ENVIRONMENTAL REVIEW of SYNTHETIC FUELS

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INTRODUCTION

In response to the shift in the U.S. energy supply priorities from natural gas and oil to coal, the Environmental Protection Agency (EPA) has initiated a comprehensive assessment program to evaluate the environmental impacts of synthetic fuel processes having a high potential for commercial application. This overall assessment program is being directed by the Fuel Process Branch of EPA's Industrial Environmental Research Laboratory, Research Triangle Park (IERL-RTP).

The primary objectives of the EPA Synthetic Fuels Environmental Assessment/Control Technology Development Program are 1) to define the environmental effects of synthetic fuel technologies with respect to their multimedia discharge streams and their health and ecological impacts, and 2) to define control technology needs for an environmentally sound synthetic fuel industry. The synthetic fuel technologies being studied in this program include low/medium-Btu gasification, high-Btu gasification and liquefaction. To achieve the program's overall objectives, the EPA has defined six major task areas that are discussed in this review: current process technology background, environmental data aquisition, current environmental background, environmental objectives development, control technology assessment, and technology and/or commercial development. The contractors involved in the overall program, their EPA Project Officers, and the start and completion of each contract are tabulated on page 9.

This is the third publication in a series of periodic reviews of recent activities in the EPA's Synthetic Fuels Program. The areas discussed include the activities of EPA contractors, summaries of major symposia, summaries of commercial and/or technical developments, a calendar of upcoming meetings and a list of major publications. Comments or suggestions which will improve the content or format of these reviews are welcomed. Such comments should be directed to the EPA or Radian Corporation personnel identified on page 16 of this Review.

CURRENT PROCESS TECHNOLOGY BACKGROUND

High-Btu Gasification

High-Btu Data Base Draft – TRW, Inc., recently completed a three-volume draft data base document entitled "Environmental Assessment Data Base for High-Btu Gasification Technology." Volume I of this report presents a summary and analysis of the data base and an examination of pollution control options for commercial SNG facilities. Volumes II and III (Appendices A-E) contain data sheets for individual gasification, gas purification and upgrading, air pollution control, water pollution control and solid waste management areas. The data base document presents technical data on gasification and related operations, identifies gaps in existing data, and identifies major on-going and planned programs which may generate additional data. Currently, process developers/licensors are being contacted for review of the draft data sheets. Work is in progress to provide a final proof copy of the data base document which should be published in the next few months.

Liquefaction

Environmental Assessment Data Base for Coal Liquefaction Technology, Volumes I and II – Hittman Associates has nearly completed a draft version of this report. Volume I, "Systems for 14 Liquefaction Processes," provides a summary of pertinent information for 14 of the prominent coal liquefaction systems now under development. It provides brief descriptions and flow diagrams of each system including a list of materials entering and leaving the system. The processes required to produce clean liquid fuels from coal are divided into discrete operations. Each of these operations is then further divided into discrete modules, with each module having a defined function and identifiable raw materials, products and discharge streams. Volume II, "Detailed Discussion of Synthoil, H-Coal and Exxon Donor Solvent Processes," is a detailed environmental data base report for those three processes. The characteristics of the raw waste streams, treatment and control processes, treated waste stream discharges, and the effects of those discharges on the environment are addressed.

With the exception of the solid carbon-containing residues resulting from phase separation operations, established treatment and control technology exists for the removal of most major pollutants such as sulfur dioxide, hydrogen sulfide, phenols, and ammonia. There has been less attention given to the trace organic and inorganic compounds, many of which are potentially hazardous.

The carbon-containing residues resulting from process phase separations represent a major area of potential environmental problems. Both process economics and potential environmental effects indicate the need for further work.

A difficult environmental or health characterization area is the assessment of the effects of coal liquefaction products and wastes on plant personnel. This assessment suffers from the dual handicap of undefined plant discharges and the lack of sufficient human health information.

ENVIRONMENTAL DATA ACQUISITION

General Topics

Laboratory Gasifier Pollutants — Research Triangle Institute (RTI) has now completed more than 30 runs with their laboratory gasifier, some of which were to prove the sampling systems and reactor operational systems. The gasifier has operated successfully using FMC char, Illinois No. 6 coal, Montana Rosebud coal, and a peat material. RTI has compiled a list of 102 potentially hazardous compounds for which they are performing chemical analyses. THE EPA Consent Decree list contains 42 of these compounds. Of the 42 compounds, 14 have been identified in the gasifier effluent. Of the compounds found in the effluent from RTI's laboratory gasifier, 21 also appear in the effluent from the fixed-bed-gasifier at the Morgantown Energy Research Center, 39 were reported in effluent from various coal liquefaction tests and 52 were associated with coal coking.

Results of work to date have indicated that the compounds found in MEG category 18 (phenols and related cresols) have been the major pollutants from the gasified coal. Other MEG categories with compounds that have been identified are 13 (thiols and sulfides); 15 (benzene and substituted benzene hydrocarbons); and 53 (inorganic sulfurs). Future work will be directed toward studying the influence of operating conditions on pollutant production rates and the kinetics of pollutant production.

Control Assay Development (CAD) — Catalytic, Inc. is completing laboratory procedures for conducting wastewater screening tests for coal conversion process wastes. The basic strategy followed for most wastewater streams is comprised of three distinct steps:

- By-product removal, when appropriate, to remove gross quantities of known pollutants normally recovered in commercial synfuel processes for their market value, and which do not reach a final treatment plant in high concentrations.
- Pre-screening with activated carbon and dry mutant bacteria to establish operating parameters for carbon columns and biological oxidation screening systems.
- Screening through a pre-established sequence of wastewater treatment operations to determine the applicability of the different unit operations to remove pollutants.

Technologies that have been reviewed with IERL-RTP and will be included in the wastewater CAD are filtration, carbon adsorption, bio-oxidation and ion exchange. The by-product removal step will employ unit operations practiced commercially, such as solvent extraction and stripping. By-product removal procedures are not yet completed.

Wastewater CAD testing was started in early July using a synthetic wastewater. The formulation for the organic composition was provided by the University of North Carolina, and is the feed UNC is using in their biological treatments studies.

CAD methodology for screening air emission controls is also being developed. Unit operations for the removal of particulate and gaseous (inorganic and organic) pollutants are included. The pollution control train is being developed from basic modules in the Source Assessment Sampling System (SASS). When completed, the CAD air methodology will be verified by laboratory testing.

CAD procedures for wastewater, air and solids are designed to process sufficient source samples to permit complete Level 1 testing for physical and chemical characterization, and health and ecological effects. Catalytic will also recommend additional tests, not presently contained in Level 1 protocols, to obtain data useful in subsequent investigations of specific control technologies.

Low/Medium Btu Gasification

Guidelines for Preparing Test Plans — Radian Corporation recently completed a report entitled "Guidelines for Preparing Environmental Test Plans for Coal Gasification Plants," (EPA-600/7-78-134). This document, dated July 1978, outlines a philosophy and strategy for preparing environmental assessment sampling and analysis plans. Its primary purpose is to provide general guidelines for the development of conceptually sound site-specific test plans. Five major points of test plan development are addressed: (a) defining the test objectives; (b) performing an engineering analysis of the test site; (c) developing a sampling strategy; **(d)** selecting analytical methods; and (e) defining data management procedures. Each of these areas is distinct and is discussed separately. However, the report stresses the interrelationships among the areas since the decisions which must be made within each area are dependent upon the limitations inherent within all of the other areas.

The important considerations involved in each of the five major points of test plan development are discussed in relation to three basic types of environmental tests: (a) waste stream characterization (Levels 1, 2, and 3), (b) control equipment characterization, and (c) process stream characterization. Some specific sampling and analytical methods are presented, with numerous references cited for more detailed information.

