CONTROL TECHNOLOGY ASSESSMENT FOR COAL GASIFICATION AND LIQUEFACTION PROCESSES

Final Study Plan

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16. Abstract (Limit: 200 words) A plan was detailed for an evaluation of engineering controls used in coal conversion processes. The purpose for this study was not only to evaluate the different control methods, but to assess and document monitoring devices and work practices used to reduce or eliminate such worker exposures and emissions, to assess and document personal protective equipment, and to review and assess the validity and accuracy of existing facility sampling data. Research needs were identified for new control technology and efforts were made to obtain accurate cost data for the design, installation, operation and maintenance of the controls evaluated. The first phase of the study involved a search of the existing literature for pertinent information. The second phase involved an evaluation of field facility surveys of performance and engineering control systems at various locations and analogous industries. The final phase will include the preparation of the final report. Individual case studies will be made at each location. Current control devices included valves, flanges, and miscellaneous tanks and storage bins. Various categories of control methods were discussed, including controls which result in containment of the harmful agent; controls which remove or reduce the concentration of the contaminants; controls which isolate or remove the worker from toxic agents; and controls and monitoring systems which warn the worker of hazardous conditions.

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I. INTRODUCTION

A. Background and Scope

As a result of the William-Steiger Occupational Safety and Health Act of 1970, the National Institute for Occupational Safety and Health (NIOSH) was established as part of the Department of Health, Education and Welfare. NIOSH was given authority and responsibility under the Act to conduct research studies of industry and to develop needed information regarding toxic substances and exposure of industrial workers to these substances.

For the study "Occupational Health Control Technology Assessment for Coal Gasification and Liquefaction Processes", NIOSH requested a multidisciplinary assessment of control technology that is available to prevent occupational exposure to hazardous agents in the coal gasification and liquefaction conversion industries. Technology which should be built into future plants will be identified, as will areas where additional research and development is required to assure that this technology will be available when needed. NIOSH is conducting several other studies of coal conversion processes, and a part of this study requires the contractor to be familiar with these studies and to cooperate with them. In addition, the contractor is to perform the study as a logical extension of work on the criteria document for coal gasification and coal liquefaction processes.

The approach in this study to outside evaluation of engineering controls must be planned with special care because coal conversion is not an established commercial technology. It is a developing industry, with no commercial high-Btu operations and only a few low-Btu commercial gasifiers in the United States.

The NIOSH philosophy on control technology is to make an engineering study and evaluation of existing installations, to recommend changes where better controls are available, to recommend areas where research and development is required to eliminate problems, and to communicate the accumulated information to interested parties.

NIOSH has selected Enviro Control, Inc., to perform this study of occupational health assessment for coal gasification and liquefaction processes.

B. Objectives of This Study

The objectives of this study are as follows:

- To document and evaluate effective engineering control technology which the coal conversion facilities are using to minimize worker exposure to, and emission to workplace of, toxic chemical agents and harmful physical agents;
- To assess and document monitoring devices and work practices used to reduce or eliminate such worker exposures and emissions;
- To assess and document personal protective equipment which may be used by workers in the plants and processes of interest to this study;
- To review and assess the validity and accuracy of existing plant sampling data;
- To determine research needs for new control technology;
- To seek to obtain accurate cost data for the design, installation, operation, and maintenance for the controls evaluated; and
- To produce a control technology document that will provide a set of guidelines for:
  (1) Selection of the best available engineering approach to control the most common exposure/emission problems in the coal conversion industry; and

(2) Identification of situations where personal protection may be required to supplement engineering controls, and recommendations for the most appropriate personal protection.

C. Method of Approach

The project is designed to be accomplished in three major phases.

- Phase I - preparation of a study plan that includes a literature survey of existing coal liquefaction and coal gasification projects, and a review of the status of other NIOSH, EPA, and DOE programs relevant to the present study. Enviro will continue to identify and obtain all available information on process control technology in coal conversion from literature sources, attendance at technical meetings, and personal contact with the managers of various projects under the DOE program; this information will be included in future reports.

- Phase II - evaluation of field plant surveys of performance of engineering control systems at various coal conversion plants and analogous industries. Enviro is scheduling visits to the offices of a number of engineering and construction companies to study controls now being designed for future plants.

- Phase III - preparation of the final report for NIOSH which is to include information from individual plant surveys and to discuss the projected future of the coal conversion industry. Enviro will include recommendations for control technology transfer between different segments of the industry, including analogous industries such as petroleum refineries and the ammonia manufacturing industry. Areas needing additional studies for improvement of control technology will be identified.

The plants in which site visits will be conducted include those which are subjects of NIOSH industrial hygiene characterization studies on coal gasification and liquefaction. The control technology assessment site visits are to be conducted at the same time as the industrial hygiene surveys to assure that observed operating parameters correspond to observed levels of workplace hazards. Site visits will also be conducted in at least two of the plants in the Gasifiers in Industry program. (Planned site visits are outlined in Table VI.)

Individual case study reports will be made for each site visit. Each report will be of sufficient depth, quality and format to be included directly in the final report. Enviro is planning to make some of these visits in conjunction with staff industrial hygienists working on two other NIOSH contracts, "Industrial Hygiene Characterization of Coal Gasification Plants" and "A Study of Coal Liquefaction Processes". A semi-quantitative analysis will be made at the beginning of the three-week in-depth industrial hygiene survey Enviro is making as a part of the characterization studies. Based on this sample, additional in-depth characterization studies can be made by the industrial hygienists during the three-week survey at each plant site. A description of process unit operations, hazard potential, exposure sources, number of people working, start-up modes, and shutdown modes of each process will be included. Any special controls associated with each mode will be noted so that in cases where the normal processes are used, Enviro will be able to assess the value of the additional control of the operating unit.

Enviro is scheduling three-week in-depth surveys at plant sites as part of the industrial health characterization of coal liquefaction and gasification studies. The control technology assessment (CTA) team is scheduled to cooperate with each of these surveys. The CTA survey at each site is scheduled for one week--that is, the first week of the in-depth survey. The analyses of samples from the in-depth survey will be a part of the CTA report. As a result of this plan, the control technology assessment study will be broadened without additional cost to NIOSH.

D. Approach to Occupational Health Control Technology

Control technology, as considered from an occupational health perspective, includes several categories of applied engineering. Traditionally, occupational health engineering controls have been grouped into three major categories:

- Substitution
- Isolation
- Ventilation

In theory, application of these principles in appropriate combinations can achieve satisfactory control over the workplace environment and can assure an environment of suitable quality.

Coal conversion technology is in the demonstration stage. All previous NIOSH CTA studies have been made in mature functioning industries where the cost effective limitations were severe. In this study, NIOSH has the opportunity to participate in the development of the industry and in the identification of engineering control technology at a basic level in a cost effective manner. (NIOSH is aware that to freeze engineering control technology at this basic stage could result in greater, rather than less, occupational health exposures.) Therefore, Enviro feels that an expansion of these categories is in order. For this study, Enviro plans to examine the following categories of control technology:

- Category I: Elimination by substitution of unit process or hazardous materials;
- Category II: Application of current technology to specific equipment designed to contain emissions within process equipment;
- Category III: Devices to control hazardous emissions once they enter the work environment;
- Category IV: Controls used to isolate workers or prevent contact with the toxic agents; and

- Category V: Monitoring systems which warn workers of hazards and initiate corrective methods.

This approach, when combined with the unit operations segregation of the process, classifies the hazards within the very complex coal liquefaction and gasification operations.

The following examples further define Enviro's proposed categories and describe how each of these categories fit into the evaluation of various controls in the coal conversion plants and related industries. In providing these examples, Enviro has drawn heavily on the experience of our engineers and hygienists from their work in the coal gasification and liquefaction industries.

Category I

Toxic materials are controlled by elimination or substitution of entirely different processes, equipment, or materials. These types of controls depend on state-of-the-art technology in each specific industry and may be implemented primarily to upgrade the technology of the industry rather than to control health hazards. An example of this technology comes from commercial operation of the Lurgi gasifiers at SASOL.

> Heavy tar produced by the Lurgi gasifiers at SASOL is dirty (40% solids), is difficult to handle, and has little value. For years, SASOL has buried the tar; however, in early 1978 SASOL completed tests on a new SASOL-Lurgi design to recycle heavy tar back to the gasifier to produce additional gas and light tar-oil and to eliminate the cost and potential exposure of handling the tar.

