ENVIRONMENTAL REVIEW of SYNTHETIC FUELS

EPA

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INTRODUCTION

The *Environmental Review of Synthetic Fuels* is prepared as part of the Environmental Protection Agency's program to evaluate the environmental impacts of synthetic fuel processes. EPA's program was initiated in response to the shift in U.S. energy supply priorities from natural gas and oil to coal. It is directed by the Fuel Process Branch of EPA's Industrial Environmental Research Laboratory in Research Triangle Park, NC (IERL-RTP).

The major objectives of the EPA Synthetic Fuels Environmental Assessment/Control Technology Development Program are 1) to define the environmental and health effects of multimedia discharge streams, and 2) to define control technology needs for an environmentally sound synthetic fuels industry. The synthetic fuels from coal technologies being studied in this program include low/medium-Btu gasification, high-Btu gasification, and liquefaction.

To achieve the overall program goals, EPA has defined six major task areas: current process technology background, environmental data acquisition, current environmental background, environmental objectives development, control technology assessment, and impact analysis. The contractors involved in the program, their EPA Project Officers, and the duration of each effort are tabulated on Page 6.

This issue of the *Environmental Review of Synthetic Fuels* summarizes recent activities in EPA's synthetic fuels program. Activities of EPA contractors are covered in sections on current process technology background and environmental data acquisition. Highlights of technology and commercial developments, major symposia, a calendar of upcoming meetings, and a list of major publications provide up-to-date information on national and international development in synthetic fuels technology.

Comments or suggestions which will improve the content or format of these *Reviews* are welcome. Such comments should be directed to the EPA or Radian Corporation personnel identified on page 15 of this *Review*.

CURRENT PROCESS TECHNOLOGY BACKGROUND

General Topics

Technology Assessment Report for Synthetic Fuels— Radian Corporation has completed a technology assessment report on the use of synthetic fuels produced from coal as precombustion emission controls for new industrial boilers. The report (EPA-600/7-79-178d, see "Recent Major Papers and Publications") is one in a series of technology assessment reports designed to aid EPA in determining the technological basis for developing New Source Performance Standards (NSPS) for industrial boilers.

The synthetic fuels technologies considered in the report were coal gasification (low-, medium-, and high-Btu) and liquefaction. Major emphasis was placed on examining the reduction of SO_x, NO_x, and particulate emissions in the industrial boiler flue gases.

Based on detailed analyses of costs, energy, and environmental impacts, low-Btu coal gasification was selected as the "best synthetic fuels from coal" emission control technique for industrial boilers. Two low-Btu gasification systems, the Wellman-Galusha gasifier with either the Stretford (W-G/S) or monoethanolamine (W-G/MEA) acid gas removal process, were selected for the detailed analyses. Two coal feedstocks (low-sulfur western and high-sulfur eastern) and five boiler capacities (8.8, 22, 44, 58.6, and 117 MW heat input) were also considered in performing the detailed analyses.

All of the low-Btu gasification systems examined were capable of meeting the most stringent target NO_x and particulate emissions control levels considered (86 ng NO_x/J and 4 ng particulates/J heat input to the boiler). With respect to SO_2 emissions, the W-G/S systems using a low-sulfur coal feed could achieve a stringent target emission control level of 43 ng SO_2/J heat input. Using a high-sulfur coal feed, the W-G/S systems could achieve a moderate target control level of 150 ng SO_2/J heat input. The W-G/MEA systems were only considered for the high-sulfur coal cases and could be designed to achieve either the moderate or stringent target SO_2 control level.

Cost analyses indicated that the annualized costs of the gasification/low-Btu gas-fired boiler systems were approximately 20 to 170 percent greater than the annualized costs of an equivalent capacity (on a boiler heat input basis) direct coal-fired boiler without pollution controls. The percentage increase in incremental costs of pollution control varied indirectly with boiler capacity. For a given boiler capacity, the W-G/S system using low-sulfur coal had the lowest incremental costs, while the W-G/MEA system using high-sulfur coal had the highest incremental costs. All of the low-Btu gasification/boiler systems consume more energy (40-65%) than equivalent capacity uncontrolled coal-fired boilers. The low-Btu gasification systems are also sources of gaseous, liquid, and solid discharges. However, there appear to be no uncontrollable adverse environmental impacts.

Liquefaction

Revision of Environmental Assessment Data Base Report—Hittman Associates, Inc., is updating a 1978 report, *Environmental Assessment Data Base for Coal Liquefaction Technology*. Volume I of this document (EPA-600/7-78-184a) includes process descriptions, efficiencies, and state-of-the-art summaries for 14 liquefaction processes. Volume II (EPA-600/7-78-184b) is an environmental characterization report which focuses on the H-Coal, Exxon Donor Solvent (EDS), and Synthoil processes. Detailed estimates are given for the raw waste streams, treatment/control processes, treated waste stream discharges, and associated environmental effects.

The revised report will examine the 14 original processes, with particular emphasis on the most advanced direct liquefaction processes, for example, SRC-I, SRC-II, H-Coal, and EDS. The revised Volume I will discuss:

- Overall technology status.
- Coal liquefaction process operations (coal pretreatment, coal liquefaction, separation, and product purification and upgrading).
- Pollution control modules.
- Technology assessment summary.

In-depth evaluations of the system operations and pollution control modules will be presented in the revised Volume II. The revised report will be accompanied by an overview document summarizing the information on costs, efficiencies, commercialization potential, environmental impacts, and discharge streams.