Application of SAM/IA Methodology — Radian applied the SAM/IA (Source Analysis Model) Methodology to waste stream data obtained from an environmental sampling and analysis program at a Chapman (Wilputte) low-Btu gasification facility. The SAM/IA methodology provides a rapid screening technique for assessing the pollution potential of gaseous, liquid and solid waste streams. Major simplifying assumptions implicit in the use of SAM/IA include the following:

- The substances currently in the Multimedia Environmental Goals (MEG's) list are the only ones that need to be addressed at this time.
- Transport of the components in the waste streams to the external environment occurs without chemical or physical transformation of those components.
- Actual dispersion of a pollutant from a source to a receptor will be equal to, or greater than, the safety factors normally applied to convert acute toxicity data to estimated safe chronic exposure levels.
- The minimum acute toxicity effluent (MATE) values developed for each substance are adequate for estimating acute toxicity.
- No synergistic effects between the waste stream components are considered.

In performing a SAM/IA analysis, values for "degree of hazard" and "toxic unit discharge rates" associated with the pollutants and the waste streams are determined. The degree of hazard for each pollutant is defined as the ratio of the pollutant's concentration in the stream to its respective MATE value (health or ecological). The degree of hazard for a waste stream is determined by summing the degree of hazard for each pollutant in the stream. The toxic unit discharge rate is determined by multiplying the degree of hazard value by the waste stream flow rate.

The waste streams sampled and anaylzed by Radian using SAM/IA were:

- coal feeder vent gas,
- separator vent gas,
- gasifier ash, and
- cyclone dust.

The results of the SAM/IA analysis for the sums of the "degree of hazard" and "toxic unit discharge" associated with the four waste streams are given in Table 1. These results indicate that all of these waste streams have potentially adverse health and ecological effects. The coal feeder vent, separator vent and gasifier ash streams had the highest "toxic unit discharge" values for health, while the gasifier ash and cyclone dust had highest values for ecological effects.

Radian emphasized that there are several important factors that need to be addressed in evaluating the sampling and analysis results using SAM/IA methodology. These factors include the following:

- The coal feeder and separator vent waste streams will probably not be present and hence are not representative of new low-Btu gasification facilities.
- Only a few compounds with low MATE values accounted for a majority of the calculated "degree of hazard" and "toxic unit discharge" sums for each stream.
- The SAM/IA results need to be compared to bioassay results for the waste streams tested. (See Table 2.)

From the data presented in Table 2, the results of the SAM/IA analysis compare favorably with the bioassay test for the cyclone dust and the coal feeder and separator vent gases. However, the SAM/IA results from the gasifier ash are not consistent with the bioassay results. The SAM/IA analysis indicates that there is a moderate potential health and ecological hazard associated with the ash, while the bioassay tests indicate a low potential.

Tests Continue at Overseas Gasifier — Radian has arranged to conduct a series of environmental tests of the Lurgi gasification facility (Kosovo Kombine) at Obilic, Yugoslavia. Phase I of these tests is designed to measure the emission levels of specific major and minor pollutants emitted from the Kosovo plant. The first sampling effort was completed in late 1977, while the second effort was completed in July 1978.

The second phase of the Kosovo test program will be directed towards characterizing the emissions of minor and trace pollutants from the Kosovo plant. Phase II sampling is scheduled to start in the Spring of 1979.

A related test effort at the Kosovo plant will commence this Fall. This sampling program will involve ambient air monitoring at three locations within the Kosovo plant. Pollutants of major interest will be organics and airborne particulates.

High-Btu Gasification

Preparation for Testing — The TRW, Inc. coal gasification environmental assessment program places considerable emphasis on environmental sampling and analysis at selected sites. To date, several preliminary discussions have been held with DOE, Carnegie-Mellon University and several private process developers to arrange for sampling activities. Arrangements are currently being made with IGT regarding acquisition of environmental data and analysis of selected samples at the HYGAS pilot plant located in Chicago, Illinois. Discussions are continuing with Krupp-Koppers for the purpose of acquiring data on a Koppers-Totzek coal gasification facility. TRW has also contacted the American Lurgi Corporation to solicit their assistance in planning and performing an environmental assessment of coal gasification.

Liquefaction

Analysis for Radionuclides — Hittman Associates, Inc. has completed a draft report, "Analysis for Radionuclides," which addresses the levels of uranium, thorium, and their decay products found in coal, SRC, coal flyash, and SRC flyash samples. The samples were obtained from Georgia Power Company's Plant Mitchell during May and June 1977, when combustion tests were made to compare the environmental emissions resulting from the use of coal and SRC in the boilers. Gross alpha and beta activities were also measured in the samples.

Uranium and thorium were observed to be present at concentrations ranging from 0.8 to 39 ppm and 3.73 to 20.5 ppm, respectively. Calculated levels of other radionuclides in secular equilibrium with uranium and thorium were found to range from 7.4 x 10^{-17} to 1.02 x 10^{-4} ppm. Quantitative alpha measurements could not be made due to the self absorption of the alpha particles in the samples. Beta measurements, however, could be taken and were found to be on the order of 50 pCi/g.

Levels of radionuclides in the samples were also compared with reported levels of uranium and thorium in coal and SRC and with estimated emissions from coal-fired power plants. Uranium and thorium levels in the samples were found to be of the same order of magnitude as those reported in the literature. Data obtained from Plant Mitchell and other coal-fired power plants, as well as data obtained in this report, were used to estimate the level of uranium-238 which may be discharged from a power plant. The estimated level was found to be 0.2 g/m^3 (9 gr/100 ft^3) which is lower than the allowed general public dose radiation level of 7.0 g/m^3 (300 gr/100 ft^3). Therefore, the radionuclide levels present in the tested samples do not appear to pose a significant problem from a radiological toxicity standpoint. Further analysis of various types of coals and SRC products is recommended, however, before this may be concluded on an overall basis.

Analysis of Coal Liquefaction Samples — Level 1 standard wastewater analyses have been performed on SRC samples which have been passed through a treatment system. Hittman Associates, Inc. has completed Level 2 organic analyses for SRC wastewater, product, and residue samples, and for H-Coal wastewater. The results will be incorporated into a draft report scheduled for completion in the winter of 1978.

Other work currently underway is Level 1 inorganic analysis on SRC and H-Coal wastewater samples. Level 2 analysis will be initiated soon on SRC samples on the basis of the Level 1 results.

Standards of Practice Manual — Hittman Associates has prepared a Standards of Practice Manual for a coal conversion process. Released in June 1978, "Standards of Practice Manual for the Solvent Refined Coal Liquefaction Process" (EPA-600/7-78-091) provides an integrated multimedia evaluation of control/disposal options, emissions, and environmental requirements associated with a hypothetical 8000 m^3/day (50,000 bbl/day) SRC-II facility.

The initial portion of the report provides a description of the overall process. A basic flow sheet, showing all processing steps, was developed from existing design and economic studies and pilot plant data. This flow sheet identifies the processes and identifies all relevant process waste streams. Streams entering and leaving each process module are identified in terms of quantity and composition. Any waste streams that have to be treated by control/disposal measures are characterized in detail. For these streams, the characterization includes quantity, conditions, composition, and identification of the components that must be treated to comply with environmental regulations. The quantities, concentrations and forms of the components are estimated to fullest extent possible.

Applicable control/disposal practices are specified in accordance with waste stream characteristics and pertinent environmental requirements. Costs associated with the controls are delineated and best practices identified. Based on a preliminary assessment of available data on quantities and constituents in SRC waste streams, it appears promising that conventional control equipment can be used to achieve compliance with emission control standards. Costs for control equipment are significant, but do not appear to be prohibitive.