Category II

Current control technology is applied in an attempt to contain the harmful agent within the process equipment and to prevent its release into the work environment.

The equipment in all coal conversion plants, manufacturing either gaseous or liquid fuels, includes high and low pressure pumps, which can be centrifugal and/or reciprocating; high and low pressure valves; flanges; some sort of

feed mechanism such as lockhoppers; instrumentation; heating furnaces; piping; and many miscellaneous tanks and storage bins. In all processes, liquids with solid particles (slurries) are pumped. In some instances, all three phases are in the same stream. The equipment is subject to erosion, corrosion, hydrogen embrittlement, and heat expansion and contraction. Gasketing materials suffer degradation and become loose.

Slurries and contaminated liquors erode equipment, especially rotating equipment and valves. Acid gases such as hydrogen sulfide attack most equipment, especially at elevated temperatures. Alternately, chloride stress cracking may occur at the lower end of the temperature spectrum, at the dew point of water. Iron carbonyl formation may occur at still lower ambient temperatures. Hydrogen embrittlement and cavitation weakens structures. As a result, gases leak from equipment, liquor spills occur, and in some cases these leaks cause explosions. Maintenance personnel who take equipment apart come in contact with fumes, liquors, and solid deposits on the equipment. Table I lists the potential exposure points to be studied.

In pilot plants built to date, much of the pumping equipment, valves, packings, etc., have been off-the-shelf items not fabricated to meet the unique demands of process streams in coal conversion plants, as in the following example:

> At the Koppers-Totzek plant at the Modderfontein #4 Ammonia Plant in Johannesburg, South Africa, minus 200-mesh coal is passed from a 200-ton surge bin to Fuller pumps which feed the coal into a pneumatic conveyor system. When originally installed, the Fuller pumps leaked coal copiously. The problem was overcome by slowing the pumps from 1800 rpm to 450 rpm and by substituting a nitrogen-purged stuffing box for the original mechanical seal.

The instrumentation that will be required to control the process presents a special problem in coal liquefaction and gasification. The in-line instrumentation selected for use in coal liquefaction and gasification processes

TABLE I

Potential Exposure Points

Equipment or Process	Remarks	Coal Gasification	Coal Liquefaction
1. Slurry pumps	- Leaks at gaskets and flanges	x	x
	- Personnel contamination during maintenance	x	x
2. Pressure pumps	- Leaks from gaskets, seals, and flanges	x	x
	- Leaks due to erosion and corrosion	x	x
3. Grinders and pulverizers	- Dust leaks at joints	x	x
	- Inert and/or flue gas leaks	x	x
4. Piping	- Leaks due to erosion and corrosion	x	x
	- Leaks due to erosion, corrosion, and cavitation in three-phase systems		x
5. Letdown and control valves	- Leaks due to erosion and corrosion of valve internals	x	x
	- Leaks due to gasket failure	x	x
6. Gas/liquid separation tanks	- Leaks due to erosion and corrosion of tanks, joints, and valves	x	x
	- Leaks due to gasket failure	x	x
7. Distillation units	- Leaks at joints, valves and piping	x	x
	- Liquid spills at pumps, flanges, valves	x	x
8. Gas purification	- Leaks due to corrosion (may leak H_2S, CO, and combustible gases)	x	x
9. Residuals and catalysts	- Dusting from catalysts	x	x
	- Contamination from spills	x	x
10. Coal charging mechanism	- Leaks from lockhoppers in high pressure systems	x	
11. Ash discharging systems	- Leaks from erosion and corrosion	x	x
	- Leaks in letdown mechanism	x	x
12. Poke holes	- Leaks around seals	x	
	- Leaks during testing	x	
13. Valves	- Leaks from erosion and corrosion on valve seats	x	x
	- Leaks from tar buildup	x	x

can contribute to worker exposure. Factors that contribute to worker exposure include the following:

(1) Leaks in the instrument and at points where the instrument sensors are connected to process equipment;

(2) Emissions of hazardous components during calibration of instruments;

(3) Emissions of hazardous components during routine maintenance and troubleshooting; and

(4) Off spec products and emissions, and spills of process streams which may occur when in-line instruments fail to function.

The study plan proposed here considers the following:

- Needs of coal liquefaction processes for in-line process instrumentation;
- Commercially available in-line process instruments whose published performance specifications indicate they are suitable candidates for coal gasification and liquefaction processes;
- Performance of these instruments in commercial processes with unit operations and process equipment operated under conditions similar to those encountered in coal liquefaction processes;
- Assessment of in-line process instruments now in use in coal gasification and liquefaction plants; and
- Identification of areas in existing coal gasification and liquefaction plants which need better in-line process instrumentation.

Needs for additional instrumentation will be identified during discussions with plant engineers responsible for the design and operation of coal liquefaction and gasification process plants. The needs then will be ranked in order of importance on the basis of potential for reducing worker exposure or for maintaining existing acceptable exposure levels.

The sampling points are another area for exposure of workers to toxic materials in coal conversion plants. These sampling points are often located on bypass lines. Once the sample is obtained, the sampling line is cooled off, then the line is broken and the sample is taken to the lab for analysis. When the line is broken, the worker may be exposed to fumes

from the liquid in the line between the two shutoff valves. In addition, workers in analytical laboratories may also be exposed to toxic materials if proper precautions are not taken during analysis of these samples.

Category III

Controls which are designed to remove or reduce the concentration of contaminants from the workplace environment once they have escaped from process equipment will be discussed in Category III. It will be necessary to study the composition of the process streams to determine the possible toxic materials which may be a part of workplace emissions.

The classic example of this type of control is the application of ventilation to control vapors and gases. Other examples include the use of special work practices to remove coal tar residues from equipment and other surfaces in order to prevent contact with skin. Examples are given below.

> Removal of tar from structures and equipment is difficult. At SASOL, hot gas-liquor (containing over 3000 ppm phenols) is recommended; at the SRC pilot plant, an alkaline solution is recommended; and at HYGAS, steam-cleaning is used. In all cases, solutions to the cleaning problem pose hazardous conditions of their own. One of the nonhazardous solutions recommended in the *Criteria for a Recommended Standard...Occupational Exposure in Coal Gasification Plants* is the use of strippable paints or whitewash on structural surfaces.

Most coal conversion plants are of open construction, so that there is little or no accumulation of toxic gases in any of the plant areas. However, there are occasional operations or tasks where local ventilation is used, as in the following examples:

(1) At the SRC plant, a local exhaust system has been installed at the Sandvik belts so that toxic gases developed along the length of the belt may be removed quickly.

(2) At Cresap, an exhaust hood is used to remove toxic gases during the drum filling operation. At other times, the system is shut off.

(3) And also at the SRC plant, mobile flexible exhaust ducts are used to control fugitive emissions from the precoat (diatomaceous earth and asbestos) addition glove boxes.

Such a local, periodically used system may be installed:

- In areas where periodic leaks are anticipated and cannot be controlled by other means;
- In areas where onstream maintenance will be required;
- When sufficient sampling data is available to make informed decisions on duct placement;
- As an interim measure until long-range control technology is developed and installed; and
- Where exposure sources are intermittent (e.g., in reactors during maintenance).

Category IV

Controls which remove or isolate the worker from toxic agents in the workplace are discussed in Category IV. Examples of these include remote controls located in isolated control rooms, protective clothing, respiratory protection, and administrative controls such as job rotation and other work practices.

(1) The main control rooms at coal liquefaction and coal gasification pilot plants and commercial plants surveyed by Enviro are generally located away from the main process areas. This includes HYGAS, Agglomerating Ash, METC, CO_2 Acceptor, Bi-Gas, Synthane, Synthoil, Solvent Refined Coal, Cresap, SASOL, Modderfontein, Ruhrgas, and the University of Minnesota. The low-Btu commercial plants are notable exceptions, however, only at the SRC plant did we notice shelters located apart from the process area. One of the observations at Cresap was that the crowded conditions make it difficult to maintain and/or service the equipment. In future plants, ECI recommends additional spacing between the various pieces of equipment, thereby reducing the exposure of the maintenance crews because of more efficient operation. Better spacing would aid in reducing the exposure points to which an employee would be subjected at any one location.

