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CROW TRIBE
OF
INDIANS

SYNFUELS FEASIBILITY STUDY

VOLUME IV

PART B: HEALTH AND SAFETY
PART C: SOCIOECONOMICS

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VOLUME IV

PART B: HEALTH AND SAFETY
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PART C: SOCIOECONOMICS

SECTION B
HEALTH AND SAFETY ASSESSMENT

1.0 INTRODUCTION

This health and safety assessment is developed in support of the Synfuels Feasibility Study for the Crow Tribe of Indians. It identifies and assesses potential worker health and safety hazards and recommends control strategies including engineered controls, work practices and protective equipment to prevent or minimize these hazards.

The proposed plant is in the preliminary stage of development; therefore, this assessment is limited to providing a basis for control strategies. It is premature to list specific control methods since equipment, operating procedures, and staff organization are not formalized.

This assessment is based on a review of the Process Design Basis (ref 1) and technical information in the literature. The proposed plant has many process units which are similar to those currently operating in petroleum refineries with proven records of safe operation. However, there may be a potential for greater numbers and higher concentrations of toxic substances in the gasifier.

Relevant technical information regarding occupational health and safety hazards and control measures for synfuels plants similar to the one under consideration is based on experience with commercial and pilot plants.

This assessment highlights potential health and safety hazards in synfuels plants which include toxic gases, potential carcinogenic substances, and harmful physical agents. However, these potential hazards can be effectively mitigated by engineered controls and work practices.

1.0 (Continued)

Health and safety studies identifying the potential risks and the methods of mitigating these risks will be established during the detailed engineering phase of the work. Additionally, Sasol can provide health and safety technical expertise and information, as part of the licensing agreement.

In addition to informing the client of potential hazards and control strategies, this assessment can facilitate responses on health and safety to concerned outside parties such as labor organizations, permitting agencies, technical societies, and the general public concerned with protecting the environment.

This assessment indicates that workers at the proposed Crow Tribe of Indians Synfuels plant can be effectively protected from health and safety hazards by integrating the control measures presented in Sections 7.0 and 8.0. The selection and implementation of these integrated controls will be dictated by a combination of economics, feasibility and effectiveness.

2.0 SUMMARY

The objective of this health and safety assessment is to provide necessary information for consideration in the engineering design of the proposed synfuels plant. By effectively reducing the potential hazards to workers in the early stages of plant design and development, the risk of adverse health and safety effects can be substantially lowered. This is a worthwhile objective for plant personnel providing benefits to the client in the form of; reduced liability due to decreased litigation and reduced insurance premiums, higher productivity arising from fewer plant shutdowns, lower absenteeism and labor turnover rates and decreased medical and health care costs due to less injury and illness.

The information included in this assessment provides a basis for integrating engineered controls into the design and layout of the plant. Also, it can be useful in selecting process and safety equipment which respond to health needs, and in identifying staffing requirements for health and safety personnel.

A review of the Occupational Health and Safety Administration (OSHA) regulations was undertaken. These are the only regulations applicable to the proposed plant. There are also recommendations, guidelines, codes and standards developed by government and industrial organizations which are taken into account in this assessment.

Another input to the assessment is a review of the available health and safety data base. Potential health and safety hazards are identified according to the various process units of the plant. In addition, health and safety effects are explained for each of the hazards.

2.0 (Continued)

Based on the above inputs, controls to prevent or mitigate the potential hazards are recommended. Health and safety related controls are discussed and summarized in terms of design considerations, plant layout and reliability analyses.

Work practices that supplement engineered controls are divided into special procedures, administrative controls, personal protection equipment, and medical surveillance and monitoring. In each case, the special requirements are identified and solutions proposed. Emergency considerations are also addressed.

3.0 SCOPE OF WORK

The Lurgi coal gasification process generates emissions which are different from those associated with more conventional plants. A few of the emissions contain potentially hazardous materials. It is imperative that the plant designer recognizes that although these potential hazards to personal health are not yet well documented and defined, control equipment and methods to protect operating personnel must be included in the plant design. However, most of the hazards are commonly found in petroleum refineries and chemical processing plants. In addition, the only truly unique equipment found in the synfuels plant is the gasifier vessel and accessories. The operating record of Lurgi coal gasification plants has equalled that of most heavy industries over the past decade.

3.1 HEALTH

The health assessment will include the following items:

(1) A review of applicable federal, tribal, state and local health regulations; review of codes and guidelines from allied industries such as petroleum refining, petrochemical, coal mining and conversion processes.

(2) A review of control measures currently in use, including published judgements on their effectiveness. This information may be taken from National Institute for Occupational Safety and Health (NIOSH) health studies, coke oven operations, coal liquefaction units, the CRESAP pilot plant facility in West Virginia, and commercial-scale plants in South Africa.

3.1 (Continued)

(3) A technical description of the various health control measures that are included in the plant design. These include engineered control, work practices, protective clothing, sanitation, workplace and personnel monitors, as well as surveillance and record keeping.

(4) A review of physical contact with, or inhalation of potentially hazardous or toxic products, emissions or effluents.

(5) A review of exposure to vibration or noise in specific areas within the plant.

3.2 SAFETY

The safety assessment will include:

(1) A description of both general and specific safety control measures to be implemented during construction and operation phases of the synfuels plant. These measures include engineered controls, work practices and procedures, monitoring, noise control, protective clothing and equipment.

(2) Review of physical contact with hot equipment or corrosive materials.

4.0 FACILITY DESCRIPTION

The plant is a complete "grass roots" facility for the conversion of coal into consumer energy products, primarily pipeline quality substitute natural gas (SNG) and electrical power for export. Coal from either the Westmoreland Mine or the proposed Shell mine and raw water from the Bighorn River are the only natural resource materials used in the plant.

The coal gasification and by-products treating processes are licensed by Lurgi and have been successfully demonstrated on a commercial scale in South Africa. The methanation process is also based on Lurgi technology. The off-site and utility systems for this plant are all based on commercially proven technology.

The plant uses the best available control technology to protect the local environment. Particulate matter and sulfur oxides are removed from flue gases; coal dust is contained within closed conveying and storage systems. The plant water management system is designed to achieve zero effluent discharge. Solid wastes from the plant are made suitable for safe disposal as landfill. Mechanical equipment is designed for low noise operation to maintain the relatively quiet local environment.

4.1 PROCESS DESCRIPTION

Coal enters the plant at the Coal Screening Unit which classifies and distributes the as-received coal to provide sized coal (2 inch x 1/4 inch) for feed to Lurgi gasifiers and coal fines (less than 1/4 inch) for boiler fuel.

Coal is gasified by reaction with steam and oxygen. The resultant gas is cooled and combined with gas produced in the Texaco Partial Oxidation Unit. The combined stream is reacted in a Lurgi Shift Conversion Unit to generate additional hydrogen by the reaction $CO + H_2O = CO_2 + H_2$. The Shift Conversion Unit produces the proper H_2-to-CO ratio for the methane synthesis reaction.

4.1 (Continued)

The shifted gas is cooled, condensing steam and hydrocarbons. Products from the gas cooling area are a liquid stream called "gas liquor" containing water, phenols, tars, oils, and naphtha and a "raw gas" containing hydrogen, carbon monoxide, carbon dioxide, sulfur compounds, methane and light hydrocarbons.

In the Gas Purification area, the Lurgi modified Selective Rectisol Unit condenses naphtha and removes carbon dioxide and sulfur compounds from the raw gas. Products from the Gas Purification area are a pure gas for methanation, naphtha which is hydrotreated for sale as a potential gasoline blending component, and two effluent streams; a CO_2-rich acid gas stream containing the sulfur and light hydrocarbon compounds and an H_2S rich acid gas stream containing CO_2 and light hydrocarbons.

A Lurgi Methanation Unit reacts carbon monoxide, carbon dioxide and hydrogen in the pure gas to produce methane. An excess of carbon dioxide is fed to the Methanation Unit and is removed in the SNG Purification and Compression Unit. The resultant product "SNG" is compressed to pipeline delivery pressure.

The gas liquor produced in the Gas Cooling Unit flows to the Lurgi Gas-Liquor Separation Unit where gas-liquor is separated into aqueous and hydrocarbon streams. The hydrocarbon water stream flows to the Tar Distillation Unit for further processing. The aqueous stream flows to the Phenosolvan Unit. The phenols are extracted and sent to the Texaco Partial Oxidation Unit. The aqueous stream, after phenol removal, flows to the U.S. Steel Ammonia Recovery Unit where ammonia is recovered and purified to produce a saleable by-product.

4.1 (Continued)

The Tar Distillation Unit separates the hydrocarbon stream containing tars, oils, and naphtha into a naphtha stream sent to the Naphtha Hydrotreating Unit and a tar/oil stream sent to the Texaco Partial Oxidation Unit. The Lurgi Naphtha Hydrotreating Unit hydrotreats the naphtha recovered in the Rectisol and Tar Distillation Units to reduce the sulfur, oxygen, nitrogen and reactive unsaturated hydrocarbon content of the naphtha. The naphtha product is suitable for use as gasoline blending component.

In the Partial Oxidation Unit the phenols, tar and oil are reacted with oxygen to produce additional "raw" synthesis gas. This gas is sent to the Shift Conversion Unit. The H_2S rich acid gas stream from the Rectisol Unit is enriched in H_2S content in a Shell ADIP Unit and processed in a Claus Unit for sulfur recovery. The Claus Unit off-gas is processed in a Shell SCOT Unit and flows to a Peabody-Holmes designed Stretford Unit for by-product sulfur recovery. The CO_2-rich acid gas stream from the Rectisol Unit is also processed in the Stretford Unit. The Sulfur Recovery Unit off-gas containing some hydrocarbons and unreacted sulfur compounds is incinerated in the Steam Superheating Unit to convert these compounds to carbon dioxide and to sulfur dioxide. The flue gas is discharged to the atmosphere.

4.1.2 UTILITIES AND OFFSITES

Coal fines are sent to the coal fired steam boilers where 1500 psig superheated steam is generated. The steam flows to the power generation unit where steam turbine driven generators produce the total power requirement for the plant plus surplus power for sale.

The boiler flue gas is treated for sulfur removal using lime in a Davy McKee Saarberg-Hoelter Desulfurization Unit. A flue gas containing a low concentration of SO_2 is produced and a nonhazardous gypsum sludge suitable for landfill is recovered.

4.1.2 (Continued)

The plant water management system is based on a zero liquid discharge philosophy. The aqueous streams generated in the facilities are processed in an activated sludge treatment system. The Process Cooling Towers are designed to evaporate the treated wastewater.

The balance of the utility and offsite units are similar to conventional refinery systems. Therefore, they are not described in this section.

5.0 REVIEW OF OCCUPATIONAL HEALTH AND SAFETY REGULATIONS AND GUIDELINES

5.1 INTRODUCTION

This section discusses occupational health and safety regulations and guidelines applicable to the proposed plant. Federal Occupational Safety and Health Administration (OSHA) standards are the only regulatory requirements pertinent to this project with regard to occupational health and safety. This section also discusses National Institute for Occupational Safety and Health (NIOSH) guidelines and industrial guidelines. Since OSHA regulations, NIOSH, and industrial guidelines periodically change, they will be reviewed again during the detailed engineering phase of the work.

5.2 DISCUSSION OF REGULATIONS

OSHA, an agency of the U.S. Department of Labor, is responsible for monitoring work environments in the U.S. for compliance with safety and health standards. In some cases state and local governments share responsibility for administering occupational health and safety standards. Approximately one-third of the states have requested authority for workplace inspections and other activities be delegated to them. Delegation of authority is granted only after a detailed plan of implementation at the state level is developed and approved by OSHA.

The Federal OSHA Office in Billings, Montana, was contacted to obtain a summary of applicable occupational health and safety regulations. OSHA personnel stated that it is the only governmental agency authorized to promulgate and enforce health and safety standards applicable to the synfuels plant, since the state has not requested to be delegated this authority (ref. 2). OSHA compliance inspections can be expected once or twice per year.

5.2 (Continued)

OSHA standards applicable to the design and operation of the plant are found in the Federal General Industry Standards (ref. 3). The Standards applicable to the construction of the plant are found in the Federal Construction Standards (ref. 4).

All industries and construction projects must comply with the above standards. Tables 5-1 and 5-2 summarize the major standards impacting plant design, construction and operation. OSHA has no current plans to promulgate specific standards for the coal gasification industry (ref. 2).

5.3 DISCUSSION OF GUIDELINES

5.3.1 NIOSH Guidelines

NIOSH is an agency of the U.S. Department of Health and Human Services which develops and recommends standards to OSHA. NIOSH has addressed and continues to study potential hazards related to coal gasification plants and has published several documents on which to base possible future standards (refs.5 and 6).

NIOSH's recommendations do not have the force or effect of law, however, they can serve as guidelines in the design and operation of the proposed plant. These guidelines have been reviewed in preparing the Identification and Assessment section.

5.3.2 Industrial Guidelines

Several industrial organizations such as the American Society of Mechanical Engineers (ASME), the American National Standards Institute (ANSI), the National Fire Protection Association (NFPA), the American Petroleum Institute (API), and the National Gas Processors Supplies Association (NGPSA), have developed codes and standards based on industrial experience. These industrial codes are recommended practices although compliance is voluntary. Many OSHA standards have been adopted from these industrial codes. Appendix A summarizes the major agencies and organizations whose standards or codes are relevant to the proposed gasification process.

