OCCUPATIONAL SAFETY AND HEALTH:

A DU PONT COMPANY VIEW

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INTRODUCTION

Occupational safety and health ranks high among major public issues of the day. The creation of the Occupational Safety and Health Administration and the National Institute for Occupational Safety and Health in 1970 was a clear indication that worker protection will be a top item on the social agenda for some time.

The current concern has been stimulated in large part by recent incidents in which workers have been harmed by exposure to substances in amounts once considered safe. The cases that have attracted the most attention are those in which employees working with asbestos, vinyl chloride or bis-chloromethyl ether were found to have developed cancer as a result of exposure to these materials. Widespread publicity has also surrounded the illnesses developed by workers in pesticide plants in Virginia and Texas.

The incidents concerning carcinogenic materials in particular came as a tragic surprise to many people in industry, government and the scientific community. They have helped focus public attention on chronic occupational hazards, especially long-term exposure to low levels of toxic substances.

Acute hazards -- those that cause injury or illness through an accident or one-time exposure -- remain a stubborn

problem. Yet, most acute hazards are now well documented and many industries have made important gains in reducing accidents and injuries. The dimensions of the chronic hazard problem, on the other hand, are just coming to light, and it is these findings that draw attention and concern. The hazards are more subtle, more insidious and more complex than most dangers previously encountered in the workplace. The purpose of this paper is to discuss in some detail these hazards and their effect on the health of employees. In addition, the paper describes the efforts of one company -- Du Pont -- to identify and control health risks posed by carcinogenic chemicals and other chronic hazards.

HISTORICAL PERSPECTIVE ON EMPLOYEE SAFETY

Among the first laws aimed at protecting workers were the child labor laws passed in England in the 19th century. In the U.S., the first child labor laws were passed in the 1840s. Laws pertaining to factory safety appeared in the latter part of the 19th century, and by 1900, most heavily industrialized states had at least rudimentary safety legislation. Its effectiveness, however, was quite limited. Statistics on occupational injuries early in this century often told a dismal story. For example, in 1907, there were 3,242 fatalities in coal mines and some 4,534 railroad workers were killed on the job.

In the U.S., workmen's compensation laws were initiated in the early 1900s. The first law to be upheld in court was passed in 1911, and it was many years before all the states accepted the need for workmen's compensation. The early laws provided limited coverage and small benefits, and some observers believe these and other laws pertaining to worker safety continued to be inadequate, for the most part, into the 1960s.

Historical evidence such as this leaves little doubt that occupational safety and health for many years failed to command strong, sustained public interest.

Early Efforts to Improve Safety

Nevertheless, during this period, efforts were being made by segments of industry to improve workplace safety. Industry established the National Safety Council in 1913. While year-

to-year figures are not strictly comparable due to changes in companies reporting to the NSC, the organization's statistics show a decline in the frequency of injuries between 1926 and 1932. The rate rose during World War II, then dropped to its lowest postwar rate in 1962-64. Death rates per 100,000 workers were at their highest in 1936 for manufacturing and in 1937 for non-manufacturing members of NSC. Since then, the death rate has declined about 50 percent and reached its lowest rate in recent years.

The Federal government has been involved in occupational safety and health since the late 19th century. The first industrial hygiene survey in the U.S. was made for the Department of Labor in 1902. The U.S. Public Health Service's Division of Industrial Hygiene was established in 1914. The first comprehensive safety and health legislation was the Walsh-Healey Act of 1936, which set standards for government contractors. The law, however, provided no real enforcement structure. There was little further action at the Federal level until the 1960s, when legislative efforts culminated in two far-reaching laws: the Coal Mine Health and Safety Act of 1969 and the Occupational Safety and Health Act of 1970.

The Development of Industrial Medicine

Essential to the development of occupational safety and health measures has been the growth of industrial medicine.

The physician who is said to be the "father of industrial medicine" was Bernardino Ramazzini, an Italian physician. He

published his first book on occupational diseases and injuries in 1700, recommending greater attention be paid to such health problems. However, industrial medicine as a discipline did not begin to make real progress until early in this century.

In the decade of 1910, a number of pioneering texts in industrial medicine were published. The organization now known as the Occupational Medical Association was formed in 1915. The American Academy of Occupational Medicine was established in 1946, with Dr. George H. Gehrmann of Du Pont as its first president.

While doctors have been aware for decades that certain diseases can be traced to occupational hazards, it has taken time to develop precise knowledge and sophistication. The problems of known toxic substances, such as mercury, lead and methyl alcohol, were relatively well-defined long ago. On the other hand, other hazards went unrecognized and some illnesses were misdiagnosed over long periods. X-radiation, for example, was sometimes treated as a novel plaything until the deadly effects of exposure began to turn up, and even then the hazards of low doses of radiation were not well understood. It was known for years that exposure to asbestos could cause the lung disease asbestosis, and asbestos was implicated in cancer. Not until the mid-1950s, however, was there strong epidemiological evidence that asbestos fibers could cause the cancer called mesothelioma. Tumors of the bladder were associated with aniline dye production early in this century; only later was it found that not aniline, but other agents were actually causing the cancers.

Increasing sophistication in industrial medicine has resulted from expanded knowledge in biochemistry and toxicology. Fundamental discoveries in the chemistry of living cells have revealed how substances can alter basic physiological processes. Scientists also have become more aware of how materials can affect health when metabolized by the body, and when they work in concert with other substances present in the body or in the environment.

Measuring Trace Amounts

New measurement techniques that can detect minute quantities -- even down to parts per billion for some materials -- have been developed over the past few years and the technology is still being refined and improved. The value of these techniques is twofold. First, they contribute to our understanding of chronic exposure simply by telling us what substances are present in tiny amounts. Second, the tolerance levels being established are often in the very low range -- a few parts per million, for example, or occasionally a few parts per billion. Modern instrumentation is the only means of determining whether these levels are actually being maintained or exceeded.

An example of the strides made in measurement are new gas chromatograph detectors which identify specific types of compounds present in a material. Before these detectors were developed, the gas chromatography method could measure certain substances in concentrations no lower than parts per million. Now, gas chromatographs can measure parts per billion of some substances. In a row of peas between New York and London, one pea would be one part per billion.

THE DIMENSIONS OF THE PROBLEM

How many people are seriously injured on the job each year? How many are made ill by work-related causes? How many die from accidents at work and from diseases caused by workplace hazards? Is the situation getting worse or improving?

It is difficult today to come up with hard-and-fast answers to any of these questions. Statistics on occupational safety have been compiled for years by the National Safety Council and the Bureau of Labor Statistics. The NSC collects information from its member companies and various government agencies. Reporting by the members is done rigorously and consistently on a year-to-year basis, and the figures accurately reflect the safety records of these industries.

The accuracy of nationwide statistics, however, is another matter. Some studies have shown that reporting to government of injuries and illnesses varies from state to state, industry to industry, and company to company. It is particularly difficult to obtain reliable figures on illnesses and fatalities related to the workplace.

Further complicating the picture are the new criteria for reporting injury and illness instituted by OSHA in 1971. The change in reporting standards makes it difficult to compare data and determine recent trends in safety performance, and it will take time for the new system to be interpreted and used consistently by reporting companies.

Workplace Injuries -- How Frequent?

As an example of the confusion, there are three different figures for national injury rates that can be cited from three different sources -- each with its own degree of reliability. According to OSHA, there were 3.5 disabling injuries and illnesses for each 100 man-years (or 200,000 hours) of work in 1974. The total number of cases was 2,000,000.

The National Safety Council estimates that there were 13.2 injuries per million man-hours worked. Using the same time period that OSHA uses, there were 2.6 injuries per 200,000 hours. The NSC estimated a total of 2,500,000 cases. The OSHA and NSC figures are not on comparable bases. The NSC estimate is based on several sources while OSHA's estimate is based on a statistical probability sample representing less than the total work force.