Emissions after controls are compared with Multimedia Environmental Goals (MEG's) and a number of areas are identified as discharging specific constituents in excess of the MEG's. In coal preparation—specifically in coal receiving and crushing—chromium, aluminum and, in some cases, arsenic are found to be emitted in concentrations significantly higher than their respective MATE

Table. 1. SUMS OF THE DEGREE OF HAZARD AND TOXIC UNIT DISCHARGE FOR THE GASIFICATION PLANT'S WASTE STREAMS

	Degrees of Hazard[a]		Toxic Unit Discharge[b]	
Stream	Health	Ecological	Health	Ecological
Coal Feeder Vent Gas	5.0×10^7	410	3.0×10^6	24
Separator Vent Gas	1.0×10^8	2.1×10^3	6.0×10^7	1.2×10^3
Cyclone Dust	1.7×10^3	8.1×10^6	2.7×10^3	1.3×10^7
Gasifier Ash	1.8×10^5	1.0×10^6	3.1×10^6	1.9×10^7

[a]Degree of Hazard is defined as the ratio of a pollutant's concentration in a stream to its minimum acute toxicity effluent (MATE) value. The numerical values shown are summations for all pollutants identified in the stream.

[b]Toxic Unit Discharge is determined by multiplying the value for Degree Hazard by the waste stream flow rate.

Table 2. SUMMARY OF SAM/IA ANALYSIS AND BIOASSAY TEST RESULTS FOR THE WASTE STREAMS FROM THE CHAPMAN LOW-BTU GASIFICATION FACILITY

	Degree of Hazard[a, b]		Toxic Unit Discharge[c]		Bioassay Test	
	Health	Ecological	Health	Ecological	Health[d]	Ecological[e]
Coal Feeder Vent Gas	5.0×10^7	4.1×10^2	3.0×10^6	24	High	High
Separator Vent Gas	1.0×10^8	2.0×10^3	6.0×10^7	1.2×10^3	High	NA
Cyclone Dust	1.7×10^3	8.1×10^6	2.7×10^3	1.3×10^7	Low	High
Gasifier Ash	1.8×10^5	1.0×10^6	3.1×10^6	1.9×10^7	Low	Low

[a]Degree of Hazard is defined at the ratio of a pollutant's concentration in a stream to its minimum acute toxicity effluent (MATE) value. The numerical values shown are summations for all pollutants identified in the stream.

[b]Potential for hazardous health and ecological effects can be estimated by the following:

Potential effect	Degree of Hazard
High	$>10^7$
Moderate	$10^5 - 10^7$
Low	$10^2 - 10^5$
Inconclusive	$<10^2$

[c]*Toxic Unit Discharge is determined by multiplying the value of Degree of Hazard by the waste stream flow rate.*

[d]Health tests included: AMES, Cytotoxicity (WI-28, RAM), Rodent Acute Toxicity.

[e]Ecological tests included: Soil microcosm, plant stress ethylene.

NA — Test not conducted.

values. Chromium and vandium exceed their MATE values by factors of less than 10 in air emissions from steam generation. Gasifier slag contains metals at concentrations that exceed MATE limits by significant amounts. Included are chromium, cobalt, nickel, barium, arsenic, tin, zinc, and selenium. Several metals (magnesium, nickel, scandium, and barium), in wastewater effluent are also at concentrations higher than their MATE values.

A listing of existing environmental regulations, standards and guidelines is also included in the manual. There are no existing regulations directed toward SRC facilities, so limits for related industries such as oil refineries, petrochemical processing plants and coal-fired steam electric plants are assessed as a guide for possible SRC plant regulations.

Air Emissions from Solvent Refined Coal Combustion – Hittman Associates has evaluated some of the data obtained from the SRC combustion test conducted at Georgia Power Company's Plant Mitchell during the months of March, May and June 1977.

Significant reductions in SO_2 emissions were observed. SO_2 emissions were in compliance with the existing New Source Performance Standards (NSPS) of 520 ng/J (1.2 lb/10^6 Btu) input. However, if 85 percent SO_2 removal is required, as is being proposed by EPA at the time of this writing, then compliance is doubtful. Due to the firing conditions (excess air values), NO_x emissions for a normal combustion condition are uncertain.

The electrostatic precipitator used throughout the test was an old (1946) Research Cottrell unit which was inefficient for SRC flyash collection. Total collection efficiencies ranged between 17 and 46 percent. When a more modern precipitator was briefly tested, collection efficiency increased to approximately 95 percent. Additional testing appears necessary to provide a more accurate account of actual atmospheric particulate emissions associated with the combustion of SRC.

Pollutant Evaluation and Effects for SRC – Hittman Associates is preparing a draft report, "Pollutant Evaluation and Effects for the Solvent Refined Coal Process."

The report is one of a series in an ongoing effort to characterize the potential environmental effects of various waste streams likely to be associated with the operation of a standard-sized Solvent Refined Coal (SRC-I and SCR-II) facility utilizing 28,000 metric tons (31,000 tons) of Illinois No. 6 coal per day. The objectives of this study are to: (1) conduct a more detailed evaluation of SRC pollutants that were characterized earlier in the Standards of Practice Manual for the SRC liquefaction process, and (2) to estimate the potential effects of various pollutants on the environment in a multimedia context. Beyond this, an effort is made to estimate the potential environmental effects of the various potential pollutants associated with an SRC plant located in a known geographical area (i.e., White County, Illinois).

CURRENT ENVIRONMENTAL BACKGROUND

General Topics

Federal and State Environmental Standards – Compilations of existing and proposed environmental standards promulgated by federal, state, regional, and international authorities are being prepared by Pullman Kellogg. Summary lists of "most stringent standards" are also being prepared for air, for water, and for solid waste disposal. The lists are being compared with existing information on Multimedia Environmental Goals to yield a series of projections for environmental goals that may be recommended for application 2, 5, and 10 years in the future. These recommendations are made in view of both existing and developing control technologies.

With the summary of most stringent environmental standards as the principal criterion, commercial and developing technology for control of liquid effluents, gaseous emissions and solid wastes has been surveyed for technical and economic applicability. The ultimate goal is maximum recycle of liquid streams and such control of gaseous emissions and solid waste which will allow the proposal of a technically feasible and economically practical scheme for zero discharge of pollutants to the environment. Heavy emphasis is placed on means that are economically and technically realistic and practical.

ENVIRONMENTAL OBJECTIVES DEVELOPMENT

General Topics

Process Assessment Criteria – Hittman Associates continue to develop a methodology which ranks candidate processes according to the need for further attention in an environmental assessment. For processes of concern to the EPA, assessment criteria include the likelihood, timing, and extent of commercialization. Hittman chose the Decision Alternative Rational Evaluation (DARE) model to assist in the weighting of each process assessment criterion.

CONTROL TECHNOLOGY ASSESSMENT

General Topics

Coke Oven Emission Controls – Catalytic, Inc., as part of their task to study the application of coke oven controls to coal conversion systems, has made a brief literature survey on the health effects of coke oven emissions. (Note: A summary of the technical aspects of the study was discussed in Vol. 1, No. 2 of the "Environmental Review of Synthetic Fuels.") The summary findings of the study to date are:

- Exposure to coke oven emissions provides an elevated risk for cancer and non-malignant diseases to coke oven workers and a moderate risk among lightly exposed workers (non-oven workers in coke plant).
- The general population in the vicinity of the coke oven plant should be considered more susceptible to these risks than the work force, especially for development of chronic bronchitis, since the population may include the young, the old, and the infirm.
- There are only about 2 orders of magnitude difference in exposure levels (estimated) between lightly exposed workers and people living in the vicinity of a coke plant. Since it is assumed that levels down to 1 percent of those to which the non-oven workers in coke plants are subjected could cause an increased risk to the general population, a significant health effects risk is present among the general population in the vicinity of coke oven plants.