(2) The SRC pilot plant has the most conscientious clothing code of any plant surveyed to date. This includes frequent changes of clothing and necessary protective equipment. Most important, all clothing is changed at the end of the shift and is then cleaned and washed. Workers have a dirty-clean locker room with mandatory shower.

(3) Respirator protection is available at all pilot plants but does not seem to be greatly used. SASOL may have the most practical program: If a leak occurs--get out. A properly protected inspection crew then investigates. All employees working in tanks or other areas containing toxic fumes wear air line respirators with filters to remove compressor oils.

Work practices concerning safety are carefully followed in all plants. These work practices are consistent with the requirements for each plant, and are established because of the equipment, raw materials used, end products, and waste materials end products. Some of these work practices are detailed in *Recommended Standards for Occupational Health and Safety in Coal Gasification Pilot Plants.*

Category V

Controls and monitoring systems are designed to warn the worker of hazardous concentrations of agents and to initiate remedial action. Examples of such controls in various industries are numerous and include systems for labeling and for monitoring certain toxic substances such as carbon monoxide (CO), vinyl chloride, hydrogen sulfide (H_2S), oxygen (O_2), etc.

(1) At the CO_2 Acceptor pilot plant--a totally enclosed structure--CO monitors were placed in all rooms. Then, all potential leak points were tightened until all gauges read below 30 ppm. The coal gasification criteria document recommends that an indicator gas system be used to define leaks of substances which may be hazardous at concentrations lower than the NIOSH-recommended levels for the indicator. Such gases might be CO, H_2S, or methane (CH_4), depending on the unit operation being monitored. Such a system was also in use at the Agglomerating Ash pilot plant.

(2) Rapid leak detection continues to be essential to the success of vinyl chloride control programs: (1) it allows timely containment and/or repair of leaks soon after they occur; (2) it assists in reducing exposure by activating visual alarms when high concentrations of vinyl chloride exist and respiratory protection is needed; (3) it serves as an indication of control effectiveness and need for action; and (4) it directs the efforts of the control program by pinpointing recurring problem areas. It should be no less successful in coal gasification.

> Such rapid leak detection systems are typically designed to initiate alarm lights in the affected areas and the control rooms. Actuation of the system may require that respiratory protection be used and/or that employees evacuate the area. Simultaneously, a protected worker using a portable hydrocarbon detector locates the emission source and makes the necessary repair.

The rapid leak detection strategy for the coal conversion processes is essentially identical to that used in the PVC plants (NIOSH research report, *Engineering Control Technology Assessment for the Plastics and Resins Industry,* March 1978). However, because of the complexity, and difficulty of analysis of the components of the workplace emissions, the substance to be monitored will have to be an "indicator" substance. Depending on the unit operation, the "indicator" will be either CO or H_2S. Total analysis of the process gas will be required for each coal used so that the relationship between the toxic substance and the indicator can be established.

E. General Comments

As in many other industries, the process development units (PDUs) and pilot plants are subject to complex air, water, and occupational health regulations promulgated by the Environmental Protection Agency, the Occupational Health and Safety Administration, as well as state and local regulatory agencies. However, because this is a new industry, the regulatory agencies have been more concerned about the possibilities of exposure of the workers (and environment) to toxic agents. For example, for the WESCO project a total of 53 permits must be obtained before the plant can be built. All of the engineering and construction companies and the operators of the various PDUs, pilot plants, demonstration plants, etc., have recognized the need for protection of the workers and are investing substantial amounts of money in engineering control applications. However, these controls are based on information available at the time of installation and construction, and in some situations, workers continue to be exposed to hazardous chemical physical agents. It is the aim of this and other NIOSH studies to reduce worker exposure to within acceptable health levels.

The majority of the occupational toxic hazards which have been identified in the coal conversion industry occur via inhalation. In the case of maintenance workers, exposures by contact with tar substances are more prevalent. Work practices are a major component of control technology. However, the introduction of new controls may cause workers to become complacent; they may actually be exposed to greater amounts of toxic materials after the improvements are made than before. Installation of engineering control equipment, although important, is more effective with proper operation by the worker. Proper maintenance of this control equipment assists in minimizing hazardous exposure and insures optimum performance of the equipment. Reducing exposure of workers depends partly on the maintenance program and on the skill, motivation, and expertise of the operators in the area.

II. PROCESS ASSESSMENT

The field of coal conversion is undergoing very rapid changes; consequently it is necessary to establish a flexible study plan which can be modified to meet the introduction of new features in the technology over the period of the contract. It is also necessary to establish and maintain exceptionally close liaison with the project officer so that visits to the various plants can be coordinated and completed within the time specified.

This study plan is structured to include equipment currently being developed in the construction and maintenance field. Enviro will assess the applicability of control technology, identify deficiencies which can be met by research and development targeted to specific needs, and estimate the time by which these needs must be met. The plan emphasizes identification of technology which should be included in future demonstration and full-scale conversion plants, as well as in pilot plants.

The study plan is based on the combined past experience of Enviro personnel from visits to over 30 PDU's, demonstration plants, commercial plants, and engineering and construction companies. It is also based on the personal experience of Enviro personnel in manufacturing, research and development,

pilot plant operation, process design, equipment design and instrumentation in both coal conversion and analogous operations. Further, Enviro is using its existing library of literature on coal conversion for initial support in development of this study plan. This library is currently being supplemented by literature searches under NIOSH contracts for characterization of coal liquefaction pilot plants and for characterization of coal gasification plants. In addition, information specialists are searching the literature for information that is specifically concerned with the control technology used in coal conversion plants. The study plan will be augmented at future dates to include the various aspects of control technology as it affects coal conversion and may well be amended as new information is acquired either at the research site or from the literature.

Most of the publications may be out-of-date in some respects. For example, the quarterly reports published by the Department of Energy, Division of Coal Conversion, are nine to twelve months behind the date of the contract monthly reports, and twelve to eighteen months behind the actual work itself. Enviro will contact the managers of various plants and research projects in order to keep abreast of this swiftly moving frontier of technology. Enviro will also make full use of contacts in industry; personal contacts with project managers on the extensive EPA projects; the Electric Power Research Institute (EPRI); and the trade associations, in particular the American Gas Association (AGA), the Gas Research Institute (GRI), and the American Petroleum Institute (API). Another source of information, in addition to that obtained from literature and personal contacts, will be the existing knowledge and understanding of the project manager and all the members of the assigned staff, supplemented and updated by Enviro's involvement in parallel projects such as oil refinery characterization, surface mine respiratory hazards, Gasifiers in Industry, etc.

A. Unit Operations

Enviro will use the unit operation concept to systematize and to analyze the engineering control technology under assessment. Enviro has previously used this concept in preparing the *Criteria for a Recommended Standard... Occupational Exposure in Coal Gasification Plants* and the *Recommended Health*

and Safety Guidelines for Coal Gasification Pilot Plants. This approach was also used by EPA for evaluation of background data relating to new source performance standards for Lurgi gasification written by Cameron Engineers and by DOE in subdividing various coal gasification and liquefaction processes. (It should be noted that some unit operations, such as water biological treatment, oxygen generation, steam generation, power generation, tailgas incineration, stack gas scrubbing, and other utility operations will not be studied in this assessment. These items are more properly the subject of separate studies for those particular fields.)

The breakdown in Table II is an example of process division into unit operations; the breakdown for each site visit will be unique to that particular plant.

B. Site Visit Arrangements

Enviro recognizes the importance of establishing a good working relationship with the plant management prior to initiating any control technology assessment survey. In this program, Enviro will be dealing with private industry and federal agencies.

As a result of the NIOSH-ERDA interagency agreement of 1976, standard protocols for plant visits have been established for DOE-funded projects. According to this protocol, it is the responsibility of the NIOSH project officer to establish contact with the designated DOE interagency officer and to explain to him the purpose of the work NIOSH wishes to have performed. (At the present time, the designated DOE officer is Mr. John Abrahams, DOE/FE/ESP.)

Following the initial contact, the Enviro program manager, with the approval of the NIOSH project officer, will establish a regular communication with the DOE officer, and through the DOE officer, with the DOE program manager to keep him informed on the specific plants that are to be visited and of the proposed visit schedule. In the visit-planning stage, the Enviro program manager, with the approval of the appropriate NIOSH and DOE officials, will contact and work closely with the pilot plant or program manager and other staff members as required.