Although only a small portion of all industrial codes have been adopted by OSHA, compliance with applicable industrial codes is essential to avoid criminal negligence suits if major accidents occur. Incorporating industrial recommendations and other self-imposed rules of conduct enhances the reliability of the plant and the welfare of its workers.

5.3.3 Revisions and Additions to Existing Regulations

OSHA regulations periodically change due to factors such as political climate, lobbying by labor groups, new health and safety data or litigation. Therefore, it is necessary to review and update all pending or proposed regulations as well as existing regulations before beginning detailed engineering.

Information on current, pending and proposed OSHA regulations is obtained by contacting the OSHA Public Information Office in Washington, D.C. (ref. 27).

5.3.4 General Duty Clause

The Occupational Safety and Health Act (ref. 8), which established OSHA, contains a general duty clause - Section 5 (a) (ref. 1). This clause states:

> "Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees."

The ramification/implication of this clause is that the employer is also responsible for protecting his workers from all potential safety and health hazards for which no OSHA standard exists, but are recognized within the industry.

5.3.5 Selected OSHA Regulations

Tables 5-1 and 5-2 list current OSHA regulations that will or may have a major impact on the design, construction and operation of the proposed plant.

TABLE 5-1

SELECTED OSHA REGULATIONS IMPACTING THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY*

Regulation Designation	Title of Regulation	Description of Applicable Regulation
Subpart A	General	Assigns basic responsibility of occupational health and safety to the employer - that no employee is required to work in surroundings or under conditions detrimental to the employees welfare.
Subpart C	General Safety and Health Provisions	
1910.20	Access to employee exposure and medical records	This standard requires an employer who maintains or contracts for employee medical records to preserve those records. These medical records include (1) information indicative of employee exposures to toxic materials or harmful physical agents, (2) results of medical examinations and laboratory tests, (3) any opinions or recommendations of a physician or other health professionals, (4) and

*These regulations are from the OSHA General Industry Standards, 29 CFR 1910.

TABLE 5-1 (Continued)

SELECTED OSHA REGULATIONS IMPACTING THE CROW TRIBE OF INDIANS
SYNFUELS FEASIBILITY STUDY

Regulation Designation	Title of Regulation	Description of Applicable Regulation
1910.20 (Cont'd)		any employee medical complaints relating to worker exposure. Whenever an employee or designated representative requests access to a record, the employer shall provide access to that employee's medical records in a reasonable time. The employer shall also assure immediate access of representatives of OSHA. Rules of agency practice and procedure governing OSHA access are contained in 29 CFR 1913.10. This subpart also has rules on the transfer of medical records when an employer ceases to do business. The employer shall either transfer these records to the successor employer or preserve these records for thirty years.

TABLE 5-1 (Continued)

SELECTED OSHA REGULATIONS IMPACTING THE CROW TRIBE OF INDIANS
SYNFUELS FEASIBILITY STUDY

Regulation Designation	Title of Regulation	Description of Applicable Regulation
Subpart G	Occupational Health and Environmental Control	
1910.94	Ventilation	This standard lists many ventilation standards for operations such as grinding, polishing, abrasive blasting, spray finishing and degreasing solvent handling. Generally, the maintenance and post-startup construction will be impacting by this standard. This standard essentially lists some of the requirements for the equipment used to maintain the air contaminant standards listed in 1910.1000.
1910.95	Occupational noise exposure	This standard has been recently amended to include a hearing conservation program which requires: (1) providing personal protection devices to all employees exposed to a TWA* of

*TWA - time weighted average for an eight hour period.

TABLE 5-1 (Continued)

SELECTED OSHA REGULATIONS IMPACTING THE CROW TRIBE OF INDIANS
SYNFUELS FEASIBILITY STUDY

Regulation Designation	Title of Regulation	Description of Applicable Regulation
1910.95 (Cont'd)		85 dBA or greater, (ref. 2) monitoring the work place for noise when information indicates that any employee exposure may equal or exceed 85 dBA or above and (ref. 5) an audiometer testing program for all employees exposed to a TWA of 85 dBA or above and maintaining records of work place and personal noise exposure measurements. Sound frequency is considered in audio measurements. Additionally, this standard lists permissible duration times for sound levels over 90 dBA.
1910.96	Ionizing radiation	This standard will apply to radiation producing equipment or sources such as x-ray machines used for nondestructive testing, or radiation sources such as radiocobalt for radiography.
1910.97	Non-ionizing radiation	This standard will apply to radiation sources such as microwave equipment.

TABLE 5-1 (Continued)

SELECTED OSHA REGULATIONS IMPACTING THE CROW TRIBE OF INDIANS
SYNFUELS FEASIBILITY STUDY

Regulation Designation	Title of Regulation	Description of Applicable Regulation
Subpart H	Hazardous materials	This subpart lists standards for handling hazardous materials such as, acetylene, hydrogen, flammable liquids, and anhydrous ammonia.
Subpart J	Personal Protective Equipment	This subpart lists general standards for personal protective equipment such as safety glasses, respirators, hard hats and safety shoes. The employer will be responsible for supplying these protective devices.
Subpart K	Medical and First Aid	This subpart requires the employer to ensure the ready availability of medical personnel for advice and consultation on matters of personal health.
Subpart L	Fire Protection	This subpart lists general standards for common fire protection equipment such as extinguishers, sprinklers, hose systems and signaling systems. This subpart draws extensively from NFPA Standards.
Subpart N	Material Handling and Storage	The particular significance of this subpart is the standards applicable to overhead and gantry cranes which

TABLE 5-1 (Continued)

SELECTED OSHA REGULATIONS IMPACTING THE CROW TRIBE OF INDIANS
SYNFUELS FEASIBILITY STUDY

Regulation Designation	Title of Regulation	Description of Applicable Regulation
Subpart N (Cont'd)		may be a part of foreign licensor's packaged engineering designs. Lurgi gasifiers usually have built-in lifting devices to facilitate maintenance. The lifting devices on foreign designed process units will be required to meet U.S. OSHA Standards.
Subpart Z	Toxic and Hazardous Substances	
1910.1000	Air Contaminants	This section defines exposure criteria as well as listing quantitative exposure standards for air contaminants such as CO, H_2S and coal dust. The complete list, Table Z-1, is quite extensive. Generally, these exposure standards are the average minimum levels that produce measurable effects on humans. This list of air contaminants and corresponding exposure standards should serve as guidelines for incorporating engineered controls into the plant design.

TABLE 5-1 (Continued)

SELECTED OSHA REGULATIONS IMPACTING THE CROW TRIBE OF INDIANS
SYNFUELS FEASIBILITY STUDY

Regulation Designation	Title of Regulation	Description of Applicable Regulation
1910.1029	Coke oven emissions	Coal gasification is similar to coke production. Although this standard applies to the operation of coke ovens, the relative similarity of producing coke by destructively distilling and carbonizing coal to coal gasification gives this standard greater importance in the absence of specific coal gasification standards. This standard should provide operators of coal gasification units a guideline for operating and maintaining these units.

TABLE 5-2

SELECTED OSHA REGULATIONS IMPACTING THE CONSTRUCTION OF THE CROW TRIBE OF INDIANS SYNFUELS FACILITY*

Regulation No.	Title of Regulation	Description of Applicable Regulation
Subpart A	General	
1916.3	Inspections - right of entry	This section gives the Secretary of Labor or any authorized representative the right of entry to any site of construction to inspect a facility for compliance with the safety and health standards.
Subpart C	General Safety and Health Provisions	
1926.21	Safety training and education	Requires construction contractors to establish and supervise programs for the education and training of employees in the recognition, avoidance and prevention of unsafe conditions. Employees required to handle or use harmful substances shall be instructed regarding their safe handling and use, and be made aware of the potential hazards, personal

*These regulations are from the OSHA Construction Standards, 29 CFR 1926.

TABLE 5-2 (Continued)

SELECTED OSHA REGULATIONS IMPACTING THE CONSTRUCTION OF THE CROW TRIBE OF INDIANS SYNFUELS FACILITY

Regulation No.	Title of Regulation	Description of Applicable Regulation
1926.21 (Cont'd)		hygiene and personal protective measures required. All employees required to enter into confined or enclosed spaces shall be instructed as to the nature of hazards involved, the necessary precautions to be taken and in the use of protective and emergency equipment required.
Subpart D	Occupational Health and Environmental Controls	The subpart is similar to Subpart G in the General Industry Standards. It lists requirements for medical services and first aid, vermin control, employee food service facilities and radiation exposure protection.
1926.52	Occupational noise exposure	Refer to 1910.94
1926.55	Gases, vapors, fumes, dusts and mists	Refer to 1910.1000

TABLE 5-2 (Continued)

SELECTED OSHA REGULATIONS IMPACTING THE CONSTRUCTION OF THE CROW TRIBE OF INDIANS SYNFUELS FACILITY

Regulation No.	Title of Regulation	Description of Applicable Regulation
Subpart E	Personal Protective and Life Saving Equipment	This subpart lists requirements for personal protective devices such as goggles, face shields, respirators, safety belts, lifelines and landyards. This subpart also lists requirements for temporary heating devices.

6.0 IDENTIFICATION AND ASSESSMENT OF POTENTIAL HEALTH AND SAFETY HAZARDS

6.1 INTRODUCTION

This section discusses .d summarizes potential occupational health and safety hazards associated with the proposed facility. Potential hazards are addressed according to a unit process number sequence established by Fluor's design basis (ref. 1). An attempt is made to subdivide the potential hazards into worker health and worker safety categories. The basis for this subdivision is that health hazards are generally related to discernible disease stresses, that is, imbalances or disruptions of regulatory mechanisms responsible for smooth and effective organ functioning. Safety hazards generally involve harm to workers that may be of an immediate and/or violent nature and are generally related to accidents and injuries. These include burns, electrical shocks, cuts, bruises, sprains, broken bones, loss of limbs, eyes and hearing. It is noted that in some cases a specific health hazard may lead to a safety hazard or sometimes the converse may be true. For example, both health and safety hazards exist for hydrogen sulfide. It is an acute toxic hazard (inhalation of 1000-2000 ppm may be fatal after a single breath) but in higher concentrations (4.3 vol percent is the lower explosive limit), it is also a potential explosive hazard.

In general, the potential health and safety hazards in the synfuels plant results from leaks, spills and fugitive emissions during operation, maintenance or sampling. Many of the potential exposures are similar to those experienced in the petroleum and petrochemical industries. In coal gasification facilities, the main products are methane, carbon monoxide, hydrogen, and carbon dioxide. Low concentrations of straight chain hydrocarbons, polynuclear aromatic hydrocarbons (PNA's) and heterocyclic aromatic compounds are also formed during the coal gasification process. PNA's and heterocyclic aromatic compounds are derived from a combination of the complex chemical structure of coal and the gasification conditions. These

6.1 (Continued)

compounds are suspected of being carcinogenic. The SASOL I Plant in South Africa is a more complex petrochemical facility than the proposed synfuels plant, yet it has operated successfully without any reported adverse health impacts. Nevertheless, this assessment will address the potential health hazards due to the presence of suspected carcinogens and toxic substances.

Table 6-1 summarizes the general health and safety hazards to which workers may be exposed in the key process unit areas of the proposed plant. Table 6-2 is a comprehensive summary of potential health and safety hazards and their effects according to process unit number. A discussion of the health hazards is presented and is followed by a similar discussion of safety hazards.

6.2 HEALTH HAZARDS

Health hazards in the proposed plant are exposure to chemical and physical agents. Chemical agents consist of:

(1) solids including coal and catalyst dust, ash, spent catalyst, sludges, spent activated carbon or ion exchange resin, sulfur, inorganic salts.

(2) liquids including tars, oils, gas-liquor, naphthas, filter backwash, filtrates, phenols, and methanol.

(3) gases and vapors including carbon monoxide, carbon disulfide, carbon dioxide, hydrogen sulfide, ammonia, hydrogen, nitrogen oxides, methanol, and hydrogen chloride and organic vapors.

Physical agents include: noise, ionizing or nonionizing radiation, asphyxiants, heat, and cold.

TABLE 6-1

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH & SAFETY HAZARDS IN THE CROW TRIBE OF INDIANS SYNFUELS PLANT
(by Major Process Area)

Potential Health & Safety Hazards	MAJOR PROCESS AREA					
	Coal Handling & Preparation	Coal Gasification	Ash Removal	Tar Removal	Acid Gas Removal	Product Upgrading
HEALTH						
Coal Dust	X	X				
Catalyst Dust						X
Tars & Oils		X		X		
Carbon Monoxide	X	X			X	
Hydrogen Sulfide				X		
Gas-Liquor				X		
Inert Gases	X	X				
Noise	X	X				
SAFETY						
Fire/ Explosion	X	X		X	X	X
Heat		X	X			

6.2 (Continued)

Chemical and physical agents that may be present in a specific process unit, and for which OSHA standards exist, are summarized in Table 6-3. Table 6-4 is a list of trace elements typically found in coal (ref. 5) and for which OSHA standards exist (ref. 3). The presence and concentration of trace elements will depend on such factors as coal type, location in coal seam, and the process conditions. The concentration of trace elements in the atmosphere should present a minimal health risk to plant personnel. Some potential hazardous substances do not have OSHA standards. In some of these cases, NIOSH recommendations or threshold limit values of the American Conference of Governmental Industrial Hygienists should be consulted (refs. 9, 10). In other cases, no standards or guidelines exist. In these cases. For example, in the case of PNA's which are suspected carcinogens, the coal for exposure should be as low as practical.

