17. Preventing Work-Related Injury and Illness in the Future

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Preventing Work-Related Injury and Illness in the Future

Looking ahead in occupational safety and health, except in the most general way, is as difficult and open to error as predicting the future in any field. In general, changes in plant and manufacturing techniques, shifts in types of jobs, and attention to controlling hazards are expected to reduce work-related injury and illness. Some new and exotic hazards are certain to accompany new processes, but what has been learned from controlling or failing to control current workplace hazards can be applied to recognizing and controlling the new ones.

To some extent, the workplace of tomorrow will be the workplace of today. Some worksites and industries will change little, and even in those that change, seemingly mundane factors will continue to contribute to workplace injury and illness. Inadequate guarding of machinery, poorly designed hand and power tools, and inappropriate walking and working surfaces will not go away without attention to injury prevention. Some long-known health hazards remain problems. For instance, silica dust in plants, mines, and foundries continues to cause ill health. The absence of controls in such situations underlines the importance for policymakers to understand how incentives for adopting controls work and do not work.

The look at the future in this chapter is very much constrained by knowledge of the present. The changes that are described are evolutionary, not revolutionary. That is not intended to imply that revolutionary changes will not take place, but it acknowledges that revolutionary changes are far harder to predict. For example, the drafters of the National Cancer Plan in 1970 failed to mention one of the most important biological advances, recombinant DNA (544), for the simple reason that it had yet to be "invented. "

The future will present a mix of the problems of today and tomorrow. The mix, it can be said with some confidence, is bound to change, and certain new, just emerging problems, are expected to capture the attention and efforts of safety and health professionals in the years ahead. This expectation is in keeping with the observation made earlier in this report that concern about the new sometimes seizes the imagination and attention of expert and lay person alike. This is particularity likely to happen when the old problems are concentrated in industries or trades that are seen to be on the way out and there is little incentive to invest in them. It is a sure bet, however, that old problems in old industries will not take care of themselves if attention is diverted from them.

FUTURE TRENDS

There are a few sources of information about expected trends in employment and other sources for predicting where new technologies are likely to be used; careful consideration of trends by leaders in health and safety could lead to the development of controls to accompany the new technologies.

The 1984 edition of ***U.S. Industrial Outlook: Prospects For Over 300 Industries (554),*** prepared by the Bureau of Industrial Economics, Department of Commerce, estimates that the U.S. population will grow throughout the 1980s at a rate similar to that of the 1970s-0.9 percent per year. The rate remains the same because the effects of changes in fertility, immigration, the age of the population, and mortality roughly cancel out. The predictions for increases in fertility rates and legal and illegal immigration and decreases in mortality would, by themselves, lead to an expected increase in the population growth rate. Balancing those is the fact that women born during the baby

boom of the 1940s and 50s are passing out of their most fertile years, reducing the number of women having children. Reduced mortality and aging of the baby boomers will produce an increase in the average age of the population.

The labor force increased by 23 million (26 percent) between 1972 and 1982. Part of the growth resulted from the unprecedented increase in the number of women entering the work force, the remainder from the entry of young men. This spectacular rate of growth will not continue during the next decade, when 17 million people (a ***16*** percent increase) are expected to enter the work force. These projections indicate that prevention of injury and illness in the next 5 years will be affected by an aging work force including an increasing number of women.

Even this very general information can be of value to health and safety professionals as they look ahead to the next decade. For instance, older workers may respond differently to prevention training than younger workers. Women will require different considerations in the ergonomic design of jobs and personal protection equipment.

Information about which industries are likely to **grow and which are likely to decline is useful for directing research in control technology and for encouraging companies to consider injury and illness prevention before a new plant is built and new technologies installed. Anticipation of prob**lems in the planning stages can help prevent serious problems later on. Gaining industries cited in the 1984 report include the motor vehicle and electronic-product-related groups. However, the most rapid growth was expected in the service industries. The injury rate in those industries—computer, banking, legal, and medical services and related activities—is lower than the all-industry average. Nevertheless, the number of people employed in them means that attention to safety and health in those industries will be increasingly important in the future.

