CHAPTER 2

THE SIGNIFICANCE OF THE OCCUPATIONAL ENVIRONMENT AS A PART OF THE TOTAL ECOLOGICAL SYSTEM

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OCCUPATIONAL AREA IS PART OF THE WHOLE

The occupational ecological system is a significant part of the total ecological system. Since it can be measured, we can exert some control over it and make contributions to the health and well-being of the people in the occupational ecological system. These contributions can favorably affect the impact of the total system on our population since a worker may spend one-fourth of his time in the occupational area, and workers are a significant part of the total population.

The purpose of this chapter is to examine the relation of the occupational environment to the total ecological system, to observe the significance of this relationship to the work of the industrial hygienist, and to recognize the favorable effect that his work in the occupational environment could have on the total system.

Nonoccupational exposure is an exceedingly complex and variable factor. Recognition of such exposure is necessary to an understanding of the overall environmental impact on man. The man who drove to work in heavy traffic or walked down a busy street received much greater exposure to carbon monoxide from automobile exhaust than he would have in an acceptable work area. Similarly, a worker who smokes one pack or more of cigarettes per day will be exposed to many times the amount of carbon monoxide that he would be exposed to in an acceptable work environment. This smoker would also be exposed to many times the amount of particulate matter from his smoking than he would contact in an acceptable work area.

There are many other nonoccupational exposures but these examples serve to illustrate two obvious areas of excessive exposure in the nonoccupational area. Such exposures cannot be ignored by those responsible for the health and well-being of people even if their responsibility is primarily in the occupational area.

OCCUPATIONAL INTERACTION WITH NONOCCUPATIONAL

In considering the occupational area one must recognize the interaction with the nonoccupational area and the significance of this interaction to the health and well-being of the individual.

We learned a long time ago that a man who drinks a lot of alcoholic beverages is much more susceptible to injury from exposure to carbon tetrachloride; also, that a man with excessive exposure to silica dust is more susceptible to tuberculosis. Such possible interactions should be kept in mind.

The following illustration demonstrates a different kind of interaction. We were studying the blood bromide concentration of men exposed to low concentrations of methyl bromide in their work. The environmental exposure in their operating area was carefully measured. The exposure was well within acceptable limits. Clinical studies verified this fact. It was valuable to establish a relationship between exposure and blood bromide at exposures within acceptable limits, as this would be useful in the future as a clinical check on the workmen.

One day a workman from this group was found to have a blood bromide concentration sufficiently high to be of concern if it had come from exposure to methyl bromide. Investigation revealed that he had been taking inorganic bromide medication which accounted for the high blood bromide.

Workmen may be brought to the clinic for regular preventive checkups. Biochemical measurements on these workmen may be exceedingly valuable to verify acceptable exposure, also to catch any indication of fluctuations in operating conditions and allow correction before significant exposure can occur. This is a very useful system, but we must be sure we have all the facts before we conclude what caused any observable biochemical changes.

THE INDIVIDUAL AS PART OF THE ECOLOGICAL SYSTEM

Ecology is defined in Webster's dictionary (1971) as "The science of the totality or pattern of relations between organisms and their environment." I prefer to call ecology the science of the interaction of *everything* with *everything else*. The ecological system is the system within which these interactions take place.

The ecological system is not exactly synonymous with the environment. My environment includes everything around me. The ecological system *includes* me. The individual person is a highly significant factor in the control of the environment in the interest of the health and well-being of the person.

A freight elevator was installed with all the usual safety devices. It was approved by state inspectors. A switch on the door made it necessary to close the door before the hand switch would operate the elevator. A tall lanky lad found that he could get his toe to operate the switch closed by the elevator door, and with contortion he could

still reach the operating switch. It would have been easier to close the front door, but it was a challenge. He was that rarity, a man with the reach to do it. No one knows how many times he operated the elevator this way, but one day he left his other foot over the edge of the elevator and seriously injured that foot when the elevator passed the next floor. Yes, fools can be very ingenious in overcoming "foolproof" engineering.