TABLE II

POTENTIAL BREAKDOWN OF COAL CONVERSION OPERATIONS INTO UNIT OPERATIONS

Unit Operations		
Coal Gasification		Coal Liquefaction
High-Btu (Lurgi)	Low-Btu (Stoic Two-Stage Gasifier)	Consol Synthetic Fuel
• Coal Storage	• Coal Storage	• Coal Storage
• Coal Preparation	• Coal Preparation	• Coal Preparation
• Coal Feeding (high-pressure lockhopper)	• Coal Feeding (low-pressure lockhopper)	• Coal Feeding (slurry mixing, high-pressure pumping)
• Gasification	• Gasification	• Preheat
• Water Quench	• Electrostatic Precipitation Cyclone	• Extraction
		• Cooling
• Gas--Gas-Liquor Separation	• Tar Recovery & Storage	• Solids Separation
• Gas Cooling	--	• Liquid Distillation
• CO Shift	--	• Solvent Recovery
• Gas Purification (Rectisol)	--	• Solvent Return to Slurry
• Methanation	--	• Extract Feed to Hydrogenation
• Feed to Pipeline	--	• Catalytic Hydrogenation
--	--	• Gas Recycle & Cooling
--	--	• Liquid Recovery
		• Distillation
Auxiliary Processes		
• Tar, Tar-Oil, Gas-Liquor Separation	--	• Solids Residue & Hydro Residue Liquor Recovery
• Gas-Liquor Treatment (Phenosolvan)	--	• Water Treatment
• Gas Sulfur Recovery (Claus, Stretford)	--	• Gas Sulfur Recovery (Claus, Stretford)
• Ammonia Recovery	--	• Ammonia Recovery
• Water Biological Treatment	--	• Water Biological Treatment
--	--	• Coal Gasification (medium-Btu)
• Oxygen Generation	--	• Oxygen Generation
• Steam Generation	--	• Steam Generation
• Power Generation	--	• Power Generation
• Product Storage	--	• Product Storage
• Miscellaneous Utilities	--	• Miscellaneous Utilities
• Tail Gas Incineration	--	• Tail Gas Incineration
• Stack Gas Scrubbing	--	• Stack Gas Scrubbing

A lead time of up to several months may be required for a site visit. Actual visit dates should be flexible because there is never any guarantee that a coal conversion pilot plant will be onstream on any given date.

Enviro has established a working relationship with AGA, GRI, and other private industries during the development of the coal gasification criteria document. These contacts will be equally beneficial for the development of coal control technology assessment. Likewise, our contacts with API and EPRI, created through mutual interest in occupational health aspects of coal conversion, will be advantageous for this study.

In addition, Enviro will coordinate the study with labor groups as appropriate under 42 CFR 85a.

C. Site Visit Protocol

Before each site visit, Enviro will prepare a site visit protocol that generally will be the same for each site. However, because of the differences that will be encountered during each visit, the specifics of each protocol will be adjusted to make the greatest use of the time spent on site. These protocols will be sent to the project officer for his approval and, following the NIOSH project officer's approval, to the DOE or industry representative before the site visit. These protocols will be designed so that the report for each visit may be included directly into the final report. Enviro will complete the site visit report within 30 days of receiving the analysis of the samples taken during the comprehensive industrial hygiene characterization survey. In cases where Enviro visits an engineering office, the site visit report will be completed within 30 days of completion of the visit.

A copy of the preliminary report will be sent to the project officer and to the manager of the site visited. Comments from both the project officer and the site manager will be incorporated into the final site report. These final site reports, intended for inclusion in the public files, will be

forwarded to the NIOSH project officer and the site manager within two weeks after comments have been received by Enviro. (Trade secret information will be handled according to 42 CFR 85a, 5.b.)

In addition to the information generated by the site visits, information about control technology for coal liquefaction and gasification plants will be generated by continuing literature searches. However, much of the pertinent "how-to" information of interest to this project does not get into the literature. In many cases, especially at the pilot plant level, such information may not even appear in the monthly reports. Enviro will obtain this information by telephone conversations with those actively engaged in the given project. In other instances, Enviro will refer to its trip reports of site visits to the Fluor and WESCO offices in Irvine, California; the ANG plant in Detroit, Michigan; and especially the SASOL and Modderfontein plants in South Africa and the Ruhrgas plant in Germany. In several cases, pilot plant operations have been completed and the plant closed down since they were visited by Enviro while researching the *Criteria for a Recommended Standard...Occupational Exposure in Coal Gasification Plants*. Such plants include the CO_2 Acceptor pilot plant in Rapid City, South Dakota; the Agglomerating Burner coal gasification plant located near Columbus, Ohio; the Synthoil PDU and the Synthane pilot plant located in Bruceton, Pennsylvania; and the Steam Iron pilot plant located near IGT's HYGAS plant in Chicago, Illinois. In these cases, the experience of the Enviro personnel will supplement information in the Enviro file.

D. Survey Sites

Table III is a list of possible liquefaction survey sites that may be available for visits by Enviro personnel. Table IV is a list of possible gasification survey sites. Table V lists the possible site visits that deal with equipment studies, product studies, and services rendered by construction and engineering companies that might be of interest to the coal technology assessment.

TABLE III

CONTROL TECHNOLOGY ASSESSMENT:
POSSIBLE LIQUEFACTION SURVEY SITES

	Site or Process	Location	Status	Previously Visited	Remarks
1.	Solvent Refined Coal SRC I	Birmingham, Alabama	On-Going Design		This program will be an alternative to SRC II.
2.	Solvent Refined Coal SRC II	Denver, Colorado	On-Going Design		Important major effort of technology currently of interest will correlate this work with Ft. Lewis Pilot Plant
3.	Fluor Construction and Engineering	Irvine, California	On-Going Design	X	Fluor has on-site experience in design of two major gasification projects and the experience of operating the CSF process at Cresap. In past work, they gave major support to DOE projects.
4.	POGO, COED, SRC (R. M. Parsons)	Los Angeles, California	On-Going Design		Parsons has been dealing with liquefaction since 1961 and is especially knowledgeable on materials of construction. Parsons developed the first of the released development designs.
5.	Coal to Gasoline	Marcus Hook, Pennsylvania	On-Going Design		Project at bench-scale level.
6.	CSF Process	Cresap, West Virginia	Operating Pilot Plant, Fiscal 1979	X	Major pilot plant using combination of liquefaction processes. Long history of problems and problem solving.
7.	SRC I or SRC II	Ft. Lewis, Washington	Operating Pilot Plant, Fiscal 1979		Major pilot plant using combination of liquefaction processes. Long history of problems and problem solving.
8.	H-Coal	Catlettsburg, Kentucky	Start up scheduled early 1979		Largest of pilot plants. Variety of processes to be looked at. Is joined with Ashland Oil Refinery.
9.	TOSCOAL	Golden, Colorado	Awaiting DOE Funding		Only possibility to review Pyrolysis process and rotating kiln operation.
10.	SRC	Wilsonville, Alabama	Operating PDU Fiscal 1979		Repeat of Ft. Lewis operations to some extent. Very reliable. Smaller unit.
11.	Occidental Oil	Laverne, California	Shutdown, Spring 1978	X	Private operation. Specialized process. Information may be difficult to obtain.
12.	COSTEAM	Grand Forks, North Dakota	PDU Operating 1979		Process of potential economic interest.
13.	SRL	Grand Forks, North Dakota	Project Completed		Process of potential economic interest.
14.	SYNTHOIL	Bruceton, Pennsylvania	Plant Mothballed	X	
15	Exxon Donor Solvent	Baytown, Texas	Start up scheduled 1980		Major pilot plant using refinery experience.
16.	Hydrocarbonization	Oak Ridge, Tennessee	Bench scale operation 1979	X	
17.	Zinc Chloride	Library, Pennsylvania	Small PDU Operation 1979	X	Bench scale operation at present Process not of wide scale interest.
18.	Mobil -- Coal-Methanol Gasoline	Paulsboro, New Jersey	Line rack operation		
19.	COED	Princeton, New Jersey	Project completed		Personnel relocated. Information will be difficult to obtain.