The third figure, often cited as industry's safety performance, is the record for NSC members. These companies have about 6.4 million employees, out of a total work force of 88 million. NSC members reported an injury rate of 10.2 disabling injuries per million man-hours, or about 2 per 200,000 hours in 1974.

How Much Occupational Illness?

There is even more uncertainty over the extent of illness caused by workplace factors. The figures cited above, for example, all contain some cases of occupational illness as well as occupational injury. Just how many cases, however, is difficult to determine.

OSHA's figures give some breakdown on illness vs. injury. The agency reported a total of 60,000 work-related illnesses resulting in lost time from the job in 1974. (These cases include acute illnesses from which employees recover in a short time, as well as chronically debilitating sickness.) But the 60,000 figure may understate the real problem because employers may not report the actual number of occupational diseases. If true, the lack of accurate reporting could be partly due to different interpretations of reporting requirements, and, perhaps, mostly due to the difficulties in recognizing or tracking an occupational illness as such.

The lack of accurate data has not discouraged the practice of estimating the extent of occupational illness. Against the OSHA-reported 60,000 illnesses in 1974, for example, there is the U.S. Public Health Service estimate of 390,000 new cases of occupational disease each year.

Occupational Fatalities

How many people die from work-related causes? The NSC estimates that 13,500 fatalities occurred in 1974. According to reports received by OSHA, a total of 5,900 died of work-related injuries and illnesses in 1974. Both organizations recognize that there is a basic problem in getting accurate, comparable data on fatalities, and efforts are being made to improve and standardize the reporting. At least part of the problem stems from the previously mentioned difficulties in getting information on occupational illnesses. Retirees who die from chronic diseases related

to their occupations are unlikely to be included in the statistics. More important, there is little agreement, even among the experts, on the criteria for attributing a particular death to a work-related cause. Neither the record-keeping nor the state of knowledge is adequate to permit conclusive statements.

Again, the lack of reliable information has not discouraged estimates from being made. One estimate that has received wide public circulation is from The President's Report on Occupational Safety and Health of 1972. It states that there may be as many as 100,000 deaths a year from work-related illnesses. This figure is extrapolated from studies in three hazardous industries -- uranium mining, hard-rock metal mining, and smelting. The "excess deaths" due to disease among workers in these industries were attributed to occupational causes and were used to figure an occupational disease death rate for all working people -- including all those in less hazardous jobs. Du Pont believes that the statistical method does not stand up to logical analysis.

Better Data Needed

On the other hand, those who think the annually reported government figures are the tip of an iceberg can reasonably point to evidence that the figures are inaccurate -- and may well be on the low side. Detailed studies of industries have revealed discrepancies in reporting and instances of unreported occupational illnesses.

Inadequacies of available data, however, are not an excuse for conjecture. Better information is called for. The

reporting rules must be refined and enforced, but beyond these steps society needs to learn more about the causes and the diagnosis of occupationally related illness.

One step that may promote better understanding of the problem is the widening use of the OSHA criteria for identifying and reporting illness and injury. The National Safety Council started using the new standard in 1977 and many industries are adopting it (including Du Pont). Companies often find it necessary, however, to expand the system to yield the current information needed to monitor their safety performance.

DU PONT'S EMPLOYEE PROTECTION PROGRAM

The Du Pont Company has said it will produce materials only if they can be manufactured, transported and used safely. Consistent with this policy, the company has a tradition of diligence in employee protection and for many years has achieved the best safety record of any large industrial company in the U.S.

The company's safety program had its beginnings in the early years, when the only product was black powder, which posed an explosion hazard. An explosion in 1818 killed 40 employees. The company founder, Eleuthère Irénée du Pont, assumed responsibility for the establishment and enforcement of safe practices. This commitment by top management to employee safety has been an essential element in the company's program over the years.

Du Pont holds that all injuries can be prevented, which means it does not accept any predictable level of injury in any operation. However, the goal is not zero risks. There will always be some element of risk in any operation.

Safety is a line responsibility of management. Each supervisor is responsible for the safety of his employees, and each employee knows that he is responsible for his own safety and that of his fellow workers.

These basic policies underlie the safety achievements of the company and its employees. In 1975, there was only one

disabling accident for each four million man-hours worked on the job. That is about one-fortieth the rate of all industry and one-tenth the rate in the chemical industry.

Injury and acute illness are the primary targets of this program. Du Pont is increasing its efforts to make sure that its safety performance extends to the control of long-term exposure to low levels of hazardous substances.

The attack on chronic occupational health hazards must include three elements. There must be a comprehensive program of medical surveillance to monitor the health of employees and spot problems quickly. There must be a sophisticated toxicological research effort to identify subtle hazards and help determine safe exposure limits, which then can be translated into safe manufacturing processes and work practices. And there must be a broad effort to collect and analyze epidemiological data on illness and causes of death among employees. This data can help as a "double check" by revealing areas of risk that need further investigation.

Du Pont has had all of these elements in place for a number of years, and is working to strengthen those efforts that need greater stress in light of the new kinds of problems that are being identified. The next few pages describe medical surveillance, toxicological testing and epidemiological programs in the U.S. in general terms. The paper then turns to a discussion of the cancer problem, the risk of occupational cancer, and how Du Pont is mobilizing its resources against this risk.

DU PONT'S MEDICAL SURVEILLANCE PROGRAM

In a sense, Du Pont's program of medical examination and care for employees began in the early 1800s. E. I. du Pont's personal physician, Dr. Pierre Didier, looked after employees and their families and Du Pont paid for medical care of employees injured in the black powder mills.

Development of a Medical Program

The company was one of the first firms to institute a regular medical surveillance program on a formal basis. It began in 1915 with the hiring of a full-time medical director. The same year the Executive Committee established a system of regular voluntary physical examinations for employees at the company's expense. Shortly afterward, individual plants began hiring physicians to provide on-site medical services.

Dr. George Gehrmann became Du Pont's third medical director in 1926. He was a leader in developing occupational medicine as a medical specialty and during his tenure the Du Pont medical surveillance effort was expanded. On his recommendation, the company established the Haskell Laboratory for Toxicology and Industrial Medicine, instituted a program to aid in rehabilitating employees who are alcoholics, and began providing psychiatric services.

Today, the corporate Medical Division in Wilmington consists of six corporate advisors -- the director, two assistant directors, two biostatisticians and an advisor on alcoholism -- plus 20 others on the corporate medical staff, including physicians, nurses, and technicians.

At plant sites there are about 65 full-time M.D.s, 50 part-time M.D.s, about 200 physicians who provide services on a fee-for-service basis, and approximately 165 full-time nurses.

A System of Medical Examinations

When employees first come to work for Du Pont, they are given a physical examination. If assigned to an area where exposure to hazardous substances could present a problem, they may be given special tests to determine whether they are especially susceptible. The tests serve as a baseline in monitoring an employee's future health.

Monitoring for most employees consists of periodic medical examinations every two years for person 40 and under and annually for those over 40. The recommended basic content of these is a health history questionnaire, an examination by a physician, chest x-ray, vision and hearing checks, a test for lung function, urinalysis, and blood tests. Electrocardiograms are recommended for employees at age 35, 40, every three years to age 51, and annually thereafter.

The advantages of computerizing the results of employee physical exams are being studied. Computers may help make recording of results more accurate and more efficient.

Special tests may be run on employees who could become exposed to highly toxic substances, and usually they are done more frequently than regular examinations. Plant physicians establish monitoring programs with the aid of consultants in the Medical Division and Haskell Laboratory.

Plant physicians are expected to play a larger role in finding, evaluating and alleviating occupational health problems. The company sponsors meetings of its plant doctors, normally in conjunction with the annual American Occupational Health Conference, where educational opportunities are available.

