and forming impact plugs. This is true even at the lowest limestone-to-coal ratio tested (~0.25).
- We are unable to feed 8% moisture coal at rates higher than about 680 kg/h (1500 lb/h) through the 6-in. rotary valve. The valve speed above 14 rpm does not give the coal enough time to fall into the pockets.
- At feed rates greater than 500 kg/h (1100 lb/h), the 8% moisture coal tends to stick in the rotary valve pockets. This appears to result from a kind of "impact sticking" in the rotary valve pockets.

Because of the high feedrate problems, we have reduced the maximum coal feedrates from 908 kg/h (2000 lb/h) to 635 kg/h (1400 lb/h). In order to run low coal feedrates (227 kg/h or 500 lb/h), it will be necessary to reduce the volume of the rotary valve pockets by installing false bottoms. The present pocket size causes unacceptably large fluctuations in coal flow at rotor speeds low enough to get 227 kg/h. We plan to complete all the runs at high and intermediate coal flows before making this revision.

12.10 Materials Evaluation and Testing — Task 12

R. H. Cooper, Jr., T. G. Godfrey, R. E. Potter,
J. H. DeVan, and R. A. Bradley

12.10.1 Contract objective

The objective of this task is to experimentally determine the envelope of operating conditions which will result in safe and reliable performance of in-bed materials. This goal is to be met with a three-phased program. The first phase involves thermodynamics calculations including all likely reactants and products from combinations of selected candidate alloys and in-bed environmental conditions. The second phase includes exposures of candidate materials in carefully controlled environments simulating the range of possible AFBC environments that could be envisioned in normal and off-normal operation. The third phase will be made up of eight 200-h exposures of materials in an actual fluidized bed. Operating conditions for these runs will progressively vary from normal to off-normal.

12.10.2 Status summary

To ensure that materials information generated by this activity is provided to TVA in a manner that will have a meaningful impact on the operation of the pilot plant facility, an accelerated schedule for all three subtasks has been adopted. As a result of this accelerated schedule, some aspects of all three subtasks are being carried out concurrently. A summary of the progress on each of the three subtasks follows.

Subtask I — Thermodynamic Calculations — This activity remains dormant pending accumulation of sufficient results of the other tasks to direct or suggest additional calculations.

Subtask II — Muffle Furnace Tests — Three 150-h runs at 900°C (1650°F) have been completed in the gas-metal apparatus covering a range of 10^{-8} to 10^{-21} atm P_{O_2} and 10^{-10} to 10^{-4} atm P_S . Examination of the samples, both uncoated and coated with calcium sulfate deposit, is under way. Preliminary observations indicate that sulfidation-oxidation corrosion has occurred with Alloy 600 showing extensive attack at $P_{O_2} \approx 10^{-16}$ atm in the coated and uncoated condition, and almost no attack at $P_{O_2} \approx 10^{-8}$ atm. Alloy 800 appears to be the next most attacked while the samples of types 304 and 310 stainless steel were least affected. These observations are considered tentative because the specimens showed areas of attack on the inner surface inconsistent with that on the outer surface. We feel that a crevice corrosion mechanism might be operating because of the fused quartz specimen support assembly. Several experiments are being contemplated to elucidate the possible mechanisms.

Subtask III - In-Bed Tests - All specimen tubes required for the eight 200-h tests at FluidDyne have been prepared and shipped to Minneapolis. Shakedown runs at FluidDyne have been successfully concluded with all specified run conditions achieved. The arrangement of the 33 specimen tubes in the 45-tube array has been identified. The specimens are concentrated in regions thought to be most corrosive or aggressive based on prior experience in this combustor.

12.11 References for Section 12

1. C. Y. Wen and L. H. Chen, "A Fluidized Bed Combustor Freeboard Model," 6th AFBC Conference 1980, Atlanta, Ga.
2. R. R. Cranfield and D. Geldart, *Chemical Engineering Science*, Vol. 24, pp. 935-947, 1974.

13. FOSSIL FUEL APPLICATIONS ASSESSMENTS

13.1 Coal Cogeneration/District Heating Plant Assessment

M. A. Karnitz and R. L. Graves

13.1.1 Objective

The objective of this work is to provide the Office of Coal Utilization of DOE with an evaluation of the coal-fired closed-cycle gas turbine as a cogeneration power plant specifically for district heating in the Minneapolis-St. Paul area. This entails a preliminary design study, including a cost estimate. The design study is a cooperative effort between ORNL, United Engineers and Constructors (UE&C), and Northern States Power (NSP). Design of an extraction steam system for the same application is being carried out simultaneously by UE&C and will allow a comparative evaluation of both cogeneration plants. These design studies are part of a considerably larger program involving other divisions of DOE with the objective of evaluating district heating in Minneapolis-St. Paul.