TABLE IV

CONTROL TECHNOLOGY ASSESSMENT:

POSSIBLE GASIFICATION SURVEY SITES

	Site or Process	Location	Status	Previously Visited	Remarks
1.	CE Combustion	Windsor, Connecticut	Operating Pilot Plant, Fiscal 1979		Only low-Btu pilot plant operation specifically designed for direct use at utilities.
2.	Synthane	Bruceton, Pennsylvania	Project Terminated	X	Extensive operating experience.
3.	Slagging Lurgi	Grand Forks, North Dakota	Operating Pilot Plant, Fiscal 1979		Only operating Lurgi in U.S.A.
4.	HYGAS	Chicago, Illinois	Operating Pilot Plant, Fiscal 1979	X	Will have firsthand knowledge through consultants.
5.	CO_2 Acceptor	Rapid City, South Dakota	Project Completed	X	ECI has information from previous visit.
6.	Stirred Fixed Bed	Morgantown, West Virginia	Operating, Fiscal 1979	X	Operation undetermined. Insufficient information from previous visits.
7.	Steam-Iron	Chicago, Illinois	Project Terminated	X	Consultants' background information.
8.	Agglomerating Burner	Jackson, Ohio	Project Terminated	X	Personnel relocated. ECI will attempt phone contact for equipment information.
9.	Bi-Gas	Homer City, Pennsylvania	Operating Pilot Plant, Fiscal 1979		Complete plant operations.
10.	GE Fixed Bed	Schenectady, New York	Operating Pilot Plant, Fiscal 1979	X	
11.	Westinghouse	Waltz Mill, Pennsylvania	Operating Pilot Plant, Fiscal 1979		Possible alternate. Information obtainable here also available at other sites.
12.	Tri-Process	Monroeville, Pennsylvania	Operating Pilot Plant, Fiscal 1979		Possible alternate.
13.	Ash Agglomerate	Chicago, Illinois	Operating Pilot Plant, Fiscal 1979		Insufficient wide appeal. Will obtain information from consultant.
14.	Peat Gas	Chicago, Illinois	Operating Pilot Plant, Fiscal 1979		Insufficient wide appeal. Will obtain information from consultants
15.	Clean-Coke	Monroeville, Pennsylvania	Project Terminated		Small scale. Will not permit proper evaluation.
16.	Powerton	Pekin, Illinois	Scheduled Start-up 1980		Large-scale Lurgi
17.	Atomics, Inc.	Canoga Park, California	Operating, Fiscal 1979		Insufficient wide appeal
18.	Applied Technology Corp. Pittsburgh, Pennsylvania	Pittsburgh, Pennsylvania	Project Terminated.		
19.	Catalytic Gasification	Baytown, Texas	Not out of POU status		Privately developed process. Little information available. May use Synthane pilot plant.
20.	Slagging Lurgi	Ponca City, Oklahoma	On-Going Design		Major demonstration plant design.
21.	Co-Gas	Pittsburgh, Pennsylvania	On-Going Design		Major demonstration plant design

Table IV, cont'd

	Site or Process	Location	Status	Previously Visited	Remarks
22.	Texaco Partial Oxidation	Memphis, Tennessee	On-Going Design		Major medium-Btu design for intermediate plant. Will be used by W. R. Grace for manufacture of ammonia.
23.	U-Gas	Memphis, Tennessee	On-Going Design		Of interest. Will obtain information from consultant.
24.	Coal-Con	New York, New York	Terminated	X	Will visit Dravo for information on this project.
25.	ANG Coal Gasification	Detroit, Michigan	Start plant construction 1979 (?)	X	Detailed design of plant should be advanced.
26	El Paso Natural Gas	El Paso, Texas	Plant at design stage	X	Interested in occupational health and CTA not far advanced.
27.	Pannandle Eastern	Houston, Texas	Plant at design stage	X	Plant design not far advanced.
28.	Ruhrgas	Dorsten, Germany	Operating plant	X	Will apply information obtained to CTA.
29.	SASOL I	Sasolburg, Africa	Operating plant	X	Will apply information obtained to CTA.
30.	SASOL II	Los Angeles, California	At design construction stage	X	Fluor is lead engineering company.
31.	Westfield	Westfield, Scotland	Used as research facility		Does not wish to participate in technically detailed public exchange.
32.	Modderfontein	Johannesburg, Africa	Operating	X	Will apply information obtained to CTA.
33.	Glen-Gery	York, Reading, Pennyslvania	Operating	X	Antracite gasification. New control technology. Part of Gasifiers in Industry program. Plants well run.
34.	National Lime & Stone Co.	Gary, Ohio	Operating	X	Have visited. Will use obtained information on CTA.
35.	Holston	Kingsport, Tennessee	Operating	X	Have visited. Will use obtained information on CTA.
36.	Dow Chemical	Midland, Michigan			Privately developed. Gasification & liquefaction. Have not considered control technology
37.	University of Minnesota	Duluth, Minnesota	Fully operational 1978	X	Gasifiers in Industry program. Plant on stream. Has extensive industrial health investigation. Has new control technology which is being investigated by University of Minnesota under direction of ORNL.
38.	Pike County	Pike County, Kentucky	Design stage	X	Gasifiers in Industry program. Not yet under construction
39.	Rocketdyne	Canoga Park, California	Semi-PDU Operating 1979		Project not presently of commercial interest.
40.	Bell Aerospace, Textron	Buffalo, New York	PDU Operation		

TABLE V

CONTROL TECHNOLOGY ASSESSMENT
POSSIBLE SITE VISITS--EQUIPMENT, STUDIES, SERVICES

Equipment or Product Study	Company or Location	Status	Previously Visited	Remarks
SRC Combustion	Con Ed New York, N.Y.	Some tests completed		No reason to visit, results reported in detail.
SRC Hydroprocessing (H-Oil)	Cities Service Lake Charles, La.	On-going		H-Oil process similar to H-Coal.
Product Upgrading		On-going		At bench scale. Should be reported in literature.
Char Gasification	Texaco, Inc. Los Angeles, Ca.	On-going		At bench scale. Should be reported in literature. Privately financed.
Filter Construction	Johns-Manville	Filter tested	X	Will inspect at Ft. Lewis SRC plant.
Solvent Precipitation	Lummus	To be tested at SRC in 1979		Will inspect at Ft. Lewis SRC plant.
Solvent Precipitation	Kerr-McGee	To be tested at Wilsonville, Ala. in 1978-79		Will compare literature with Ft Lewis and Cresap plants.
Solvent Precipitation	Conoco	To be tested at Cresap, W.Va.		Will inspect at Cresap.
Coal Feeders	Foster Wheeler			Will follow literature. Upgrade information by telephone at end of project.
Screw Feeder	Ingersoll Rand			Will follow literature. Upgrade information by telephone at end of project.
Screw Feeder	General Electric	Under test 1978	X	Will follow literature. Upgrade information by telephone at end of project.
Coal Feeder	Lockheed			Will follow literature. Upgrade information by telephone at end of project.
Lockhopper Valve	Consolidated Controls			Will follow literature. Upgrade information by telephone at end of project.
Valve Design	Fairchild			Will follow literature. Upgrade information by telephone at end of project.
Valve Material	Battelle			Will follow literature. Upgrade information by telephone at end of project.
Coal Grinding	(Kennedy Van Soun)			Will follow literature. Upgrade information by telephone at end of project.
Liquid Phase Methanation	Chem Systems	Under test 1977-79	X	Will follow literature. Upgrade information by telephone at end of project.
Coal Pump	Jet Propulsion Lab			Will follow literature. Upgrade information by telephone at end of project.

Table V, cont'd

Equipment or Product Study	Company or Location	Status	Previously Visited	Remarks
Instrumentation	Argonne National Lab			Will follow literature. Upgrade information by telephone at end of project.
Water Purification	Water Purification Association			Will follow literature. Upgrade information by telephone at end of project.
Survey of Industrial Coal Conversion Equipment	ORNL			Will follow literature. Upgrade information by telephone at end of project.
Gasification	C. F. Braun, Los Angeles, Ca.	Completed work 1978		Have been DOE technical gasification advisors since 1965 (?).
Liquefaction	R. M. Parsons, Los Angeles, Ca.	On-going since 1961		Have been DOE technical liquefaction advisors.
Gasification	Universal Oil Products	Started 1978		Have just begun in this role.
Coalcon	Bravo	Completed	X	Project adviser to ERDA.