EPIDEMIOLOGICAL SURVEYS

Epidemiological studies on employees are an important part of Du Pont's program to control hazards. The studies help turn up health risks that could be present in groups of employees. The studies that have received the most attention recently are those that deal with cancer, and they are discussed later in some detail.

Currently there are two biostatisticians and a staff of six conducting surveys of Du Pont employees' health records. This work has been going on for 20 years and has resulted in several publications, including epidemiological studies of diabetes, alcoholism and heart disease. The studies analyzed factors that increase the risk of developing these diseases, incidence in relation to job and income level, and the effects of these diseases on absenteeism and lifespan.

The data accumulated and the expertise acquired during the long period in which these studies were carried out put the company in a good position to maintain a close watch on the employee population for the effects of subtle hazards. Epidemiological studies can serve as a "double check" on problems that might not be turned up through other means.

The company is using the newest computer technology available -- the first experimental prototype, in fact -- to improve data access and retrieval in its epidemiological studies.

DU PONT'S EXPERIENCE IN TOXICITY CONTROL

Du Pont has a long history of dealing with toxicity problems. An early example is tetraethyl lead, a gasoline anti-knock additive, which the company began making in the mid-1920s. The high degree of toxicity of this material was not known at first, and there were cases of illness and some fatalities. Production was stopped. The Federal government subsequently set low exposure levels, and Du Pont devised methods to meet these standards. The essential elements of the system are a completely closed manufacturing process, monitoring of the workplace environment and frequent physical examinations for employees, including a biological monitoring program.

Haskell Laboratory -- A Key Facility

In controlling the hazards of such toxic chemicals as lead, a toxicological research facility is of critical importance. In 1935 Du Pont established Haskell Laboratory for Toxicology and Industrial Medicine, one of the first such facilities in industry. It has been expanded several times and has played a larger and larger role in the company's occupational safety and health programs over the years.

Haskell's responsibility is to screen compounds, conduct laboratory tests, recommend standards where necessary to limit exposure to chemicals, and advise company plants, research centers, and customers of possible problems and corrective measures. It does research in toxicology and testing techniques. The staff of 180 includes 75 persons with technical degrees. The recently completed addition is in full use, and by the end of 1977, the total staff will number about 190.

Testing at Haskell

The laboratory performs a wide range of literature searches and studies to determine possible toxic effects of 600 or more chemicals each year. Animal studies involve inhalation, skin and eye contact, feeding, and some injection. After animal tests demonstrate basic safety, further tests may be done on human volunteers to check for allergic or other irritating reactions.

The cost of an animal test can reach $500,000 -- the bill for testing a product for chronic hazards such as carcinogenicity. In its new addition, Haskell has facilities to test the effects of chemicals on aquatic life. The addition also contains laminar flow rooms for animal tests, where the air is purified so that complex chronic studies are unlikely to be complicated by random bacterial infection. The laboratory also supervises tests by outside consultants to determine whether a substance will persist in or be harmful to the environment.

In some cases, Haskell findings can keep a product from being marketed by Du Pont. For example, the company was searching recently for a fire retardant to treat synthetic fibers and found an effective chemical, a brominated biphenyl. After 13 different tests, ranging up to 22 weeks in length, Haskell recommended that the material not be used because it was both toxic and not readily degraded in the environment. The compound was not used.

The scope of the laboratory's work is indicated by the animal population, which ranges between 5,000 and 10,000, mostly

rats. In chronic tests, 33 different kinds of tissues are taken from each animal to check for a number of toxic effects. The laboratory also does tests for birth defects and chromosome damage.

Haskell performs studies on chemicals at the request of the company's manufacturing departments, and it also may initiate studies on its own. New products -- at an increasingly early stage of development -- are tested, as are products changed by reformulation.

Often, an entire battery of tests is not necessary because the scientific literature may already contain all or most of the knowledge needed to determine how a chemical should be handled. The laboratory is tied in by direct line with toxicity data at the National Library of Medicine and elsewhere.

The Haskell staff includes a group of physicians and hygienists who travel to plants and laboratories to provide on-site consultation on toxicity problems. The consultants identify problems, evaluate the potential hazards and recommend methods of keeping employee exposure to a safe level. Their recommendations may be translated into equipment to reduce exposure by a special group of design engineers in the Engineering Department.

Du Pont is currently studying ways to strengthen its ability to identify toxicity hazards at plants, and to quickly move from test results to protective measures at the point of manufacture. The effort will require additional industrial hygienists to help put knowledge to practical use, and more comprehensive industrial hygiene surveillance at plants.

An Example: Controlling Cyanogenic Chemicals

One comprehensive and long-standing effort in toxicity control is Du Pont's program for cyanogenic chemicals used in the manufacture of dyes, agricultural and rubber chemicals and other products. The hazards of these chemicals have been known for years, and the company's program dates from the 1930s. Cyanosis is a deficiency of oxygen in the body tissues caused by the chemicals' interfering with the ability of hemoglobin to carry oxygen through the bloodstream. The chemicals -- aromatic amines and nitrobodies -- can enter the body through the mouth, by skin contact or by inhalation.

Over the years, changes in the design of manufacturing units have reduced employee exposure. These have included the use of pumps rather than air pressure for transferring materials; improved ventilation in buildings and especially for critical operations; enclosed equipment and use of instruments to monitor the process; dikes around storage tanks, and improved designs and materials for seals and gaskets.

The work areas are monitored periodically for traces of cyanogenic materials.

In many operations, depending on the product involved, employees change their work clothing daily. Butyl rubber gloves and overshoes are worn for additional protection against possible skin contact with cyanogenic materials in many operations.

Du Pont developed the "Chem Proof Air Suit," a protective garment with its own air supply which is worn during operations that might result in exposure to cyanogenic chemicals.

New employees are given medical examinations to reveal any health problems, such as anemia, that might make them more susceptible to exposure. Thereafter, the employee participates in a medical surveillance program designed to check the effectiveness of the engineering and work practice controls which are in operation. Urinalyses and blood analyses are done at frequent intervals. If elevated results are found, there is additional testing and review of the employee's work practices. Monthly reports help in evaluating the overall program.

Medical efforts have resulted in better methods for diagnosing and assessing the degree of cyanosis. Du Pont scientists also have improved the treatment of cyanosis, shortening recovery time.

Actual cases of cyanosis are infrequent. When one occurs, treatment is immediate and around-the clock. Recovery is complete, with no lingering effects.

THE HAZARDS OF CHRONIC EXPOSURE: CANCER AND OTHER PROBLEMS

The current concern over occupational health has been focused largely on the hazard presented by materials that are carcinogenic.

Cancer, of course, is not the only problem associated with chronic exposure. The possible adverse effects of continued exposure to chemicals has long been recognized -- as in the link between alcoholism and cirrhosis of the liver. Chemically-induced cancer differs from most of the better known effects of chronic exposure in that genetic information carried by the cell's DNA is believed to be altered by the chemical. In this respect it is like two other effects. The first of these is mutation -- a change in germ cells that is inherited, or a change in body cells, called a somatic mutation, which is not inherited but can lead to major functional changes in the cell or even death of the cell. The second effect is teratogenesis, chemically-induced birth defects. Carcinogenesis, mutagenesis, and teratogenesis all can be life-threatening and each involves a process that in its last stages is irreversible.

At present, there is no extensive amount of scientific knowledge concerning mutations or birth defects in human beings due to chronic exposure to chemicals. This makes it difficult to gauge the extent of the problem. Many substances are known to cause mutations of bacterial cells, and some have been shown to

affect animal cells, but the degree of hazard for man is seldom clear. Birth defects and those mutations in germ cells that are passed on to subsequent generations are just part of the problem. The effect, if any, of mutations of non-germ (somatic) cells on health is also an open question.