The EPA has announced that in early 1979 it will propose a standard for coke oven emissions under the National Emissions Standards for Hazardous Air Pollutants (NESHAPS). A public hearing will be held approximately 30 days afterward. This will be the first time that such a diverse group of air contaminants classified as "coke oven emissions" rather than a specific chemical compound or hazardous material is proposed under this regulatory category.

The initial standard will specify limits and other requirements for coke oven emissions from the charging operation and topside leakage. Subsequently, standards for the other major emission sources related to coke oven operations will be proposed. Placing the enforcement under NESHAPS not only recognizes the hazardous nature of coke oven emissions, but provides regulatory control of both new and existing coke oven facilities.

Evaluation of Control Technologies for Particulates and Tar Emissions — The Applied Research Division (ARD) of Dynalectron Corporation, under subcontract to Hydrocarbon Research, Inc. (HRI), is conducting a study to evaluate alternative control technologies for particulates and tar emissions from coal converters. A comprehensive literature search has been carried out to characterize the emissions of particulates and tars from various types of coal converters. Computerized literature searches of Chemical Abstracts, Engineering Index, Pollution Abstracts, U.S. and foreign patents, government publications, and numerous journals were made to identify sources of information on those emissions. In addition, other EPA contractors and over 20 process developers were contacted for emission and process data. Emission data are being compiled and tabulated in terms of total particulates, total tars, the chemical composition of both the particulates and tars, particle size distribution, and other pertinent exhaust gas parameters. The emission data are being organized according to generic coal-converter categories (e.g., fixed, fluidized and entrained-bed gasifiers).

A literature search is also being made to identify and characterize the performance of alternate control technologies for particulates and tars. The computerized literature searches discussed above and library searches have been made to identify pertinent sources of information on these control technologies. Data on the performance of the alternate control devices are being organized according to generic categories (e.g., cyclones, electrostatic precipitators). A summary of available performance data for high-temperature particulate removal devices has been included in the work.

Study of High Temperature Desulfurization Technologies — The Applied Research Division (ARD) of Dynalectron Corporation, under subcontract to HRI, is also conducting a study of high temperature desulfurization technologies for coal converters. A comprehensive search has been carried out to identify hot gas cleanup (HGC) technolgies at all stages of development. This search was directed not only at HGC technologies developed specifically for coal conversion, but also at other related industrial applications such as coke-oven and refinery gases. Computerized literature searches of Chemical Abstracts, Engineering Index, U.S. and foreign patents, government publications and numerous journals were carried out. A thorough U.S. patent search was also conducted separately. HGC process developers and evaluators, HGC project officers at the U.S. Department of Energy, and other EPA contractors were contacted for additional information.

Twenty-two HGC processes have been identified. All available sources of information have been reviewed for each of these processes. Status descriptions for each of the 22 HGC processes are being summarized. An interim report of the status of the identified HGC processes is being prepared.

Assessment and Control of Wastewater Contaminants from the Production of Synthetic Fuels — Under an EPA grant, the University of North Carolina has initiated bench-scale testing of processes which treat wastewater resulting from the production of synthetic fuels from coal. Recently, coagulation studies have shown the best pretreatment to be acidification of wastewater to pH 5. During these studies, the following removals have been observed: tar, 90 to 95 percent; and TOC, 15 percent. Doses of alum and synthetic organic polymers remove only small amounts of tar and TOC. Studies of activated sludge, biodegradation, aquatic bioassay, and adsorption are continuing.

Coal Gasification

Coal Gasification — Gas Cleaning Plant — The coal gasification-gas cleaning facility at North Carolina State University is scheduled to be completed this summer. After shakedown, the initial tests will study the methanol acid gas removal process.

During the next budget period, October 1, 1978 through September 20, 1980, the research will follow three principal lines of investigation:

- measurement and characterization of emissions,
- process/environmental modeling, and
- evaluating the kinetics, thermodynamics, and transport phenomena associated with the gasification and gas purification steps.

Among the potential acid gas removal processes to be considered are those using monoethanolamine, hot potassium carbonate, and the dimethyl ether of polyethylene glycol.

Liquefaction

Control Technology for the H-Coal and Exxon Donor Solvent Processes — The Applied Research Division (ARD) of Dynalectron, under subcontract to HRI, is evaluating control technologies for the H-Coal and Exxon Donor Solvent (EDS) coal liquefaction processes. The evaluation is based on design information for the pilot plants being built. The H-Coal and EDS pilot plants have capacities of 6.3 kg/s (600 tons/day) and 2.6 kg/s (250 tons/day) of coal, respectively. Both plants are located adjacent to existing oil refineries.

For purposes of evaluating control technologies, the conceptual commercial processes are divided into several sections (process modules) such as coal handling, reaction and primary separations, gas treatment, water treatment, and solids disposal. For each of these sections, the input and output streams are determined. The emissions are then characterized and the technology analyzed for its applicability to commercial-size plants.

The pilot plants, as designed, are not completely integrated and they do not treat the H_2S-containing gases. These gases will be sent to existing Claus plants in the adjacent refineries. Similarly, wastewater streams will be fed to existing refinery wastewater treatment plants. As a result, any assessment of control technologies, based on the pilot plant design, is not complete and alternative conceptualized designs will be developed.

Furthermore, some of the solids from the vacuum tower bottoms and anti-solvent de-ashing system are disposed of in landfills. It has frequently been mentioned that these solids can be used to produce the hydrogen necessary for the reactors. Conceptual designs of systems which use these solids for hydrogen production and for final disposal of the resulting solid wastes will be developed. Other alternative control technologies are also being studied, however.

Zero Discharge Options for Coal Liquefaction — In evaluating existing and proposed zero discharge options in related industries to determine their applicability to the SRC process, preliminary indications are that zero discharge of wastewaters from the SRC process is technically feasible. However, the design and construction of such a facility will result in an economic penalty over conventional plant design.

For the purposes of this study, Hittman Associates developed a zero discharge water management system for a conceptualized 8,000 m^3/day (50,000 bbl/day) SRC-II facility. In this design, four treatment schemes are necessary. The first treats blowdown from cooling towers in several stages, resulting in reuse of 95 percent of the blowdown as a makeup and concentration of dissolved salts to a solid form for disposal. The second recovers salable materials from process condensates. Phenols, ammonia, and sulfur are recovered in relatively pure state and, assuming good markets exist for each, credit from the sale of these materials would be used to reduce the payback period on the high capital expenditures necessary for recovery equipment. The third scheme treats intake water to levels necessary for cooling, process and domestic requirements. The fourth treats wastewaters from hydrogen generation, regeneration of demineralizers, and recycled wastewater from hydrogenation.

It should be pointed out that the zero discharge system used in this project is only one of many systems which could be designed using current technology. A draft report of this work is being prepared.

TECHNOLOGY AND/OR COMMERCIAL DEVELOPMENT

Powerton Project Name and Emphasis Changed – The Powerton Combined Cycle Test Facility Project has been renamed the Gasifier Development Program Test Facility. Along with the name change, the test facility's emphasis will be shifted to gasifier development. Initially, two 3-m (10-ft) diameter Lurgi units will process 8.4 to 10.5 kg/s (800 to 1000 tons/day) of coal. The resulting product gas will be used in combined cycle generating systems. Construction is scheduled to begin next spring and initial operation should begin early in 1981. The dry-ash Lurgi units will be tested for 3 years, after which they will be replaced by slagging Lurgi units.

DOE to Award SRC Studies' Contracts – DOE is prepared to award two contracts ($6 million each) for the process design of solvent refined liquid and solids plants as soon as funding can be approved. The two companies selected for the contract awards are Gulf Oil Company and Southern Company Services, with Air Products / Chemicals, Inc. and Wheelabrator Cleanfuel Corp. assisting the Southern Company subsidiary. It will take 6 to 9 months to complete the designs after the contracts are signed.