The Environmental Protection Agency (EPA), in cooperation with the National Institute for Occupational Safety and Health (NIOSH), has considered the production of a document that would concentrate on environment and occupational health and safety. As planned, the outlook would have two parts. In the first, data available from Federal sources about current and expected employment levels, injury and illness rates, compliance with Occupational Safety and Health Administration (OSHA) regulations and EPA air and water quality regulations, solid waste disposal, and energy and water use would be presented for each four-digit Standard Industrial Classification code. Insofar as possible, information about occupational and environmental measures would be presented for each industry covered in the Department of Commerce Industrial Outlook. A very useful feature of the EPA/NIOSH document is that all the data are entered in a computer network so that users with personal computers can carry out their own analyses. The second part of the document is a narrative, profiling each of the industry groups in terms of environmental safety and health, highlighting trends in the work force, the use of new technology, the handling of hazardous substances, and other related matters (220).

OPPORTUNITIES FOR PREVENTION

Many new technologies should be inherently safer for workers than those of the past, but new processes will require modification of old or fabrication of new controls. Eight kinds of workplaces are discussed here as examples of changes that are expected:

- Energy-related industries:
  - Synthetic fuel production
  - Coal mining
  - Off-shore oil drilling
- Modernizing old industries
  - Steelmaking
  - Automobile manufacturing
- New industries
  - Semiconductor manufacturing
  - Biotechnology industries
- Rapidly growing occupations
  - Office work

In terms of expected numbers of workers, the industries vary. Synthetic fuels may or may not become important in the future and even if they do, large-scale production will take time to achieve. Should that happen, a new work force will have to be trained, and employment in the industry could take off. Coal mining and offshore oil drilling are employing more workers now. With the introduction of larger, more efficient machinery in mining, the number of miners is expected to plateau and then decline. Oil drilling employment will increase or at least remain constant so long as the search for oil fields is profitable. Steel and auto manufacture, despite some recent resurgence, are not expected to employ as many as they did in the **1970s.**

Jobs in the semiconductor-related technologies are expected to increase. Biotechnology is, perhaps, at a point in its development analogous to that of the semiconductor business a decade or two ago. If some of the newly created biotechnology firms are successful, there should be more jobs in this field, but the maximum number of workers is likely to be small and they will be highly trained.

Technologies affecting office work crosscut all sectors, both public and private, and are rapidly growing as the U.S. economy becomes increasingly information-oriented. It is expected that the number of workers in offices or at least doing work that is now associated with offices will increase over the next few decades.

Consideration of future employment opportunities is directly related to health and safety. Not only do different jobs carry different risks, but more important, work is essential to good health. A number of studies have shown that medical services are more heavily used during periods of unemployment, that mental health problems increase in number and severity, and that suicides increase. Working is good for health, and proper attention to identifying and controlling hazards in the workplace can prevent injuries and illnesses.

Energy-Related Technologies

The fuel crises of 1973 and 1978 led to dramatic changes in the production and use of energy in the United States. The Department of Energy was formed, and resources were marshaled for the Nation to become energy independent through finding new energy sources and new technologies for conserving energy. Production of liquid fuels from coal, oil shale, and tar sands will involve new technologies and new hazards, and new controls will be needed. Increased coal use will stimulate the purchase and use of new mining machinery that will require appropriate controls.

Synfuel Production

Synthetic fuel (synfuel) production methods break down complex molecules of relatively **abun**dant and naturally occurring carbonaceous material such as coal or oil shale to produce simpler, cleaner, more efficient fuel. Although these technologies have been used before on a small scale, they have never been economically competitive with fuel production from crude oil and have remained commercially undeveloped. These technologies, though, could eventually be adopted by the United States to achieve energy independence.

