PROTECTING WORKER SAFETY AND HEALTH IN COAL CONVERSION

Murray L. Cohen
National Institute for
Occupational Safety and Health
Rockville, Maryland

Abstract

The National Institute for Occupational Safety and Health (NIOSH) is responsible for developing recommended standards for occupational exposures to chemical and physical hazards, including those which arise in newly developing technology. An assessment of the potential deleterious impact on the occupational environment by coal conversion technologies is in progress, including the identification of possible hazardous exposures to workers and the development of strategies for control of these exposures.

NIOSH has developed occupational safety and health guidelines for coal gasification pilot plants and is preparing recommended standards for coal conversion processes that will likely be commercialized in the U.S. by 1985. The methodology includes a world-wide literature survey, visits to operational facilities, and evaluation of the occupational safety and health practices and records in coal conversion plants.

A unique process orientation forms the basis of the occupational safety and health recommendations, with emphasis on real-time monitoring of indicator substances to identify problem areas and fugitive emissions. Engineering controls, safe work practices, industrial and personal hygiene, medical examinations and recordkeeping, and personal protective equipment complete the recommended standard.

The need to simultaneously develop control technology and advance process engineering for coal conversion technologies is evident. Potential occupational health and safety problems can be prevented by proper attention to these considerations in the design of synfuel plants.

PROTECTING WORKER SAFETY AND HEALTH IN COAL CONVERSION

The National Institute for Occupational Safety and Health (NIOSH) is responsible for developing recommended standards for occupational exposures to chemical and physical hazards, including those which arise in newly developing technology. Since April 1976, the Institute has been involved in a project to identify potential hazardous exposures to workers in coal gasification plants. Strategies for control of these exposures are also being developed.

The project has been divided into two parts. *Recommended Health and Safety Guidelines for Coal Gasification Pilot Plants* have been developed, and will be transmitted to the Energy Research and Development Administration (ERDA) later this year for consideration for implementation in the ERDA research and development facilities. In August, work began on the *Criteria for Recommended Standards for Occupational Exposures in Coal Gasification Plants.* This NIOSH criteria document will address coal gasification processes that will likely be commercialized in the United States by 1985. In May 1978, the recommended standards will be transmitted to the Department of Labor Occupational Safety and Health Administration for consideration for rulemaking.

It is important to note that the development of criteria documents includes substantial review at five different stages of drafting. Reviewers include NIOSH staff and consultants, other federal and state agencies, and representatives of industry, labor unions, and academia.

The protocol followed in the development of each of these documents includes a world-wide literature survey and review, visits to operational facilities, and evaluation of the occupational safety and health practices and records in coal gasification plants. The recommendations for control of hazardous exposures have in all cases been based upon the operational experiences of existing facilities. Similar data from industries with analogous exposures, such as coke ovens and coal liquefaction

plants, have also been considered in the identification of potential hazards to workers.

A process oriented approach is being used in the development of these recommended standards, as opposed to the more traditional single hazard approach. The processes are divided into operational units characterized by certain hazards. Recommendations for control of exposures are then designed in unit packages that are specific for each process unit. The recommendations emphasize real-time monitoring of indicator substances to identify problem areas and fugitive emissions. Engineering controls, safe work practices, industrial and personal hygiene, medical examinations and recordkeeping, and personal protective equipment complete the recommendard standard.

PILOT PLANT DOCUMENT

The pilot plant worker may be exposed to toxicants by inhalation of gases or airborne particles, skin deposition of airborne material, contact with contaminated surfaces. and accidental ingestion. In maintenance operations, liquid and solid residues may be encountered that would not ordinarily constitute normal operational hazards (NIOSH 1977).

The range of toxicants and possible health effects is extremely wide, from simple chemicals like carbon monoxide to complex mixtures of organic carcinogens. This complexity is further complicated by the special problems associated with carcinogens: long latent period, doubt about "safe" levels, and unpredictable multiagent interactions (NIOSH 1977).