The task of defining the hazards of mutagenesis is hampered by lack of a broadly applicable test for mutagenicity in mammals.

At Haskell Laboratory, tests for teratogenicity are conducted with increasing frequency, especially on high-volume chemicals. As women move into jobs once held solely by men, more compounds must be checked.

No Quick, Easy Answers on Cancer

The puzzles surrounding genetically active agents extend to the carcinogens. Some of these substances appear to damage DNA, but the mechanism by which a healthy cell is transformed to a cancerous one has not been established.

Aside from these fundamental questions, there are practical difficulties. For example, the most definitive laboratory test for carcinogenicity at present is to expose animals over their lifetimes -- two or three years for small rodents. Large numbers of animals must be used, and it is a complex, time-consuming and costly process. Translating the results into meaningful conclusions for human beings is difficult.

Billions of dollars have been spent on cancer research, and the high level of spending continues. There has been some progress in early detection and in survival rates. The attack on cancer is carried out in universities, private research centers, government agencies and industry, and much useful knowledge is being uncovered. Yet, the basic mysteries remain, and no one is holding out hope of easy answers or near-term solutions.

The lack of better understanding and more effective therapies makes it all the more important that employees be adequately protected against substances that can cause the disease.

CANCER IN AN INDUSTRIAL SOCIETY

For a number of years the search for a cause -- or causes -- of cancer has been focused on the possible role of viruses. Viruses are likely suspects because they act upon the genetic material in the nuclei of cells, and there is evidence that cancer results when the genetic mechanisms are disrupted. Viruses have been linked with some types of cancer, especially leukemia, in animals. The possible links between viruses and cancer in humans, however, are much more tenuous.

A great deal of research on the virus-cancer link is still going on, but recently the attention of the scientific community has turned increasingly toward environmental causes of cancer. Occupationally-related cancer falls into the "environmental cause" category.

It has been estimated that up to 90 percent of all cancer can be attributed to factors in our environment -- not just materials in the air and water, but also factors such as diet, occupation, exposure to sunlight and radiation, and cigarette smoking. In large part, the environmental causes have gained prominence because of advances in epidemiology. Studies have shown that, when people move from one culture to another, they tend to acquire the health and disease patterns of their new environment. A classic example is that of Japanese who have emigrated to the U.S. In Japan, stomach cancer is much more prevalent than in the U.S., while rates for the large intestine, breast and prostate are lower. Within a generation or two after immigration, the Japanese immigrants move much closer to the U.S. incidence patterns.

Since Japanese-Americans tend to marry within the ethnic group, it is highly probable that the change in cancer profile is caused by the new environment.

Attributing up to 90 percent of cancer to environmental factors is, however, not really an answer to the cancer problem. Questions remain: What are those environmental factors? Which ones are the most important in terms of the amount of disease they cause? The answers could help us reduce the incidence of cancer.

What Are the Environmental Factors?

The experts do not have easy answers because data are lacking. As a result, scientists emphasize different factors. Some point to evidence that "lifestyle" causes are at the root of most cancer. Cigarette smoking, for example, may account for 80 percent of all lung cancer deaths, according to the American Cancer Society. Cigarette smoking has also been linked to other types of cancer. Dr. Ernst L. Wynder of the American Health Foundation, for example, has stated that some 40 percent of all male cancer deaths can be attributed to smoking. International studies of diet and cancer show that those countries having a diet high in animal fats have a relatively higher incidence of colon cancer. High-fat diets have also been linked with increased risk of breast and uterine cancer. These are among the most common forms of cancer in the U.S. The scientists who emphasize this evidence attribute a small percentage of the disease to chemicals introduced into the environment.

On the other hand, there is a lengthening list of agents that we now know are capable of causing cancer in animals. The list of known human carcinogens has also grown. These developments have fueled speculation that our industrial society with its widespread use of chemicals has set the stage for a dramatic rise in the incidence of cancer.

Getting the Facts on Cancer

Putting together an accurate picture of the cancer problem in the U.S. is a complex undertaking. Statistics compiled by different agencies are sometimes contradictory. Furthermore, in lumping together all the figures and stating them in terms of nationwide trends, some important facts may be overlooked.

Even when all the complexities are taken into account, however, the evidence today does not support the idea that the increasing use of industrial materials has produced a rapid rise in the incidence of cancer.

To begin with, about one-fifth of all deaths in the U.S. can be attributed to cancer. It is tne second leading cause of death, after cardiovascular disease, which accounts for about 40 percent of all deaths. Roughly half of all cancer deaths are caused by the three most common forms of the disease -- cancer of the lung, the large intestine and the breast.

It is true that the total number of cancer deaths in the U.S. has risen substantially, but this statistic by itself is misleading. The total population has gone up also. In addition,

cancer is a disease which strikes more frequently among people who are middle-aged and older. The increase in cancer cases to a great extent simply reflects an aging population. Success in fighting infectious diseases that once killed so many people at earlier ages has resulted in a population with larger numbers of older people. To get the true picture of the trends, the gross data must be put in terms of frequency per 100,000 population and must be age-adjusted to allow for changes in the size of age groups.

When this is done, the increases in cancer do not appear as dramatic. The American Cancer Society says, in fact, that "The overall incidence of cancer has decreased slightly in the past 25 years." ('76 Cancer Facts and Figures)

That statement concerns the incidence of cancer, and statistics on incidence generally do not carry the same degree of certainty as do statistics on death rates. According to the Monthly Vital Statistics Report of the National Center for Health Statistics, there were 360,472 deaths due to cancer in 1974. The age-adjusted death rate for cancer was 1.5 percent higher than the rate for 1970 and 4.8 percent above the rate for 1960.

Cancer Deaths by Sex and by Site

This increase in the death rate must be further analyzed to understand the significance of historical trends. The rate, for example, must be broken down by sex. According

to the American Cancer Society, the age-adjusted death rate from all types of cancer per 100,000 population declined 9 percent among women between the periods 1951-53 and 1971-73. The rate increased 19 percent for men.

The disparity in trends between men and women calls for further analysis of the data -- this time, by type, or site, of the cancer. It can be quickly seen that the increased death rate for men is mainly due to lung cancer, which has grown by 135 percent over the 1951-53 to 1971-73 period. There was a 173 percent increase in lung cancer for women, with a sharp upturn coming in recent years. This was the most rapidly growing type of cancer, by far, for both men and women. The death rate for several other kinds of cancer has remained about the same, with several types showing decreases. For example, the death rates due to uterine cancer and to stomach cancer in both men and women have declined. There is a slight decrease in colon and rectal cancer.

Lung cancer, then, is the chief culprit in the gradually rising cancer rate. Experts attribute most lung cancer to cigarette smoking, with perhaps a certain percentage caused by air pollution. The American Cancer Society estimates that the number of deaths from lung cancer would be reduced 80 percent if all cigarette smokers stopped smoking.

Thus, the overall trends of cancer, and the trends of specific types, do not provide support for the thesis that cancer is increasing rapidly as the result of industrialization.

Arguments Supporting Industrial-Causes

Industrialization in the U.S. has been going on for a great many years. The chemical industry, for example, had its beginnings in the second decade of this century. It would seem that there has been ample time for problems to become apparent.

There are, however, experts who believe that the rapid industrialization in recent years may cause a growing cancer rate in the future. They point out that many chemicals have come into common use in the last 30 years, and that more and more are thought to be carcinogenic. Because of the latency period -- often 15 years or more -- between exposure to a carcinogen and appearance of the disease, many scientists think it is reasonable to conclude that an increased cancer rate due to chemical exposure could show up in the next several years.

In addition, evidence has been presented which links high cancer rates today with exposure to industrial substances. The National Cancer Institute has done an epidemiological study showing there are high rates of some types of cancer in industrialized counties of the U.S.