Congress established the U.S. Synthetic Fuels Corporation (SFC) to fund projects that would lead to production of clean and safe energy. The SFC has proposed guidelines to monitor emissions in the workplace and to the surrounding environment (653):

> Any contract for financial assistance shall require the development of a plan, acceptable to the Board of Directors, for the monitoring of environmental and health-related emissions from the construction and operation of the synthetic fuel project **(486).**

Plans requesting financial assistance are to include details of a monitoring system, listing substances to be monitored; the frequency, location, methods, and durations of monitoring; and worker exposure and health surveillance programs. A worker registry is required to integrate worker exposure data, medical records, demographic information, and job classification codes so that any trends in work-related injury and illness can be identified.

Production of liquid fuel from shale oil involves liberation of some chemicals that are carcinogenic, and studies of pilot plant workers in this country report dermatitis, eye irritation, and thermal burns from job exposures. Fire and explosion are hazards because of the operating temperatures and pressures necessary for synfuel production.

Table 17-1 lists the potential hazards that could be expected in a coal liquefaction plant. Problems are encountered during coal handling and preparation, during the process itself, and during waste treatment. Estimates have been made of the chemical products and byproducts that might be found at each point in the process so that worker protection can be considered during design (575).

Concern about these hazards has contributed to systematic analysis of plans of future synfuel plants in an effort to anticipate causes of injury or illness. For instance, NIOSH reports one example of the success of this approach. High pressure vessels for coal liquefaction operate at extremely high pressures and temperatures and contain flammable material. Engineers, recognizing the potential hazard from a high-pressure vessel used in a bench-scale (laboratory-sized) coal liquefaction process, placed protective barriers around it. When the vessel unexpectedly exploded, harm was prevented. In another instance, reinforced concrete walls between the liquefaction system and the operating control room protected operators from injury and operating controls from damage. The unharmed operators were able to shut down the process, thus preventing further explosions and fire. These same techniques could be applied in future operations to prevent harm at all levels of operation *(575).*

Coal Mining

Most coal is **used** in the traditional way to generate power directly in steam plants, and its use has increased during the past decade of uncertainty about oil supplies. Use is expected to increase further, to double, in fact, by the year 2000, to as much as two billion tons per year (536).

Mining and moving coal are hazardous. Over 100,000 coal miners have been killed since 1900), and coal workers' pneumoconiosis (black lung disease) has taken a high toll. **A** mortality study of 23,233 miners selected randomly from those eligible for United Mineworkers of America health and retirement funds as of January 1, 1959 and followed through December 31, 1971 with 99 percent followup, reported excess mortality for stomach cancer, influenza, asthma, tuberculosis, and accidents (392) (see table 17-2). Unless steps are taken to assure prevention of work-related injury and illness in coal mines, an increase in production may lead to excess morbidity and mortality.

Changes in technology are introducing new hazards into the mine. For instance, the diesel en-

Table 17-1 .—Potential Occupational Hazards in Coal Liquefaction Plants

System, unit operation or unit process	Potential hazards
Coal handling and preparation system.	Coal dust, noise, fire, explosion, asphyxia (nitrogen and carbon monoxide gases), burns
Liquefaction system	Phenols, ammonia, tars, thiocyanates, PAH's, carbon monoxide, hydrogen sulfide, hydrocarbons, fires, explosions, burns, high pressures, noise, ash, slag, mineral residue, spent catalyst
Separation system	Oils, phenols, hydrogen cyanide, ammonia, hydrogen sulfide, burns, fires
Upgrading and gas purification	Light hydrocarbons, phenols, ammonia, hydrogen sulfide, carbon dioxide, carbon monoxide, burns, fire, explosion, high pressures
Shift conversion	Tar, naphtha, hydrogen cyanide, fire, catalyst dust, burns, hot gases (carbon monoxide, hydrogen)
Methanation [a].	Carbon monoxide, methane, nickel carbonyl, spent catalyst dust, fire, burns
Waste treatment facilities	Hydrogen cyanide, phenols, ammonia, particulate, hydrocarbon vapors, sludges, spent catalyst, sulfur, thiocyanates