III. CONTROL TECHNOLOGY ASSESSMENT PLANS

As a result of the range of site characterizations required for this project (see Table VI), ECI has developed four site visit plans:

Plan A--Nonplant Sites
Plan B--Pilot Plants
Plan C--Plant Sites Previously Characterized
Plan D--Plant Sites of Special Interest

Two to five days will be required to complete the on-site control technology/sampling aspects of each visit. At each site, ECI will:

- Explain the purpose of the CTA project, how it fits into the NIOSH program, and the scope of our plans for the visit;
- Request information concerning the plant process operations from plant personnel; and
- Complete a preliminary walk through of the plant to permit the CTA team to become familiar with the physical realities of the plant so that final details of sampling can be worked out. (This item will not be included in Plan A.)

A. Plan A--Nonplant Sites

Plan A will be used for those site visits which are made to offices in engineering or corporate headquarters. The bases for these discussions will be flow sheets, P&I drawings (where available) and Enviro's background knowledge of the process.

The CTA team will discuss the project with the engineering staff and other appropriate company representatives. The basis for discussion will be the site visit protocol developed especially for the visit and mailed to the company prior to the visit. (It is Enviro's experience that detailed

protocols stimulate disscussions.) The engineering staff will be interviewed by the full CTA team (engineers and hygienists). The engineers will concentrate on the specific technology, while the hygienists will interpret the discussion from an occupational health viewpoint.

During the meeting, costs of engineering control technology installation and maintenance will be discussed by the CTA engineer(s). The CTA hygienist, who will be present at these meetings, will approach the problems brought up during the discussion from the viewpoint of the industrial hygienist.

B. Plan B--Pilot Plants

The initial procedure under Plan B will be similar to that of Plan A. Discussion here, however, will center on the experience and learning process of the pilot plant personnel. Questions on maintenance will be directed toward finding out what type of system works better and why one system was chosen over another. Special emphasis will be placed on sampling equipment and/or work practices for taking samples in order to determine the worker hazard during both the sampling and analytical activities.

This sampling plan will be used by the control technology assessment team when the site visit is made with the industrial hygiene characterization team under either of the NIOSH contracts. The CTA visits will be made at the beginning of the three week in-depth industrial hygiene survey. The CTA team under this plan will take a minimum number of samples. The industrial hygiene characterization team will make a detailed study of the site and will take the number of samples required to make an in-depth industrial health characterization of the site. The data obtained from this industrial hygiene characterization will be used, where applicable, by the CTA team.

The cost of the installation and maintenance of control equipment will be discussed. The CTA team will obtain the history of the maintenance that has been done on a specific piece of equipment in the area. Enviro will attempt to determine whether a better piece of eqiupment has become available since the installation of the equipment in question in any particular area. The CTA team will endeavor to get opinions from the plant personnel concerning the capability of the equipment that is in use.

In addition to the discussions, the CTA engineer will study each piece of equipment, equipment subsystems, and the overall process while it is in operation. Particular pieces of equipment such as hot high pressure slurry reciprocating pumps may be examined several times during the visit to determine whether any deterioration has taken place during the visit.

While the engineer(s) are making their studies, the industrial hygienist(s) will study actual fugitive emissions from the equipment. For this purpose, calibrated direct-reading instruments, such as a carbon monoxide indicator (MSA), hydrocarbon analyzer (HNu 101), and Draeger or MSA detector tubes, will be used for:

- Ammonia
- Carbon disulfide
- Carbon monoxide
- Hydrogen cyanide
- Hydrogen sulfide
- Mercaptans
- Oxides of nitrogen
- Oxides of sulfur

Should the level of contamination be excessive in the vicinity of specific equipment, the hygienist will obtain sufficient readings to develop isoline around the equipment. Readings will be taken around all equipment in each section.

C. Plan C--Plant Sites Previously Characterized

The Plan C format is the one that will be used when the CTA team visits sites at which industrial hygiene characterizations have been made by plant personnel or other investigating groups. An example of this type of operation is the Exxon Donor Solvent plant at Baytown, Texas. The plant, which is being built by Exxon using available refinery experience, is being carefully monitored for the industrial health aspects. The CTA team will obtain this information from the Exxon industrial hygienist and use it as a part of the analysis of the control technology.

The initial procedure under Plan C will be similar to that of Plan A. However, the discussions will concentrate on the control technology designed into the equipment in each of the unit operations. Enviro engineers will also discuss with plant engineers the installation and maintenance costs of each of the installed pieces of control technology equipment. A history of the frequency of maintenance and remedial actions taken will also be discussed.

At these sites, the industrial hygienist will use a hydrocarbon analyzer (HNu 101) to locate points where hydrocarbons are found. He will also, where appropriate, attempt to establish isolines for higher levels of concentration of the gases. The industrial hygienist will also use MSA or Draeger detector tubes for analysis of the following:

- Ammonia
- Carbon disulfide
- Carbon monoxide
- Hydrogen cyanide
- Hydrogen sulfide
- Mercaptans
- Oxides of nitrogen
- Oxides of sulfur

In addition, Enviro may include limited area sampling by the following methods:

a. Charcoal tubes
    1. aliphatics
    2. low molecular weight aromatics
b. Silica gel tubes
    1. phenols
    2. aromatic amines
c. Silver membrane filter/Chromasorb cassettes
    1. PAH's
    2. benzene-solubles
d. PBC filter cassettes
    1. total particulates
    2. respirable dust
e. Cellulose acetate filter cassettes for trace metals

Plan D--Plant Sites of Special Interest

In Plan D, the control technology assessment team will take a complete series of samples in order to categorize worker exposure to toxic gases at each of the unit operations. Enviro anticipates using this plan at the H-Oil process plant at Lake Charles, Louisiana; at the Glen-Gery plant in York, Pennsylvania; and at the Pike County Gasifiers in Industry unit in Pike County, Kentucky.

Discussions will be based on the experiences which the plant operating and maintenance engineers have had with the control technology in each of the unit operations. At the H-Oil process plant, similarities with the H-Coal process will be discussed and evaluated.

At the Glen-Gery plant, changes which can be made in control technology as a result of gasifying anthracite will be determined.

The CTA team will also make a walk through survey with the plant engineer and other appropriate plant representatives. During the survey, unit operations where controls are present will be inspected, and those with no controls will be identified. Unit operations where frequent leaks occur will be identified and inspected, and activities which involve a break in the integrity of the closed system will be identified.

The CTA industrial hygienist will be present at these meetings and during the walk-through survey, and he will determine the type of sampling which will be required in order to obtain the information which Enviro will use for the analysis of the control equipment.

The HNu 101 hydrocarbon analyzer will be used for the survey; in addition, MSA or Draeger tubes will be used for:

- Ammonia
- Carbon disulfide
- Carbon monoxide
- Hydrogen cyanide
- Hydrogen sulfide
- Mercaptans
- Oxides of nitrogen
- Oxides of sulfur

The area sampling will be conducted with the following sample devices, with the actual type being determined by the type of plant and the operating conditions:

a. Charcoal tubes
    1. aliphatics
    2. low molecular weight aromatics
b. Silica gel tubes
    1. phenols
    2. aromatic amines

Silver membrane filter/Chromasorb cassettes
    PAH's
    benzene-solubles

d. PVC filter cassettes
    1. total particulates
    2. respirable dust
e. Cellulose acetate filter cassettes for trace metals

As discussed in the best and final offer for "Occupational Health Control Technology Assessment for Coal Gasification and Liquefaction Processes," Enviro will only acquire and analyze incremental samples for the purposes of this study. This incremental number consists of those samples required for information not being provided by other ongoing contracts. These contracts include our industrial hygiene characterization of coal gasification and liquefaction facilities as well as studies (e.g., petroleum refinery) being performed by other NIOSH and EPA contractors. The following sampling strategy also incorporates comments made by the project officer on 29 January 1979.

ESTIMATE FOR NON-DIRECT READING SAMPLES REQUIRED FOR THE OCCUPATIONAL HEALTH CONTROL TECHNOLOGY ASSESSMENT FOR COAL GASIFICATION AND LIQUEFACTION PROCESSES

Method of Analysis	Sample No.
Metal Analysis--Filters analyzed qualitatively by emission spectroscopy	5
Chromasorb Absorbent Analyses*	20
Benzene Solubles (BSFTPM) Gravimetric	25
Impinger Samples Using Colorimetric Methods	30
Charcoal Tube Analysis for Organic Solvents	50
TOTAL SAMPLES	130

*Tenax absorbent is being replaced by Chromasorb because more reliable sampling results are obtained with Chromasorb.