The only published study indicating adverse worker health effects in a synfuels plant comes from information collected at Institute, West Virginia in the early 1950's (refs. 5, 10). This plant was a high pressure direct coal liquefaction facility. Although the West Virginia process differs significantly from the proposed plant, some of the chemical substances produced may result in similar potential health hazards. Skin cancers were reported for ten workers in the West Virginia facility at an incidence rate significantly higher than expected in the general population. However, it was noted that the workers in this plant did not maintain good personal hygiene practices. Comprehensive industrial hygiene measures, as used today in all U.S. synfuels pilot plants, were not implemented in the West Virginia plant until after the cancers were identified. The data does suggest a risk of skin cancers (ref. 10). However, a follow-up study reported by NIOSH (ref. 10) suggested that the West Virginia workers did not have an increased risk of systemic cancer, which was the original reason for conducting the study. The only other available evidence of increased cancer risk to coal gasification workers are from the studies of

6.2 (Continued)

coke oven and gas workers where similar kinds and concentrations of chemicals were emitted to the work environment (refs. 5, 10). However, in these cases the emissions were not contained as they would be during normal operation in the proposed plant.

Current industrial hygiene practices that have been employed in coal gasification and liquefaction pilot plants in the U.S. appear to be successful. No adverse health effects have been reported to date.

Coal gasification facilities may have higher concentrations of potentially carcinogenic substances than in the petroleum industry. However, with good engineered controls and work practices, many of the potential hazards are minimized or prevented.

6.3 SAFETY HAZARDS

Safety professionals generally consider the term safety to mean an environment free from man-equipment-material interactions that result in accidents. The term accident has evolved to mean an occurrence leading to physical harm, property damage, or business interruption resulting from an undesired event. Most safety programs address accident prevention in the precontact, contact, and postcontact stages. Preventing accidents during the design stage is a primary goal. However, because of economics and practicalities, not all potential accidents can be addressed at this stage. The contact stage generally involves addressing potential safety issues not incorporated into the engineering designs. Postcontact accident control involves prompt investigation of an accident by identifying the cause and recommending controls to ensure that similar losses are prevented in the future.

Process safety controls are established within the petroleum and petrochemical industries for a broad range of production facilities. Such controls are generally incorporated into the design, construction, and

6.3 (Continued)

operation of chemical process plants. Controls include adherence to piping and vessel codes, material specifications, and operation practices to ensure worker's safety and to maintain process reliability.

In the proposed synfuels plant, the major safety hazards include worker exposure to heat stress, cold, general accidents, and injuries such as those associated with moving equipment and components, fire, and explosion. In addition, some safety hazards always exist because of human error.

Table 6-2 lists the potential occupational health and safety hazards according to process units. Control technologies and investigative actions to prevent or eliminate these hazards are listed in Table 7-1.

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
01 Coal Screening & 02 Coal Distribution	Health		
	Coal Dust	Coal workers' pneumoconiosis "Black Lung," chronic disease caused by accumulation of coal dust in lungs.	11
	Inert Gas	Potential asphyxiation hazard of nitrogen gas if accumulated in confined spaces.	12
	Safety		
	Fire/Explosion	Coal dust represents potential fire and explosion hazards.	5
	Accidents/Injuries	Moving equipment can lead to accidents and injuries.	5
	Noise	Exposure to continuous, impulsive or impact noise from screens, blowers, fans may result in acute or chronic loss of hearing, OSHA limits may be exceeded. Noise also has health implications.	13

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
03 Ash Handling Unit	Health Ash	Consists of gasifier ash, boiler ash, flue gas desulfurization (FGD) sludge, and ash storage/ disposal. Wet gasifier ash may contain high levels of soluble oxides potentially causing worker contact dermatitis. FGD ash may also cause dermatitis.	5
	Noise	See process Unit 01 and 02 above.	13
	Trace Elements	Specific element(s) concentration(s) and length of exposure may cause reverse health effects.	5
	Safety Heat	Hot ash or surfaces during sampling or maintenance could cause burns.	5
		Malfunction of gasifier ash discharge may cause exposure to steam, resulting in thermal burns.	5
10 Coal Gasification	Health Coal Dust Attrition	Dumping coal from conveyor into bunker.	11

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
10 Coal Gasification (Continued)	Gasifier Ash	Repeated contact may cause dermatitis.	5
	Toxic Gases	Gases include hydrogen sulfide (H_2S), ammonia (NH_3), hydrogen cyanide (HCN), carbon monoxide (CO), and carbonyl sulfide (COS) exposure which may cause either acute and/or chronic health effects.	5, 14, 15
	Tars/Oils	Exposure to toxic constituents such as ammonium sulfide, phenols, benzene, toluene, xylene; also contain substances which are suspected carcinogens or mutagens i.e., polynuclear aromatic hydrocarbons (PNA's), N-heterocyclic aromatics and their derivatives.	5, 15
	Trace Elements	See Unit 03.	5
	Safety Heat	Heat stress due to gasifier combustion temperatures that are typically 700-1000°F. Also potential exposure to high pressure steam and product gas.	5

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
	Fire	Combustible hydrocarbon gases from gasifier.	5
	Explosion	Rapid combustion due to increased oxygen concentration. Possibility of lines or valves plugging due to materials cooling.	5
	Noise	See Units 01 and 02; noise problems in this unit may result from gases flowing through pipes, valves and other components, and by compressors. In general, noise hazards are less than Units 01 and 02.	3
11 Shift Conversion	Health Toxic Gases	Includes toxic gases such as CO, H_2S, NH_3, and HCN as well as carbon dioxide (CO_2), hydrogen (H_2), methane (CH_4), ethane (C_2H_4), ethylene (C_2H_2). Polynuclear aromatics may be present at low concentrations.	5
	Catalyst (Confidential) Dust	Exposure to catalyst dust may occur during loading and unloading; respiratory problems, toxicity. Possibility of hazard arising from catalyst decomposition is slight.	1

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
11 Shift Conversion (Continued)	Safety Fire	Presence of hydrogen, hydrocarbons, and carbon monoxide presents some risk of fire, if a leak develops.	5, 16, 1
	Heat	See Unit 10.	5
	Explosion	Methane forms explosive mixtures (with air 1/10 by volume or 1/2 by volume with oxygen). Mixtures of ammonia and air will explode when ignited under some conditions.	16
12 Gas Cooling	Health Toxic Gases	Gases include CO, H_2S, and COS. CO and H_2S may cause acute toxic hazards. The health hazards of carbonyl sulfide are not well known.	1, 14, 15
	Gas Liquor	Skin irritation; also exposure to toxic and potentially carcinogenic materials during maintenance, repair, or spills.	5
	Safety Fire	See Unit 11.	5
	Explosion	See Unit 11.	16, 1
	Heat	See Unit 10.	5

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
13 Rectisol	Health		
	Toxic Gases	See Unit 12.	5
	Organic Vapor	Methanol (MeOH) regeneration could be a source of leaks. Potential neurotoxic, cardiovascular, eye and skin effects; dimethylsulfide is an eye irritant.	5, 16
	Refrigerant Gases	Worker exposure to potential toxic refrigerants during maintenance, repair, leakage.	5
	Safety		
	Fire	CH_4, propylene, H_2S, H_2, flammable gases, and vapors represent potential for fire, if a leak develops.	5
	Cold	Insulation required to avoid low temperatures.	5
	Explosion	Certain gases (CH_4, H_2S) if allowed to concentrate could reach lower explosive limit.	5
	Noise	See Unit 10.	

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
14 Gas-Liquor Separation	Health		
	Gas-Liquor	Contains mostly water; phenols, sulfides, and ammonia are substances workers may be exposed to during maintenance and repair; skin, respiratory irritation.	5, 1, 15
	Tars/Oils	See Unit 10.	5
	Toxic Gases	Include H_2S, CO, CO_2, acute toxic hazards.	5
	Trace Elements	See Unit 3.	5
	Safety		
	Fire	See Unit 11.	5
	Explosion	See Unit 11.	5
15 Tar Distillation	Health		
	Gas-Liquor Oils	See Unit 10.	
	Heavy Tar/Oils	See Unit 10.	
	Tar Naphtha Fraction	See Unit 10.	5
	Safety		
	Fire	Potential fire problem due to naphtha volatiles.	5

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
16 Naphtha Hydrotreating	Health		
	Naphtha Fractions	See Unit 10.	5
	Toxic Gases	Include H_2S, CO, CO_2, ethane, propane, butane; acute toxic hazards.	5, 15
	Organic Vapors	Naphtha (aromatics) - exposure during maintenance, repair, leaks, spills, skin irritation.	5
	Safety		
	Fire & Explosion	Due to presence of hydrogen and methane.	5
17 Phenosolvan	Health		
	Gas-Liquor	See Unit 14.	5, 1
	Organics	Phenols cause skin, eye irritation, burns - also affects liver, kidneys, and central nervous system; iscpropylether (IPE) irritates skin and eyes; anesthesia; crude phenol may contain cresols and xylenols as well as high boiling tar acids which are toxic. Exposure may occur during a leak, maintenance, or plant upset.	16

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
17 Phenosolvan (Continued)	Safety		
	Fire	IPE is flammable; can form explosive peroxides in presence of light.	5
	Heat	Heat stress, thermal burns from steam.	1
18 Ammonia Recovery	Health		
	Gas-Liquor	See Unit 14.	5, 1, 15
	Organic Vapors	See Unit 17.	5, 1, 15
	Toxic Gases	Include H_2S, CO_2; NH_3 acute toxic hazards.	5, 1, 14, 15
		Exposure to ammonia, phenols. Phosphoric acid, sodium hydroxide may cause skin-eye irritation and chemical burns.	16
	Safety		
	Fire	IPE, H_2S.	5, 16
	Explosion	Lower explosive limit H_2S, IPE.	5
	Heat	See Unit 17.	1
19 Sulfur Recovery	Health		
	Toxic Gases	Include H_2S, NH_3, CO_2, CO, C_2-C_4, COS, SO_2; potential inhalation of bauxite dust from Claus process (pulmonary problems).	5, 1, 14, 15

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
19 Sulfur Recovery (Continued)	Contaminants	Methanol in rectisol gas (see Unit 13, methanol). Certain compounds have been identified in the Stretford process whose biological activity is not well documented, including: thiosulfate, sodium meta-vanadate and sodium anthraquinone disulfonate.	17, 18, 19
	Hydrocarbons	Toxic exposure may result from ADIP unit leaks; naphtha.	8
	Safety Fire	H_2S, H_2, fuel gas.	16
20 Vent Gas Incineration	Health Toxic Gases/Vapors	Includes H_2S, CO, COS, CO_2, $C-C_4$ sulfur dioxide (SO_2); acute/chronic toxicity.	1, 14, 15
	Noise	Air blowers are designed not to exceed OSHA limits.	1
	Safety Fire	Presence of H_2, H_2S, fuel gas.	16, 1
21 Methanol Synthesis & Purification	Health Toxic Gases	Include CO, CO_2; acute toxicity; respiratory system.	1, 14, 15

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
21 Methanol Synthesis & Purification (Continued)	Organic Vapors	Methanol, see Unit 13, Alcohols.	5, 16
	Catalyst (Confidential) Dust	Exposure to catalyst dust may occur during loading and unloading; respiratory problems, toxicity.	1
	Safety Fire	Presence of H_2, CH_4, fuel gas, alcohols.	16, 14, 15
	Explosion	Presence of CH_4.	16
	Heat	See Unit 17.	1
22 Methanation	Health Toxic Gases	Includes CO, CO_2, CH_4, H_2; acute toxicity.	1, 14, 15
	Catalyst (Confidential) Dust	Respiratory problem during maintenance, repair, catalyst regeneration. Nickel is the most probable metal catalyst for methanation; which can result in nickel carbonyl, $Ni(CO)_4$; formation problems may arise for a short period on startup or shutdown.	16
	Safety Fire	Due to presence of H_2, CH_4, fuel gas, MeOH.	4, 1, 14, 15

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
22 Methanation (Continued)	Explosion	Due to presence of CH_4, see Unit 11.	16
	Heat	Heat stress due to exposure to high pressure steam for turbines.	1
23 SNG Purification and Compression	Health Toxic Gases	Includes exposure to CO, CO_2; acute toxicity cardiovascular	1, 14, 15
	Safety Fire	Due to presence of H_2, CH_4.	16, 1, 14, 15
	Explosion	Due to presence of CH_4.	16
	Heat	See Unit 22.	1
24 POX	Health Sour Liquid Products	Includes exposure to oil, tar, phenols; naphtha, see Unit 13.	5
	Toxic Gases	Includes exposure to CO, CO_2, H_2S, COS, NH_3, HCN; acute toxicity.	1, 14, 15
	Ash	See Unit 3.	1
	Noise	See Unit 10.	