[a]Indirect liquefaction

SOURCE: (575),

Table 17.2.-Standardized Mortality Ratios Among Coal Miners[a]

	Deaths		
Cause of death	Observed	Expected	SMR[b]
All causes	7,628	7,506.1	101.6
All malignant neoplasms	1,223	1,252.2	97.7
Respiratory organs	373	331.0	112.5
Stomach cancer	127	91.9	134.9[b]
Major cardiovascular diseases	4,285	4,501.2	95.2[b]
Chronic and unqualified bronchitis	26	29.0	89.7
Influenza	28	14.8	189.6[b]
Emphysema	170	118,3	143.7[b]
Asthma	32	18.3	174.9[b]
Tuberculosis	63	43.3	145.5[b]
Coal worker's pneumoconiosis	187	—	—
Accidents	408	283.0	144.2[b]

[a]Coal miners covered by the United Mineworkers of America health and retirement funds The vital status of 22,998 miners was verified.
[b]Standardized mortality ratio (SMR) is significantly different from 100 at the 5 percent confidence level

SOURCE (392)

gine is increasingly replacing electrically powered mine equipment. The exhaust emissions from such engines include cancer-causing polynuclear aromatic hydrocarbons, respiratory system irritants, and asphyxiating carbon monoxide and carbon dioxide.

Control technologies for diesel engines are well known. Diesels operating under ideal conditions, with proper maintenance and operation, produce minimal amounts of contaminants. In underground coal mines, ventilation can be increased to keep contamination at a minimum. Filters, recirculation of exhaust gases through the engine, catalytic converters, and exhaust scrubbers can also be used to clean the exhausts (477). Such controls are difficult and require high degrees of maintenance to assure that they are functioning properly.

Other examples of a production technology that may increase risk of injury in the mines include continuous miners and long-wall mining. Continuous miners are machines that cut into a coal vein and transfer loose coal back to a conveying mechanism for transport to the surface. While they increased productivity when they were phased into the mines from **1950 to 1970, the fatality rate rose slightly and the disabling injury rate continued at a relatively constant level. Long-wall mining is a mining method** in which a machine extracts coal by moving back and forth across a face while conveying the coal to one of two tunnels dug parallel to each other and at right angles with the coal face. The coal is transported to stations for transfer to the surface via conveyors running through the tunnel. Supports at the face protect miners while allowing the roof to cave in behind the face just worked, preventing unwanted roof fall. Longwall mining may reduce fatalities but not necessarily injuries or harmful dust levels ***(536).***

Outer Continental Shelf Oil Production

Another energy area expected to grow is oil and gas production on the outer continental shelf. Demand for energy has led to the development of technologies for deep water oil and gas exploration in remote locations and under extreme environmental conditions. An increasing number of workers, already at high risk because of the nature of oil extraction, will face even greater risks of work-related injury and illness. In the period 1970-79 employment in outer continental shelf oil and gas exploration grew by 71 percent (to a work force of 61,500) for an average annual growth of 3 percent. Moreover, there was a 20 percent per year increase in two years, 1978 **and 1979 (319).**

There are two areas of concern. The first is the design **and stability of drilling rigs. A combination of bad weather and inadequate structural strength has resulted in major catastrophes, such as the failure of a mobile offshore drilling unit** in 1982 in the North Atlantic that killed 84 ***workers.***

The second area is the risk to workers from the work itself. Drilling is frequently continuous, being done in shifts 7 days a week, under difficult conditions. Drill space is cramped and pipes, tubing, tongs, and other material are heavy and cumbersome. Walking and working surfaces are slip pery from drill fluids. The work is outside, so weather is often a factor. The severity of these conditions is heightened on offshore drill rigs and may be expected to be even more severe on offshore units located in remote areas, where weather may be extreme.