The actual sampling required will be unique to each plant and will be detailed in the individual site visit protocols. Because of the different types of sites to be visited, the above four plans have been established to meet the requirements of the contract.

IV. PROPOSED SITE VISITS

The NIOSH contract states that "site visits to twenty plants, including one foreign plant, will be conducted" (i.e., in-depth surveys which include a description and an evaluation of control technology); also, of these twenty visits the contractor shall visit those pilot plants previously defined in NIOSH contracts for the characterization of coal liquefaction and coal gasification plants. Further, two of the Gasifiers in Industry low-Btu plants shall be visited. Enviro recommends a visit to two countries for a study of the Lurgi process and a visit to the International Coal Conversion Agency for an exchange of information. The contract specifies nine of the twenty site visits, leaving the balance of eleven to the contractor's office. Those site visits specified in the contract and additional site visits selected by the contractor are detailed below.

A. Site Visits Specified in Contract

Liquefaction

- CFS process - Cresap, West Virginia
- SRC process - Ft. Lewis, Washington
- H-Coal process - Catlettsburg, Kentucky
- TOSCOAL - Golden, Colorado

Gasification

- Synthane process - Bruceton, Pennsylvania
- Combustion Engineering entrained-bed gasifier - Windsor, Connecticut

Gasifiers in Industry

- University of Minnesota at Duluth - Duluth, Minnesota
- Pike County Project - Pike County, Kentucky (alternate: Glen-Gery Colonial Plant - York, Pennsylvania

Foreign Plants

- Lurgi process - East Germany and Yugoslavia

B. Additional Site Visits Selected by the Contractor

Analogous Processes

For the related-industry visits, Enviro will make visits to two oil refineries and to a large ammonia manufacturing facility. In addition, site visits to demonstration plants are recommended.

Oil refineries will be chosen to maximize the number of processes which are related to those which might be found in a commercial coal liquefaction or high-Btu coal gasification plant. In a refinery, Enviro personnel will be able to study the high-pressure catalytic cracking plant, the acid-gas treating plant, the sulfur recovery plant, distillation and other handling of oils which contain a high percentage of aromatic oils, and the treatment of water which contains dissolved oils or phenolic materials. Enviro will visit Cities Service, in Lake Charles, Louisiana, and Exxon Donor Solvent, in Baytown, Texas.

Enviro recommends that the CTA team should not make a visit to a coke-oven plant. These relatively open processes bear little or no resemblence to the high-pressure coal liquefaction and coal gasification processes or low-pressure, low-Btu operations and would not contribute to this study.

Ammonia plants are of particular value to this project because of their long record of interest in occupational safety and health. The W. R. Grace & Company ammonia plant will be visited to observe control technologies used to handle flammable gases at high pressures and high temperatures, acid-gas facilities and other high pressure operations associated with an ammonia plant.

Contractors are actively engaged in the design of four DOE-sponsored demonstration plants and are a good source of control technology engineering information. Enviro will visit the group in charge of designing the Slagging Lurgi coal gasification demonstration plant in Ponca City, Oklahoma. The

second visit will be to Fluor Engineers and Constructors, who are doing a "conceptual design for an advanced coal liquefaction commercial plant" in Irvine, California. The third visit will be to the Parsons Corporation, Pasadena, California, which is in the process of making a major conceptual demonstration plant design. The fourth will be to the Gulf Minerals Resources Company, Denver, Colorado, which is designing a 6,000-tpd, SRC-II plant to be built in Morgantown, West Virginia.

Commercial High-Btu Coal Gasification

The ANG Coal Gasification Company in Detroit, Michigan, is committed to build a commercial plant at the earliest possible date and is seeking DOE/FERC permission and means for financing commercial coal gasification plants. ANG has actively sought and received DOE help in applying for a loan guarantee. Because of ANG's advanced state of preparation, Enviro has targeted them for a site visit.

Medium-Btu Coal Gasification

Because of the importance of Lurgi coal gasification in the early development of high-Btu coal gasification in the United States, Enviro will visit at least one Lurgi plant located in the United States. Because of the time constraints of this contract, the only possibility of such a visit may be to the Illinois Coal Gasification group, located in Chicago, Illinois, to discuss the pipeline gas demonstration plant. In addition, Enviro will visit the W. R. Grace & Company plant in Memphis, Tennessee, to discuss the synthesis gas for ammonia production demonstration plant, which utilizes the Texaco Partial Oxidation coal gasification process.

Enviro will discuss processes that may be of potential economic interest and, in addition, will meet with the construction and engineering companies that have had past experience in the design of coal conversion units. Enviro will meet with major construction companies that are in the process of designing coal conversion units at the present time, in order to keep current on the latest information on control technology.

In Europe, Enviro will visit the East German Lurgi gasifiers. Enviro has received reports that the East Germans have improved operations more than their counterparts in West Germany or at SASOL. While in Europe, Enviro will visit the Kosovo Coal Gasification Plant in Yugoslavia, which has been in operation for a number of years. This plant uses the Mark IV design of the Lurgi gasifier. The Yugoslavs have developed the operating procedures for this modern plant with little outside help. DOE recommends a visit to the International Coal Conversion Agency in Paris so that there can be an exchange of information on the various operations concerning coal conversion that are being developed in the European community.

Table VI lists proposed site visits for the control technology assessment contract. As additional information is obtained, the list may be revised so as to include site visits which may provide more information than those currently listed.

The site visits were selected to provide a broad range of experiences from design through commercial plants in a number of ongoing processes. Enviro recognizes that, for reasons beyond our control, some visits may have to be postponed or cancelled. At that time, Enviro will contact the project officer with alternate site visit plans.

TABLE VI

CONTROL TECHNOLOGY ASSESSMENT:

PROPOSED SITE VISITS

	Site	Approximate Date	Personnel	Length of Trip/Days	Cost*	Remarks
	LIQUEFACTION					
1.	CSF Cresap, W.Va.	2nd Qtr, 1979	D. Telesca R. Tanita J. Bochinski R. Cooperman	7	$428 428 428 428	Part of the NIOSH liquefaction industrial hygiene survey.
2.	SRC Ft. Lewis, Wash.	1st Qtr, 1979	D. Telesca R. Tanita	7	$770 770	Part of the NIOSH liquefaction industrial hygiene survey.
3.	H-Coal Catlettsburg, Ky.	1st Qtr, 1980	D. Telesca R. Tanita	7	$466 466	Largest pilot plant to be operated. Adjacent to Ashland Oil Company refinery. Variety of processes to be examined.
4.	TOSCOAL Golden, Col.	1st Qtr, 1980	D. Telesca R. Tanita	3	$444 444	Only possibility to review Pyrolysis process and rotating kiln.
	GASIFICATION					
1.	Combustion Engineering Windsor, Conn.	4th Qtr, 1978	D. Telesca	4	$302	Only low-Btu pilot plant specifically designed for direct use by utilities. Part of NIOSH industrial hygiene survey.
2.	Exxon Donor Solvent Baytown, Texas	4th Qtr, 1979	J. Evans D. Telesca D. Cubit R. Tanita	7 (a)	$602 602 602 602	Major pilot plant using available refinery experience. Industrial health aspects being carefully monitored by Exxon.
3.	Synthoil Bruceton, Pa.	2nd Qtr, 1979	J. Evans D. Telesca R. Tanita J. Bochinski J. Cooperman	3 (b)	$228 228 228 228 228	Some interesting technological differences. CIA interest.
4.	Slagging Gasifier Ponca City, Okla.	3rd Qtr, 1979	J. Evans D. Telesca R. Tanita	7	$666 666 666	Major demonstration plant. Design for process of immediate interest.
	GASIFIERS IN INDUSTRY					
1.	University of Minnesota Duluth, Minn.	2nd Qtr, 1979	J. Evans D. Telesca R. Tanita	5	$496 496 496	Gasifiers in Industry Program. Has extensive industrial hygiene investigation. Has new control technology.
2.	Pike County Project Pikeville, Ky.	3rd Qtr, 1979	D. Telesca	5	$366	Second Gasifiers in Industry unit. Extensive industrial hygiene investigation by ORNL.