The data base revision will be completed in the summer of 1980. For more information on the original report, see the *Environmental Review of Synthetic Fuels,* Vol. 1, No. 3 and Vol. 2, No. 2.

ENVIRONMENTAL DATA ACQUISITION

Gasification

Source Test and Evaluation Programs—Source Test and Evaluation (STE) programs comprise a major portion of an environmental assessment of synthetic fuels technologies. The major goal of each STE program is to gather the data required for evaluating (1) the environmental and health effects of the multimedia waste streams at specific facilities and (2) the associated control technology.

Radian Corporation has completed two STE programs, and the final reports are now available. The first STE report (EPA-600/7-79-185) concerns a facility which uses a Wellman-Galusha gasifier, and the second (EPA-600/7-78-202) deals with Chapman low-Btu gasification. (Some major conclusions from the first report are presented in the "Report Summary" section of this issue.)

Radian is conducting additional STE programs at four other facilities. Three of these are U.S. sites incorporating Wellman-Galusha, Riley Morgan, and Foster Wheeler/Stoic gasifiers, respectively. The fourth is a Lurgi gasification facility (Kosovo Kombine) at Obilic, Yugoslavia. Results from these efforts will be summarized in subsequent issues of the *Environmental Review of Synthetic Fuels* as the final reports become available. (For more information on the Kosovo program, see the *Environmental Review of Synthetic Fuels,* Vol. 2, No. 3. Also, Hittman Associates, Inc.'s STE's of a SRC II pilot plant are described in Vol. 2, No. 4).

Test Run Results Compared to Model Predictions for Fluidized Bed Gasifier—Preliminary test run results from the coal gasification and gas cleaning facility at North Carolina State University (NCSU) compare favorably with those predicted by a kinetic model.

The NCSU facility is providing environmental assessment data concerning both the gasification and gas clean-up processes. It incorporates a pressurized (0.8 MPa [100 psig]) fluidized bed reactor capable of gasifying a 6.3-g/s (50-lb/hr) coal feed stream. The raw product gas passes through a particulates, condensables, and solubles removal (PCS) system, which consists of a cyclone separator followed by a venturi scrubber. Acid gas removal occurs downstream from the venturi scrubber in two packed towers (an absorber and a stripper) separated by a rich solvent flash vessel.

Table 1 shows results from one of the gasifier test runs, along with the model predictions for a fluidized bed gasifier. This particular test run involved steam-oxygen gasification of pretreated Western Kentucky #11 bituminous coal (10 × 80 mesh size). Only the gasifier and PCS system were used, without integration of the acid gas removal system. Coal was fed at an average rate of 3.2 g/s (25.6 lb/hr); the average bed temperature and pressure were 971 °C (1780 °F) and 0.8 MPa (100 psig), respectively.

The comparison shown in Table 1 demonstrates a strong correlation between experimental results and model predictions. Both the actual carbon conversion in the reactor and the product gas flow rate were lower than predicted, and this may be attributable to imperfect mixing in the reactor and uncertainties in kinetic parameters. In addition, since the model is for an ideal adiabatic reactor, it predicted less O_2 than was actually required.

For more information on the NCSU facility, see the *Environmental Review of Synthetic Fuels,* Vol. 2, No. 4.

TABLE 1. COMPARISON OF TEST RUN RESULTS WITH FLUIDIZED BED MODEL PREDICTIONS[a]

Parameter	Model Prediction	Experimental Results
Carbon Conversion, %	45	42
O_2 Required, Nm^3/s	0.63 (1.40 scfm)	0.74 (1.65 scfm)
Product Gas Rate Nm^3/s, N_2 free	3.82 (8.5 scfm)	3.42 (7.6 scfm)
Product Gas Composition %; N_2 free basis		
H_2	29	26
CO	20	18
CO_2	15	16
CH_4	1	0.5
H_2O	35	39

[a] **Department of Energy, *Coal Conversion Systems Data Book,*** Report HCP-12286-01, Washington, D.C., 1978.

TABLE 2. PNA HYDROCARBONS[a] IN COAL GASIFICATION[b] TAR

Compound	Illinois No. 6	Montana Rosebud	Wyoming Smith-Roland	Western Kentucky No. 9	North Dakota Zap Lignite
	Test Run Production Factor ($\mu g/g^c$)				
Naphthalene[d]	570	440	160	930	37
Benzothiophene	120	30	12	48	5
C_1 & C_2-naphthalenes	410	550	550	370	140
Biphenyl	72	51	43	60	15
Acenaphthylene[d]	360	320	49	200	22
Acenaphthene[d]	89	73	43	93	13
Fluorene[d]	180	220	84	180	28
Phenanthrene[d]	470	250	95	470	27
Anthracene[d]	160	97	35	170	11
Fluoranthene[d]	260	130	32	160	9.4
Pyrene[d]	190	110	26.0	110	3.8
Benzo(a)anthracene[d]	92	120	5.2	78	0.72
Chrysene[d]	80	83	7.4	93	0.71
Benzo(b)fluoranthene[d]	59	44	1.6	33	0.22
Benzo(k)fluoranthene[d]	30	21	1.2	21	0.14
Benzo(e)pyrene	39	34	0.87	27	0.072
Benzo(a)pyrene[d]	66	48	1.4	39	0.12
Indeno(1,2,3-cd)pyrene[d]	2.1	30	<0.29	9	<0.14
Dibenzo (a,h)anthracene[d]	52	60	<0.29	12	<0.14
Benzo(g,h,i)perylene[d]	36	48	<0.29	6	<0.14
Crude Tar	33000	18000	29000	30000	7300

[a] Determinations from gas chromatography-flame ionization detector.
[b] Fixed-bed gasification of 8 x 16 mesh coal at 1.4 MPa (200 psia).
[c] μg product compound/g coal loaded.
[d] EPA priority pollutant.