Modernizing Old industries

U.S. manufacturers are facing intense competition from Japanese and Western European companies, and that sector of the U.S. economy may be declining. The declines have been attributed to inadequate investment in new plant, changing market conditions, rising labor costs, and cost-generating Government regulations. Whatever the exact reasons—and they are a matter of argument—it is agreed that the U.S. steel industry is no longer the first in the world. Changes in the qualities of cars that induce people to buy an auto resulted in U.S. consumers buying more foreign-built models, and U.S. domination of auto sales is a thing of the past. Both these industries are retooling and retrenching to meet the foreign threats, and there will be opportunities to build in features to prevent work-related injury and illness.

Steelmaking

Steelmaking is one older U.S. industry that must change if it is to survive. Increased research, development investment, and the use of new technology are all required to compete with steelmaker from other countries (538). Unfortunately, this has become a chronic public policy problem. As mentioned in chapter 16, the Steel Tripartite Advisory Committee, made up of steelworkers, steelmaker, and Government officials, was established by President Carter in the 1970s to attempt to revitalize this industry.

The Committee's Working Group on Technological Research and Development concluded that (458):

> environmental and occupational safety and health issues should be considered as an integral part of technological research and development in the steel industry. Research in steel technology should continue to take into consideration features for protecting workers and improving the ambient environment both with respect to new and to existing steel facilities.

The Working Group went on to recommend Federal funding for research and development and for demonstration plants. These recommendations were agreed to in recognition of the high risk of work-related injury and illness in steelmaking, and the opportunity to reduce costs through development, demonstration, and adoption of control technologies.

New technologies for steelmaking are more productive and likely to cause fewer work-related injuries and illnesses. For example, continuous casting is used to produce 80 percent of Japanese steel and 32 percent of U.S. steel. It requires less energy, costs less per ton of steel produced, and produces higher quality steel and less pollution. It also eliminates soaking pits and reheating furnaces and requires less coke making, three steps in the traditional process that produce emissions that are associated with disease. In general, better working conditions exist in continuous casting steelmaking plants.

Another new steel technology is direct reduction of iron ore rather than the current process of blast furnace and coke oven. Since direct reduction can be done without coke, risk of lung cancer from coke oven emissions can be eliminated. Other technologies that show promise for the 1990s and that can be made less likely to cause work-related injury and illness include formcoking (another process reducing coke oven emissions), direct casting of sheet and strip metal from molten steel, and one-step steelmaking directly from ore. In the latter two processes, potentially hazardous steps in the process are eliminated, thus reducing risk of worker harm.

The same changes that improve production and reduce risks will cause further shrinking of the work force. In the late 1970s, 450,000 workers were employed in steel; in 1983, the number was less than 250,000, and it continues to decline.

Automating

Automating includes many kinds of industrial operations, ranging from metalworking in steel-

works and foundries, to forging and machining of metal parts, to fabrication of plastic parts, and, finally, to assembly. Hazards in the steelworks and foundries include noise, heat, dust, and gas. Forging and machining are also hazardous. Auto body painting presents special hazards due to the large volumes of paint and solvents used during assembly. Stress-related illness may result from monotonous work and shift work.

Conventional controls are available for these hazards. Local exhaust and dilution ventilation are widely used in all phases of manufacture and can be expected to be improved in new processes. Automated spray painting in booths reduces or eliminates worker exposure. The use of robots in areas of high hazards can reduce risks to workers.

Robots or automated manufacture also introduces hazards. There have been cases here and abroad of workers being injured or killed by automated machines. This points to the need for machines to stop when workers inadvertently come in contact with them or to be installed where they keep workers out of danger zones while the machine is connected.

New Technologies

New technologies that are burgeoning or promise to burgeon into full-scale industries present opportunities to prevent work-related injury and illness in the early stages at low cost. The most successful of the new industries is the semiconductor industry, and the most glamorous of the promising ones is biotechnology.

Photo credit: NIOSH

This paint spraying line has been automated using robots. Future developments in robotics may reduce worker exposures in other hazardous operations

Semiconductor Manufacture and Related Industry

The continuing demand for computer and video devices for industry and commerce, coupled with consumer electronics and computer technologies for microelectronic applications, is expected to fuel the growth of this industry.