Misoperational problems are not limited to mechanical injury. There was the individual who liked a window wide open. Under certain wind conditions the air from the window blew across the face of a hood so as to allow volatile chemicals to escape from the face of the hood into the work area around the hood.

There was also the man who liked to "sniff" perchloroethylene. He arranged his work so that he could be "high" on perchloroethylene a large part of his work day.

The individual is a significant part of the occupational ecological system. His understanding and cooperation are essential to attaining a healthful work environment. We hope this understanding will carry over to some degree to the nonoccupational ecological system.

PEOPLE IN THE ENVIRONMENT

An important factor in the environment of an individual is "people." People in both the occupational and the nonoccupational environments are of significance to the health and well-being of that individual.

One day the psychologist in our personnel department asked me if we were having any complaints of noise from a certain operation. I told him we were, but we could find no justification for the complaints based on noise measurements made in the area. He commented, "You won't; the workers just don't like the foreman."

In another instance we found it desirable to coordinate a careful study of the environment with a concurrent clinical study of the workmen in the area. One group of older, experienced workmen refused to cooperate. They liked the foreman and their work and were afraid we might make some changes. With friendly understanding, the purpose was explained and they were reassured. You are always dealing with people in the occupational environment.

Another illustration introduces a different problem. Joe came into the clinic with a mashed thumb. The physician tried to get an understanding of the reason for the accident. He asked, "What happened, Joe?" "Oh, I got my thumb in between a couple of drums." "You have a good record, Joe, why did this occur?" "I was thinkin'." "What were you thinking about, Joe?" "Oh, I was thinkin' about my wife's sister." Knowing that health or financial problems in the family may worry people, the physician asked, "What's wrong with your wife's sister?" Joe answered with ecstatic fervor, "Doc, there just *ain't nothin' wrong* with my wife's sister."

We should recognize that people in the *nonoccupational* environment may have an effect which may result in misoperation. Such misoperation can lead to exposure to chemical substances, physical energies, or mechanical injury. This can occur either on or off the job.

The problem of people in the environment is not measured by any analytical instrument, though the instrument may measure a misoperation caused by people. The problem of people is not controlled by preventive engineering alone, though it can help. Effective operation requires a good understanding of people and the ability to get their understanding and cooperation. This is an obligation of the industrial hygienist, the physician and other persons responsible for control of the environment in the interest of the health and well-being of the workmen.

CHEMICALS, ENERGIES AND ORGANISMS

The usual considerations in the occupational environment are more measurable than people. Chemical substances are a concern of the industrial hygienist. Physical energies include: ionizing radiation, a concern of the health physicist; heat, light and noise, a concern of the industrial hygienist; and mechanical injury, a concern of the safety engineer. Then there are biological organisms (other than man) which are a concern of the sanitary engineer.

These are part of the environment both on and off the job. These can be controlled in the occupational environment by good engineering and good operating procedures attained with the understanding and cooperation of the employees. Yes, people are also very important here.

We observed that men from a specific operation were reporting to the clinic with mild complaints which seemed similar to complaints that would be expected from an over-exposure to a solvent used in the operation. Careful analysis by the industrial hygienist, in many locations and at many different times, did not show enough solvent in the air to cause the trouble. A continuous recording analytical instrument was devised in the research laboratory and installed in the operating area. Through its use we found that when either the supervisor or the industrial hygienist was not around, the operator was inclined to leave a leak or spill to be cleaned up by the next shift operator. The men named this instrument the "Squealer" as it was telling us of their misoperation. They began to work with an eye on the recorder. They realized that when the "Squealer" did not squeal they felt better. They changed the name of the instrument to the "Stink clock." The supervisor told us he saved the price of the instrument by reduced solvent loss, and that the overall operation by the men greatly improved. We had their understanding and their cooperation. They realized that we were interested in their health and well-being.