Pollutants from Synthetic Fuels Production—Research Triangle Institute (RTI) is conducting a project to measure the wide spectrum of pollutants generated by coal gasification under a variety of experimental conditions. Over 60 laboratory gasifier runs have been completed using nine different fuels, including peat, lignite, subbituminous coal, bituminous coal, and anthracite. Experimental variables include coal type, pretreatment condition, mesh size, reactor pressure, and temperature. Several gasifier effluent streams such as reactor residue, tar and water condensates, and product gas have been analyzed to determine the nature and concentrations of various species. Ames bioassay studies on the tars and their fractions have shown active mutagenicity, which is attributed largely to the presence of polynuclear aromatics (PNAs).

The experimental procedure involves removing tar and aqueous condensates from the gasifier and separating them by filtration. The tar is then fractionated, and the various fractions are analyzed by gas chromatography and mass spectrometry.

Table 2 presents typical values for PNA hydrocarbons in coal gasification tar and aqueous condensates. These results were obtained under similar gasification conditions for five U.S. coals, ranging from lignite to bituminous. Except for C_1- and C_2-naphthalenes (which have been grouped), the compounds are presented in order of increasing boiling point. All 16 of the EPA Consent Decree List PNAs were found in the tar.

As shown in Table 2, large variations occur in the yield of PNA compounds from the various coals tested. The largest PNA yields are associated with the higher rank bituminous coals. The Montana Rosebud coal gave rise to relatively high levels of 5- and higher-ring PNAs.

Future studies will identify and quantify the specific chemical species in gasifier tar which contain nitrogen, sulfur, and oxygen. Studies will examine the toxic and mutagenic properties of both the specific compounds and the fractions in which those compounds occur. For instance, the tar base fraction is known to exert a strong influence similar to that associated with PNAs. The specific compounds responsible for this effect will be explored by chemical analysis and bioassay testing of the tar base fraction.

Results from RTI's ongoing research will be reported in subsequent issues of the *Environmental Review of Synthetic Fuels*. (For information on earlier studies, see Vol. 1, Nos. 1, 2, and 3; and Vol. 2, Nos. 2, 3, and 4. See also the three final reports which are now available and are listed in "Recent Major Papers and Publications" in this issue.)

Sampling Completed at Koppers-Totzek Facility—TRW, Inc., has completed a sampling program at the commercial Koppers-Totzek facility at Modderfontein, South Africa. The sampling program, conducted jointly with Krupp-Koppers of West Germany, represents a major internationally coordinated effort to obtain and analyze environmental data on the Koppers-Totzek gasification system. Results should aid greatly in determining the impact of similar commercial facilities in the U.S.

Multimedia samples are being analyzed in South Africa at both the Modderfontein plant laboratory and the nearby MacLachlan and Lazar analytical laboratories. In addition, portions of the water samples were preserved and air-shipped to TRW for detailed Level 2 analyses.

Results from these efforts will be published when available in subsequent issues of the *Environmental Review of Synthetic Fuels*.

TECHNOLOGY AND COMMERCIAL DEVELOPMENT

SRC Production Costs May Double—The costs of two solvent refined coal (SRC) projects may be twice the amount estimated prior to preliminary design. One of the demonstration plants is to be built in Morgantown, WV, and involves an agreement between the United States, the Federal Republic of Germany, and Japan to share responsibility for financing the project. The Morgantown plant has been designed to produce liquid synthetic fuels roughly equivalent to 3180 m^3 (2 × 10^4 bbls) per day. A similar facility, planned for Newman, KY, will demonstrate coal conversion to solid fuels.

The price for each of the two SRC plants, originally set at $700 million, is now expected to exceed $1 billion. This means product cost may approach $220/$m^3$ ($35/bbl). At first, DOE officials attributed the cost increases to inflation, construction expenses, and extension of plant lifetime from 2 years to 5. Low coal reactivity, mountainous terrain, and plans for increased coal stockpiling are cited in a more recent DOE disclosure concerning additional costs at the Morgantown facility.

Despite increased costs, DOE and Congress have decided to continue their support of the two demonstration projects. The West German government has reinforced their commitment, and negotiations are reportedly underway to broaden support to include research and commercialization costs. Japan is expected to follow suit. The goal of the projects is to provide technical, economic, and environmental information to private industry to aid in the development of a comprehensive synthetic fuels program. (For additional information on the Morgantown project, see *Environmental Review of Synthetic Fuels*, Vol. 2, No. 2.)

Catlettsburg Project Receives More Funding—A desire to speed commercialization of a coal liquefaction process has prompted the Senate Appropriations Committee to increase DOE's 1980 H-Coal project budget by $7.5 million. The money would finance a 2-year commercialization study of the Catlettsburg, KY, H-Coal pilot plant operated by Ashland Oil. It is possible that plans for a demonstration-sized facility would then be bypassed, and funding directed toward construction of a commercial-sized complex. If accelerated, the program could result in the operation of a facility capable of producing 3180 m^3 (2 × 10^4 bbls) of synthetic fuel daily by 1985. (For additional information on the Catlettsburg project, see *Environmental Review of Synthetic Fuels*, Vol. 1, No. 2, and Vol. 2, No. 1.)