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
24 POX (Continued)	Safety Fire	Due to presence of H_2, CH_4, H_2S, O_2.	16, 1
	Explosion	Due to presence of H_2S, CH_4, O_2.	16, 1
	Heat	See Unit 17.	1
25 Hydrogen Production	Health Toxic Gases	Includes exposure to CO, CO_2, CH_4.	1, 14, 15
	Safety Fire	Due to presence of H_2, CH_4.	16, 1
40 Oxygen Plant	Health		
	Safety Fire & Explosion	High concentrations of oxygen on create explosion hazard.	16, 1
	Heat	Heat stress due to exposure to high pressure steam; cryogenic hazards.	1
41 Steam Generator	Health Coal Dust	See Unit 1.	11
	Ash	See Unit 3.	5
	Toxic Gases	Exposure to flue gases such as CO_2, SO_2, HC, NO_2.	5

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
41 Steam Generator (Continued)	Water Treatment & Chemicals	Hydrazine hydrate; powerful reducing agent; poison - causes delayed eye irritation; sodium phosphate and skin irritation. Minimal problem in the dilute concentrations normally used.	1
	Safety Heat	See Unit 10.	1
42 Power Generation	Health Electricity	Electric shock.	1
	Safety Accidents	In and around power generation machinery.	
	Heat	Heat stress from high pressure steam.	1
43 Flue Gas Desulfurization	Health Toxic Gases	Exposure includes SO_2, CO_2, NO_2, HC; acute toxicity.	1
	Safety Heat	Potential heat stress, boiler flue gas.	1
44 Raw Water Treating Unit	Health Acid	Contact with sulfuric acid chemical burns.	1

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
44 Raw Water Treating Unit (Continued)	Chemical Dust	Respiratory problems from dusts in using sodium aluminate, polyelectrolytes.	1
	Treatment Chemicals	Skin irritants and chemical burns from sulfuric acid, caustic, detergent, calcium oxide.	1
45 Boiler Feed Water and Condensate Treating	Health Treatment & Cleaning Chemicals	Potential exposure during maintenance, repair, cleaning of treatment units, also see Unit 44.	1
46 Air & Nitrogen Supply	Health Chemical Dusts	Exposure to activated alumina may cause respiratory irritation.	
47 Process Cooling Water	Health Water Treatment Chemicals	Exposure to dispersant chemicals, biocides, corrosion inhibitors, and pH controlers during operation, maintenance and repair may cause irritation, chemical burns.	1
48 Utility Cooling Water	Health Water Treatment Chemicals	See Unit 47.	
49 Potable Water	Health Water Treatment Chemicals	Potential exposure to chlorination chemicals and reverse osmosis preparation chemicals.	1

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
50 Utility Water	Health Water Treatment Chemicals	Potential exposure to biocides may cause skin irritation.	
51 Firewater	Health Chemical Foam	Potential exposure to foam may cause skin irritation.	1
52 Fuel Gas	Health Toxic Gases	Exposure to such gases as CO, CO_2, HC.	1
	Safety Fire	Due to presence of H_2, CH_4.	1
	Explosion	Due to presence of H_2.	1
53 Flare System	Health Toxic Gases/ Vapors	Exposure to such gases as CO, COS, CO_2, NH_3, HC.	1
	Organic Liquids	Includes tar, oil, naphtha, phenols.	
54 Tank Farm and Dispatch	Health Toxic Gases/ Vapors	Exposure to such materials as NH_3, naphtha, crude tars, IPE may result in respiratory irritation.	1
	Tars/Oils	Exposure possible during maintenance, repairs, spills, leaks.	1

TABLE 6-2

SUMMARY OF POTENTIAL OCCUPATIONAL HEALTH AND SAFETY HAZARDS BY PROCESS UNIT NUMBER (Cont'd)

Process Unit Number Function	Potential Occupational Hazards	Health/Safety/General Comments	Reference
54 Tank Farm and Dispatch (Continued)	Safety		
	Fire	Due to volatile materials in storage.	1
	Explosion	Mixtures of ammonia and air will explode when ignited under favorable conditions.	1
	Heat	Heat stress due to hot product storage.	1

TABLE 6-3

OSHA EXPOSURE LIMITS FOR POTENTIAL HAZARDS IN THE CROW TRIBE OF INDIANS SYNFUELS PLANT

COMPOUND (ABBREVIATION IF ANY)	OSHA STANDARD[a][b] PPM	MG/M³	AREA AFFECTED AND/OR HEALTH EFFECTS	PROCESS UNIT WHERE FOUND	REFS
Chemical Agents					
Ammonia (NH_3)	50	35	Respiratory irritant	Coal gasification, shift conversion, gas-liquor, gas cooling separator, ammonia recovery, POX, product storage sulfur recovery, rectisol.	(5, 10)
Benzene (C_6H_6)	10 25-ceiling 50-10 min. peak		Blood changes, leukemia	Coal gasification, gas cooling, rectisol.	(5)
Carbon Dioxide (CO_2)	5000	9000	Respiratory system	Coal gasification, shift conversion, gas cooling, phenosolvan, gas-liquor separator, POX, sulfur recovery, methanol synthesis and purification, hydrogen production, steam generator, flue gas desulfurization, flare system, fuel gas, methanation and co-production, SNG purification and compression, vent gas incineration, ammonia recovery, naphtha hydrotreating.	(5, 10)

TABLE 6-3

OSHA EXPOSURE LIMITS FOR POTENTIAL HAZARDS IN THE CROW TRIBE OF INDIANS SYNFUELS PLANT (Continued)

COMPOUND (ABBREVIATION IF ANY)	OSHA STANDARD[a][b] PPM	MG/M³	AREA AFFECTED AND/OR HEALTH EFFECTS	PROCESS UNIT WHERE FOUND	REFS
Carbon Monoxide (CO)	50	55	Cardiovascular system, lungs, nervous system, blood	Coal gasification, shift conversion, gas cooling, rectisol, gas-liquor separator, naphtha hydrotreating, phenosolvan, sulfur recovery, process steam superheater, methanol synthesis/purification, methanation/co-production, SNG purification/compression, POX, H_2 production, fuel gas, flare system.	(5, 10)
Carbon Disulfide (CS_2)	20			Coal gasification, gas cooling, sulfur recovery.	(5)
Coal Dust		2.4 if respirable fraction is less than 5% S_1O_2; if respirable fraction is more than 5% S_1O_2, respirable mass formula is (10 mg/m³)/(%S_1O_2 +2).	Lung	Coal screening, coal distribution, coal gasification phenosolvan, ammonia recovery.	(5, 10)

TABLE 6-3

OSHA EXPOSURE LIMITS FOR POTENTIAL HAZARDS IN THE CROW TRIBE OF INDIANS SYNFUELS PLANT (Continued)

COMPOUND (ABBREVIATION IF ANY)	OSHA STANDARD(a)(b) PPM	MG/M³	AREA AFFECTED AND/OR HEALTH EFFECTS	PROCESS UNIT WHERE FOUND	REFS
Coal Tar Pitch Volatiles (CTPV)		0.15	Lung and skin cancer	Coal gasification, tar distillation, gas-liquor separation.	(10)
Cresol	5	22	Skin, liver, kidneys, and pancreas	Coal gasification, gas cooling, phenosolvan.	(5, 10)
Hydrogen Cyanide (HCN)		5 (Skin) as CN 10 (Skin)	Thyroid, blood, and respiratory system	Coal gasification, gas cooling, phenosolvan, rectisol, sulfur recovery.	(5, 10)
Hydrogen Sulfide (H_2S)		20 (ceiling) 50 (maximum ceiling 10 min.)	Eye irritation; severe acute effects on central nervous and respiratory	Coal gasification, shift conversion, gas cooling rectisol, gas-liquor separator, naphtha, hydrotreating ammonia recovery, sulfur recovery, vent gas incineration, POX, flare system, methanation.	(5, 10)
Isopropyl Ether (IPE)	500	2100	Anesthesia, irritation to skin and eyes	Phenosolvan, ammonia recovery, tank farm, and dispatch.	(5)

TABLE 6-3

OSHA EXPOSURE LIMITS FOR POTENTIAL HAZARDS IN THE CROW TRIBE OF INDIANS SYNFUELS PLANT (Continued)

COMPOUND (ABBREVIATION IF ANY)	OSHA STANDARD(a)(b) PPM	MG/M³	AREA AFFECTED AND/OR HEALTH EFFECTS	PROCESS UNIT WHERE FOUND	REFS
Methanol (MeOH)	200	260 acidosis	Blindness, metabolic acidosis	Rectisol, methanol syntheses and purification, tank farm, and dispatch.	(5)
Naphtha	100	400	Irritating to skin; mucous membranes of upper respiratory tract; photosensitivity; chemical burns; central nervous system depression	Coal gasification, shift conversion, gas cooling, rectisol, naphtha hydrotreating, tank farm, and dispatch.	(9)
Nickel Carbonyl Ni $(CO)_4$	0.001	0.007	Lung, heart, liver, and spleen carcinogen	Methanation (if nickel catalyst used).	(5)
Phenol	5	19	Skin, eyes, central nervous system, liver, and kidney	Coal gasification, shift conversion, gas cooling, phenosolvan, gas-liquor separation, ammonia recovery, tank farm, and dispatch.	(5, 10)

TABLE 6-3

OSHA EXPOSURE LIMITS FOR POTENTIAL HAZARDS IN THE CROW TRIBE OF INDIANS SYNFUELS PLANT (Continued)

COMPOUND (ABBREVIATION IF ANY)	OSHA STANDARD[a][b] PPM	MG/M³	AREA AFFECTED AND/OR HEALTH EFFECTS	PROCESS UNIT WHERE FOUND	REFS
Sulfur Oxide (SO_2)	5	13	Respiratory	Vent gas incineration, steam generator, flue gas desulfurization, sulfur recovery.	(5)
Toluene	200		Central nervous system depressant	Coal gasification, gas cooling.	(5, 10)
Xylene	100	435	Central nervous system depressant; airway irritation	Coal gasification.	(5, 10)
Heat Stress	NTOSH and ACGIH Guidelines (See references)		Rashes; cramps; exhaustion; heat stroke; cardiovascular system	Coal gasification; shift conversion; gas cooling; rectisol; ammonia recovery; vent gas incineration; methanol synthesis and purification; methanation and CO production; SNG purification and compression; pox oxygen plant; steam generator; power generator; flue gas desulfurication tank farm and dispatch.	(2,20)
Ionizing Radiation	Nuclear Regulatory (See OSHA Standard 1910.96 Commission also has guidelines		Blood changes; injury and possible disability; carcinogenicity; death	Coal screening, distribution; ash handling; coal gasification; shift conversion; gas cooling; gas-liquor separation; tar distillation; pox; power generation.	(3,21)

TABLE 6-3

OSHA EXPOSURE LIMITS FOR POTENTIAL HAZARDS IN THE CROW TRIBE OF INDIANS SYNFUELS PLANT (Continued)

COMPOUND (ABBREVIATION IF ANY)	OSHA STANDARD(a)(b)	AREA AFFECTED AND/OR HEALTH EFFECTS	PROCESS UNIT WHERE FOUND	REFS
Physical Agents	Noise Duration Per Day Hours / Continuous Noise Sound Level dBA Slow Response 8 — 90 6 — 92 4 — 95 3 — 97 2 — 100 1.5 — 102 1 — 105 0.5 — 110 0.25 or less — 115 Impulsive or Impact Noise Exposure should not exceed 140 dB peak sound pressure level	Hearing impairment loss	Coal screening, distribution; coal gasification; gas cooling; gas-liquor separator; POX; rectisol; sulfur recovery; vent gas incineration.	(5, 1, 10)

(a) See Reference 3
(b) 8 hr-time weighted average

TABLE 6-4

OSHA STANDARDS FOR SOME COAL-RELATED TRACE-ELEMENTS

Trace Element (Chemical Notation)	OSHA Standard, mg/m^3 (8 hr. time weight average, except as noted)
Antimony & compounds (Sb)	0.5
Arsenic metal & compounds (As)	0.5
Barium (Ba)	0.5
Beryllium (Be)	0.002; 0.005-*C; 0.025-30 min. peak
Boron (B)	0.7
Cadmium (Cd)	0.2; 0.6-C (Cd dust) 0.1; 3-C (Cd fume)
Chromium VI (Cr)	1 (metal & insoluble salts)
Cobalt (Co)	0.1-(metal, fume, dust)
Copper (Cu)	0.1-(fume) 1-(dust & mists)
Lead (Pb)	02. (inorganic compounds & leads)
Lithium (Li)	0.025 (as lithium hydride)
Magnesium (Mg)	15 (magnesium oxide fume)
Mercury (Hg)	1 $mg/10m^3$-C 0.01 (alkyl mercury); 0.04-C
Molybdenum (Mo)	5-(soluble compounds); 15-(insoluble compounds as Mo)
Nickel (Ni)	0.007-(nickel carbonyl) 1-(metal & soluble compounds as Ni)
Selenium (Se)	0.2-(selenium compounds as Se)
Silver (Ag)	0.01-(metal & soluble compounds as Ag)
Tin (Sn)	2-(inorganic compounds except oxides) as Sn

TABLE 6-4 (Continued)

OSHA STANDARDS FOR SOME COAL-RELATED TRACE-ELEMENTS

Trace Element (Chemical Notation)	OSHA Standard, mg/m^3 (8 hr. time weight average, except as noted)
Uranium (U)	0.25-(insoluble compounds as U)
	0.05-(soluble compounds as U)
Yttrium (Y)	1
Zinc (Zn)	1-(zinc chloride fume)
	5-(zinc oxide fume)

Modified from References 3-11

* C Ceiling value

7.0 CONTROLS FOR PROTECTING WORKERS FROM EXPOSURE TO HAZARDS

7.1 GENERAL DISCUSSION

This section presents and summarizes controls that can be used to protect worker health and safety in the proposed synfuels plant. Employees who will work in this plant, as those in other chemical, petrochemical plants and refineries, will be exposed to various potential hazards. These include risks of inhalation, skin absorption or possibly ingestion of hazardous chemicals and contaminants, exposures to harmful physical agents such as radiation or noise, and injuries due to accidents. These risks could occur during a plant upset, leak, spill, or during maintenance.