During regular preventive observation of the men in the clinic, lack of adverse effects may show that exposures to chemical substances in the environment have not been excessive. It should not be taken to mean that excessive exposures are impossible or unlikely under other circumstances of use.

For example, a supplier assured his customer that there was no hazard from skin contact asso-

ciated with a particular material because there had been frequent skin contacts with the material in their own operations with no adverse effects. They neglected to indicate how they handled the material, or that contacts were always followed by immediate decontamination of the skin. In use by the customer, the material was spilled on a man's skin. He was several miles out in the "bush" in northern Canada in the winter with the temperature below zero Fahrenheit, and with no water available for decontamination. The man died from poisoning due to skin absorption of the material. Simple experiments on animals in the toxicological laboratory showed that the material was very toxic when absorbed through the skin. When a supplier indicates that no problems have been encountered in handling a particular material, ask how they handle it. Ask them what toxicological information they have on the material.

In controlling the occupational environment in the interest of health and well-being, established acceptable exposure limits for a healthful environment are very useful. These acceptable exposures are expressed as "acceptable concentrations" by the American National Standards Institute and as "threshold limit values" by the American Conference of Governmental Hygienists (such standards are discussed in detail in Chapter 8). These limits are not exacting scientific thresholds of response. They are the judgments of people with knowledge and experience. The intelligent use of these limits depends on the understanding and judgment of the man who must control the occupational environment.

We must recognize that the industrial hygienist usually deals with a variable exposure. Enough analyses are needed to clearly define the probable fluctuations and to establish a significant time weighted average. Maximum concentrations must be determined as well as duration and frequency of peaks of exposure. The summation of this information to define the exposure situation requires the good judgment of a knowledgeable industrial hygienist. The application of the established acceptable limits for a healthful environment also requires the good judgment of a knowledgeable industrial hygienist. Acceptable limits cannot be used effectively as just a routine check point.

Those people responsible for suggesting acceptable limits or for using acceptable limits are part of the ecological system — the industrial hygienist, the physician, the toxicologist and all the other environmental control people. The effectiveness of their operation can have a very significant effect on the occupational ecological system.

When an injury does occur, clinical observation of the victim can provide very valuable information and should be reported in the literature. As was discussed in the previous section, the exposure can be variable. Most important, be sure you know all of the chemical substances or physical energies to which the victim was exposed and, hopefully, quantitation of exposure.

During the early development of 2,4 dichlorophenoxy acetic acid (2,4 D), careful toxicological studies were made on animals in the toxicological laboratory. It was concluded that the material at the high dilution used in the field as a weedkiller was not a significant hazard. After years of use there was a report of a death in Canada from 2,4 D. The man drank a glass full of the diluted solution from the spray tank with suicidal intent. The physician who observed the man in the clinic and the manager of the contract spray company where the solution had been mixed, both confirmed that it was, in fact, 2,4 D. Calculating from the toxicological information, I did not think this was possible. An agricultural scientist was going to visit the area where this death occurred so I asked him to investigate. He asked the foreman of the spray crew, "What did you use as a weedkiller before you used 2,4 D?" "Oh, we used sodium arsenite." "Then you stopped using sodium arsenite?" "No, we just added 2,4 D to the sodium arsenite."

The man who died had drunk enough sodium arsenite to have killed ten people. When you draw a conclusion from that first clinical case, be sure you know all of the materials to which the victim was exposed. This serves as a reminder that people are involved, people between you and the actual circumstances of the incident.

As previously stated valuable information on the nature and amount of exposure can be obtained by biochemical measurements on a person suspected of exposure. This depends on the absorption, transport, metabolism and excretion of the material. Blood, urine or exhaled air analysis can give valuable clues to the nature of certain of the materials to which the person was exposed. The analysis used depends on the way the body handles the material in question. Many volatile organic materials are exhaled in the breath. Infrared analysis can give an indication of the nature of the material and some indication of the amount of exposure.