New Technique Tested for In-Situ Gasification— Hoe Creek, WY, was the test site for a new technique involving in-situ coal gasification. Engineers from Lawrence Livermore Laboratory linked vertical wells with a horizontal channel in a successful effort to control the direction of coal combustion. The new technique avoids problems incurred when gasification is attempted utilizing natural channels which may become blocked or may burn in undesired directions. Oxygen-enriched air was used to promote combustion and stabilize burn rates, thereby providing more consistent gas flows.

Gas produced by the Hoe Creek project could be utilized for heating or may serve as raw material for the production of ammonia, methanol, or gasoline. It was estimated that over 4.5 Gg (5000 tons) of coal have been gasified.

First Eastern Coal Gasified Underground—For the first time, eastern coal has been successfully gasified in situ during a DOE test near Princeton, WV. Reverse combustion was accomplished via a technique involving ignition at the base of one borehole and the introduction of pressurized air into another borehole to direct the combustion pathway. Previous attempts to gasify eastern coal had been hampered by the tendency of the coal to swell and eliminate air pathways needed for continued combustion. The Princeton project was expected to convert about 907 Mg (1000 tons) of bituminous coal, and was reported to produce over 28,000 m^3 (1 × 10^6 ft^3) of synthetic gas per day. The heating value of the gas synthesized was estimated to be 20 percent that of natural gas.

IGT Promotes Synthetic Fuel Development—Institute of Gas Technology (IGT) president, Bernard S. Lee, recommends extensive proliferation of synthetic fuels production facilities. This suggestion was based on an IGT study indicating that synthetic fuels produced from domestic coal and mineral supplies are more economical than foreign oil subject to inflation, U.S. currency devaluation, and supply inconsistency. The proposed $90 billion expenditure would allow construction of plants capable of supplying the 400,000 m^3 (2.5 × 10^6 bbls) per day production goal set by President Carter for 1990.

Economics of Alternative Fuels Discussed—At present, synthetic fuels produced by coal gasification and liquefaction are more expensive than natural oil and gas. This was the general consensus of attendants at the World Petroleum Congress held in Bucharest. Presentations and discussions focused on the costs, technology, and practicality of synthetic fuel production. It was agreed that technology is available to produce synthetic fuels, but reductions in initial investment costs are needed to improve the competitive status of coal conversion. Another problem faced by the synthetic fuels industry is the low thermal efficiency of its primary products. The cost of refining coal is proportional to the quality of the product, so that gasoline from coal is very expensive. It is possible that cost inequities may be overcome if oil and gas prices escalate more rapidly than the costs entailed by plant construction and synthetic fuels production.

A few examples of alternative fuel sources which are economically attractive were cited. The SASOL plant in South Africa gasifies coal to obtain feedstocks for ammonia synthesis. Oil sands and oil shale deposits may also provide cost efficient alternative fuel sources. Great Canadian Oil Sands, a subsidiary of Syncrude Canada Ltd., produced 2,600,000 m^3 (16.4 × 10^6 bbls) of synthetic crude oil in 1977 and 1978 at an average cost of $53.87/$m^3$ ($8.54/bbl). Continually increasing oil and gas prices justify further development of these resources.

Response to DOE Low/Medium Btu Coal Gasification Program Continues—DOE is considering five new proposals received in response to announcement of its Low/Medium Btu Coal Gasification Program. Coal conversion technology and industrial utilization of low and medium Btu gas will be the subjects of DOE funded study. Eight contracts valued at over $1.8 million have already been granted since the program was initiated in March. Utilities and industries located in New Jersey, Mississippi, West Virginia, Missouri, and Illinois have submitted the five proposals, valued at $500,000, which are now receiving consideration. Further selection of a third set of proposals is expected to occur this year. (For additional information on the DOE program, see the *Environmental Review of Synthetic Fuels*, Vol. 2, No. 4.)

New Gasification Processes Increase Capacity— Krupp-Koppers GmbH (Essen, W. Germany) is testing a modification of the Koppers-Totzek process which allows coal gasification to proceed at twice original capacity by doubling the number of feed injectors on the gasifier unit. The modified Koppers-Totzek design replaces the standard two-headed gasifier with a four-headed system. Advantages attributed to the new units include investment savings, lower specific heat losses, and a reduction in the amount of space needed for operation. Two 9.5 kg/s (900 ton/d) fertilizer plants in India will serve as sites for the initial commercialization of the system. A Brazilian company, Petrobas, also plans to operate a pair of four-headed gasifiers to supply synthesis gas for a 6.3 kg/s (600 ton/d) ammonia plant.

In addition, Shell Oil Company has assisted Krupp-Koppers in designing a high pressure gasification process which may increase operation capacity to 12 times the original Koppers-Totzek process. The standard Koppers-Totzek system is operated at atmospheric pressure, whereas the Shell Koppers process would be run at 3 MPa (30 atm), reducing the amount of compression synthesis gas must undergo prior to usage. A Shell Koppers demonstration plant in Germany is reported to synthesize gas which is 10 percent cheaper than raw gas obtained via the original process.

BGC Lurgi Slagging Gasifier and Texaco Unit Team Up—The advantages of a SNG production process using two synergistic slagging gasifiers may promote its rapid commercialization. The Fluor combination coal gasification process utilizes a British Gas Company Lurgi slagging gasifier in conjunction with a Texaco gasification unit. Dual gasification equipment installed at the SNG plant chosen for study resulted in increased productivity and lowered costs in comparison to conventional Lurgi coal gasification facilities. Operation of the combined system is dependent on waste heat steam generation, eliminating the need for coal-fired boilers. Phenolic liquors produced in Lurgi gasification processes balance liquid requirements for Texaco slurry preparation. Costly treatment of process water to remove ammonia and phenols is unnecessary, and phenolic liquors no longer constitutue a disposal problem because they are gasified. The process also results in primary methane which can be used in methanation of the SNG product. One study presented cost comparisons between the combined gasifier system and a conventional Lurgi plant and indicated that $300 million in total plant capital could be saved by the combination system in the production of a given amount of SNG from a given amount of coal.