One aspect of the study was the higher rate of certain types of cancer in 139 counties with a high concentration of chemical manufacturing. As the authors of the study point out, there are many other variables which can affect the results of such a survey. Although efforts were made to adjust for differences in population density and for the presence of other kinds of industrialization, the adjustments did not eliminate these factors. Urbanization and industrialization in general, then, could play a part in the higher cancer rates.

Furthermore, there are no reliable data on cigarette consumption by counties, and this important factor could have a great bearing on the cancer rates in the counties concerned.

For these reasons, county-by-county epidemiological studies have not provided proof that a high cancer incidence is directly related to industrial substances.

Nor do international statistics show any clear-cut pattern. According to the American Cancer Society, of 44 reporting countries, the one with the highest cancer death rate for men is Luxembourg; the second, Scotland; third, Czechoslovakia; fourth, Finland; fifth, Austria. The U.S. ranks 19th for males and 18th for females. Interpreting these numbers is difficult. The accuracy of records varies from country to country, and it would be necessary to analyze the trends for different types of cancer to begin to arrive at conclusions. It is possible to say, however, that the gross data do not reveal any high degree of correlation between cancer and industrialization.

Occupational Cancer -- A Small Percentage?

A question of vital interest to Du Pont and other manufacturers is: How much cancer may be attributed to occupational exposure? Any incidence of cancer resulting from on-the-job hazards, of course, is very serious because it involves human suffering and possible loss of life. Especially tragic are instances in which cancer might have been prevented if knowledge of the hazard had been greater or if more diligent precautions had been taken.

The statistical question, however, is impossible to answer precisely because of the lack of epidemiological data to separate the occupational from other causes. John Higginson, an epidemiologist who is director of the International Agency for Research on Cancer, of the World Health Organization, estimates that less than 1 percent of all cancers have been shown to be related to occupational factors. John H. Weisburger of the American Health Foundation recently estimated that up to 5 percent of all cancer cases might be job related. Others have put the figure at 10 to 15 percent. But the current lack of knowledge about carcinogenesis and the "guesswork" nature of all estimates must be acknowledged.

In a sense, of course, the size of the percentage is beside the point. The important fact is that the occupational cancer threat in most cases can be controlled by reducing exposure through modern technology. The challenge to industry is clear.

The "Two-Hit" Theory of Carcinogenesis

Most current ideas about causes of cancer are based on the assumption that most environmentally caused cancer results from the action of a single agent on the body.

There is another theory of carcinogenesis that seems to be gaining credence among scientists. This is the "two-hit" or multistage theory. In simple terms, it postulates that two or more "events" are generally necessary to produce cancer. These events would be changes in cell biology and would probably be body cell (somatic) mutations, that is, the nucleic acids

involved in the replication of cells would be affected. An event might be an inherited mutation which predisposes a person to cancer. A few inherited mutative diseases have been identified which greatly increase the risk of some types of cancer, but these are relatively rare. Other genetic pre-conditions might be less obvious -- involving, for example, the level of an enzyme in the body. Some of the mutations that initiate the cancer mechanism might arise spontaneously, and thus represent a core of disease that would be impossible to eliminate.

Other "hits" affecting cellular reproduction might come from factors in the environment from sunlight to diet to chemicals. The agents causing the event might not be carcinogenic by themselves, or an event could take place as part of the natural aging process.

Some laboratory and epidemiological evidence supports the two-hit thesis. There are, for example, documented cases of co-carcinogens in which two substances acting together greatly increase the risk of cancer. If it does take two or more events to complete the carcinogenesis process, then the question of environmental causes is even more complex.

DU PONT AND THE RISK OF OCCUPATIONAL CANCER

Du Pont makes or uses some chemicals that have been identified as carcinogenic, and is squarely in the midst of the occupational cancer issue. The company's long-standing commitment to the safety of its employees obviously extends to the carcinogen problem. Determining what is safe in handling carcinogens is more difficult than with most other kinds of hazardous materials, but Du Pont believes that these substances can be handled safely. It is committed to closing down any operation where they cannot be.

The company's experience with beta-naphthylamine -- widely reported in the media -- is a case in point. In the 1930s, a company doctor noted an unusually high incidence of bladder tumors among employees who worked with dyes at a plant in New Jersey.

The cause was identified as beta-naphthylamine, a dye intermediate. Extensive engineering and process improvements were initiated. Employees were made aware of the hazard and were given special and frequent medical examinations. Finally, a closed manufacturing system was developed, reducing employee exposure to below the level measurable by the analytical methods then available. No employee who worked only on this new unit has developed a bladder tumor. This unit for producing beta-naphthylamine was closed down in 1955. Upwards of 300 cases of bladder tumor among

Du Pont employees exposed to beta-naphthylamine have been recorded over the years -- mainly resulting from exposure during a period of 30 years ago, or earlier.

Du Pont reported on its experience with beta-naphthylamine in medical journals in the 1930s. Significantly, this incident was considered something of a rarity by the scientific and medical communities, as well as by the industry, at that time. It was not taken as an indication that a large number of other substances might also be carcinogenic.

The Attack on Cancer Risk

In the Du Pont Company, the task of identifying carcinogenic substances normally begins at Haskell Laboratory. In the laboratory's early years, a high proportion of its work was testing for toxicity, considering doses that could cause health problems over a short period. This work led to strict controls on substances that are acutely toxic. Chemicals that are carcinogenic may also have other severe toxic effects, which means that some materials that turn out to be carcinogens have already been under tight controls as acute toxic substances.

Haskell has been increasing the number of its long-term, low-concentration tests. Much of the new space recently added to the laboratory is devoted to this work. Federal legislation has focused increasingly on requiring long-term tests on all

drugs, food additives and agricultural chemicals before they are marketed. This type of testing is also increasing due to the growing concern over carcinogenicity.

Du Pont has an established process for identifying problem chemicals. It begins with Haskell and the respective Du Pont operating departments reviewing the products, by-products and other chemicals used in manufacturing. From this review, a selection of candidates is made for further study.

A number of factors are considered in this selection. One is a chemical's structural similarity to known carcinogens. If a compound falls into a certain class of chemicals -- polycyclic aromatic hydrocarbons, for example -- it attracts immediate suspicion. Guilt or innocence by association, however, is not a foolproof method. One notorious instance where the analogy method did not work was hexamethylphosphoramide (HMPA). It is not closely related to a known carcinogen, yet inhalation studies in rats showed it to be one of the most potent carcinogens Haskell has ever studied.

Another identification factor might be references to the chemical in scientific literature. Here again, there are pitfalls. For example, the National Institute for Occupational Safety and Health has published a list of 1,500 substances linked to cancer by scientific references. Du Pont's analysis holds that many of the items on the list should not be implicated because the evidence cited is in error, inadequate, or contradicted by other evidence.

Another problem is sheer numbers. No precise estimate exists of the total number of chemicals in commercial use, but the figure is most certainly in the range of several thousand.

One Haskell scientist puts the number at 20,000, but only a small percentage of these would be widely used. How many have been tested for carcinogenicity? Again, the figures are not available, although the NCI is putting the statistics together. One estimate is that about 6,000 chemicals have undergone testing for cancer. Many of these tests were made on compounds not widely used, and many were inadequate by today's standards.

Attention may also be drawn to a product by the potential exposure involved. A high volume product typically presents a more widespread risk.

In some cases, a search of the scientific literature will turn up previous studies on a compound providing sufficient evidence that a chemical should be treated as carcinogenic. In other instances, Haskell will conclude that the situation merits further testing -- and testing itself presents some highly complex challenges.