These conditions cannot be met by protective measures, monitoring procedures, and medical tests that are simply the sum total of controls for each individual toxicant. The complexity of the potential hazards calls for innovative control strategies (NIOSH 1977).

Few data are available concerning the workplace environment and other occupational health factors in coal gasification plants. The somewhat better documented health hazards of coke ovens, coal liquefaction, and similar plants are relevant, but not fully acceptable as models for coal gasification (NIOSH 1977).

The structure of the document includes a detailed description of a representative process, identification of toxicants and potentially hazardous operations, a review of health effects associated with the toxicants and diseases observed in association with coal processing, recommendations for worker protection, monitoring procedures, safety considerations, and recommendations for research to meet identified gaps in knowledge and technology for worker health and safety protection.

The coal gasification processes used as references are seen in Table 1. Synthane is the representative process for development of control strategies, and significant differences or unique characteristics of the other processes are noted in the document.

The unit processes for which specific control strategy packages have been developed are coal preparation, pretreatment and gasification, quench and scrubbing, CO shift conversion, acid gas scrubbing, methanation, sulfur recovery and waste water treatment, and the handling of condensable hydrocarbons, ash, and char.

Health effects data that serve as the basis for the recommendations are reviewed for the following toxicants:

- Aliphatic hydrocarbons
- Ammonia
- Aromatic Amines
- Aromatic hydrocarbons
- Arsine
- Carbon disulfide
- Carbon monoxide
- Carbonyl sulfide
- Heterocyclic aromatics
- Hydrogen chloride
- Hydrogen cyanide
- Hydrogen sulfide
- Mineral dust and ash
- Nickel carbonyl
- Nitrogen oxides
- Nitrosamines
- Phenols
- Polycyclic aromatic hydrocarbons
- Sulfur oxides
- Trace elements

Other types of data essential for develop-

TABLE 1

COAL GASIFICATION SYSTEMS USED AS REFERENCES

Process	Pressure, psig	Product: Temperature, °F	Product: Gas Quality	Product: Liquids	Coal Feed	Status (Dec. 1976)	Type
HYGAS, Steam-Oxygen	1000[a] 1000-1500[c]	1300-1900	Medium or high	Light oil and tar	Lignite Sub-bituminous Bituminous[b]	Operational	Pilot
CO_2 Acceptor	150[a] 150-300[c]	1500-1850[d]	Medium or high	None	Lignite Sub-bituminous	Operational	Pilot
MERC Unit	200[a] Atmos-300[c]	Combustion zone 2400-2500 Gas off take 1000-1200	Low, medium, or high	Light oil and tar	Lignite Sub-bituminous Bituminous	Operational	Pilot
Synthane	1000[a] 600-1000[c]	1500[a] 1400-1800[c]	Medium or high[e]	Light oil and tar	Lignite Sub-bituminous Bituminous[b]	Start-up	Pilot
Bi-Gas	Upper stage (entrained flow) 1000-1500 Lower stage (vortex flow) 1000-15000	1400-1700 2800	Medium or high[e]	(Doubtful)	Lignite Sub-bituminous Bituminous	Start-un	Pilot
Agglomerating Burner	Atmos-100	1800	Medium or high	(Questionable)	Lignite Sub-bituminous Bituminous[b]	Start-up	PDU
Steam-Iron	1000-1200	Hydrogasifier 1300-1700 Producer 2000-3000	Hydrogen	None	Char	Under construction	Pilot

[a]Normal operating pressure.

[b]Must pretreat agglomerating bituminous coal.

[c]Optimal range.

[d]Coal bed 1500°F, regenerator 1840°F.

[e]Can be converted to low-Btu gas production.

Source: NIOSH Recommended Health and Safety Guidelines for Coal Gasification Pilot Plants.