While DOE has stipulated that both designs would process 63 kg/s (6000 tons/day) of coal, Wheelabrator and the Electric Power Research Institute maintain that a 10.5 to 21 kg/s (1000 to 2000 ton/day) plant would be sufficient to demonstrate commercial scale equipment . EPRI is basing its opinion in part on the belief that a 63 kg/s (6000 ton/day) plant would require some equipment not currently available. However, DOE maintains that, at a minimum, a 63 kg/s (6000 ton/day) plant is required to demonstrate commercial scale equipment.

Explosion at BIGAS Plant Initiates Review – A mid-February explosion at DOE's BIGAS coal gasification pilot plant in Homer City, PA, has brought about a major review of the facility. An inductor feeding char into the reactor became clogged and backed up, causing an explosive mixture to enter into a line and resulted in the explosion. A team of consultants was called in to check the operations and safety of the plant after the explosion and fire. DOE managers decided the overall plans for the plant needed to be reevaluated.

Homogeneous Catalysts for the Water-Gas Shift Reaction – Researchers at the University of California (Santa Barbara), the University of Georgia, and the University of Rochester have reported the use of homogeneous catalysts to promote the water-gas shift reaction. The shift reaction involves the reversible conversion of carbon monoxide and water into hydrogen and carbon dioxide. The new homogeneous catalysts promote the reaction at temperatures of 370 to 470 K (210 to 390°F). The standard heterogeneous catalysts (such as iron and chromium oxides) promote the shift reaction at high pressures and temperatures of 620 to 720 K (660 to 840°F). Although hydrogen yields in the experimental homogeneous systems have been low, lower energy costs are possible than with the heterogeneous catalysts.

Research at the University of California has primarily involved mixed metal systems containing ruthenium and iron carbonyls. Carbonyl complexes of iridium and rhodium have also been used in mixtures of ruthium and iron carbonyls. The metal complexes form active complexes in acidic or basic aqueous solutions.

Research at the University of Georgia has involved solutions containing carbonyl complexes of iron, chromium, molybdenum, and tungsten. Current research is on conditions required to maximize hydrogen production. Researchers are also investigating catalyst poisoning by compounds such as H_2S and COS.

Research at the University of Rochester has involved hydrated tin chlorides and platinum-containing salts.

Test Run Successful at COGAS Pilot Plant – The COGAS-designed pilot plant in Leatherhead, England, has completed a successful test run of more than 200 hours that demonstrated the feasibility of the coal gasification process. The test, the latest of 22 conducted at the pilot plant, successfully gasified coal chars from Illinois, West Virginia, and the United Kingdom. It demonstrated the flexibility and control of the COGAS process and showed that domestic high-Btu substitute natural gas and oil can be produced in substantial quantities. The success of the tests may cause a reversal of the earlier decision by DOE to halt design work of a proposed demonstration plant in Illinois, based on the same process.

Successful Use of Caking Coals by Conoco – Conoco Coal Development Company's tests at a Lurgi pilot plant in Westfield, Scotland, have successfully completed a 5 day run using highly caking, high-sulfur Pittsburgh No. 8 coal. Previous successful tests were conducted with a mixture of coke and Pittsburgh No. 8 coal. Conoco hopes this successful run will satisfy DOE and allow the continuation of design work on a slagging Lurgi demonstration plant planned for Ohio. Conoco did receive an extension from DOE to continue operation for a month or two. If their runs continue to be successful, DOE may authorize resumption of the design work.

DOE Selects Two Firms for Coal-to-Gas Plant Designs – Foster Wheeler Development Corp. and Combustion Engineering, Inc., have been selected by DOE to design low-Btu coal gasification plants to fuel electric generating units. Each company would receive about $2.5 to $3 million in government funding for the design work, which will take approximately 20 months. Authorization to proceed with detailed design of one or both of the projects may come from DOE under a 50/50 cost-sharing arrangement. DOE estimates each demonstration plant will require between $50 and $100 million in direct spending if they are to be in operation by 1984. Foster Wheeler's proposal entails use of a chemically active fluidized-bed gasification process now under development at the Esso Research Center, Abingdon, England. It would be tested at an Appalachian Power Company plant at Cabin Creek, WV. Twelve kg/s (1100 tons/day) of high-sulfur, highly caking Ohio bituminous coal will be processed with the resulting fuel gas used to fire a 90 MW generator. Foster Wheeler Energy Corp. will be the A-E subcontractor.

Combustion Engineering proposed a commercial plant that uses an entrained-flow atmospheric pressure gasifier to produce gas for use in a combined cycle application at Gulf States Utilities' Westlake, LA, station. The gasifier will process 14 kg/s (1300 tons/day) of high-sulfur, highly caking Midwestern coal. C-E's Lummus subsidiary will be the A-E subcontractor.

Laboratory Analysis of Condensate from Pilot Plants – Argonne National Laboratory recently initiated a 5-year program for the analysis of organics in process streams of high and low/medium-Btu gasification pilot plants. The first phase of the effort will involve characterization of trace organics in HYGAS pilot plant condensates. A parallel effort is also being conducted at Argonne for the biological characterization of waste stream constituents in order to identify which compounds or sample fractions are carcinogenic and/or mutagenic.

Financial Plan for Mercer County, No. Dakota, Coal Gasification – A consortium of five major pipeline companies headed by the American Natural Resources Co. of Detroit, with the assistance of DOE, has devised a plan to finance a 77 Nm^3/s (250 x 10^6 scf/day) coal gasification plant in Mercer County. The plan, called an "all events tariff," enables the pipeline companies to increase their rates to customers by enough to cover their debt, which will amount to approximately $675 million, even if the project fails for any reason. The companies will put up above $225 million in equity, which would not be recoverable from customers if the plant failed for technical or financial reasons. The plan still has to be approved by the Federal Energy Regulatory Commission (FERC). If the plan is approved, the plant may be on stream in Mercer County by 1982.

Low-Btu Gasification Process Nears Market — A consortium of Allis-Chalmers Corporation and 11 utility companies has privately financed development of a low-Btu gasification process that is nearly ready for commercialization. The consortium's KilnGas process is currently the focus of a 3-year basic engineering program in which a 0.1 kg/s (10-ton/day) pilot plant is being used to generate design data for a commercial plant. The process is expected to be ready for commercial use by 1982. The KilnGas process is based on the use of refractory-lined rotary kilns with special ports to permit the introduction of air and steam to a tumbling bed of coal, and lends itself to the production of fuel for combined cycle power generation.

Comparison Results Released on Combined Cycle Systems — Fluor Engineers and Constructors, Inc., conducted a study for the Electric Power Research Institute on five hypothetical gasification-combined cycle power plants. The results showed construction of the GCC power plants could cost as much as 15 percent less than that of conventional coal-fired power plants and operation of such plants could be as much as 20 percent less. Of the five GCC systems studied, most have the potential of being commercialized within the next decade. Some of the processes also presented environmental advantages because of the high temperature operation and simplicity. The study compared power plants with capacities of 1000 MW, using advanced gas turbine technology (with a combustion of 1570 K, 2400°F), a Lurgi dry ash gasifier, a British Gas Corp. slagger, and entrained-bed processes by Combustion Engineering, Foster Wheeler and Texaco.