Microelectronics has been estimated to have a world market of more than $19 billion and employ a work force of 500,000 worldwide (258).

The risk of work-related injury appears to be lower and illness appears to be higher in this industry. In 1981 the Bureau of Labor Statistics reported the injury incidence rate for semiconductor and related devices as 4.6 cases per 100 full-time workers and lost-workday cases as 2.0 per 100 workers, compared with an all-industry average incidence rate of 8.3 cases per 100 workers and lost-workday cases of 3.8 per 100 full-time workers (608). The California Department of Industrial Relations conducted a survey in 1980 that showed workers manufacturing semiconductors had 1.3 illnesses per 100 workers compared with a rate of 0.4 per 100 workers in the general manufacturing industries. Lost time resulting from work-related illness was three times more common among semiconductor workers (18.6 percent of all lost-workday cases) than in general manufacturing industries (6.0 percent of all cases) from 1980 to 1982. Almost half (46.9 percent) of all work-related illness among Californian semiconductor workers in this period was reported to result from exposure to toxic substances (258).

Known health hazards include metal fumes from soldering, toxic chemicals such as epoxy resins and chloronaphthalene, silica flour used in making insulating materials and dielectrics, solvents for decreasing solder joints, and acids for etching printed circuits. The volumes of these chemicals used in California in 1979 were large: Over two million gallons of solvents; more than two million gallons of sulfuric, hydrofluoric, and other acids; more than one-half million gallons of sodium hydroxide and other caustics; and over one and one-half million cubic feet of arsine, phosphine, diborane, and other toxic cylinder gases were used in processing semiconductors (258).

Existing technologies, if applied, should be sufficient to control these hazards. Local exhaust ventilation is appropriate for soldering and etching operations. Substitution may be appropriate where solvents are found to be more toxic than expected. Replacement of carbon tetrachloride and trichloroethethylene (after they were shown to be carcinogenic among laboratory animals) with perchloroethylene is an example of this.

Biotechnology

Recombinant DNA technologies, operating at moderate pressure and temperature, have fewer inherent physical hazards than traditional chemical processes, which sometimes operate at dangerously high pressures and temperatures. Furthermore, to the extent that biotechnology uses pinpoint production techniques to produce particular chemicals, it will eliminate the currently encountered mixtures of chemicals, contaminated with unwanted toxic compounds, that are common in conventional chemical synthesis.

Biotechnology's hazards center on the possibility that the microbes used in it or products produced from them will be harmful to human health or the environment. Since some of these organisms are "new," in that they have been produced by genetic engineering, there is concern among some people that they present significant risks (541,548). Most experts in the field see the organisms being used for or proposed for use as production organisms as "crippled" and unable to survive outside the laboratory or workplace.

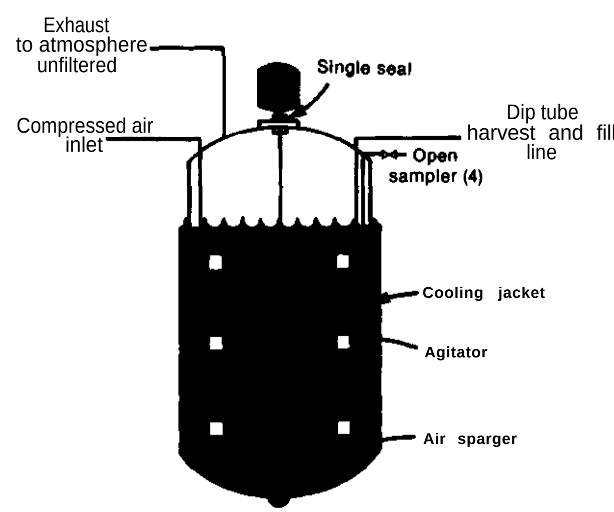
More of a problem are "new" micro-organisms developed to be released into the environment. Because they will have to compete with organisms that occur naturally, they cannot be crippled. For that reason, EPA is now considering regulating the intentional release of such organisms, and Congress has expressed interest in a regulatory scheme.