13.1.2 Status summary

There was no change in status during the month of June.

13.2 Industrial Boiler Applications

O. H. Klepper and E. C. Fox

13.2.1 Objective

The purpose of this work is to define the technologies required to meet the range of allowable emissions for new industrial boilers, the relative merits of these technologies, and to identify needed research and development. Industrial boiler capital costs developed in this program will be incorporated in the CONCEPT computer program for use in this and in future studies.

13.2.2 Status summary

Subtask A - Selection of emission standards and associated boiler criteria. A range of emission limits was estimated that is intended to bracket the requirements of the regulations for new industrial boilers that are to be issued in 1981. These judgements were developed considering the present requirements for utility and industrial boilers, state emission limits, and discussions with EPA (Research Triangle, N.C.) and with air quality control agencies in several states.

Subtask B - Steam supply system characterization. A Draft Statement of Work was prepared to provide the basis for a subcontract with an Architect-Engineer for developing the design and cost characteristics for a variety of industrial steam supply and associated emission control systems. In addition, a Technical Basis for Industrial Steam Supply Systems was prepared to guide the Architect-Engineer in that effort.

It is planned to contact candidate Architect-Engineer firms early in July to discuss a contract for developing the industrial steam supply designs and costs needed to carry out Task B, Steam Supply System Characterization.

13.3 District Heating Turbine Assessment

H. I. Bowers

13.3.1 Objective

The objective of this task is to assess the technical and economic factors related to modifying the design of new power plants to provide thermal energy for district heating by using the cogeneration process.

13.3.2 Status summary

The contract arrangements with Burns & Roe for the turbine study are awaiting the approval of the Oak Ridge Operations Office.

14. PERFORMANCE ASSURANCE SYSTEM SUPPORT FOR FOSSIL ENERGY PROJECTS

T. W. Pickel, H. A. Mitchell, B. R. Everman,
H. A. Nelms, L. Parsly, A. N. Smith

Performance assurance support is being provided for major DOE-Fossil Energy projects. This support covers the areas of reliability, system safety, and quality assurance. Current activities include support for the liquefaction projects being managed by DOE and a failure modes and effects analysis.

14.1 Objective

The ORNL Performance Assurance System Support Office is responsible for acquiring, generating, and disseminating information relating to performance assurance (PA). The Support Office will provide performance assurance related technical support services to those Fossil Energy programs under the decentralized management control of the Oak Ridge Operations (ORO) Office and to programs under the direct management control of the Washington Headquarters Office. The Support Office will, as required, design and develop appropriate procedures, tools, and methodology necessary to provide the PA support services indicated.

14.2 Status Summary

Two specific tasks have been initiated at the request of Fossil Energy Headquarters Office: (1) preparation of generic failure modes and effects analyses and (2) assistance to ORO projects to review contracts and deliverables.

A revised draft of the failure modes and effects analysis (FMEA) for a generic coal slurry preheater has been completed and is being reviewed. The analysis of 25 slurry preheater components indicated 15 failures which are considered to be high risk. These critical events are defined by a risk matrix of probability of failure and severity of the consequences.

In order to assure safe and reliable operation of the plant, the following design and operating considerations related to the slurry preheater must be considered.

1. Decoke the preheater coil at every shutdown.
2. Perform ultrasonic inspections of coil at regular intervals.
3. Size dikes around heater to contain reactor contents.
4. Blank and purge burner and fuel lines during maintenance.
5. Provide block valves and bypass valves to allow manual operation of burner fuel flow.

6. Establish maintenance procedures for purging firebox before light-off.
7. Size snuffing steam supply for reactor contents spill in firebox.
8. Record slurry purge flows and slurry exit temperatures at regular intervals.
9. Provide redundant controls to limit slurry exit temperature.

Recently, support was provided to DOE-ORO as part of Task 2 to audit quality assurance activities at the H-Coal pilot plant. An on-site visit was made to perform a QA appraisal. J. A. Nichols (DOE) was the official auditor and H. A. Nelms (UCC-ND Engineering) served as a technical advisor. The focus of the visit was on what a QA staff should or could do and the current reporting processes. The project is in the process of attempting to hire a qualified QA administrator but, to date, has been unsuccessful.