Conversion of Caking Coals Problems Solved — Westinghouse Electric Corp. has completed the second of the two main steps in its gasification process and seems to have solved two major problems associated with caking coals. Test runs totaling 1,100 hours have been completed on a 0.15 kg/s (15-ton/day) fluidized-bed, pressurized, agglomerating gasifier at Waltz Mill, PA. The gasifier can handle char and raw coal feeds. The two problems solved are: the tendency of some eastern coals to stick together; and need for efficient removal of ash formed during gasification. Caking Pittsburgh seam coal was run through the gasifier for 24 hours without problems and produced 4.7 MJ/Nm^3 (120 Btu/scf) gas at about 1.5 MPa (15 atm) and 1200 to 1366 K (1700 to 2000°F). A longer, 7-day, continuous test of caking coals is planned by Westinghouse. The testing was performed under contract to DOE.

Coal Liquefaction Process Patent Received — The Houdry Division of Air Products and Chemicals has received patent No. 4,075,082 for a coal liquefaction process. It outlines a method of hydrodesulfurizing and liquefying carbonaceous feedstocks using a hydrogenation catalyst from a Group VI or VIII metal, such as nickel cobalt, molybdenum or chromium. Commercial possibilities are being considered although the process is still being evaluated by Air Products.

Exxon Coal Liquefaction Project Underway — Construction has begun in Baytown, TX, on the $110 million pilot plant which is part of the $240 million commercial development project for the Exxon Donor Solvent coal liquefaction process. The pilot plant is scheduled for completion in November 1979 and will process 2.6 kg/s (250 tons/day) of coal. The EDS process is expected to produce distillate low-sulfur liquid fuels at a rate of 0.44 m^3/metric ton (2.5 bbl/ton) of coal feed. DOE is providing half of the project funding; the other half will come from a group of U.S. and Japanese companies and the Electric Power Research Institute.

SRC Solids Demonstration Plant Evaluated — The design approach for a solvent refined coal solids demonstration plant has been evaluated by the Electric Power Research Institute for DOE. One remaining question to define is the best system for liquid-solids separation. The evaluation also recommends that the hydrogen production system be compatible with the solids separation system. The present method of solidifying the coal product must be redesigned into a direct and contained cooling process to ensure environmental acceptability. Sulfur emission standards for SRC solids plants need to be defined because tighter standards could cause the process to become impractical. The report also states that any demonstration plant would have to process between 10 and 20 kg/s (1000 and 2000 tons/day) of coal to provide sufficient information prior to the commercialization phase.

Alternate Conversion Route for Western Coal — Oak Ridge National Laboratory has developed a bench-scale, simplified coal conversion process that produces pipeline-quality gas and light oil. It requires no char gasifier, oxygen plant, or methanator, and consumes very little net hydrogen. A fluidized-bed reactor at 833 K (1040°F) and hydrogen pressure of 2 MPa (300 psi) cause mild hydrocarbonization of coal. Resulting products are 46 percent clean char, 21 percent pipeline gas, 20 percent oil, and 13 percent water. The estimated total capital cost for a 386 kg/s (36,700-ton/day) plant using low-sulfur western coal is $1.7 billion. Excluding the cost of coal, annual operating costs are estimated at $55.8 million for the conversion plant and $28 million for the power plant. Burning 21 percent of the char can satisfy process-heat requirements. The plant would yield approximately 43 Nm^3/s of (140 million scf/d) of gas products and 0.08 m^3/s (42,000 bbl/d) of 1 percent S light oil.

EPRI Sponsors Equipment Cooling Methods Project — The Electric Power Research Institute has authorized a 4-year, $20 million research project to demonstrate methods to cool equipment used to burn coal gases and liquids. Temperatures required for the most efficient burning of coal gases and liquids (1480 to 1530 K or 2200 to 2300°F) cause rapid deterioration of the high-alloy metals used in combustion equipment. EPRI says a wider variety of metals, reducing equipment costs, could be utilized if these temperatures could be lowered to below 980 K (1300°F). A combustion-turbine/steam turbine combined cycle system will receive emphasis in testing because it is thought to be the most efficient coal-derived fuel system. It uses hot gas from the combustion turbine to heat water, producing steam that drives a turbine which generates electricity. EPRI plans to test water- and air-convection cooling methods on the section of the turbine from the burner to exhaust.

New Coal Liquefaction Process Developed in South Africa — A new process to extract oil, other fuels, and by-products from coal has been discovered by South African scientists. The research was sponsored by the South African Coal Oil and Gas Corp. (SASOL), the Council of Scientific and Industrial Research, and the Fuel Research Institute. The existing process is accelerated and yield of fuel and by-products are increased up to 70 percent. The process features the economic use of coal, tar, and brown coal. The resulting products are a high quality fuel and varied by-products. Researchers say that manipulation of the reaction conditions can produce varied amounts of light hydrocarbon gases, gasoline, diesel, and heavy oil.

PROJECT TITLES, CONTRACTORS, AND EPA PROJECT OFFICERS IN FUEL PROCESS BRANCH ASSESSMENT PROGRAM

Project Title	Contractor	EPA Project Officer
Environmental Assessment of Low/Medium-Btu Gasification (March 1976-March 1979)	Radian Corporation 8500 Shoal Creek Blvd. Austin, Texas 78758 (512) 454-4797 (E. C. Cavanaugh/G. C. Page)	William J. Rhodes IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Environmental Assessment of High-Btu Gasification (April 1977-April 1980)	TRW, Inc. 1 Space Park Redondo Beach, CA 90278 (213) 536-4105 (Chuck Murray)	William J. Rhodes IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Environmental Assessment of Coal Liquefaction (August 1976-August 1979)	Hittman Associates 9190 Red Branch Road Columbia, MD 21043 (301) 730-7800 (Wayne Morris)	William J. Rhodes IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Control Technology For Products/By-Products (September 1976-September 1979)	Catalytic, Inc. 1500 Market Street Center Square West Philadelphia, PA 19102 (215) 864-8104 (A. B. Cherry)	Chester A. Vogel IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Control Technology For Converter Output (January 1977-January 1980)	Hydrocarbon Research, Inc. P. O. Box 6047 134 Franklin Corner Road Lawrence Township, NJ 08648 (609) 896-1300 (John Kunesh)	Chester A. Vogel IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Waste Stream Disposal and Utilization (April 1977-April 1980)	Pullman Kellogg Research and Development Center 16200 Park Row Industrial Park Terrace Houston, Texas 77054 (713) 493-0291 (Louis Bostwick)	Chester A. Vogel IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
General Support (April 1976-1978)	Cameron Engineers, Inc. 1315 South Clarkson Street Denver, CO 80210 (303) 777-2525 (Ted Borer)	L. David Tamny IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2709
Acid Gas Cleaning Bench Scale Unit (October 1976-September 1981) (Grant)	North Carolina State Univ. Department of Chemical Engineering Raleigh, NC 27607 (919) 737-2324 (James Ferrell)	William J. Rhodes IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Water Treating Bench Scale Unit (November 1976-October 1981) (Grant)	Univ. of North Carolina Department of Environmental Sciences and Engineering School of Public Health Chapel Hill, NC 27514 (919) 966-1052 (Phillip Singer)	William J. Rhodes IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Pollutant Identification From A Bench Scale Unit (November 1976-October 1981) (Grant)	Research Triangle Institute P. O. Box 12194 Research Triangle Park, North Carolina 27709 (919) 541-6000 (Forest Mixon)	William J. Rhodes IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851

REPORT SUMMARY

Applicability of Petroleum Refinery Control Technologies to Coal Conversion

by

M. Ghassemi, D. Stehler, K. Crawford, and S. Quinlivan

As part of a program aimed at the environmental assessment of high-Btu gasification technology, a study was conducted to determine the applicability of refinery pollution control systems to the control of gaseous liquid and solid wastes generated in coal gasification and liquefaction facilities. The study included a collection of toxicological and health effects data on components in analogous wastes in coal conversion and refining industries. As a first step in this effort, the refinery waste streams were reviewed and those likely to have counterparts in coal conversion processes were characterized. Based on the considerations of (a) availability of data on waste stream characteristics, (b) attainment of or nearness to commercialization status, and (c) representation of integrated operations producing upgraded or refined gaseous or liquid products, three coal conversion processes were selected as being representative. These processes are Lurgi, Koppers-Totzek and COED. The process/ waste streams from these processes were characterized and those streams having refinery counterparts were identified. The refinery control technologies for the management of refinery process/waste streams were then evaluated from the standpoint of applicability to their counterpart waste streams in coal conversion. All the data on waste stream characteristics and control technologies were obtained from the published literature and process vendors.