Water Issue Provokes Controversy—Water availability may prove to be a major issue in the future of a synthetic fuels program. The director of the U.S. Water Resources Council, Leo Eisel, claims that no comprehensive program exists to supply the needs of plants which must be built to meet President Carter's synthetic fuels production goals. The economics of coal gasification and liquefaction are improved if plants are located near coal deposits. Northern plains states, which represent a significant proportion of coal-bearing areas in the United States, are concerned that water allocations for future synthetic fuels plants may threaten existing water users.

Estimates of the volume of water to be consumed by commercial coal conversion facilities vary considerably. Anywhere from 15,000 to 235,000 m^3 (4 to 62 $\times$ 10^6 gal) of water could be used daily by a commercial scale liquefaction plant. More information from demonstration-sized facilities is necessary to assess fully the influence that the water controversy may have on synthetic fuels industries.

Nickel Catalyst Enhances Gasification and Liquefaction Processes—Researchers at Battelle Memorial Institute have developed a new solution that catalyzes coal conversion processes. The solution, which contains hydrogen and a dissolved transition metal catalyst, reacts more efficiently with coal than does molecular hydrogen alone. The nickel Ziegler catalyst is prepared by reacting nickel carboxylate with an aluminum alkyl in an organic solution. Hydrogen is then added to the product to form the catalytic solution.

EPRI Spokesmen Testify Before Congress—At recent congressional hearings EPRI division directors, Balzhiser and Spencer, nominated the electric utility industry as a primary market for synthetic fuels, and called for cooperation between government and industry to develop, demonstrate, and commercialize a synthetic fuels program. Balzhiser contended that the requirements of utility plants are flexible enough to allow them to serve as the initial market for a synthetic fuel industry. The possibility of this stable market represents a mutual advantage to synthetic fuel development in that capital investment risks are lessened. Spencer cites the 1978 power plant and utility Fuel Use Act (FUA) which should compel the electric utility industry to increase synthetic fuel utilization, and pointed out EPRI studies which indicate the economic attractiveness of coal gasification combined cycle power generation.

SASOL Technology May Serve U.S. Needs—South African technological expertise in synthetic fuels manufacture is being marketed in the U.S. through an agreement between SASOL, Ltd. (Johannesburg, South Africa) and Fluor Engineers and Constructors, Inc. SASOL and Fluor are presently conducting a feasibility study for Texas Eastern Corp. Texas Eastern is considering an Ohio River Valley plant which would combine Lurgi gasification and Fischer Tropsch processes. SASOL uses similar indirect liquefaction processes to produce oil from coal and contends that direct liquefaction process technology may not be feasible in the near future. Fluor maintains that a SASOL-type plant completed in 1985 could result in synthetic fuel which would be competitive in price with fuels produced by conventional refineries using $300/$m^3$ ($48/bbl) crude oil. (For more information on SASOL plants, see *Environmental Review of Synthetic Fuels*, Vol. 1, No. 3.)

SASOL II Nears Completion—The Secunda, South Africa, SASOL II project is nearing construction completion and is ready to begin testing its Lurgi gasification equipment. The SASOL II plant will produce gasoline, fuel oil, and a variety of chemical feedstocks via a series of gasification, liquefaction, and refining techniques. It is expected that annual product yield will exceed 1.5 Tg (1.5 $\times$ 10^9 metric tons). If all goes as planned, full production should be possible by the end of 1980.

The SASOL II project will differ somewhat from a sibling project in Sasolburg, South Africa. Tailgas from the new plant will be recycled to optimize liquid fuel production rather than utilized for towngas production. This will result in a thermal efficiency rating which is lower (40 percent) than that of the older plant (60 percent).

Federal Support Would Speed Commercialization of Over 30 Gasification Facilities—Continued governmental support of the synthetic fuels industry could result in commercialization of over 30 high Btu coal gasification facilities capable of producing 85 km^3 (3 $\times$ 10^{12} ft^3) of gas by the turn of the century. This was the opinion voiced by American Natural Resources Vice President, William T. McCormick, Jr., at the annual meeting of the Pacific Coast Gas Association. McCormick reviewed seven coal gasification projects which are in the design stage, emphasizing the Mercer County, ND, project which is closest to construction. The ND plant would utilize Lurgi gasification with methanation, as would the majority of the projects McCormick discussed. Federal support of these projects will increase the probability of commercial operation by the mid-1980's.