Testing for Carcinogenicity

One complicating factor is the lack of an exact correlation between animal carcinogens and human carcinogens. Some strains of mice, for example, are prone to develop tumors, perhaps resulting in "false positives." Some chemicals prove to be negative in one species of animal, positive in others.

There are other problems. Animals are usually exposed to one substance at a time in a controlled situation, while men are in contact with many different agents simultaneously. What is

the effect of multiple exposure? Furthermore, the material is sometimes given to animals in a way in which man would never be exposed.

Despite the difficulties, scientists generally believe that there is a high probability that a substance which causes cancer by a relevant means of contact in an appropriate mammalian species of laboratory animal will also be a human carcinogen at a sufficiently high dose level. To date, arsenic appears to be the only substance that is carcinogenic in man, but not in animals.

Long-term tests present challenges in controlling very low dosage exposure to large numbers of animals over the animals' entire lifetime -- about two years for rats. Inhalation tests are especially demanding and require large amounts of laboratory space. At Haskell, lifetime tests often involve three groups of animals exposed to three different concentrations of the chemical. The multiple tests are to determine whether a "no-effect" level can be achieved as a basis for setting exposure levels for human beings. This may be an extension of work in certain other laboratories that are mainly interested in exposing animals to high concentrations to determine whether a compound causes tumors.

Du Pont and the Carcinogen "Screens"

The expense and, particularly, the time span involved in long-term testing have led scientists to search for short-term "screening" tests. One is the Salmonella/microsome test devised by Dr. Bruce Ames of the University of California. The test measures the ability of chemicals to induce mutations in specific

strains of bacteria. Because bacteria multiply rapidly, mutagenicity can be established fairly quickly. The Ames test has been applied to a few hundred of the thousands of compounds in evidence. It has proven useful because about 90 percent of the known human or animal carcinogens that have been subjected to it have proven to be mutagenic. Not every chemical which is mutagenic to bacteria in the Ames test will cause cancer, but the possibility is strong enough that a "positive" Ames test becomes a warning flag, a signal that further testing will be needed.

Haskell was one of the first industrial toxicological laboratories to begin using the Ames screen. Now, the laboratory is using even newer screening tests and is helping break new ground in proving their validity. An assay that measures mutagenic activity in cultured mammalian cells is being evaluated for possible routine use. This assay, which utilizes CHO (Chinese Hamster Ovary) cells, was developed by Dr. Abe Hsie of Oak Ridge National Laboratory. Assays in which mammalian cells are used should provide more relevant data for predicting risk to humans than assays that involve bacteria.

Another screen involves the use of a strain of mouse cells which are especially sensitive to chemical carcinogens and actually become cancerous, rather than simply showing mutations. The test was developed by Dr. Charles Heidelberger of tne University of Southern California. Haskell scientists are among the first to apply it to industrial situations. This test could become a tool to study the actual transformation of normal cells to the cancerous state.

When a Chemical Is Carcinogenic

If Haskell's testing or the weight of evidence in the scientific literature indicates that a chemical may be a carcinogen, certain steps are taken. The manufacturing department, in cooperation with Haskell, will classify the chemical as causing cancer in humans, as causing cancer in animals, or as suspected of causing animal or human cancer.

Once a chemical has been classified, the first concern is to safeguard the health of employees with a program which may include revision of work practices, requirements for additional protective equipment, process changes, or other improved engineering controls. Employees are informed of the classification and are told why the additional precautions are necessary.

A program for measuring and monitoring exposure levels may already be in effect. If not, it is instituted. Employee medical histories are examined to determine possible adverse effects on health. Medical surveillance procedures, as well as the recording of employee exposures, are undertaken.

Depending on the circumstances, a variety of agencies and organizations may be notified of Du Pont's actions with respect to the substance. Those informed will include customers, appropriate governmental agencies, other producers, and scientific publications and other media.

If safe handling of the substance cannot be assured promptly, production is shut down and sales are halted until adequate safeguards are developed.

As of August, 1977, Du Pont had classified 24 chemicals under this system. They range from byproducts present in very small amounts to chemicals such as carbon tetrachloride that are intermediates for high-volume products. One classified compound is the solvent used in making "Kevlar" aramid fiber. In the case of this material, hexamethylphosphoramide (HMPA), there had been no prior studies indicating that it was a carcinogen before Du Pont began its tests. When long-term animal tests showed it to be carcinogenic, Du Pont notified Federal and state agencies and sent letters to scientific journals.

Employee exposure was reduced and research has been undertaken to find a new system that would eliminate HMPA entirely.

How Many Carcinogens Are There?

Du Pont has identified 24, but what is the total number of known carcinogens that present occupational hazards? The number of carcinogens generally recognized has been growing. Meanwhile, the compiling of lists has given rise to considerable debate over what criteria chould be applied in labeling a material carcinogenic.

As mentioned, NIOSH has listed 1,500 materials associated with cancer in scientific references. But when more definite proof of carcinogenicity is required, the list of agents becomes much shorter. For example, the Du Pont list and two others have a total of 57 substances.

One of these lists contains the 17 carcinogens for which OSHA has adopted regulations. (Many of the regulations are based on information originally developed by industry.) The regulations limit employee exposure and require monitoring of concentration levels in regulated plant areas.

Du Pont makes two and uses one of the chemicals on the list, and formerly made or used certain others. (A fourth item on the OSHA list has been detected in non-hazardous amounts in a closed waste stream and is destroyed in waste treatment.)

The other well-known list is the American Conference of Governmental Industrial Hygienists' list of substances in industrial use that have proven carcinogenic in man or animals.

As mentioned, the total number of items classified by Du Pont or ACGIH, or regulated by OSHA is 57.

Another Weapon: Du Pont's Records on Employee Health

In 1956, Du Pont established a cancer registry, a record of all active employees who develop the disease. Epidemiological data on cancer is also compiled on death rates of current and retired employees. This system appears to have been the first of its scope in industry. Many other firms are now in the process of collecting similar data. The purpose is to have sufficient information for comparing employees' rates of cancer with other population groups, and for comparing the rates of different company locations with the total company rate. The ultimate objective is a system for helping determine whether any cancers may be related to occupational exposure.

Not included among the incidence data are the cases of bladder cancer resulting from exposure to beta-naphthylamine, described earlier. They were deliberately omitted so as not to mask any significantly high incidence due to other causes, and their

omission has been made clear in all information that has been made public.

The Limitations of Epidemiology

Epidemiological studies deal not with absolute but with "statistically significant" answers. This judgment is reached by first establishing a norm against which a particular phenomenon is measured. If the phenomenon deviates from the norm by a standard, commonly used probability, then it is said to be statistically significant. The process minimizes the possibility that a deviation is due to chance alone, but it does not eliminate that possibility. Under standard methods, then, there is always a possibility that an excess cancer incidence at a given plant might be due to chance. An abnormally low number might also be a chance occurrence.

An important detail in a study that reveals an abnormal rate is the degree of abnormality. A cancer rate does not have to be extremely high in order to be significant. It only needs to be high enough so that it is probably not due to chance.

Perhaps the most perplexing limitations of epidemiological studies are the uncontrolled variables. A higher-than-expected cancer rate among workers, for example, might be the result of some factor in their workplace -- or some other factor they have in common. Many factors can contribute to the development of cancer, including diet, cigarette smoking, genetics, and environmental pollutants. The point is that the science of epidemiology yields conclusions that are not always as precise as the column of statistics might suggest. It deals more with

indications of risk than with hard-and-fast conclusions. Studies can show where more detailed surveys of people or laboratory animal tests are needed to determine whether a cause-and-effect relationship actually exists between a disease and a certain factor.

What the Records Show About Du Pont Employees

Du Pont provided its cancer incidence records to a subcommittee of the U.S. House Committee on Interstate and Foreign Commerce, on request. The data showed that the cancer incidence rate of the company's male employees in the period 1956 through 1974 was 21 percent lower than the incidence rate for the general U.S. population. During that period, 2,950 males developed cancer, compared to the 3,691 cases that would have been expected based on estimates by the NCI from a 1969-71 survey of nine regions of the U.S.