TABLE VI, cont'd

	Site	Approximate Date	Personnel	Length of Trip/Days	Cost*	Remarks
	ANALOGOUS PROCESSES					
1.	W. R. Grace & Co. Memphis, Tenn.	2nd Qtr, 1979	J. Evans D. Telesca R. Tanita	6	$480 480 480	Major medium-Btu design plant. Also site of analogous process--ammonia plant.
2.	Exxon Refinery Baytown, Texas	4th Qtr, 1979	J. Evans D. Telesca D. Cubit R. Tanita	7 (a)	$350 HAF** 350 350 350	Major refinery.
3.	Cities Service Lake Charles, La.	1st Qtr, 1980	J. Evans D. Telesca D. Cubit R. Tanita	6 (f)	$572 572 572 572	Major refinery. Uses H-Oil hydrofining technology.
	MEDIUM-BTU					
1.	Illinois Coal Gasification Chicago, Illinois	2nd Qtr, 1979	J. Evans D. Telesca R. Tanita	5	$424 424 424	"Large-scale" Lurgi gasification unit. Of interest to CIA study.
	COMMERCIAL GASIFICATION					
1.	ANG Plant (Lummus) Detroit, Mich.	3rd Qtr, 1979	J. Evans D. Telesca R. Tanita	4	$320 320 320	Plant construction to have begun in 1979. Detailed design should be advanced. Anticipate same outstanding cooperation shown in past.
	OTHER					
1.	COSTEAM Grand Forks, N.D.	3rd Qtr, 1979	D. Telesca R. Tanita	3 (d)	$396 396	Process of potential economic interest.
2.	SRL Grand Forks, N.D.	3rd Qtr, 1979	D. Telesca R. Tanita	2 (d)	$100 HAF 100	Process of potential economic interest. Some interesting technological differences were identified here. Of CIA interest.
3.	Slagging Lurgi Grand Forks, N.D.	3rd Qtr, 1979	D. Telesca R. Tanita	2 (d)	$100 HAF 100	Only operating Lurgi unit in U.S.A. May be part of industrial hygiene program.
4.	Solvent Precipitation Cresap, W.Va.	2nd Qtr, 1979	D. Telesca	--	Costed on previous trips	Will inspect while at Cresap.
5.	Filter Construction, SRC Ft. Lewis, Wash.	1st Qtr, 1979	D. Telesca	--	Costed on previous trips	Will inspect while at Ft. Lewis.
6.	Solvent Precipitation, SRC Ft. Lewis, Wash.	1st Qtr, 1979	D. Telesca	--	Costed on previous trips	Will inspect while at Ft. Lewis.
7.	SRC II, Gulf Minerals Denver, Colo.	1st Qtr, 1980	J. Evans D. Telesca R. Tanita	3	$444 444 444	Important major effort of technology, currently of interest. Will correlate this work with Ft. Lewis pilot plant information. Expect major innovations in CIA technology because of Gulf interest in occupational health. Demonstration unit.

	Site	Approximate Date	Personnel	Length of Trip/Days	Cost*	Remarks
8.	Synthane Bruceton, Pa.	2nd Qtr, 1979	J. Evans D. Telesca R. Tanita J. Bochinski J. Cooperman	3 (b)	$150 NAF 150 150 150 150	Extensive operating experience. Part of industrial hygiene program. Typical tar-producing fluid-bed gasifier.
9.	H-Coal Hydroprocessing Lake Charles, La.	1st Qtr, 1980	J. Evans D. Telesca D. Cubit R. Tanita	6 (f)	$300 NAF 300 300 300	H-Oil process similar to H-Coal. Inspection will enable ECI to compare commercial facility with pilot plant.
10.	Screw Feeder, GE Schenectady, N.Y.	3rd Qtr, 1979	J. Evans R. Tanita	2	$214 214	Under test. One of the few operating on-demand units in U.S.A. Good industrial hygiene program. Innovative CIA program. Proven new gasifier coal feeding mechanism. Gasifier similar to Lurgi.
11.	C. F. Braun Alhambra, Calif.	4th Qtr, 1979	(c)	(c)	4 man team	Have been DOE advisors in gasification. Will have excellent CIA information background.
12.	Texaco Refinery Wilmington, Calif.	4th Qtr, 1979	(c)	(c)	$1,014 per man	Operating refinery and research and development center. Discuss CIA for control technology.
13.	R. M. Parsons Pasadena, Calif.	4th Qtr, 1979	(c)	(c)		Parsons has been dealing with liquefaction since 1961. Especially knowledgeable about materials. Developed the first of the released development designs.
14.	Occidental Oil	4th Qtr, 1979	(c)	(c)		Occidental Research Corporation (ORC) is a wholly-owned subsidiary of Occidental Petroleum Corporation. Will discuss the ORC process for flash pyrolysis coal liquefaction.
15.	HESCO Los Angeles, Calif.	4th Qtr, 1979	(c)	(c)		Working with Fluor on the coal gasification project at Four Corners, N.M.
16.	Fluor Engineers & Constructors Irvine, Calif.	4th Qtr, 1979	(c)	(c)		Fluor has on-site experience in design of 2 major gasification projects plus the experience of operating Cresap and the designing of prototype plants. Anticipate major CIA contribution.
17.	Rockwell International Rocketdyne Div. Canoga Park, Calif.	4th Qtr, 1979	(c)	(c)		Space technology approach for coal gasification (flash hydropyrolysis).
18.	Dravo Pittsburgh, Pa.	2nd Qtr, 1979	J. Evans D Telesca R. Tanita J. Bochinski J. Cooperman	2 (e)	$178 178 178 178 178	Major demonstration plant design. Will combine with effort to obtain information on COALCON and low-Btu processes.
19.	Bi-Gas Homer City, Pa.	2nd Qtr, 1979	J. Evans D. Telesca R. Tanita J. Bochinski J. Cooperman	2 (e)	$100 NAF 100 100 100 100	Complete plant operation. A major facility containing most unit operations.

TABLE VI, cont'd

	Site	Approximate Date	Personnel	Length of Trip/Days	Cost*	Remarks
20.	Glen-Gery York, Pa.	2nd Qtr, 1979	D. Telesca R. Tanita	2	$100 100	Gasifiers in industry plant contains new control technology. Anthracite gasification. Could prove popular.
21.	Europe	3rd Qtr, 1979	J. Evans D. Telesca R. Tanita	15	$1,696 1,696 1,696	Visit to: (1) Schwarze Pumpe, East Germany. Visit to operating Lurgi gasifier. Reports indicate that East Germans have improved operations more than West German and SASOL counterparts. (2) Kosovo Coal Gasification Plant, Yugoslavia. Self-taught group. Have ongoing relationship with DOE. (3) International Coal Conversion Agency, Paris, France. Recommended by DOE for up-to-date information of European projects.

(a) Combined trip. Team will stay in Baytown, Texas, over weekend. Length of trip--14 days. Weekend per diem. One airfare for trip.
(b) Combined trip. One airfare for trip. Total length of trip--6 days.
(c) Combined trip. Team will stay in Los Angeles over weekend. Length of trip--12 days. Four man team--J. Evans, D. Telesca, D. Cubit, R. Tanita--will visit Fluor and WESCO. After Fluor visit group will break up into 2 two-man teams and visit the remaining sites. Weekend per diem. One airfare for trip.
(d) Combined trip. One airfare for trip. Total length of trip--7 days.
(e) Combined trip. One airfare for trip. Total length of trip--4 days.
(f) Combined trip. One airfare for trip. Total length of trip--10 days.

*Cost includes travel, per diem including travel time, and local travel only.
**NAF = no airfare.

V. ANALYTICAL PROCEDURES

The procedures which are being used for the analyses of samples taken for the control technology assessment for coal gasification and liquefaction processes are described in detail in the report, "Sampling and Analytical Procedures for the Industrial Hygiene Characterization of Coal Gasification and Liquefaction Pilot Plants."

This report, which will be periodically reviewed and updated, was prepared for Contracts 210-78-0101, "A Study of Liquefaction Processes," and contract 210-78-0040, "Industrial Hygiene Characterization of Coal Gasification Plants."

VI. LITERATURE REVIEWS

Literature reviews are being conducted under contracts 210-78-0101, "A Study of Coal Liquefaction Processes," which is an industrial hygiene characterization of coal liquefaction plants, and contract 210-78-0040, "Industrial Hygiene Characterization of Coal Gasification Plants."

Since these surveys also serve as a general background for the present study, copies will be forwarded to the CTA project offices when the surveys are completed. An ongoing survey of literature pertaining to relevant process and control technology will continue over the life of the control technology assessment.

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