PROJECT TITLES, CONTRACTORS, AND EPA PROJECT OFFICERS IN EPA'S IERL-RTP SYNTHETIC FUEL ENVIRONMENTAL ASSESSMENT PROGRAM

Project Title	Contractor	EPA Project Officer
Environmental Assessment of Low Btu Gasification (March 1979-March 1982)	Radian Corporation 8500 Shoal Creek Blvd. Austin, TX 78766 (512) 454-4797 (Gordon C. Page)	James D. Kilgroe 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 Evaluation of Coal Liquefaction (July 1979-July 1982)	Hittman Associates, Inc. 9190 Red Branch Road Columbia, MD 21043 (301) 730-7800 (Jack Overman)	D. Bruce Henschel IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2825
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)	Robert A. McAllister IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2708
Water Treatment 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) 966-1023 (Philip Singer)	Robert A. McAllister IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2708
Pollutant Identification From a Bench Scale Unit (November 1976-October 1981) (Grant)	Research Triangle Institute P.O. Box 12194 Research Triangle Park, NC 27709 (919) 541-6000 (Forest Mixon)	N. Dean Smith IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2708

REPORT SUMMARY

Environmental Assessment: Source Test and Evaluation Report — Wellman-Galusha (Glen-Gery) Low-Btu Gasification (EPA-600/7-79-185)

by

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The Wellman-Galusha gasification system is one of the few types of coal gasifiers applied commercially in the U.S. at this time. At the York, PA, plant of the Glen-Gery Brick Co., a Wellman-Galusha gasification system is used to convert anthracite coal into a low-Btu gas which is then used as a fuel for a brick kiln.

This facility was selected for study in a Source Test and Evaluation (STE) program recently completed by Radian Corporation. The major goal of this STE program was to perform an environmental assessment of the waste streams from the gasification system.

The Glen-Gery facility was selected for the STE program for several reasons. For one, it uses a commercially operating gasifier typical of those currently in service in the U.S. The Glen-Gery facility also affords an opportunity for significant contribution to the low-Btu gasification technology data base for systems using anthracite. Such installations yield a raw product gas that is essentially tar- and oil-free. This feature simplifies the task of obtaining representative process and waste stream samples for environmental characterization. In addition, because this facility is part of the U.S. Department of Energy's (DOE's) Gasifiers in Industry Program, it includes special instrumentation that facilitates the collection of both process and environmental data.

A complete environmental assessment of a process requires thorough examination of both the compositions and the flow rates of multimedia process and waste streams. Samples of 12 process and waste streams were obtained, as well as flow rate data and data for several operating parameters. The major results from these efforts are summarized below.

Waste Stream Characterization

The seven multimedia waste streams sampled at Glen-Gery were characterized through bioassay testing and SAM/IA (Source Analysis Model) evaluation. The SAM/IA evaluation, based on chemical analyses, provides a rapid screening technique for evaluating the pollution potential of multimedia waste streams. It is applied as part of EPA's standardized methodology for interpreting results from environmental assessment test programs. Two evaluation indices are used in performing a SAM/IA evaluation: Discharge Severity (DS), and Weighted Discharge Severity (WDS). The individual DS values for components of a discharge stream may be summed to give the Total Discharge Severity (TDS) for that stream. (These terms are explained more fully in the *Environmental Review of Synthetic Fuels,* Vol. 2, No. 4.)

Bioassay analysis involved testing both health and ecological effects, as described in the EPA Level 1 Environmental Assessment Manual (EPA-600/2-76-160a).* Figures 1 and 2 summarize the SAM/IA evaluation and bioassay test results for the seven multimedia waste streams sampled. As shown, all seven waste steams have a potential for hazardous effects according to the SAM/IA evaluation. However, the TDS values reported for the Glen-Gery facility were, in general, lower by two orders of magnitude when compared to TDS values reported for a bituminous coal gasifier in a previous study (EPA-600/7-78-202). Results of the bioassay screening tests also support the relatively low potential for harmful effects associated with the Glen-Gery waste streams. In addition, the harmful effects of the gaseous waste streams are reduced because of their low flow rates.

Table 3 presents major conclusions and recommendations of the STE, based on SAM/IA and bioassay test results. Also shown are priorities, based on the SAM/IA evaluation, for future chemical analyses for each waste stream. Specific compounds should be identified where the worst case unidentified organics are the main contributors to the DS.

*For a description of the current EPA methodology, see EPA-600/2-78-201.

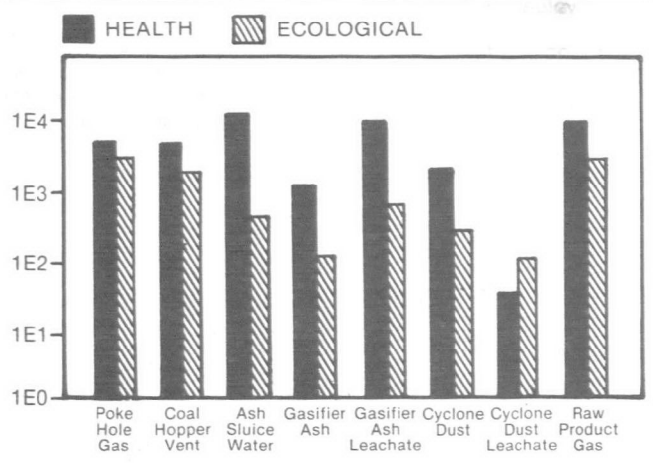
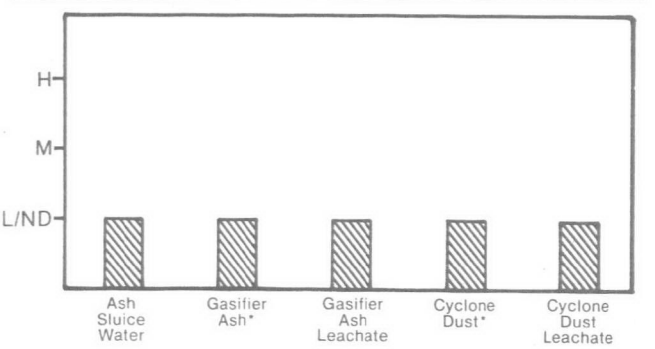