Compared to the relatively large amount of actual data available for many refinery waste streams, very little data are available for waste streams generated in integrated commercial coal conversion plants. The insufficiency of characterization data on coal conversion waste streams, which constitutes a major obstacle to accurate and detailed assessment of the applicability of refinery control technologies to coal conversion waste streams, stems primarily from the non-existence of commercial Lurgi, Koppers-Totzek and COED processes in the U.S. and from inapplicability of some of the data from U.S. pilot coal conversion facilities to large-scale operations. For many of the unit operations where some discharge stream characterization data are available, such data are not comprehensive in that all streams are not addressed and all potential pollutants and toxicological and ecological properties are not defined. Commercial gasification and liquefaction facilities which are in operation in foreign countries do not generally incorporate design and operating features which would likely be employed in a facility in the U.S. to minimize waste generation and to control pollutant discharge. Moreover, the coals used at these facilities differ from those which will be employed at commercial plants in the U.S. Although many of the unit operations for gas and liquid processing which may have applications in commercial coal conversion have been tested or used commercially in other industries, their performance in coal conversion service has often not been evaluated.

Comparison of Refinery and Coal Conversion Streams

Based on the review of the available data and from a control technology applicability viewpoint, a limited number of refinery and coal conversion process/waste streams appear to have certain similar characteristics. These streams and the basis for their similarities are listed in Table 3. Despite the noted similarities, there appear to be significant composition differences between the analogous streams which would affect applicability and design of a control technology. For example, while both the refinery process sour gases and the quenched product gas from coal gasification contain H_2S and CO_2, the H_2S concentration is considerably higher and the CO_2 level is significantly lower in most refinery sour gases (16 to 65% vs. 1 to 2% and 2 to 5% vs. 7 to 32%, respectively). Even when selective H_2S removal processes are used, the treatment of the coal conversion raw product gas results in the production of a concentrated acid gas stream with CO_2 levels much higher than those in refinery sour gases.

Unlike sour waters from refineries which contain high levels of both sulfides and ammonia, most coal conversion condensates contain low levels of sulfide and moderate levels of ammonia. Because of the differences in the nature of the raw material (crude oil vs. coal) and the processing steps employed, the dissolved and particulate organics (oils, tars, organic acids, etc.) found in coal conversion wastes are different from those in refinery wastewaters. The organics in coal conversion wastes are generally more aromatic than those in refineries, which are largely aliphatic. These differences in wastewater characteristics are also reflected in the characteristics of oily and biosludges resulting from wastewater treatment. In comparing coal conversion waste streams with their analogs in refineries, it should be noted that there can be wide differences between stream composition from different coal conversion plants depending on the coal processed, conversion process used, and onsite product upgrading methods employed.

Applicability of Refinery Control Technologies

The refinery control technologies which may find application to coal conversion are listed in Table 4. Some of the control processes (e.g., sulfur recovery plant tail gas treatment processes) would be applicable to waste streams in a coal conversion plant and their design would essentially be the same as in refinery applications. Other processes such as Stretford, Claus and steam stripping would require varying levels of modification to account for differences in waste composition. Because of limited data on certain waste characteristics (e.g., biodegradability of organics and settleability of suspended solids in wastewaters), the applicability and efficiencies of processes such as biooxidation, flotation, sludge dewatering, and emulsion breaking in coal conversion application cannot be accurately assessed at this time. With the exception of very few processes (e.g., Rectisol and DGA acid gas treatment processes and Stretford tail gas treatment process) which have been tested in coal conversion applications, the processes listed in Table 4 have not been employed in such an application. For the processes which have been used in coal conversion, only limited data are available on process design and performance. Even though the processes listed in Table 4 appear applicable to coal conversion wastes, the true test of applicability and definition of criteria for large-scale design and cost estimation requires laboratory and pilot-scale testing. It should also be noted that the suitability of a control process for use in coal conversion plants cannot be determined in isolation from other processes and waste treatment operations within an integrated coal conversion facility. The selection of a specific control process is merely an element in the overall waste management plan for a facility which includes considerations of overall emissions/effluent limitations, energy and raw material availability and costs.

Some of the components in refinery and coal conversion wastes are important from the standpoint of presenting potential occupational health hazards to plant workers and adverse health impact on the general population. Several of the hazardous waste components such as H_2S, CO_2, CO and mercaptans are not unique to refinery or coal conversion wastes and are emitted from a variety of other industrial and non-industrial sources. The hazardous characteristics of many of these commonplace substances are generally well documented. The hazardous chemicals which are more unique to coal conversion and refineries fall into three categories: polynuclear aromatics, heavy metals and organometallic compounds, and low molecular weight aromatic substances. Many of the control technologies used in both refineries and coal conversion plants should result in partial or total removal of the hazardous waste components. However, the fate of many of the hazardous components in pollution control processes is not well known, and the requirements for additional controls cannot be defined at this time.

TABLE 3. SIMILAR REFINERY AND COAL CONVERSION WASTE STREAMS

Refinery Streams	Coal Conversion Counterparts	Major Similarities
Gaseous		
Process sour gas	Quenched product gas, acid gas and fuel gas (from liquefaction)	High H_2S and ammonia content; presence of CO_2
Catalyst regenerator off-gas	Raw product gas and char combustion flue gas	High CO and particulates, NO_X and N_2
Fugitive emissions	Fugitive emissions	Hydrocarbons, sulfur compounds, ammonia
Liquid		
Sour waters	Raw product gas quench condensate, waste liquor purge (from liquefaction) and shift condensate	Ammonia, sulfide, phenols, oil and grease/tar
Oily waters	Raw product gas quench condensate and waste liquor purge (from liquefaction)	Oil and grease/tar; phenols
Solid		
Spent catalysts	Spent shift, methanation, hydrotreating, and Claus plant catalysts	Metals (Ni, Co, Mo, etc.), bauxite
Sludges	Oily and biosludges	Oil and grease/tar, inerts, biomass, refractory organics