There are basically three elements essential to control of occupational hazards. These are engineered controls (directly impact the design and/or operation of the plant), work practices including administrative controls (provide additional protection when engineered controls are not adequate or feasible and are generally based on prior experience and subjective judgement), and personal protective equipment and clothing (used when neither engineered controls nor work practices provide acceptable protection to compliance levels). Where possible, engineered controls should be considered the first line of defense for protecting workers and reducing exposures to within established limits or standards.

Control monitoring, while not a technique for reducing worker exposure, is critical to the entire control effort. This is because monitoring instruments verify the controls' effectiveness, detect additional hazards that may warrant controls and when used in conjunction with warning devices alert workers to hazards immediately threatening life and health. Monitoring is discussed in the next section with work practices, personal protective equipment and clothing and emergencies.

7.1 (Continued)

There are several foreign plants in operation, including the SASOL complex in the Republic of South Africa, using similar technology to the proposed synfuels plant. In the case of SASOL, the lack of published information is for proprietary reasons. Information on engineered controls in this section is based on several NIOSH documents (5, 10, 6,22). In addition, current state of the art information on engineered controls has been obtained through discussions with NIOSH and DOE personnel (23, 15).

The following examines engineered controls to protect worker health and safety. Discussions are included on design considerations and plant layout. It is noted that although health and safety controls are discussed separately, in many cases a given control method will provide both health and safety protection.

7.2 HEALTH-RELATED CONTROL CONSIDERATIONS

Engineered controls are used to reduce or minimize exposure to chemical and physical agents. Some engineered controls have been used at the source of exposure, including substitution of less hazardous substances for ones that are identified to be hazardous. The source of exposure may be isolated from the rest of the process by physical enclosure. Preventive maintenance can be used to reduce the risk of leakage resulting from fugitive emissions. Local exhaust ventilation is another method for reducing exposure at the source.

Table 7-1 provides an overview of recommended controls, including engineered controls, work practices and protective equipment and clothing for each of the process units in the plant. Also included are potential hazards for which the controls are needed and general comments where appropriate.

7.3 DESIGN CONSIDERATIONS

Under normal operating conditions the major portion of the proposed plant is a closed process* ensuring no leakage of potentially hazardous materials. However, during maintenance, repair, process sampling, or due to fugitive emissions, some process materials may escape into the work place. Most of the potential health hazards associated with the process materials are not unique in that they are recognized problems throughout the chemical process industries. What is unique is that coal gasification emissions can be potentially carcinogenic because they contain N-heterocyclic aromatic and polynuclear aromatic (PHA) compounds. Petroleum-derived materials generally do not contain as high concentrations of these compounds as materials derived from coal gasification processes. Because many of these materials are potentially carcinogenic, reliable engineered controls are needed. In some cases engineered controls are supplemented with work practices, administrative controls, and protective equipment and clothing to achieve worker protection.

There are a number of design factors that are listed in this synfuels study that require engineered controls to ensure worker protection. These include: (a) maintenance and repair; (b) valves; (c) seals; (d) flanges; (e) pressure vessels; (f) process lines; (g) drains and sumps; (h) process sampling; (i) hot surfaces; and (m) fail safe design. Each of these are described in more detail below.

7.3.1 Maintenance and Repair

Workers performing these activities have the highest risk of exposure or contamination with potentially hazardous process materials. The proposed synfuels plant is designed so that maintenance and repair operations are performed with minimum worker exposure. Equipment to be maintained or

*Closed Process - all process materials are contained to prevent emissions within the work environment.

7.3.1 (Continued)

repaired is designed to facilitate depressurization, and if necessary, isolated from the process streams by valves or blinds, and purged with inert gas or steam and then air.

7.3.2 Valves

General valve components are designed to withstand the effects of erosion and corrosion in operations processing coal and ash. For pressure relief valves, discharges are directed away from potential work areas to minimize personnel exposure.

7.3.3 Seals

Potential worker exposure due to fugitive emissions and leaks can be minimized through proper selection of seals. Rotating shafts are designed so that seals are compatible with the process fluid environment.

7.3.4 Flanges

Frequency and severity of leaks have been reduced by grooved, concentric or other nonflat mating surfaces (5). Retightening the bolts prior to and after the process has reached operating temperature is usually successful in stopping leaks.

7.3.5 Pressure Vessels

Pressure vessels containing flammable process fluids are designed in accordance with the American Society of Mechanical Engineers (ASME) Codes. Relief valves located on pressure vessels are located or designed to prevent blockage by tars and solids or viscous materials. Redundant

7.3.5 (Continued)

valves are used where probability of blockage is high. Vessels are designed to prevent accumulation of solids and liquids requiring manual cleanout.

7.3.6 Process Lines

Design of process lines for liquids and gases should prevent erosion, leaks and solids accumulation.

7.3.7 Drains and Sumps

Drains and sumps are designed as closed systems to prevent emission of toxic or flammable gases and vapors. Explosimeters and/or combustion monitors and ventilation systems are used in conjunction with drains or sumps to prevent explosive concentrations from accumulating. Dedicated sumps should receive leakage from most pumps, valves and flanges.

7.3.8 Process Sampling Equipment

Sampling systems using a sample vessel are designed into the proposed synfuel plant system. The sample system has a flush and purge system to remove process materials, particularly flammable and toxic substances from the sampling lines but not the sampling vessel. Discharges of residual material are routed to a dedicated sump. Gas bleed lines discharge to a collection system for cleanup and disposal (10).

7.3.9 Control Room Design

The control room needs to remain functional in the event of emergency. This room is designed to withstand accident such as explosions and fires. Should a catastrophe occur, control room personnel are able to shut down a specific area or the entire plant.

7.3.9 (Continued)

Hazardous or contaminated materials are prevented from entering the control room air supply by drawing air from a safe area.

7.3.10 Noise Control

Noise may occur in and around most moving equipment, components, and high velocity process lines (10). Equipment and components are designed to minimize worker noise exposure. Where this is impractical, reduction of noise levels is considered by selecting acceptable equipment, by isolating the noise source in the plant, or by using acoustical insulation, barriers or enclosures. Noise contours may be needed to select engineered noise controls.

7.3.11 Erosion/Corrosion

Materials of construction for process equipment and components are selected to provide maintenance free operation for extended operating periods. Erosion and corrosion may become significant problems because of the high temperatures and pressures used for coal gasification process streams. In this case, erosion refers to a wearing of equipment or component material due to contact with high velocity fluids. Corrosion refers to the deterioration of equipment or component materials due to chemical action.

7.3.12 Hot Surfaces

Because of the high operating temperatures in the gasification process, insulation is needed to protect workers from coming into contact with hot surfaces. Insulation materials used on process equipment are nonreactive with the process fluids.

7.3.13 Fail Safe Design

This type of design factor ensures that the failure of any safety component used in the proposed synfuels process will always result in a non-hazardous situation. For example, if the pneumatic system in the plant fails, all pneumatic valves dependent upon this system fail in a mode that will not contribute to adverse health and safety conditions for workers.

7.3.14 Ventilation

Ventilation systems should be designed to draw air from safe areas. Local ventilation is provided during situations when excessive concentrations of toxic gases, vapors, dusts, fumes or aerosols cannot be controlled. This includes maintenance and repair operations, particularly where welding is performed. Local ventilation may also be needed around the coal handling and preparation areas particularly for size reduction equipment. General ventilation systems are necessary for such enclosed areas as laboratories, locker rooms, lunchrooms, administrative offices and maintenance buildings.

7.4 PLANT LAYOUT

A carefully designed plant layout (plot plan) can provide intrinsic health and safety protection by methods such as segregating high risk process units, and, providing adequate workspace for unencumbered maintenance, repair and operations. Loss prevention can be incorporated into the plot plan by collectively considering the demands of process design, construction of the facility, normal operation, maintenance, repair, process sampling, personal welfare and potential emergency situations.

Typical of the questions that are asked include: If a fire broke out in the tank farm unit, would there be sufficient distance between the fire and adjacent units? Generally, the answer to these questions is based on an industrial recommended practice such as "General Recommendations for Spacing" (26). In this example, the occasional high winds at the plant

7.4 (Continued)

site may require greater spacing between units in case of a fire. The following are general plant layout considerations that have been applied to the facility design.

7.4.1 Control Room

The control room is located in relation to the process scheme to facilitate operation, a safe distance from any unit vulnerable to fire or explosion. The air supply for the control room operators is drawn from a safe area (i.e., an area not vulnerable to atmospheric contamination).

7.4.2 Prevailing Winds

The prevailing winds are identified to permit safe orientation of the furnaces, flares, compressors, dusty operators (coal), and cooling towers.

7.4.3 Equipment Erection

Erection problems are anticipated regarding location of major equipment. Generally, major fixed equipment is located away from congested areas in the plant to permit erection at any phase of construction, and to permit maintenance after startup.

7.4.4 Maintenance Methods

Maintenance methods and frequency for major equipment is established. Equipment requiring frequent attention has easy accessibility.

7.4.5 Spacing

Within battery limits, spacing is sufficient to avoid compounding fire exposure problems.

7.4.6 Vessels and Tanks

Vessels and tanks with large liquid hold-up volumes are located where any accidental drainage can be safely contained by dikes.

7.5 SAFETY CONTROLS

7.5.1 General Discussion

Safety has come to mean an environment free from man-equipment-material interactions that result in accidents. Safety controls are thus techniques to reduce injuries caused by accidents or from exposure involving a single incident in the work environment.

Most safety-related controls are designed to prevent accidents involving machines, falls, fires, or explosions. Engineered safety controls include guards on pumps, insulation of pipes and equipment, pressure relieving, level control valves, guard rails, and nonslip surfaces to prevent falls as well as techniques for detecting flammable or explosive gases and vapors.

In addition to general accidents and injuries that may occur in the proposed plant, potential safety hazards due to potentially flammable and explosive substances need to be controlled. These types of hazards are controlled by the following (ref. 28):

(1) Elimination of ignition sources such as open flames and lights, smoking, equipment capable of generating sparks, welding or gas equipment.

(2) Construction of buildings/facilities to avoid collection of dust on beams, ledges, etc. Vacuuming is advisable.

7.5.1 (Continued)

(3) Construction of equipment that is dust-tight and strong enough to contain explosion pressures - or have adequate ventilation to prevent an explosion from being catastrophic.

(4) Location of dust collectors outside of buildings.

(5) Specification of inert atmospheres for grinding, conveying and similar types of equipment.

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	RECOMMENDED WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
01-Coal Screening and 02-Coal Distribution	Coal dust spontaneous combustion/ explosion	Appropriate fire detection and fighting equipment, blowout panels	First-in, First-out concept Cool use	Both engineered controls and work practices are needed
		Explosion-proof electrical systems, grounded electrical connections	Minimize coal-storage time Maintain coal piles at proper angle of repose	
	Coal dust - respiratory irritant	Ventilation systems with filters, water/detergent sprays to control dust	Good housekeeping including horizontal surfaces inaccessible to coal dust. Monitor dust concentrations as required to assure safety. Air purifying respirators should be available	
01-Coal Screening and 02-Coal Distribution (Continued)	Noise	Acoustical insulation, barriers, or enclosures; modify or isolate noisy equipment	Hearing protection must be available Monitor noise level	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
03-Ash Handling	Ash dust, trace elements	Wet ash handling system with a covered sluiceway. Cyclone separation on air exhausted from sluiceway.	Air purifying respirators for ash, dust; protective clothing. Monitor respirable ash.	Because most of ash is wet - problems should be minimal during normal operation. There is the potential for dermal contact during maintenance and repair
	Heat stress, burns	Isolation of ash in handling area when ash removed; barriers, protective insulation.	Heat protective clothing.	
10-Coal Gasification	Toxic gases (e.g., CO, H_2S, COS, HCN)	Safety relief valves and discharge of gas to flare system. Local ventilation during maintenance and repair. Auxiliary ventilation; high speed exhaust fan can be activated by monitoring system. Select components and materials to minimize maintenance.	Monitor for toxic gases; have self-contained respirators available Periodic inspection and preventive maintenance. Follow standard vessel entry procedure during maintenance. Approved respiratory equipment.	Most significant hazards will most likely take place during start-up and shutdown as the gasifier is a closed system composition of gas depends on coal type and operating conditions. Leaks in general will occur at gasifier inlet, outlet, coal or ash lockhoppers, valves, flanges, seals.

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
10-Coal Gasification (Continued)	Coal dust	Enclosed coal conveyor.	Make available air purifying respirators.	
	Tars/oils	Design equipment for pressure of tars/oils.	Prior to maintenance, drain and flush w/steam to remove condenser tars.	This hazard will occur mainly in and near the quench chamber.
			Workers should wear overalls, gloves resistant to tars/oils.	
	Fire/ explosion	If process upset occurs, automatic oxygen shut-off will prevent formation of explosive mixture inside gasifier. Maintain steam feed to further prevent formation of explosive mixtures.	Monitor vent and flare gases for oxygen.	
		Fixed monitor and hose fire fighting equipment.	Regular inspection for fire/explosion hazards.	
		Emergency power backup to cooling system where applicable.		