FIGURE 1. TOTAL STREAM DISCHARGE SEVERITIES FOR THE GLEN-GERY WELLMAN-GALUSHA WASTE STREAMS



*Ash more toxic than cyclone dust in the soil microcosm test

H: High Effects
M: Moderate Effects
L/ND: Low or Nondetectable Effects

FIGURE 2. BIOASSAY TEST RESULTS FOR THE GLEN-GERY WELLMAN-GALUSHA WASTE STREAMS

TABLE 3. SUMMARY OF THE CHARACTERIZATION OF WASTE STREAMS FROM THE GLEN-GERY FACILITY

Waste Stream	Priority for Quantitative Chemical Analysis: High (TDS, 10^2 +)	Medium (TDS, 10-10^2)	Low (TDS, 1-10)	Conclusions	Recommendations
Pokehole Gas	CO, NH_3	As, CO_2, H_2S	CH_4, NH_3, HCN, Li, Ni, SO_2	• potentially hazardous according to SAM/IA evaluation • low flow	• better seals • better maintenance • ventilation • injection of inert gas during poking operation
Coal Hopper Gas	CO, $Fe(CO)_5$	H_2S	CH_4, CO_2	• potentially hazardous according to SAM/IA evaluation • low flow	• collect and recycle to inlet air or vent to atmosphere • keep workers out of area
Ash Sluice Water	Fused Polycyclic Hydrocarbons, Alkenes, Cyclic Alkenes, Dienes, and Nitrophenols*	Fe, Ti	Phthalate Esters, Ba, Cd, Cr, Cu, CN, Fe, La, Li, Ni, V	• potentially hazardous according to SAM/IA evaluation • low potential for hazard according to bioassay tests • LD_{50} and EC_{50} were above maximum dosages administered • TDS, BOD, PO_4^{-3}, and CN^- exceed the most stringent water effluent standards	• collect and reuse as ash sluice water
Ash	Ba, Cr, Fe, Li, Mn, Ni	Fused Polycyclic Hydrocarbons*, Be, Co, Cu, Fe, Pb, Ni, Se, Th, V, Zr	Alkenes, Cyclic Alkenes and Dienes, Aromatic Amines and Diamines, Ring Substituted Aromatics, Nitrophenols*, Phthalate Esters, Al, As, Ba, Bi, Cd, Ca, Cr, Hf, Pb, Li, Mg, Mn, Si, Ag, Sr, Ti, V, Y	• potentially hazardous according to SAM/IA evaluation • bioassay tests indicate a low potential for hazard • LD_{50} and EC_{50} were above maximum dosages administered	• landfill is a possible disposal technique • further analyses for unidentified organics and bioassay tests for ecological effects

TABLE 3. SUMMARY OF THE CHARACTERIZATION OF WASTE STREAMS FROM THE GLEN-GERY FACILITY (CONTINUED)

Waste Stream	Priority for Quantitative Chemical Analysis: High (TDS, 10^2 +)	Medium (TDS, 10-10^2)	Low (TDS, 1-10)	Conclusions	Recommendations
Ash Leachate	Fused Polycyclic Hydrocarbons, Alkenes, Cyclic Alkenes, Dienes, Aromatic Amines and Diamines, and Nitrophenols*	Phthalate Esters, Zn	Cd, Ag	• potentially hazardous according to SAM/IA evaluations • bioassay tests indicate low potential • LD_{50} and EC_{50} were above maximum dosages administered • RCRA standards are not exceeded for trace elements	• further analyses for unidentified organics and bioassay tests for ecological effects
Cyclone Dust	Fused Polycyclic Hydrocarbons*, As, Ba, Cr, Fe, Pb, Li, Mn, Ni, Se	Alkenes, Cyclic Alkenes, and Dienes, Aromatic Amines and Diamines, Ring-Substituted Aromatics, Nitrophenols*, Be, Cd, Fe, Pb, Mn, Ni, Ag, Th, V, Zn	Phthalate Esters, Al, Sb, As, Ba, Ca, Cr, Co, Cu, F, Ga, Hf, Li, Mg, Hg, Se, Si, Sr, Tl, Ti, V, Y, Zr	• potentially hazardous according to SAM/IA evaluation • small flow rate • bioassay tests indicate low potential for hazard • LD_{50} and EC_{50} were above maximum dosage administered	• landfill may not be acceptable • incineration
Cyclone Dust Leachate	Mn, Zn, Fused Polycyclic Hydrocarbons*	Mn, Pb, Alkenes, Cyclic Alkenes, Dienes, and Nitrophenols*	Al, Cd, Co, Cu, Fe, Pb, Li	• potentially hazardous according to SAM/IA evaluation • bioassay tests indicate low potential for hazard • F^- exceeds most stringent water effluent standards • Pb exceeds RCRA standards	• quantitative analysis for Pb to determine if its concentration actually exceeds RCRA guidelines

*These categories of organic compounds contain the worst case compounds which provide the largest potential discharge severity for the unidentified organics of each waste stream. The categories and their corresponding worst case compounds are listed below:

Category	Compound
Fused Polycyclic Hydrocarbons	7, 12-Dimethylbenz(a)anthracene
Alkenes, Cyclic Alkenes and Dienes	Dicyclopentadiene
Aromatic Amines and Diamines	Aminonaphthalenes
Ring-Substituted Aromatics	Dibromobenzene
Nitrophenols	Dinitrophenols

MEETING CALENDAR

2nd Annual Symposium on Industrial Energy Conservation Technology and Exhibition, April 13-16, 1980, Houston, TX. Contact: Milt Williams, 6203 B Shadow Valley Drive, Austin, TX 78731; telephone (512) 345-8052.