TABLE 4. REFINERY CONTROL TECHNOLOGIES AND THEIR APPLICABILITY TO COAL CONVERSION

Refinery Control Technology	Applicability to Coal Conversion Waste Stream
Acid Gas Treatment	
Amine solvents (DEA, Fluor Econamine, etc.)	Potentially suitable for nonselective removal of H_2S and CO_2 from product gases from atmospheric/low pressure gasification/liquefaction. Also suitable for hydrocarbon removal from concentrated acid gases. Extensive solvent degradation may be encountered in coal application.
Physical solvents (Selexol, Rectisol, etc.)	Potentially suitable for selective removal of H_2S and CO_2 from product gases. Best suited to high pressure application. The resulting concentrated acid gas stream may contain high levels of hydrocarbons, thus requiring further treatment prior to sulfur recovery.
Sulfur Recovery	
Claus	Split-flow mode applicable to coal conversion acid gases containing more than 10% H_2S. Removal of ammonia and hydrocarbons from feed gases would be required to prevent ammonium bicarbonate scaling and carbon deposition on catalyst, respectively.
Stretford	Applicable to acid gases containing low levels (around 1%) H_2S. High CO_2 levels necessitate pH adjustment and result in high blow-down rates. Relatively large unit sizes would be required with high CO_2 gases. Process does not remove non-H_2S sulfur compounds.
Tail Gas Treatment	
IFP-1, Sulfreen	Suitable for Claus plant tail gas treatment; cannot achieve very low levels of total sulfur in the off-gas which may be required by emission regulations.
SCOT, Beavon and CleanAir	Sulfur removal efficiencies decrease when acid gases contain high CO_2 levels.
Chiyoda Thoroughbred 101, Wellman-Lord, IFP-2 and Shell CuO	Potentially suitable.
Fugitive Emissions and Odor Control	
Vapor recovery, incineration, source elimination	Applicable to analogous sources.
Sour Water Stripping	
Conventional stripping and Chevron WWT process	Applicable to coal conversion sour waters. The design must be modified to allow for the sulfide and often higher ammonia levels in coal conversion sour waters.
Oily Water Treatment	
API separator and flotation	Applicable; units must be designed based on specific wastewater characteristics.
Biological Wastewater Treatment	Generally applicable; biodegradability of coal conversion waste components not established.
Carbon Adsorption and Chemical Oxidation	Should be applicable; design basis must be established for the specific wastewater.
Slop Oils and Sludge Treatment (thickening, centrifugation, emulsion breaking, drying beds)	Generally applicable; design basis must be established for the specific waste.
In-Plant Waste Volume and Strength Reduction	Applicable.
Resource Recovery	Applicable to spent catalysts for material recovery; sale of tars/oils.
Incineration	Applicable to organic wastes; incinerator and emission control designs would be feed specific.
Land Disposal	Applicable.

MEETING CALENDAR

176th National meeting of the American Chemical Society, September 10-15, 1978. Contact: A. T. Winstead, ACS, Washington, D.C., 20036.

EPA Coal Cleaning to Achieve Energy and Envorinmental Goals, September 11-15, 1978, Hollywood, FL. Contact: J. D. Kilgroe, EPA, IERL-RTP, Research Triangle Park, NC, 27711.

Symposium on Potential Health and Environmental Effects of Synthetic Fossil Fuels, September 25-28, 1978, Gatlinburg, TN. Contact: J. Robert Hightower, Jr., Head, Advanced Technology Section, Chemical Technology Division, Oak Ridge National Laboratory, P. O. Box X, Oak Ridge, TN, 37830.

International Coal Utilization Exhibition and Conference, October 17-19, 1978, Houston, TX. Contact: David I. Johnson, 6006 Bellaire Blvd., Rm. No. 101, Houston, TX, 77081.

AIChE 71st National Conference, November 13-16, 1978. Miami, FL. Write: AIChE, 345 E. 47th St., New York, NY, 10017.

Environmental Aspects of Fuel Conversion Technology, April 17-19, 1979. Hollywood, FL. Contact: W. J. Rhodes (MD-61) EPA, IERL-RTP, Research Triangle Park, NC, 27711.

RECENT MAJOR MEETINGS

85th NATIONAL MEETING OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The 85th National Meeting of the American Institute of Chemical Engineers was held June 4-8, 1978, in Philadelphia, Pennsylvania. The program for the National Meeting emphasized topics related to chemical process technology, energy sources and utilization, and environmental impact of the chemical process industries. The meeting featured 74 sessions, including discussions on chemicals from coal, instrumentation and controls at fossil fuel conversion plants, utility gas produced from fossil fuels, and emissions from new coal-based energy sources. Other sessions featured discussions of the status of major synthetic fuel projects, coal liquefaction, and advances in coal conversion and utilization.

A session on chemicals from coal emphasized the potential use of coal as a petrochemical feedstock. During this session, the potential market and economics of coal-derived chemicals were discussed. Separate papers discussed methanol and gasoline produced from coal, the production of methanol from coal, and the production of petrochemicals/petrochemical feedstocks. Another paper described the hydropyrolysis of North Dakota lignite to produce a range of products including methane, ethane, benzene, toluene, xylene, ethyl-benzene, phenol, naphthalenes, and cresols.

The fossil-fuel conversion processes that operate at high temperatures and pressures require special techniques for process instrumentation and control. One session at the AIChE meeting highlighted recent instrumentation applications at fossil-fuel conversion plants. Separate papers discussed instrumentation for the H-coal liquefaction process, the test burn of solvent refined coal, the HYGAS gasification process, and the BI-GAS gasification process. Instrumentation being developed by the Argonne National Laboratory for large-scale coal conversion processes was also discussed.

Two sessions at the meeting discussed the production of low- and medium-Btu gas from coal. Several papers discussed some of the technology that could potentially be used to produce utility gas from coal. Other papers discussed the use of low- or medium-Btu gas for industrial needs. Several papers emphasized the economics and technological feasibility of low- and medium-Btu gas.

One paper at the session on utility gas discussed the agglomerating burner coal gasification process being developed by Battelle. Other papers described the Foster Wheeler-Stoic gasifier, the molten salt gasification process, and underground coal gasification. The use of coal gasification processes in combined cycle power generation systems was also discussed.

One session at this meeting focused on the atmospheric emissions from coal conversion processes. Comparisons were presented between firing coal and liquefied coal products. Several papers characterized the emissions from various coal conversion processes. RTI's parametric evaluation of pollutant formation from a laboratory coal gasifier was also discussed.

Large-scale coal conversion processes are in various stages of development. In one session, the current status of four coal gasification and liquefaction processes was discussed. Included were the Powerton combined cycle demonstration plant (featuring Lurgi gasifiers), the Illinois Coal Gasification Group's COGAS demonstration plant, the H-Coal liquefaction pilot plant, and the Exxon Donor Solvent pilot plant.

Another session at the National Meeting featured discussion of coal liquefaction processes. A conceptual process design and economic evaluation of a 0.2 m^3/s (100,000 bbl/d) Synthoil plant was presented. (The design was based on data from a bench-scale unit.) Coal liquefaction and de-ashing studies for the Consol and Solvent Refined Coal processes were also discussed. Other papers discussed the hydro-liquefaction of coal in molten zinc chloride and in the Synthoil reactor. A final paper described the effects of mineral matter on coal liquefaction processes. The catalytic liquefaction of coal by carbon monoxide and steam was discussed in a session describing advances in fossil-fuel conversion and utilization.

RECENT MAJOR PAPERS AND PUBLICATIONS

Gasification

Ahner, D. J., and S. P. Gallagher, "Influential Factors in Coal Gasification Fuel Systems for Combined Cycle Power Generation and Their Impact on Performance and Costs," Presented at the 85th National Meeting and Chemical Plant Equipment Exposition of the AIChE, Philadelphia, PA, June 4-8, 1978.

Ammons, H. L., "Instrumentation and Control at the BI-GAS Pilot Plant," Presented at the 85th National Meeting and Chemical Plant Equipment Exposition of the AIChE, Philadelphia, PA, June 4-8, 1978.

Anderson, G. L., W. G. Bair, and J. A. Hudziak, "Ultrafiltration for Coal Gasification Processes." Presented at the 85th National Meeting and Chemical Plant Equipment Exposition of the AIChE, Philadelphia, PA, June 4-8, 1978.

Barnett, F. M., J. S. Clawson, and K. C. Vyas, "Medium Btu Gas Fits Refiner's Needs," ***Hydrocarbon Processing, 57***(b), 131-133 (1978).

Broeker, R. J., "Considerations Involved in the Production of 300-Btu Gas from Coal for Industry," Presented at the 85th National Meeting and Chemical Plant Equipment Exposition of the AIChE, Philadelphia, PA, June 4-8, 1978.

Brandenburg, C. F., D. D. Fischer, and L. W. Plemmons, "The Route to the Commercialization of Underground Coal Gasification," Presented at the 85th National Meeting and Chemical Plant Equipment Exposition of the AIChE, Philadelphia, PA, June 4-8, 1978.

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