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
	Noise	Noise barrier or insulation around coal and ash locks.	Provide hearing protection, monitor noise level.	
	Heat stress	Provide for personnel protection.	Worker rotation, heat protective clothing.	
11-Shift Conversion	Toxic gases	Design unit to minimize maintenance. Specify proper valves, and seals to minimize fugitive emissions.	Monitor for CO or H_2S. Approved respiratory equipment.	
	Catalyst dust	Local ventilation system with filters during loading and unloading.	Appropriate respiratory equipment.	
	Tars/oils	Local ventilation systems may be necessary during maintenance and repair.	Flush unit with steam to remove accumulated tars/ oils. Use appropriate respiratory equipment.	
	Fire/ explosion	Install fire fighting equipment, and relief valves.	Control ignition sources. Monitor for H_2 and explosive mixtures.	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
12-Gas Cooling	Product gas	Design unit and select equipment to minimize maintenance requirements.	Preventive maintenance to reduce fugitive emissions and leaks. Approved respiratory equipment. Monitor area for product gas.	
	Tars/oils	Local ventilation system may be necessary during maintenance repairs.	Protective clothing resistant to tars/oils, approved respiratory equipment. Flush unit with steam prior to maintenance.	
	Fire/ explosion	Install explosion vents and fire fighting equipment.	Monitor process for explosive mixtures and unit area for combustible gas.	
13-Rectisol	Toxic gases organic vapors	See Unit 10.	See Unit 10.	This is a relatively reliable unit, H_2S is a potential hazard.
	Organic liquids	Closed dedicated drainage system to collect leaks from pump valves etc.	Protective clothing during maintenance and repair.	
	Noise	See Unit 02	See Unit 02	
	Cryogenics	Insulation for personnel protection.	Protective clothing to protect against cold equipment.	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
13-Rectisol (Continued)	Fire/ explosion	See Unit 10	See Unit 10	
14-Gas-Liquor Separator	Toxic gases	Selection of appropriate materials to minimize maintenance	Approved respiratory equipment Preventive maintenance. H_2S monitor	Main exposure is to escaping expansion gas, leaks from separation equipment and overflow of separation system.
	Tar/oil	Dike area around unit. Collection system for receiving and/or reprocessing spills and overflow	Protective clothing for maintenance repair, spills and leaks	
	Noise	See Unit 02	See Unit 02	
	Fire/ explosion	See Unit 10	Explosimeter and combustible gas monitors for detection of potential explosive/flammable conditions	
15-Tar Distillation	Toxic gases, vapors	See Unit 10	See Unit 10	
	Tars/oils	See Units 10, 11, and 14		

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
15-Tar Distillation	Fire/ explosion	See Unit 10	See Unit 10	
16-Naphtha Hydrotreating	Toxic gases, vapors	See Unit 10	See Unit 10 H_2S monitor Preventive maintenance to reduce fugitive emissions and leaks	
	Organic liquids	See Unit 13	See Unit 13	
	Noise	See Unit 02	See Unit 02	
	Fire/ explosion	See Unit 10	See Unit 10	
17-Phenosolvan	Organic liquids/ vapors	See Unit 13 IPE must be contained and removed immediately if leaks present Oxidation inhibitors e.g., disphenylamine, should be added to stored IPE	See Unit 13 Protective clothing to prevent phenol, IPE contact, during maintenance and repair H_2S monitor.	IPE is extremely flammable and can form potentially explosive peroxides in presence of heat, light and air

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
17-Phenosolvan (Continued)	Toxic gases	See Unit 10	See Unit 10	
	Fire/ explosion	See Unit 10	Explosimeter/combustion monitor for detection of potential explosive/ flammable situation (IPE, H_2S)	
18-Ammonia Recovery	Irritant gas	Design unit to minimize maintenance	Approved respiratory protection	
			NH_3, monitor - alarm for hazardous concentrations	
			Preventive maintenance program to reduce fugitive emissions and leaks	
	Fire/ explosion	See Unit 10	Explosimeter/combustion monitor for detection potential explosive/ flammable (NH_3, IPE)	
19-Sulfur Recovery	Toxic gases	See Unit 10	See Unit 10	
	Fire/ explosion	See Unit 10	See Unit 10	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
20-Process Steam Superheater	Heat stress	See Unit 10	See Unit 10	
	Noise	See Unit 02	See Unit 02	
21-Methanol Synthesis and Purification	Toxic gases, organic vapors	See Unit 10	See Unit 10	
	Catalyst dust	See Unit 11	See Unit 11	
	Organic liquids	See Unit 13	Protective clothing during maintenance and repair, particularly for MeOH	
	Fire/ explosion	See Unit 10	See Unit 10	
	Noise	Isolate compressors if possible. Provide acoustic insulation/ barrier/enclosure if necessary.	Hearing protection should be provided; monitor noise level.	
22-Methanation	Toxic gases, organic vapors	Design to minimize maintenance.	Approved respiratory protection CO monitor Preventive maintenance	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
22-Methanation (Continued)	Catalyst dust	See Unit 11	See Unit 11	
	Heat stress	See Unit 10	See Unit 10	
	Fire/ explosion	See Unit 10	See Unit 10	
23-SNG-Purification and Compression	Toxic gases	See Unit 10	See Unit 10	
	Heat stress	See Unit 10	See Unit 10	
	Fire/ explosion	See Unit 10	See Unit 10	
24-POX	Toxic gases, organic vapor	See Unit 10	See Unit 10	
	Organic liquids	See Unit 13		
	Fire/ explosion	See Unit 10	See Unit 10	
25-Hydrogen Production	Toxic gases	See Unit 10	See Unit 10	Industrial codes applicable
	Fire	See Unit 10	Explosion meter/combustion monitor for detection of potential explosive/ flammable situations. (H_2, CH_4)	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
25-Hydrogen (Continued)			Prevent ignition sources/ explosive concentrations	
40-Oxygen Plant	Oxygen		O_2 monitor - alarm for high concentrations	Industrial codes applicable
	Asphyxiant N_2	Ventilation for N_2 Asphyxiant	Make available self contained breathing apparatus	
	Cryogenic temperatures	Insulation for personnal protection	Protective clothing to protect against cold.	
41-Steam Generation	Heat stress	See Unit 10	See Unit 10	
	Fugitive coal dust	Suppress fugitive coal dust with water sprays, vacuum removal through bag filters, and isolation of coal dust storage.	Appropriate respiratory protection. Good housekeeping	
	Noise	See Unit 02	See Unit 02	
	Explosion - Steam	Use safety relief valves to prevent overpressure	Regular inspection of pressure equipment	
	Explosion - Combustible dust	Install blowout vents (See fugitive coal dust above)	Regular fire/explosion hazard inspections	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
42-Power Generation	Noise	See Unit 02 Isolate unit from workers not assigned to the power generation unit limit fluid velocities where use acoustic barriers/ enclosures	See Unit 02	
	Heat stress Scalding due to steam leakage	See Unit 10 Use safety relief valves to prevent over-pressure	See Unit 10 Regular inspection of pressure equipment Use reliable blinding and lockout procedures when performing maintenance	
	Electrical shock	Provide adequate electrical insulation and grounding	Clearly mark all electrical equipment and controls	
43-Flue Gas Desulfurization	(FGD) Flue gas - toxicologic effects	Install safe sampling devices	Install gas monitors around sampling areas Observe vessel entry procedures when entering a stack during shut down for maintenance	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
43-Flue Gas Desulfurization	thermal effects	Install sampling devices that isolate the bulk flow from the sampler Provide thermal insulation		
	Filter cake	Design unit to minimize maintenance	Appropriate protective clothing	
	Dust (in both wet and dry processing)	Provide dust suppression and ventilation during mixing and maintenance operations	Provide respiratory protection and protective clothing	
	Heights	Appropriate guarding and walking surfaces	Use harnesses when performing maintenance at elevated levels	
44-Raw Water Treating	Water treatment chemicals such as chlorine, sulfuric acid, and polyelectrolytes	Store chemicals in an appropriate area	Monitor for chlorine gas Provide personal protection devices such as gloves and face shields when handling water treatment chemicals	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
44-Raw Water Treating	Lime dust	Provide dust suppression equipment if necessary	Provide respiratory protection when mixing lime	
	Accidental slips or falls into channels and ponds	Provide guarding around channels and ponds		
45-BFW and Condensate Treating Unit	High pressure RO water	RO vendor should provide safety controls	Review vendor's safety controls	
46-Air and Nitrogen Supply Unit	Noise from compressors	Utilize quiet valves, reduced velocity, streamlining, lagged valves and piping, and inline silencers	See Unit 02	
	Non toxic asphyxiant-nitrogen	Locate air intake (Unit 40) in a location where no hazardous materials can be introduced into the system. Do not interconnect nitrogen lines with air lines.	Install oxygen deficiency monitors	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
47-Process Cooling Water Unit	Chemical additives (dispersants, acid, caustic, biocides, and corrosion inhibitors)	Store chemicals in an appropriate safe area	Provide protective clothing to workers handling chemical additives	
48-Utility Cooling Water Unit	Same as Unit 47		Same as Unit 47	Same as Unit 47
49-Potable Water	Water contaminants	See comments	To ensure that potable water is being produced according to specifications, regular monitoring of water quality is essential	(This unit's equipment should effectively prevent contaminants from getting into the potable water system. The administrative controls will be the primary health protection)

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
49-Potable Water (Continued)	Water treatment chemicals (chlorine, RO preparation chemicals)	Store chemicals in an appropriate safe area	Install chlorine monitoring equipment	
		RO vendor should provide safety controls for his RO unit	Review vendor's safety controls	
			Provide protective clothing and water treatment chemicals protective devices to workers handling	
	High pressure RO water	RO vendor should provide safety controls	Review vendor's safety controls	
52-Fuel Gas Unit	Toxic and asphyxiating gas	Install sampling devices which protect workers from the bulk fluid gas	Monitoring equipment	
	Fire/ explosion	Excess fuel gas is vented to the flare system. Safety relief valves should also route overpressure to flare system	Monitoring equipment	
53-Flare System	Heat	Specify flare stack height according to API guideline	Monitor radiant heat at ground level	
	Toxic gases (CO, H_2S, and HCN)	See Unit 10	See Unit 10	

TABLE 7-1

SUMMARY OF HEALTH AND SAFETY CONTROLS FOR THE CROW TRIBE OF INDIANS SYNFUELS FEASIBILITY STUDY (Continued)

PROCESS UNIT NO. - FUNCTION	POTENTIAL HAZARDS	RECOMMENDED ENGINEERED CONTROLS	WORK PRACTICES/ PROTECTIVE EQUIPMENT	COMMENTS
53-Flare System (Continued)	Fire/ explosion	Install flashback prevention devices and continuous ignition source	Monitoring equipment Observe safe vessel entry procedures when performing maintenance on system	
55-Tank Farm	Persistent fugitive emissions	Leakproof valves, seals, flanges, and tanks	Regular inspection of equipment and monitoring of fugitive emissions	
	Fire/ explosion	Containment dikes	Monitoring equipment	

8.0 WORK PRACTICES

8.1 GENERAL

Work practices are defined as all aspects of an industrial health and safety program not covered by engineered controls. These practices supplement the engineered controls described in Section 7 of this report to provide additional protection from occupational health and safety hazards. Work practices cover special procedures, administrative controls, personal protective clothing and equipment, and medical surveillance and monitoring. The objective of this section is to provide guidelines on the types and coverage of major work practices required for the proposed plant.

8.2 SPECIAL PROCEDURES

These are procedures that govern work practices in the plant. They are intended to prevent or reduce the levels of health and safety risks to which employees may become exposed. In addition to specific procedures typical to coal gasification plants, they include general practices employed in industry, particularly in petroleum refineries and the chemical industry (10, 3, 20).

8.2.1 Training

Employees should be trained to become knowledgeable about the nature of plant hazards and safety provisions available to protect themselves.

* In this section, health exposures, risks or hazards refer to discernible disease stresses while safety risks or hazards are related to accidents and injuries (See Section 6.1 of this section.)

8.2.1 (Continued)

Training should include:

(1) Initial orientation of all employees with exposure potential on the nature of the hazards, and the protective measures available.

(2) Periodic training of employees working in hazardous areas informing them of the nature of the specific hazards to which they are exposed, work practices, personal protection, industrial hygiene and medical surveillance programs.

(3) Training in methods of handling hazardous substances, procedures for cleaning up spills, personal protective equipment requirements and emergency procedures.

8.2.2 Operating Procedures

It is good practice to develop detailed operating procedures in close cooperation with plant engineers, maintenance personnel, and health and safety groups. In this way, all aspects of startup, operation, shutdown, and maintenance are optimized by being integrated into one plan. In developing these procedures, consideration is given to minimizing worker exposure to health and safety hazards. Examples of operating procedures that reduce such hazards are:

(1) Maintenance during plant shutdowns because the number of workers at risk is minimized, and the hazard potential is lower.

(2) Periodic cleanups, reconditioning or replacement of parts or equipment that need frequent maintenance is recommended. Such equipment, particularly at critical areas, should be scheduled for

8.2.2 (Continued)

thorough maintenance checks at appropriate intervals according to manufacturers' recommendations and operating experience.

(3) Proper venting and purging of lines, vessels, and closed spaces should be undertaken to prevent asphyxiation of workers, or their exposure to toxic materials.

(4) Appropriate pressurization procedures for high pressure systems are necessary to avoid leaks.

8.2.3 Personal Hygiene

Good personal hygiene practices are important for the control of exposure of workers to toxic substances. Instructions developed in facilities that prepare or use coal derived products should be considered (10,20). They include:

(1) Minimizing worker contamination or exposure through various preventive and decontamination procedures.

(2) Prompt removal of the contamination from workers though frequent washing and change procedures.