JOB HAZARD BREAKDOWN	JOB DESCRIPTION	JHB NUMBER
	COMPONENT	BUILDING
REVIEWED BY INDUSTRIAL SAFETY	PREPARED BY	DATE
DATE / INITIALS	REVIEW DATES	

SAFETY EQUIPMENT REQUIRED	TOOLS & EQUIPMENT REQUIRED	JOB PREPARATION
	HAZARDOUS MATERIALS	RELATED REQUIREMENTS
		RADIATION WORK PROCEDURE YES ☐ NO ☐ NUCLEAR SAFETY SPEC. YES ☐ NO ☐

JOB STEP	HAZARD	SAFETY RULES AND SAFE PRACTICES

PAGE 1 OF ____

54-3000-220 (1-70)

Figure 1. Job safety analysis sample form.

ment of recommendations on a unit process basis include health effects studies for the coal liquefaction and coke oven industries, and engineering data that serve to predict potential problem areas in coal gasification plants. Stream analyses, material balances, and process flow sheets from the existing pilot plants were extremely useful in this regard.

Recommendations for worker protection are prescribed in the document, and include safe work practices, engineering controls, protective equipment, workplace monitoring, medical examinations, recordkeeping, health education program, personal hygiene, and regulated areas.

Figure 1 is a sample job safety analysis form, and represents a safe work practice that should be required for all routine operations. Maintenance tasks should also include safe work permits signed in advance by both the shift supervisor and safety officer. Figure 2 shows a sample pump and shutoff valve arrangement that constitutes a simple but highly effective engineering control. Medical monitoring should include a full preemployment physical, regular checkups, long-term followup of high risk individuals, and full recordkeeping for all workers in the plant. An effective health education program must both teach the employees the hazards associated with their work, and continually remind them of the importance of the health and safety protection program.

Figure 3 is a sample layout for clean and dirty locker rooms that can assure good personal hygiene. The important points are that no contaminated work clothing or gear can be mixed with clean street clothing, or be taken from the plant facility. Figure 4 shows signs that can be used to enforce the regulated areas recommendations.

Effective workplace monitoring can be accomplished by continued monitoring of indicator substances such as CO or H_2S. This concept allows for real-time detection of leaks, indicates the time when measurements of specific substances that cannot be analyzed in real-time should be made, and easily "flags" periods when precautions for exposure to substances that are difficult or impossible to analyze at prevailing concentrations should be taken.

The characteristics of a good indicator substance are as follows: easily monitored in real-time, suitable for analysis where resources are limited, presence in ambient air at low or consistent concentrations, free from interfering substances in process stream or ambient air, and a regulated agent that must be measured anyway (NIOSH 1977).

These characteristics are the criteria for choosing a specific indicator substance in a specific process or work area. "Tailor-made" workplace monitoring programs can then be developed according to process conditions in a specific coal gasification plant.

COAL GASIFICATION CRITERIA DOCUMENT

This program is just getting underway, with an anticipated publication date of June 1978.

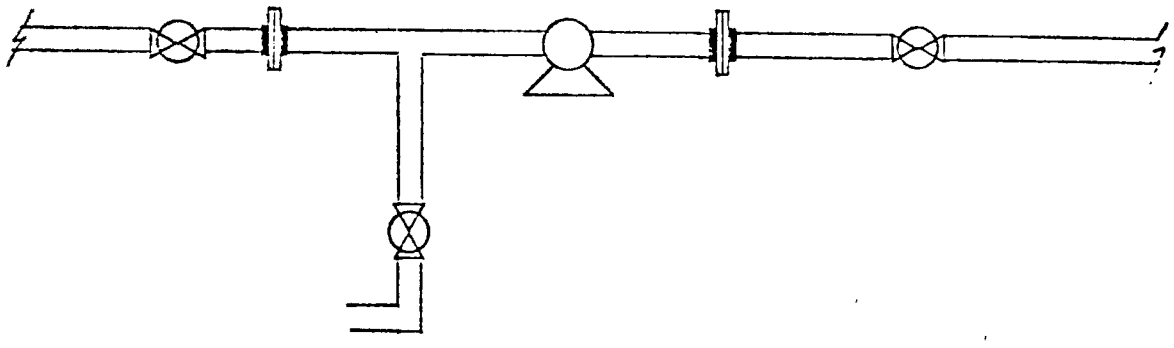

Figure 2. Pump and shutoff valve.