In the area of using micro-organisms for production, the United States appears to have studied questions of worker health more carefully than other countries. The U.S. voluntary approach to worker protection is monitored by the Research Advisory Committee of the National Institutes of Health, and NIOSH has developed guidelines for medical surveillance of fermentation and biotechnology plant workers (259a).

NIOSH industrial hygiene surveys of six industrial laboratories using recombinant DNA technologies found wide variation in safety and health practice among them. Practices ranged from "exemplary" plants with health and safety programs for workers to plants where workers were allowed to smoke and drink in the laboratory and to store beverages in laboratory refrigerators, and where procedures for biological waste-disposal were undocumented—all unacceptable practices.

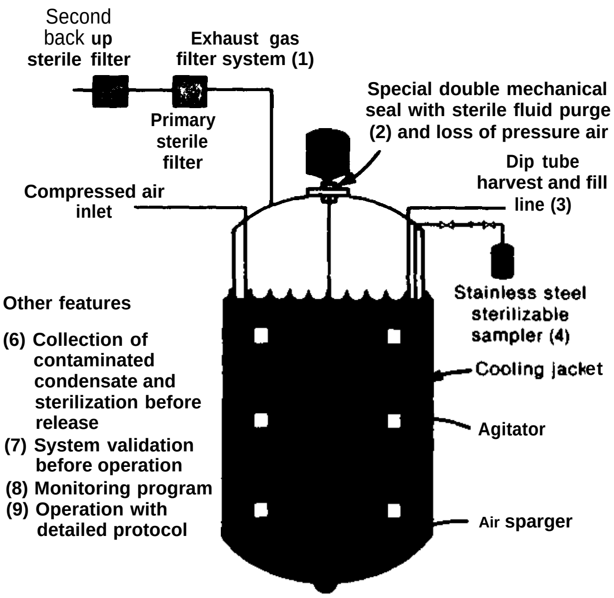
Figures 17-I and 17-2 contrast a standard fermenter with a contained one, which would contain organisms and culture media used in biotechnology. The contained fermenter provides for double filtering of exhaust gases to control emissions, a special mechanical seal at the top to provide extra protection against loss of growth medium that contains bacteria, and an alarm to warn operators of ruptured seals, thus helping prevent possible loss of contaminated broth. These features of the contained fermenter provide increased protection both to workers and the environment.

Figure 17-1 .—Features of Standard Fermenter



SOURCE: NIOSH

Figure 17-2.—Features of Contained Fermenter



SOURCE: NIOSH

Rapidly Growing Occupations

Office Work

Thirty-three million people work in office jobs in this country. The advent of new technology such as computers using video displays and advanced copying machines have changed the office. To some extent, machines can pace the work, introducing a new source of stress. Lighting and furniture, ignored in the installation of the first computers and word processors, are important to worker comfort and probably to health and safety.

The energy crisis has resulted in office buildings being tightly insulated. Unfortunately, improved insulation that keeps heat or cooled air in also prevents air exchange from cracks and other tiny **leaks** and increases indoor air pollution. Because building air is recirculated to conserve energy rather than directly exhausted to the outside, many ventilation standards are now inadequate. Formerly unacceptable, the practice of recirculation has been adopted to reduce the relatively high costs of heating and cooling. Harmful air contaminants, aerosol can chemicals, tobacco smoke, and pathological micro-organisms may reach unacceptable levels. Some building technologies also contribute to the contamination. For example, the irritating and potentially carcinogenic compound formaldehyde is emitted ***from*** plywood, and naturally occurring radioactive radon gas may be emitted from certain building sites. Even when the exact causes of workers' health problems remain unidentified, the problems have been reversed with increased ventilation.

Health effects have been related to indoor air pollution. At high concentrations, indoor air contaminants may cause irritation of sensitive tissues, and acute or chronic illness. Many substances appear to act primarily as irritants at low exposure levels, inducing local inflammatory reaction in the eyes, nose, lung, or other sites **(25).** NIOSH made 159 health hazard evaluations in response to requests between 1971 and 1983. Table 17-3 shows that irritation of eyes and throat were reported in 81 and 71 percent of the cases respectively (661).