Among female employees, the incidence of cancer was 11 percent higher than the rate for the general U.S. population. There were 693 cases in the period, compared to 623 that would have been expected. Most of the cases involved cancer of the breast and cervix. There is no indication that these types of cancers are related to the work environment, and the apparently higher incidence among Du Pont women employees could well be the result of earlier cancer detection because of regular medical exams.

Overall incidence of cancer among Du Pont employees was 80 percent that of the general population. (All Du Pont figures exclude the beta-naphthylamine cases. Even if those cases were included, however, the overall incidence of cancer among employees

would still be below that of the general population.) As a group of working persons, the employees would be expected to have a better health than the general population. Still, comparing the total employee group to the U.S. population may give an indication of large-scale problems. To discover whether the employees at a specific site or employees exposed to a specific chemical have a higher than normal risk of cancer, more detailed studies must be done. Du Pont, for example, compares each plant or laboratory site to the total company.

Detailed Studies of Plants and "Cohorts"

In performing analyses for each plant, Du Pont has found sites that have higher-than-expected rates that are "statistically significant." When this occurs, Du Pont analyzes the data to determine whether there is an indication of an occupational cause. The plant's rate is compared to the rate for the surrounding population, and many other factors that can have a bearing are also considered. For example, a rising trend not accounted for by the aging of the plant population would give a stronger indication of a carcinogen problem than an indeterminate trend. If affected employees had histories of cigarette smoking, that might account for the increased risk of cancer. Another important factor is the degree of increased incidence, since most occupational carcinogens to date have produced very high abnormal incidences. It is also important to determine whether there are "clusters" of certain types of cancer because most known occupational carcinogens cause cancer in only one or two body organs.

Du Pont is also doing "cohort" studies in which groups of employees exposed to specific chemicals during the course of their employment are followed to determine whether they have experienced excessive rates of cancer. These studies are done in cases where a known carcinogen is involved, and in cases where a material is suspected to be carcinogenic but laboratory evidence is inconclusive. These full-scale studies take several years to complete.

Du Pont's methods in making epidemiological studies have been held valid by an independent consultant, Dr. Brian McMahon, who also is chairman of the department of epidemiology at Harvard University School of Public Health. Dr. McMahon said that the data were sound and they do form the basis for drawing useful conclusions about the health of employees.

An example of the cohort type of employee-health study is one made of the health histories of Du Pont employees who worked with neoprene synthetic rubber. The population studied included nearly 1600 at Du Pont's plant in Louisville -- many of them still employed there -- and about 230 who worked at the first neoprene unit at the Chambers Works in New Jersey. This unit was closed down in 1949.

The chemical involved is chloroprene, the monomer from which neoprene is made. Chloroprene was the subject of the first comprehensive investigation undertaken by Haskell Laboratory in the 1930s, when animal tests provided data for calculating safe exposure levels.

The current chloroprene cohort study began in 1974, the year when the carcinogenic effects of vinyl chloride became known. Since chloroprene is chemically similar to vinyl chloride, the Elastomer Chemicals Department asked Haskell Laboratory to search toxicological literature for mention of chloroprene. The search uncovered two Soviet papers that claimed high rates of lung and skin cancer were found among workers exposed to chloroprene and that a high incidence of embryo deaths occurred in pregnant mice exposed to chloroprene.

Since the Soviet data seemed incomplete and inconclusive, three Du Pont representatives -- a toxicologist, a biostatistician and a research manager -- went to the Ministry of the Chemical Industry in Moscow to investigate further. Later, a letter from the Soviet Ministry of Health said that "errors in methodology... led to incorrect conclusions" in the study of chloroprene workers.

Nevertheless, the epidemiological study of Du Pont employees continued, to establish whether the cancer rate was abnormal, and studies were made of reproductive effects of chloroprene on animals to check for embryotoxicity. Male and female rats who breathed chloroprene at the maximum permitted exposure level (25 parts per million) showed no reduction in reproductive efficiency, no increase in embryo deaths, and no evidence of malformed or unhealthy offspring.

To expand the data base further, the company also joined with other manufacturers of neoprene in Europe and Japan to sponsor long-term animal inhalation tests, which are not yet complete. Results should provide valuable information on both carcinogenicity and reproductive effects. In addition, there

have been three mutagen screening tests with bacteria, two sponsored by Du Pont. No two of these tests produced the same results; both positive and negative results were noted. A Soviet study, reported in mid-1976, showed no evidence of cancer in animals from ingestion, injection or skin absorption of chloroprene.

Final results of Du Pont's epidemiological studies show no statistically significant excess of lung cancer deaths among either Louisville or Chambers Works neoprene employees, and no significant mortality difference between mechanics and other groups. However, one puzzling, and disturbing, anomaly was uncovered in the Louisville study: of five living employees diagnosed as having lung cancer (some as long ago as 1968), four are maintenance mechanics. Maintenance mechanics make up less than 20 percent of the plant force but accounted for 40 percent of the lung cancer cases. Company medical and manufacturing specialists are investigating to see if a cause can be found, or if the higher incidence is just due to chance.

Similarly, Du Pont participated in an industrywide study of lead chromate pigment manufacturers. (Du Pont had already classified lead chromate and zinc chromate pigments as suspected carcinogens.) The study disclosed a higher than normal incidence of lung cancer among workers exposed to lead chromate pigment dust, and the study stated that the evidence was consistent with the hypothesis that lead chromate could cause lung cancer. The study also disclosed an equally unexpected increase in stomach cancer at only one of the plants, the Du Pont plant, in the industry study. As is often the case with epidemiological studies, the cohort group of employees was too small to permit more positive conclusions to be drawn. To

clarify the situation, Du Pont has initiated an in-depth study of its plant by an independent consultant.

Du Pont's most recent epidemiological work, a study conducted among employees of our Camden, S.C., plant who were exposed to acrylonitrile 20 or more years ago, showed a higher-than-expected number of cases of cancer. Even though the results were "preliminary," this statistically significant deviation from the norm was immediately communicated to appropriate government health agencies, to employees, customers and the news media.

Data reported by the Manufacturing Chemists Association on tests linking cancer to acrylonitrile caused Du Pont to accelerate its epidemiological study already in progress at Camdem. This site was selected because it was the only plant where employees could have been exposed to acrylonitrile for at least 20 years -- a period generally accepted as a latency time interval for induction of cancer in humans.

Meanwhile, further studies of Camden workers, particularly a follow-up on those who left the company, as well as studies at two other plants with later start-up dates that also manufacture acrylonitrile, are now under way. Exposure has been reduced to a time-weighted-average of 2 ppm, well below the government standard of 20 ppm, a level which should present no unusual hazard to employees.

These cases demonstrate one company's effort to uncover the problems and its willingness to solve them by committing the proper resources: the technical know-how, laboratory work and the time and expertise needed to compile good epidemiological studies. The full range of the company's weapons against cancer risk have been brought into action.

PUBLIC POLICY: WHAT IS "SAFE?"

Most of the issues that attract public attention in the area of occupational safety and health eventually come down to the basic question of what is a "safe" working environment.

Answering that question is not easy when it is asked on two levels -- the broad, philosophical level and the very specific level of chronic exposure to carcinogens.