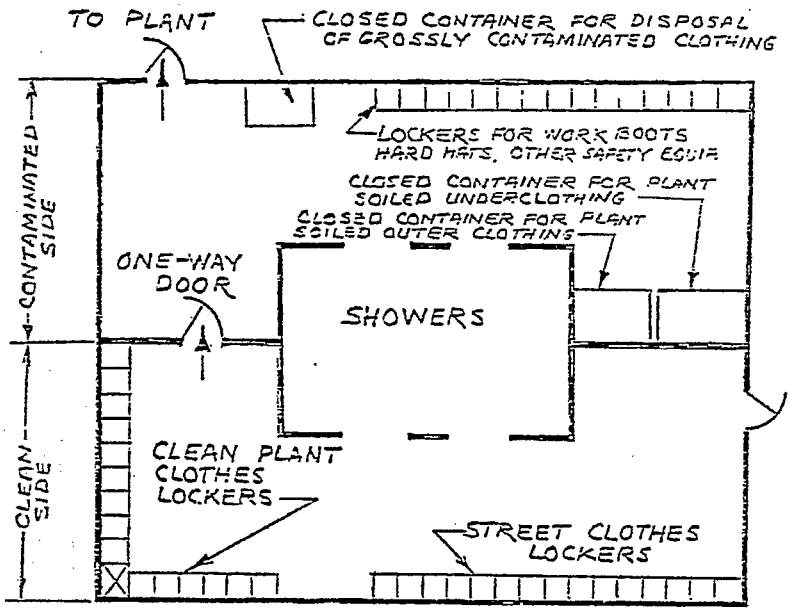

Figure 3. Sample layout for clean and dirty locker rooms.

CAUTION

Restricted Area

Authorized Employees Only

CAUTION

Cancer Suspect Agents

Respiratory Protection Required

Authorized Employees Only

Figure 4. Sample signs for regulated areas.

The criteria document will focus on the following coal gasification processes that will likely be commercialized in the United States by 1985: high-BTU (LURGI), low-BTU (bituminous or lower grade coals), and low or medium-BTU (anthracite or non-tar producing). Hazard control recommendations will be developed from a unit process perspective for each of these classes of operation and will be similar to the types of recommendations developed for the pilot plants. Since few commercial coal gasification facilities are currently operational in the U.S., the recommendations will emphasize engineering controls and design criteria for built-in margins of safety.

It is hoped that these NIOSH documents will serve as handbooks for use in developing effective comprehensive safety and health programs in the building of the coal gasification industry. The philosophy of the program is based on the principle that before a new technology is introduced or an existing technology is modified, its occupational health and safety impact should be evaluated. Historically, advances in technology have been accompanied by new hazards which are often apparent only many years later, after workers become sick or die. The styrene-butadiene rubber industry is an example. In the 1940's, with 90 percent of the natural rubber supply cut off, the Federal government financed the building of fifteen styrene-butadiene rubber plants (Morton, 1973). Three decades later, we are finding that styrene-butadiene rubber employees have a six-fold risk, as compared with other rubber workers, of dying of cancer of the lymphatic and hemopoietic systems (McMichael et al. 1976). If occupational health and safety are properly considered in developing coal conversion technologies, then these plants, hopefully, should not contribute to serious health problems twenty to thirty years from now for today's workers.

REFERENCES

1. M. Morton (ed), Rubber Technology - Second Edition. W. M. Saltman, Styrene-Butadiene Rubber, Ch. 7: 178-198. Van Nostrand Rheinhold Co., New York, 1973.
2. A. J. McMichael et al., Mortality Among Rubber Workers: Relationship to Specific Jobs. JOM, 18:3, 178-185. March 1976.
3. National Institute for Occupational Safety and Health. Recommended Health and Safety Guidelines for Coal Gasification Pilot Plants. NIOSH, Washington, D.C. 1977. (In preparation)