(3) Prevention of ingestion of contaminants by workers through measures such as avoiding facial contact, and limiting eating, drinking, or smoking to clean areas only.

(4) Observing and reporting any injuries or suspicious lesions to ensure prompt medical diagnosis and treatment.

8.2.4 Workplace Monitoring

The purpose of workplace monitoring is to identify and characterize work-place hazards so that they can be mitigated and to ensure that engineered controls are effective. Before plant start-up, a baseline inventory is prepared of hazardous substances, physical factors, and safety risks to which employees may become exposed as part of their work. Characterization of process stream constituents as well as area monitoring, and hazard detection are carried out. This information is useful to determine compliance with promulgated and recommended standards, selection of health and safety protective equipment, establishment of regulated areas, and recommendations for work-place monitoring.

Workplace monitoring includes personal exposure measurements needed to estimate the average levels of contamination encountered by an employee during a typical work day. The chemical substances and physical agents that need to be considered for such monitoring are elaborated in Table 7-1 of this report.

Monitoring should include the following:

(1) Gases such as carbon monoxide and hydrogen sulfide

(2) Coal dust (including silica content for health evaluations, and coal dust explosion index)

(3) Some organic vapors

(4) Noise

Exposure monitoring is carried out by either having the employee wear the monitoring equipment, or by locating it in the immediate vicinity of the employee. Personal sampling pumps, monitoring badges, and battery-operated personal dosimeters are usually used for employee monitoring.

8.2.4 (Continued)

When this is not feasible, monitoring in the immediate environment of the employee is undertaken using a wide range of direct reading instruments as well as sample collection devices.

The purpose of area monitoring is to measure the concentration or level of a particular hazard within a given location of the plant. Area monitoring is carried out periodically to detect changes in exposure levels, evaluate changes in the plant or employee practices, and characterize maintenance and other periodic operations. The schedule for such monitoring will depend on the baseline levels and their relations to acceptable limits.

Area monitoring can be done using a wide variety of portable field instruments, and fixed monitoring installations. Both direct reading instruments with recorders which automatically track changes, or sample collecting devices requiring processing which provide information on instantaneous conditions and trends can be employed.

The purpose of hazard detection monitoring is to warn employees of unsafe environments. Portable monitors are usually used to warn workers of explosive or combustible atmospheres, inadequate oxygen supply, or hazardous concentrations of gases. Fixed location monitors can also be used in locations amenable to them, such as in confined spaces where process leaks or other hazards can occur. Surface contamination such as polynuclear aromatic spills may be detected by surface monitors using fluorescence. However, this is an area where further research is needed to develop better detection methods. Records of monitoring should be kept. They should include concentrations and levels of hazards, frequency and severity of leaks by process area, and listing of remedial actions undertaken. The records provide a means of comparing performance with objectives, and for directing future efforts to problem areas. These data also provide a necessary input together with the medical records to evaluate

8.2.4 (Continued)

health risks and impacts to workers. Medical records are kept for a minimum of 30 years after the employment of occupationally exposed workers has ended (3).

8.2.5 Decontamination

Cleanup or decontamination practices are employed to remove or reduce the levels of contamination of working surfaces, equipment, clothing, and personnel. Special decontamination is practiced following accidental spills of hazardous materials, or indication of high levels of contamination found by industrial hygiene surveillance. Routine decontamination is recommended when materials, equipment, or personnel move from special risk areas to cleaner parts of the plant. Thus, workers should be provide with clean change rooms and washing facilities to decontaminate themselves after leaving the special risk areas, and their "contaminated" clothing should undergo periodic decontamination in appropriate laundries. Some protective clothing is disposable and should be treated as contaminated waste after use. Furthermore, an adequate number of washrooms should be provided throughout the plant to facilitate frequent cleansing by workers.

Emergency personal decontamination stations for washing eyes or showering to remove harmful materials should be provided. For example, emergency showers and eye washers are recommended throughout the plant.

It should be reemphasized that all decontamination and personal hygiene practices should be supplemented with a continual worker education program. Periodic practice drills are essential to ensure the effectiveness of these programs.

8.3 ADMINISTRATIVE CONTROLS

These are primarily measures and procedures which control and record the movement of visitors, workers, materials and equipment into and through the plant area. Their purpose is to reduce health and safety risks to both employees and visitors.

8.3.1 Restricted Areas

Nonemployees access into the plant should be controlled, as well as access of employees to hazardous areas within the plant. Areas of the plant requiring special attention are the potential risk areas where exposure to coal derived oils, tars, and other hazardous materials is possible (e.g., coal preparation, gasifiers, gas-liquor separators, gas cooling facilities).

Procedures and measures restricting access of visitors and employees to hazardous areas include the following:

(1) Procedures and possibly barriers controlling the access of non-employees beyond the gates of the plant.

(2) Visitors allowed access to the plant should be accompanied at all times by a proper escort.

(3) Limiting access to hazardous areas of the plant should be achieved by posted restrictions and controlled access entries which limit entry. It is recommended that those areas of the plant or site where potential health and safety hazards exist (e.g., areas where process or effluent streams may contain potentially carcinogenic tars and oils or high concentrations of toxic materials) should be well marked.

8.3.2 Confined Space Entry

A permit system is recommended to control entry of workers into confined spaces that might contain explosive or toxic gases, or oxygen deficient atmospheres (ref. 10). Entry procedures should be adopted to safeguard the workers, such as assignment of personal protection equipment, surveillance by an employee outside the vessel and ventilation requirements.

8.3.3 Lock-out and Tag-out

Employment of comprehensive lock-out and tag-out procedures that enable the isolation of risks. Plant equipment is operated by some form of energy. The best methol to prevent these energy sources from accidently injuring a worker is locking it out - bring then to a Zero Energy State (ZES) before starting maintenance work. Typically, this procedure assigns each responsible party (i.e., shift supervision, electrician, pipefiller) a lock and key to lock-out potentially dangerous equipment. Tags are/will also be used to document work in progress and to facilitate maintenance records.

8.3.4 Identification and Marking

Equipment and materials that are moved from potentially contaminated areas such as process areas to clean areas such as outside the plant or to repair shops should be clearly identified. Brightly colored tags are recommended to warn employees that a potential hazard exists. Color codes are also recommended to caution workers of potential risks.

8.3.5 Recordkeeping

Records should be developed and maintained which assist health personnel and plant management to characterize potential risks, mitigative actions, and detect any adverse health effects resulting from exposure. Maintaining records of the following activities is recommended:

(1) Training and follow-ups

(2) Preventive maintenance

(3) Equipment reliability information

(4) Investigation of accidents

(5) Industrial hygiene data

(6) Medical information

8.3.6 Worker Rotation

Rotation of employees has been used to limit the exposure of individual workers to hazardous chemicals or to physical agents. This approach can help keep exposures of individual workers below the maximum permissible limits in situations where they cannot be feasibly controlled by other methods. measurements should be made in such cases to assess the exposures. However, overall exposure is not reduced by rotation, rather, the same exposure is spread over a larger number of employees. Such a practice should be employed in situations where lower individual exposures provide less overall hazards. This is not the case with respect to such substances as carcinogens, where effects are conservatively considered to be proportional to dose and cumulative over the lifetime of workers, with little credit to repair mechanisms to reduce the effects.

8.4 PERSONAL PROTECTIVE EQUIPMENT AND CLOTHING

Provision and proper employment of personal protective equipment and clothing in synfuel plants help to prevent the exposure or reduce the adverse health effects of worker exposure to hazardous materials. Employment of personal protective clothing and equipment are important when engineered controls are not adequate during routine operations, maintenance, repair, and special emergencies. There is no personal protective equipment that is universal in all cases. Selection depends on the types of situations anticipated and requires tradeoffs among several options (ref. 5). Proper maintenance should be undertaken for all protective equipment to ensure reliability.

8.4.1 Work Clothing

Comfortable protective clothing is recommended that minimizes dermal exposure by covering skin surfaces, provides repellency against process liquids, and reduces the passage of vapors and aerosols (ref. 5). White jumpsuit coveralls are preferred because they are comfortable, one piece, and show contamination more clearly (ref. 5). Impregnation with fire retardants can further reduce fire risks.

8.4.2 Gloves and Footwear

Gloves and footwear should be worn to reduce skin contamination by preventing contact with coal-derived materials and organic solvents. Work shoes with steel toes can also provide safety protection. However, workers involved in the cleanup of spills or in other operation involving possible contamination of footwear should use impervious overshoes (ref. 10).

8.4.3 Respiratory Protection

Respirators should be provided to protect workers from airborne hazardous materials. They should be used mainly during emergency conditions such as leaks producing high concentrations of toxic gases and certain maintenance operations (e.g., during vessel entry when CO or H_2S levels are high and O_2 levels are low or where high concentrations of toxic airborne contamination exist). There are no universal respirators, and the selection of a suitable respirator is determined by the characteristics of particular toxicants or asphyxiants (11). In some cases, communications equipment should be added to the respirator.

8.4.4 Hearing Protection

Hearing protection should be used in areas of the plant where noise levels are in excess of the OSHA standard of 90 dBA during an 8-hour exposure (3) (e.g., Coal Screening and Distribution Units). There are two types of basic ear protectors available, namely:

(1) Ear muffs that fit over the entire ear.

(2) Ear plugs that are inserted into the ear.

Selection among these two types should be left mainly to the discretion of the worker, based on comfort (10), and to the industrial hygienist, based on effectiveness.

A hearing conservation program should be established according to OSHA Standard (3). It should evaluate the need for noise protection throughout the plant, provide hearing protection to exposed workers, and instruct them in the care and use of hearing protection devices.

8.4.5 Other Protective Equipment and Clothing

Special situations may require special protective equipment. Safety shoes and hard hats are necessary to protect against falling objects or crushing hazards. Face shields, and safety glasses provide protection from flying objects, and protect welders from U.V. radiation during welding. Barrier creams may be useful in reducing skin contact with tar and tar oil, but their effectiveness has been questioned (ref. 10). Appropriate cleansing materials and cleansing agents should be employed which are capable of removing such contaminants cool derived oils and tars from the skin, clothing, equipment and work surfaces (5). However, regular soap is recommended for use in showering.

8.5 MEDICAL SURVEILLANCE AND MONITORING

Medical surveillance of workers is a common practice in industry (ref. 50). It is important for early detection and assessment of exposure to hazardous materials. Medical surveillance is also necessary for early detection of adverse health effects before any medical treatment can proceed.

8.5.1 Pre-employment Physical Examinations

These examinations serve three purposes: 1) a general check of fitness; 2) as a baseline for further routine examinations; and 3) for identification of higher risk individuals who may require more frequent medical follow-up (e.g., older individuals that are over 45 years of age, those with five years of work with similar substances and particularly those with existing lung disease, marked abnormal bronchial mucosa, or bladder tumors to be advised as necessary (ref. 5).

Pre-employment examinations usually include (modified from [5]):

(1) Occupational history

8.5.1 (Continued)

(2) Medical history

(3) Baseline laboratory analyses including blood count and routine urinalysis

(4) Visual acuity

(5) Audiometric examination

(6) Pulmonary ventilatory function (forced vital capacity-FVC and forced expiratory volume in 1 second,-FEV-1)

(7) General physical examination

(8) Other examinations fitting specific job requirements such as OSHA's requirement for certification of fitness to use respirators, and skin examination

8.5.2 Regular Checkups

Regular checkups to detect incipient disease, physiologic changes, biochemical deviations, or evidence of adsorption of toxic agents. The frequency of examinations depends upon exposure and risk considerations. The examination should include (modified from [4]):

(1) Pulmonary function

(2) Chest X-ray

(3) Audiometric examination

8.5.2 (Continued)

(4) Skin examination

(5) Urinalysis

(6) Serum analysis

8.5.3 Termination Examination

Termination examination should be performed at the end of the project or after an individual is transferred to other job categories. It should be followed up periodically, depending on exposure and risk consideration. The same examinations for which baselines have been performed are suggested.

8.5.4 Records and Services

Full medical records, including work history and exposure data should be preserved for 30 years after termination of an employee (4). All or part of the medical surveillance can be provided through a contract with outside organizations or through the development of in-house capability.

In addition, the law requires that a dispensary or first aid station be provided for emergency care. The staffing and facilities for this station depend upon the level of medical care to be provided on site.

9.0 EMERGENCIES

9.1 GENERAL

Emergency is defined by Webster as "any sudden or unforeseen situation that requires immediate action." It can range in severity from such incidents as a minor spill of acid or contaminant to a remotely probable catastrophic event such as a major fire or explosion involving severe capital losses, injuries and deaths. It is reasonable to assume that some hazardous situations can occur in all industrial plants requiring written emergency plans to mitigate them.

Emergencies are classified as minor when they pertain to limited damages to property and materials or to minor injuries, temporary incapacitations to workers and plant shut-downs. Emergencies are considered catastrophic when they lead to loss of life, permanent incapacitation, or major economic loss. It should be remembered, however, that minor emergencies can develop into major ones, particulary when there is lack of proper response.

9.2 COMMON TYPES OF EMERGENCIES

Emergencies are commonly classified either according to their origins or to the types of hazards. Origins include hazards derived from equipment, chemical substances, power sources, or operations. Types of hazard include explosion, electrocution, poisoning, and dismemberment by machines and equipment. In some situations, multiple hazards exist such as combined fire and explosion associated with coal dust or hydrogen sulfide.

Standards and codes covering the workplace as well as most operations and equipment are discussed in Section 5.0 (Health and Safety Regulations). Control measures have been covered in Sections 7.0 and 8.0 (Engineered Controls and Work Practices.)