Taking the specific case first, experts do not agree completely on the criteria that should be used in labelling a substance carcinogenic. Testing methods raise detailed but crucial questions. A mutagen, for example, is not necessarily a carcinogen, but some scientists would like to equate the two. Should a compound be called carcinogenic if it causes tumors that appear benign? Is it carcinogenic if it results in cancer when inserted under the skin -- even though we know that cancer may result simply from the irritation itself, regardless of the chemical structure of the substance? Should a chemical be regulated as a carcinogen if it causes cancer in doses hundreds or thousands of times greater than people would be exposed to? In animal tests, how many of what species should be used? What percentage of experimental animals must contract what type of cancer before the evidence is sufficiently strong? Are the data from animal tests directly applicable to human situations, such as occupational exposure?

Scientists involved in cancer research confront these questions constantly, and their answers do not always agree.

The safety judgment is also made difficult by our lack of exact knowledge about how carcinogens work. How much exposure to a carcinogen is safe? On the one hand, it is impossible to show logically that one molecule of a carcinogen will never harm any person who might come in contact with it. Beyond that, there is the simple fact that we understand very little of how carcinogens work at the cell level. Furthermore, the latency period between exposure to a carcinogen and the appearance of cancer makes the tracing of cause and effect very difficult. These uncertainties, for some experts, are sufficient cause for large-scale banning of materials.

On the other hand, it is well known that the carcinogenic effect is dose-related. That is, the incidence of cancer and the time it takes for cancer to develop are directly related to the level of exposure. This relationship indicates that it is possible to reduce exposure to a point where cancer will not occur within the human lifespan. There is, in fact, evidence that this has been accomplished. Certain chemicals cause cancer in animals and may well have the ability to cause cancer in humans, but it appears they have not caused cancer in employees exposed to them. Widely used substances such as chloroform and carbon tetrachloride are probably in this category.

The task, then, is to broaden our knowledge of the mechanisms of carcinogenicity, and to increase the practical

applications of knowledge gained from laboratory tests. Certain tests, for example, promise to be good indicators of a carcinogen's potency, and it may become possible to extrapolate the dosage response curve from animals or animal cells to man, so that the tests become an increasingly reliable tool for establishing safe or "no-effect" levels of exposure.

These advances will take time. One reason is the scarcity of research resources to identify carcinogens. An official of the World Health Organization said in 1975 that if all available laboratories were working on the problem, they would be able to do lifetime animal tests on only about 400 substances a year. On the positive side, more of this work is being undertaken, and a great deal of scientific research is being brought to bear in industry and government, and in academic and private institutions. It seems reasonable to expect findings that will be translated into practical knowledge.

One instance of a boost in research capability is the Chemical Industry Institute of Toxicology. Du Pont and 10 other chemical companies established the Institute in late 1974. Today there are 27 member companies, and the Institute's proposed budget for 1977-79 will total nearly $15 million. A new laboratory is under construction at Research Triangle Park, N.C. The Director of the Institute is Dr. Leon Golberg, a toxicologist with international reputation. The Institute's primary objective is to test large volume commodity chemicals to identify toxicological hazards. Results of all studies will be made public.

The Broad Issue of Safety

Beyond the complexities of carcinogens, there is the broader issue of how safety in industry is to be assessed. One very workable answer to the question has been proposed by Dr. William Lowrance of Harvard University, in the book Of Acceptable Risk. The book was written while Dr. Lowrance was a Resident Fellow of the National Academy of Sciences. Lowrance states that "A thing is safe if its risks are judged to be acceptable."

That simple definition has some far-reaching implications. First, safety is judged by the acceptability of risk, not the absence of risk. Any human endeavor carries with it a certain element of risk, and the only way to eliminate it entirely is to leave off the endeavor. For example, the number of highway accident deaths could be reduced to zero by banning automobiles. That principle is pertinent at Du Pont, which holds to the goal of eliminating all accidents but recognizes that risk itself cannot be reduced to zero. The distinction is essential. The policy aims at controlling risk, not eliminating it.

Weighing Risks and Benefits

Lowrance's definition, by referring to acceptable risk, implies that safety is determined by weighing risk against benefit. The benefits to be weighed might be the value of some particular product, such as a pesticide. Do the benefits of increased food production at lower costs outweigh the hazards a chemical might

present to employees and to others? Many factors, including the availability of substitutes, the importance of the crop concerned, and the consumer's feeling about what he is getting to offset the potential risk, must be considered. The importance of a chemical in providing jobs and its significance to the overall economy also must be taken into account.

The answer will be at least partly subjective. The risks and benefits can be estimated, but whether the tradeoff is "worth it" is a matter of human judgment.

The only way to avoid this decision-making process is simply to eliminate any product or process that might present a hazard. If all materials that present hazards were eliminated -- as some persons seem to advocate -- the result would be a markedly reduced standard of living and a completely different kind of economy.

The need for decision leads to another important element in the Lowrance definition: Who takes the "acceptable risk?" Who decides whether a risk is, in fact, acceptable? Are they the same people? In an ideal situation, an individual determines for himself how much risk he is willing to take in light of all the known facts. But suppose he does not know such a decision is to be made? Suppose the individual does not have all the facts, or lacks the ability to evaluate them? He must then trust a decision-making process in which he does not have a direct hand. Such situations arise in the area of

occupational safety and health, and particularly in cases of chronic exposure, where the hazards are subtle and sometimes not well understood even by the experts.

Decisions on Safety Through a Public Process

This dilemma was addressed recently by Du Pont's former director of environmental affairs:

"It's obvious that, increasingly, decisions in the health area, including occupational health, are being made publicly, through the political process. In my opinion, this is as it should be. The decisions that need to be made about the very complex health problems of today can only be made properly through the political process. Unfortunately, the process does not yet seem to be up to the challenge. What's to be done?

"Industry must develop sound data. And this data must not only cover the cost side of the equations in health matters, but also the benefit side. And the presentation of the data must be done in a balanced fashion.

"Not only industry has a responsibility. The technical, scientific and medical communities at large must share in the effort to provide factual data on risks, costs, and benefits.

"The third major group involved -- the public at large -- and here I certainly include the legislators and the regulators, as well as the media -- needs to do its part. As difficult as it is to do when human health is an issue, the public must avoid taking positions on emotion, but rather strive to obtain the facts on an issue and then understand the facts."

The Toxic Substances Act

There are numerous regulatory mechanisms that have been set up which, in essence, serve as a means to arrive at safety judgments. One of the most recent is that established by the Toxic Substances Control Act, effective on January 1, 1977.

The act authorizes the Environmental Protection Agency to require testing of chemicals that may present "an unreasonable" risk to health or the environment. It may also require testing of materials that will enter the environment in substantial quantities or which will result in substantial human exposure.

Manufacturers must give the EPA prior notice of 90 days before manufacturing a new substance or before making significant new uses of existing materials. The EPA can prohibit or limit the manufacturing, processing or use of any chemical substance or mixture.

The act grants the EPA a fair amount of discretion in selecting chemicals for testing and in determining the safety of substances.

Richard E. Heckert, Du Pont senior vice-president and head of a Manufacturing Chemists Association committee on the legislation, has termed the act "tough and far-reaching." He said it "is workable and represents a balanced view that came out of extensive negotiations among members of Congress, industry, the EPA and public interest groups." While unreasonable administration of the law could pose problems, he said, Du Pont is convinced that sound regulation can be achieved.

The Toxic Substances Control Act represents another step toward increasing reliance on public processes to determine the acceptability of risk.

The responsibility of Du Pont and other manufacturers, meanwhile, is not changed. Each company is obliged to act responsibly in light of the best knowledge of hazards that can be obtained. In recognition that new and different kinds of hazards are being uncovered, Du Pont established a new position, Director of Health and Safety, in 1977. In the past, the extensive health and safety activities within the various departments have been coordinated through five interdepartmental committees. These committees will continue; their work will be complemented by the capabilities of the new office. It is expected that this organizational arrangement will unify and strengthen the overall health and safety effort. Such changes are an important part of Du Pont's marshaling of resources to control these hazards and maintain safe working conditions.

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