Control of indoor air pollution maybe achieved by increasing ventilation rates, eliminating the source of contamination, and air cleaning (25). Air cleaning is generally limited; although it filters particles, it does not remove gases and vapors.

Table 17-3.-Frequency of Health Complaints in 55 Office Environment investigations

Symptom	Percent of buildings with complaint
Eye irritation	81
Dry irritated throat	71
Headache	67
Fatigue	53
Sinus congestion	51
Skin irritation	38
"Shortness of breath"	33
Odor	31
Cough	24
Dizziness	22
Nausea	15

SOURCE: (661).

Ventilation standards, if they are to guard against indoor air pollution under the new conditions, need to be rewritten.

There are reports that office work, especially work involving routine use of computers for document completion and filing, is being moved from the office to the home. While working at home is attractive to many people, it will also introduce new concerns. Stress may be increased by a sense of isolation from the workplace and coworkers, and opportunities for advancement, which are a positive force in most workers' lives, may not exist. Also, to the extent that office machines bear hazards, those are likely to go unrecognized in the dispersed workplace and even more likely to go uncontrolled (25).

SUMMARY

The ability to anticipate change is fundamental to preventing work-related injury and illness. Knowledge about the sectors of the economy where changes are likely to take place, what the changes might be, and how they might affect workers will help responsible officals carry out their mandate under the Occupational Safety and Health Act and to improve occupational health and safety in other ways.

Changes can be expected in energy-related industries, modernization of older industries, industries relatively new to the economy, and in the rapidly growing area of office work. New technologies are being introduced, some of which could cause work-related injury and illness. But these changes also present opportunities for preventing work-related illnesses and injuries.

The production of synthetic fuels also creates possible worker exposures to a number of different hazardous substances, as well as a potential for fires and explosions. Coal mining has always been hazardous, not only in terms of injuries, but is also associated with increased worker illness. The use of diesel engines and new production technologies introduce new hazards underground. Operations on offshore oil and gas rigs result in relatively high injury rates.

Modernizing older industries such as steelmaking and automating should provide opportunity for additional protection of workers. Meanwhile, brand new technologies, such as electronics and biotechnology, are being introduced. Greater attention should be paid to worker health problems in the manufacture of semiconductors because of the use of toxic chemicals. Biotechnology has the potential of reducing exposures to inherently dangerous chemical processes and potentially hazardous chemical mixtures. But care must also be taken in handling the micro-organisms used in these processes.

Office work is one of the most rapidly changing occupations as new technologies are proliferating. Since one-third of the work force are in offices, even low rates of work-related injury and illness can be of concern. Three areas where attention is needed in offices are indoor air pollution, stress, and the ergonomic problems associated with VDTs.

But the problems of the past will also remain. It will be difficult to convince smaller firms to invest in control technologies, especially as they will find the financing difficult. Companies relying on older technologies, such as those found in the basic industries, remain reluctant to install controls, especially when times are hard. The tortuous process of court battles over standards is likely to continue, leaving the public and workers somewhat bewildered about the protection the Federal Government attempts to afford them.

The incentives for control that are discussed in this assessment deserve careful attention to discern how they work or do not work to encourage better health and safety programs. It is by now clear that regulations are slow to emerge from OSHA, that enforcement will always be limited by the small corps of inspectors, and that OSHA consultation services cannot reach every workplace that could benefit from them. Continuing demands from a work force and a public less willing to accept risk of injury and illness will impose greater pressures on workers' compensation, liability law and the courts more generally, and insurance companies and voluntary associations interested in health and safety.

The great interest in environmental health that developed in the 1970s remains alive and well, and interest in the role of the general environment and the workplace in health has probably become part of the overall social consciousness of the Nation. One of the measures of the importance of those ideas will be improvements in occupational health and safety in the years to come.