2nd Annual Symposium on Industrial Coal Utilization, April 17-18, 1980, Charleston, SC. Contact: Dan Bienstock, PETC, 4800 Forbes Ave., Pittsburgh, PA 15213.

88th AIChE National Meeting and 2nd Chemical Plant Equipment Exposition, June 8-12, 1980, Philadelphia, PA. Contact: Harold S. Kemp, DuPont Co., Engineering Dept. L-1257, Wilmington, DE 19898.

1980 Symposium on Instrumentation and Control for Fossil Energy Processes, June 9-11, 1980, Virginia Beach, VA. Contact: Richard Doering, Argonne National Lab, 9700 S. Cass Ave. Bldg. 316, Argonne, IL 60437; telephone (312) 972-6086.

19th ASME-AIChE National Heat Transfer Conference—Heat Transfer in Coal Conversion, July 27-30, 1980, Orlando, FL. Contact: Professor Lawrence A. Kennedy, Dept. of Mechanical Engineering, 607 Furnas Hall, SUNY at Buffalo, Amherst, NY 14260; telephone (716) 636-2729.

RECENT MAJOR MEETINGS

AIChE 72nd Annual Meeting

The American Institute of Chemical Engineers (AIChE) held their 72nd annual meeting in San Francisco, CA, on November 25-29, 1979. Panel discussions, symposia, and poster sessions covered a broad range of topics, including recent research and development in the field of coal conversion, gasification, and liquefaction.

Several symposia included presentations on fluidization and fluid-particle systems. The results of research on bubble dynamics, magnetic stabilization, and particle deposition were reported. Papers dealing with physical properties of fluidization such as density, electrostatics, pressure fluctuations, heat transfer, and component velocities were also included. More specific presentations described fluidization and fluid particle systems in coal processing. Processes such as elutriation and recycling of coal fines, ash agglomeration, and two-stage combustion appeared to result in emission reductions and greater combustion efficiency in experimental studies.

In related sessions, papers focused on design and modeling of gas fluidized bed systems. Development of models has allowed study of the effects of coal feed velocity, jetting emulsion mass, attrition rates, and heat interchange on coal conversion. Experimental techniques for fluidized bed combustion (FBC) of coal char, high sulfur coal, and agglomerating bituminous coals were discussed. Several models were presented which may facilitate industrial application of FBC experimental designs to generate steam and electrical power.

Progress in the use of western coal to supply the needs of coal gasification, combined cycle power generation facilities was described in one symposium. Potential control technology costs and environmental assessment reports for low Btu gasification facilities and SRC-II liquefaction operations were presented in two sessions on solid fossil fuel processes. One series of lectures on underground (in situ) coal gasification included presentations on field results, computerized cost estimation, and commercialization possibilities.

Several symposia on coal liquefaction techniques dealt with potential catalysts, free radical kinetics, and desulfurization compounds. One paper discussed the effect of aging on hydrotreating catalysts used in coal liquefaction. New data on rubidium- and iron-containing catalysts utilized in Fischer Tropsch synthesis reactions were presented. Further elucidation of free radical kinetics in the liquid phase reactions of coal conversion is possible via estimation methodology described by one author. Iron-containing compounds, including coal ash, were cited for their selectivity for hydrodesulfurization over hydrogenation, a characteristic which may prove valuable in development of future liquefaction processes.

Multiphase reactors such as the H-Coal reactor and the Fischer Tropsch slurry reactor served as the topic for one session. Data obtained on phase dynamics and physical properties have allowed researchers to present models available for scaling up purposes.

Several papers focused on thermodynamic analysis of synthetic fuel processing. The methodology of first law (thermal) and second law (availability) analyses was reviewed in one presentation. COED, HYGAS, and SYNTHANE processes were thermodynamically analyzed in this symposium, as well as a developmental direct liquefaction technique.

A symposium was held on new computer applications in design and analysis. Several presentations were related to coal conversion applicability. One paper described synergistic cascade refrigeration and liquefaction systems. Another presented a mathematical model for the expected performance of a HYGAS gasifier.

A two-part symposium on the status of synthetic fuels projects focused on current gasification and liquefaction plants and process development. The proposed Memphis U-Gas demonstration plant and pilot coal gasification plants operated by North Carolina State University and Combustion Engineering were the topics of three papers. HYGAS and GEGAS gas production, catalytic coal gasification, and a Brazilian ammonia production plant served as subjects for other presentations. Process development in coal liquefaction was described in papers on flash hydropyrolysis, the Exxon donor solvent process, and SRC-I. One company reported on a project which produces gasoline from coal in a single step process involving molten zinc chloride hydrocracking.

Research and development, major projects, and forthcoming programs in international synthetic fuels technology served as the emphasis for another symposium. West German, South African, and Australian progress reports were presented. Shell Koppers summarized pilot plant gasification attempts. The United Kingdom's National Coal Board and the British Gas Corporation also reported on the status of processes which they are developing for commercialization.

More information on the 72nd Annual Meeting of the American Institute of Chemical Engineers can be obtained from the AIChE Continuing Education Department. Copies of the papers presented may be requested by contacting the Engineering Societies Library, United Engineering Center, 345 East 47th Street, New York, NY, 10017.

RELEVANT 1979 EPA/FUEL PROCESS BRANCH PUBLICATIONS

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