9.3 PREVENTION OF AND COPING WITH EMERGENCIES

A successful program to prevent and cope with emergencies are built around the following seven basic elements:

(1) Declaration of management policy and leadership;

(2) Assignment of responsibility, authority,, and accountability;

(3) Maintenance of safe working conditions (covered in Section 7.0 and 8.0);

(4) Establishment of safety training (covered in Section 8.0);

(5) Establishment of an accident reporting and analysis system (covered in Section 8.0).

(6) Creation of medical and first aid programs (covered in Section 8.0).

(7) Acceptance of personal accountability by employees.

It is thus important that all managers and supervisors be assigned specific responsibilities for maintaining a safe and healthful workplace. They should be given incentives and authority to carry out their responsibilities, as well as being held accountable for results (ref. 29). Motivation and accountability should be extended to all employees with respect to the seven objectives. In addition, establishing emergency response programs, including firefighting, decontamination, medical, and first aid programs is necessary.

9.4 EMERGENCY PLANS

The main reasons for formulation of emergency plans are:

(1) Reduce response time and thus prevent a smaller emergency from develop- ing into a more serious one. Often, slight delays in response can have far reaching impacts that may aggravate the situation.

(2) Optimize response by defining lines of authority, scopes of responsibility, optimal assessments and deployment of available emergency resources, identification and correction of deficiencies in existing emergency response plans, and obtaining support from all levels of authority.

(3) Emergency plans should be prepared for both the construction and operational stages of the plant. They should cover such emergencies as construction and transportation accidents, fires, explosions, release and exposure to toxic chemicals. Emergency procedures developed for the construction and chemical industries should provide a basis for the plans*.

The emergency plan must bring together, in one document, all data relevant to a comprehensive emergency control operation. It should include the following:

(1) Identification of emergency situations, including all of the hazardous situations, their scopes, failure mechanisms and description of contributory hazards.

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* NOTE: For further discussion see references 30-35.

9.4 (Continued)

(2) Description and evaluation of emergency controls designed to minimize damages such as automatic sprinkler systems, automatic shut-offs, monitoring and warning systems.

(3) Description and evaluation of the emergency response including immediate actions by persons on the spot as well as those of following response teams.

(4) Capabilities, training and drills of emergency responders.

(5) Emergency equipment capability and availability for different types of emergencies including locations of equipment, maintenance, and reliability.

(6) Other available resources such as communication systems, transportation, utilities and services, emergency access routes, safety zones, evacuation and rescue routes.

(7) Mutual aid agreements with organizations, their capabilities and availability, including description of emergency arrangements made with them, and the necessary response times.

Emergency plans and procedures should be developed, documented and provided to all appropriate personnel prior to the operation of the plant. The emergency services should be specified for general emergencies such as fires, explosions, floods and earthquakes. They should also cover specific hazards characteristic to coal gasification plants in general and

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* NOTE: For further details see references 5, 36, & 37.

9.4 (Continued)

those unique to this plant such as spills, and air releases of specific hazardous materials*. The emergency services of the plant should be adequate until community-provided emergency services or those of mutual aid organizations arrive.

10.0 CONCLUSIONS

This comprehensive assessment provides the basis for identifying potential hazards and recommending controls that should be considered in the proposed plant. The following conclusions are drawn from the health and safety assessment.

(1) It it important to anticipate health and safety issues at the early stage of technological development. Their integration into the design and operation of a plant can prevent potential problems and reduce costs by optimizing process/control interfaces and minimizing retrofit needs.

(2) The nature of health and safety hazards, engineered controls, work practices and protective equipment and clothing in a synfuels plant are similar to those found in industries such as petroleum refining, petrochemicals and coal chemicals. Additional health and safety measures will be practiced to alleviate the concerns about the larger numbers and increased concentrations of potential carcinogenic compounds associated with the coal gasifier.

(3) Maintenance and repair operations are the main source of worker exposure to process materials via inhalation and dermal routes of contamination. This is consistent with findings of many industrial operations. Therefore, in order to reduce potential risks to workers, consideration of exposures during maintenance and repair should be included in the final engineering design.

(4) The information used in this assessment is derived from literature reviews based on pilot plant studies. Although there are no published results of worker exposure to hazards in commercial synfuel plants, nearly 30 years of commercial operation at SASOL

exists. These data are proprietary, but are available through licensing agreements with SASOL. In the interim, there is some uncertainty which has been offset by recommending a comprehensive program of engineered controls and work practices to minimize worker risk.

The only health and safety regulations applicable to the proposed synfuel plant are those promulgated by OSHA. Designs, however, are based also on existing recommendations, guidelines, codes and standards by government and industrial organizations.

There is an OSHA "general duty clause" which requires the employer to provide "a place of employment free from recognized hazards." This clause leaves the employer vulnerable to liability charges even if the OSHA regulations are fulfilled. In an attempt to overcome these problems, the health and safety assessment covers all major guidelines and codes which are applicable to the proposed plant. If followed, they will reduce subsequent liability.

There are several lines of defense to protect worker health and safety. The first and foremost is the application of engineered controls. These are supplemented by work practices, including administrative controls, industrial hygiene and medical surveillance, and protective equipment and clothing. Specific protection strategies are determined by a balance between the degree of worker protection and work requirements.

REFERENCES

1. Fluor Engineers and Constructors, Inc., Crow Tribe of Indians, Synfuels Feasibility Study Process Design Basis, Contract 835704. (Unpublished)

2. Rubin, J. Assistant Area Director, OSHA, Billings, Montana. Personal Contact. March 8, 1982.

3. U.S. Department of Labor, "OSHA General Industry Standards," Revised June, 1981.

4. U.S. Department of Labor "OSHA Construction Standards," 29 CFR 1926.

5. NIOSH, Criteria for a Recommended Standard: Occupational Exposures in Coal Gasification Plants, NIOSH Report No. 78-191, 1978.

6. NIOSH, Recommended Health and Safety Guidelines for Coal Gasification Pilot Plants, NIOSH Report No. 78-120, 1978.

7. OSHA Public Information Office, Washington, D.C. (202)523-8151.

8. Occupational Safety and Health Act, Public Law 910596, 91St Congress, S. 2193, December 29, 1970.

9. NIOSH, Occupational Diseases - A Guide to their Recognition, NIOSH Publication No. 77-181, June 1977.

10. NIOSH, Occupational Hazard Assessment, Coal Liquefaction - Volume II, NIOSH Report No. 81-132, March 1981.

11. McAteer, J.D. Miner's Manual, Crossroads Press, May 1981.

References (Continued)

12. NIOSH, Criteria for a Recommended Standard: Working in Confined Spaces, 1973, Report No. 73-1101.

13. NIOSH, Criteria for a Recommended Standard: Occupational Exposure to Noise, 1973, Report No. 73-1101.

14. U.S. Environmental Protection Agency, Control of Emissions from Lurgi Gasification Plants, EPA Report No. 450/2-78-012, March 1978.

15. U.S. Environmental Protection Agency, Environmental Assessment Report: Lurgi Coal Gasification Systems for SNG, EPA Report No. 600/7-79-120, May 1979.

16. The Merck Index, 8th Edition, Merck & Co. Inc., 1968.

17. Ellwood, P. "Meta-Vandates Scrub Manufactured Gas," Chemical Engineer, 20, 128-130, July 1964.

18. Miller, S.G. and R.D. Robuck, "The Stretford Process at East Wilmington Field," J. Petroleum Technology, 24; 535-549, 1972.

19. Moyes, A.J. and J.S. Wilkinson, "Development of the Holmes-Stretford Process," Chemical Engineer, 84-90, February 1974.

20. American Conference of Governmental Industrial Hygienists (ACGIH), Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1981", Cincinnati, Ohio, 1981.

21. National Council on Radiation Protection and Measurements (NCRP), Basic Radiation Protection Criteria, NCRP Report No. 39, January 15, 1971.

References (Continued)

22. NIOSH, Potential Health Hazards Involved with Coal Gasification, NIOSH Report No. 79-113, 1979.

23. Abrahams, J., DOE, Personal communication. March 1982.

24. Gideon, J., Personal communication. March 1982.

25. Evans, J.M. and M.L. Verden, "Safety Considerations in Coal Synfuels Operations," presented at the AIChE 15th Loss Prevention Symposium, Detroit, Michigan. August 17, 1981.

26. Industrial Risk Insurers, "General Recommendations for Spacing," 1979 Revision.

27. Kaura, M.L., "Plot Plans Must Include Safety," Hydrocarbon Processing, July, 1980. p. 184.

28. Clayton, G.D. and F.E. Clayton, Patty's Industrial Hygiene and Toxicology, Third Revised Edition, Volume I, General Principles, Wiley-Interscience Publication, 1978.

29. National Safety Council. "Handbook of Occupational Safety and Health," Chicago, Illinois. 1975.

30. U.S. Nuclear Regulatory Commission, "Reactor Safety Study and Health," Chicago, Illinois. 1975.

31. National Hazards Control Institute, Starson Corporation, Hazardous Materials Engineering, Stanton, New Jersey, 1978.

32. Stearns-Roger. Operational Safety Practices for Coal Gasification Plant - Rapid City, South Dakota, Denver, Colorado, 1972.

References (Continued)

33. Liquefied Coal Development Corporation, Safety Rules for LCDC Employees, NIOSH Meeting, January 14, 1977, Cresup, West Virginia.

34. Westinghouse Electric Corporation, Emergency Plans, Waltz Mill Site, Energy Systems Operation, WESO-P-103, 1975, 24pp. (unpublished)

35. Stearns-Rodger, Operational Safety Practices for Bi-Gas Pilot Plant-Homer City, Pennsylvania, Denver, Colorado, 1976, 54pp.

36. U.S. Department of Labor, OSHA General Industry Standards, Subpart L - Fire Protection, 29 CFR 1910.

37. U.S. Department of Labor, ERDA Manual, Chapter 0601, Emergency Planning and Response Program, 1977.

GLOSSARY

Acute:	Generally refers to poisonous effects produced within a short period of time (minutes, hours) resulting in severe biological harm or death.
Anesthesia:	Loss of sensation.
Asphyxiant:	A substance or condition that causes asphyxia-unconsciousness or death caused by lack of oxygen.
Cancer:	A malignant neoplasm (tumor or new growth).
Carcinogen:	A cancer-causing substance.
Cardiovascular:	Of or relating to pumping of blood by the heart through the blood vessels.
Ceiling:	The concentration that should not be exceeded even instantaneously.
Central Nervous System:	The brain and spinal cord (protected by the skull and vertebral column).
Chronic:	Generally refers to poisonous effects produced over a long period of time (months to years) almost always debilitating.
dBA:	Decibel is a unit measurement of noise on the "A" weighing network.

Glossary (Continued)

Dermal:	Of or pertaining to skin.
Explosimeter:	Monitoring device for measuring atmospheres containing potentially explosive substances.
Frostbite:	Relatively minor destruction of tissue due to exposure to cold temperatures.
Hazard:	An existing or potential condition that may result in a mishap.
Impact (Impulsive) Noise:	Those variations in noise levels that involve maxima at intervals greater than one per second.
Lagging:	Material used to insulate against noise.
Mutagenic:	Causing change; inducing genetic mutation.
Pneumoconiosis:	Black Lung disease; accumulation of coal dust in lungs.
Risk:	An expression of possible loss in terms of hazard severity and hazard probability.
Teratogenic:	Tending to produce malformations of the fetus without inducing damage to the mother or killing the fetus.

Glossary (Continued)

Threshold Limit Value (TLV):	Refers to airborne conditions of substances and represents conditions under which it is believed that nearly all workers may be exposed without adverse effects.
Toxicologic:	Harmful or poisonous effect of a chemical agent.

APPENDIX

Appendix A

ORGANIZATIONS OR AGENCIES WHO DEVELOP CODES, STANDARDS OR RECOMMENDATIONS THAT ARE RELEVANT TO COAL GASIFICATION

Organization/Agency	Acronym	Area(s) Related to Coal Gasification
American Gas Association	AGA	Gas handling equipment
American Institute of Steel Construction	AISC	Steel sections, beams, joints, angles
American National Standards Institute	ANSI	Pressure piping
American Petroleum Institute	API	Comprehensive applications in all areas of processing except coal handling and gasification
American Society of Mechanical Engineers	ASME	Boilers; inspection, care, welding
American Society of Testing Materials	ASTM	Metallurgical testing
American Welding Society	AWS	Welding procedures
American Water Works Assoc.	AWWA	Pipes, valves, channels, and other water treatment equipment
Department of Energy	DOE	Health, safety, environmental, emergency plans
Federal Aviation Administration	FAA	Stack heights
Environmental Protection Agency	EPA	Monitoring, emissions, controls, guidelines, regulations
National Board of Fire Underwriters	NBFU	Fire prevention/control
National Electrical Manufacturers Association	NEMA	Electric devices

Appendix A (Continued)

Organization/Agency	Acronym	Area(s) Related to Coal Gasification
National Fire Protection Association	NFPA	Fire prevention and control
National Institute for Occupational Safety and Health	NIOSH	Occupational health and safety
National Safety Council	NSC	Accident prevention, safe materials handling
Occupational Safety and Health Administration	OSHA	Occupational health and safety regulations
Public Health Service	PHS	Public health
Temperature Exchange Manufacturers Association	TEMA	Heat exchangers
Uniform Building Code	UBC	Building construction/ materials