The project is collecting a great deal of data. It is not clear that the data will be organized in a way that it can be effectively correlated or reported. Also, as one would expect, the project staff is oriented to dealing with immediate problems; little effort is applied to the identification or anticipation of future problems. In these areas it appears a QA staff could make a positive contribution.

15. INTERNATIONAL ENERGY TECHNOLOGY ASSESSMENT

The Oak Ridge National Laboratory is supporting the Lawrence Livermore Laboratory in a broad program funded by the DOE Office of International Affairs. The program is designed to alert DOE management to foreign energy-related technologies of potential interest to the United States.

ORNL has responsibility for the following three areas of work: coal liquefaction including gasifier development status, coal liquefaction materials, and atmospheric fluidized bed combustion. These efforts are closely coordinated with similar activities underway at Argonne National Laboratory in the areas of pressurized fluidized bed combustion and coal gasification materials.

15.1 Liquefaction Technology (Including Gasifier Development Status)

W. C. Ulrich

15.1.1 Objective

Broad objectives of the IETA program are to report foreign technology developments of current interest and to identify and assess those developments of significance to U.S. programs. Detailed assessments in selected areas will also be provided. A specific objective of the ORNL effort is to provide a substantive technical review of the status of foreign technology for the liquefaction of coal, including gasifier development status.

15.1.2 Status summary

A preliminary report by Gilbert/Commonwealth (G/C) on indirect liquefaction processes, with primary emphasis on those employed in SASOL plants in South Africa, was completed and submitted to ORNL for review. Other sections of this report include methanol synthesis, methanol-to-gasoline, and direct coal-to-gasoline processes.

A project review meeting was held at Argonne National Laboratory on June 25-26, 1980. Details of SASOL operations which are contained in the G/C report were presented at this meeting.

Information on SASOL-1 Lurgi Mark V gasifiers and the 150 ton/day Shell-Koppers coal gasifier was obtained from Dr. John M. Holmes, the ORNL/DOE representative to the International Energy Agency in London. He also included information on SASOL-2 startup operations and recent developments pertaining to liquefaction and gasification in West Germany.

15.2. Coal Liquefaction Materials

A. R. Olsen and G. M. Caton

15.2.1 Objective

The objectives of this phase of the assessment program are to identify materials research and development programs in foreign countries in support of liquefaction processes and to assess the programs and findings in terms of their status, applicability to U.S. coal liquefaction development and commercialization programs, and the potential value of possible cooperative agreements.

15.2.2 Status summary

Information gathering and classification is continuing. On June 25 and 26, a status review meeting was held at Argonne National Laboratory. This meeting was particularly fruitful in that the various participants were able to better identify others' positions, and some detailed arrangements for coordinating efforts were made. A means of exchanging reference material in the area of materials for gasification was established with K. Natesan of ANL. In addition, several attendees reviewed recent trips they had made to European countries so that both the status of work and potential contacts were identified.

15.3 International Survey of Atmospheric Fluidized Bed Combustion Technology

R. P. Krishnan, E. C. Fox, and K. O. Johnsson

15.3.1 Objective

The objective of this program is to provide an international assessment of the status of atmospheric fluidized bed combustion (AFBC). The assessment will describe the applications, critical problem areas, and the current developmental projects that address these problem areas in AFBC technology in foreign countries.

15.3.2 Scope

This assessment is part of a broader program designed by the DOE Office of International Affairs (IA) to alert DOE management to foreign energy-related technologies of potential value to the United States. ORNL and Argonne National Laboratory (ANL) have been assigned the area of fluidized bed combustion. ORNL will survey AFBC, and ANL will survey pressurized fluidized bed combustion (PFBC).

15.3.3 Status Summary

A questionnaire seeking information from organizations involved in fluidized bed combustion research and development in countries outside the United States was sent out. Information pertaining to the history of the organization's involvement in FBC technology, present program(s), goals for future, and opinions and plans on commercial prospects of FBC technology has been requested in the questionnaire. We are presently receiving the responses and are in the process of reviewing them.

A project review meeting was held at ANL on June 25 26, 1980. The two day meeting was called by Dr. Arturo Maimoni, Lawrence Livermore Laboratory (LLL), program manager for the International Energy Technology Assessment program. The meeting was attended by LLL, ANL, TRW, Gilbert Associates, and ORNL staff. Individual presentations were made summarizing the status of each assessment area. The report schedule, budget, and coordination of future work was also discussed during the meeting. The preliminary draft report is due in September 1980.

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