To illustrate, a man came into the clinic and reported that he had been exposed to a certain volatile solvent. Infrared analysis of his exhaled air showed that he had not been exposed to the solvent he indicated but to a very different solvent. Had the clinic proceeded on the basis of his report of exposure, the handling of the case would have been in error. Some biochemical measurements can be very useful when wisely used.

COMPLEXITY OF THE WHOLE

The ecological picture as a whole is too complex to understand or to control when considered in its entirety (both occupational and nonoccupational). Yet, those who are responsible for the health and well-being of people in the system must keep the total picture in mind.

That total picture includes the chemical substances, physical energies and biological organisms in the occupational area which we can measure and over which we can have some control. As previously discussed, the exposures can be variable. Levels of concentration alone are not enough. One must know the frequency and duration of exposures. There is no simple mathematical procedure which will give a specific numerical answer. One can determine the time weighted average and the maximum concentration, duration and fre-

quency of peak concentrations. These are meaningful if one has sufficient analytical data which represent the actual exposure conditions. These exposure conditions can then be related to the acceptable limits proposed by various organizations. This comparison gives some understanding of the significance of possible exposures in the area studied. In addition, however, one must keep in mind the complexity of the whole. The final decision requires judgment of the whole based on available knowledge and experience.

Comparable factors are in the nonoccupational area where we have little control. Hopefully, we may have some effect by carry-over of experience from the occupational area. In both the occupational and nonoccupational area the individual is an important factor. The people in the environment of the individual both on and off the job have a significant effect.

OBTAINING UNDERSTANDING AND COOPERATION

Obtaining the understanding and cooperation of people in the environment of concern is critical to effective control of that environment. This statement has been made several times in this chapter. It was a significant factor in many of the illustrations used. This is such an important part of effective control that it justifies summation here for emphasis. Without understanding and cooperation all the most careful measurements and careful engineering of an operation may be ineffective. We repeat — fools are most ingenious in overcoming "foolproof" engineering.

It is simple to state "Get their understanding and cooperation." *Getting* it is not always that simple. How does one get it? The method will vary with the industrial hygienist and with the people in the operation of concern. The following methods are suggested as having been successful under many circumstances. What you will do depends on your judgment of the particular circumstances with which you are concerned at a particular time and the people with whom you are concerned.

Previous mention was made of the value of a careful environmental survey and concurrent clinical study of the men involved as a preventive control. Before such a study is made, it is valuable to get all the men in the operation together. A regular safety meeting can be used; it should include all the people — supervisors as well as laborers. Explain what is intended and why. Invite questions from the group. Answers and explanations should be in simple, direct language which they can understand.

During the survey of the environment, the workers' interest and understanding may be helpful. You can obtain a lot of information on the operation from the individual workmen. When the survey is complete, it should be reported to the whole group. Tell them basically what was found, in language they can understand. Indicate what should be done, if anything, to assure a good work environment. When they understand that you have a sincere interest in the workers' health and well-being, it increases their cooperation in effectively controlling the operation.

When you are checking the environment of an operation, talk with the individual workmen. Ask them for information and suggestions. Including them in control efforts will result in more effective cooperation. Take every opportunity to inform all the people who may be concerned with your area of operation. Discussion at safety meetings is useful in getting information to a group. Also look for a chance for discussion with individuals, — all individuals — executives, supervisors, engineers, operators, janitors.

You should also be concerned with the design of a new production unit. Your cooperation with the engineers in design and construction can aid in giving consideration to control of the evironment. Inclusion of good environmental control principles in the design and in the construction of a new production unit is essential. It can save a lot of reconstruction later. It also can make the control of the environment in the interest of health and well-being a much more effective operation.

When talking with groups at a safety meeting or with individual workmen, take every opportunity to discuss also the application of their understanding of healthful working conditions to their off-the-job activities. Through the understanding and cooperation of the employees, we may also have a significantly favorable effect on the nonoccupational ecological system as well as the occupational; hopefully, some of the "understanding" will be carried over by the workmen to their off-the-job activities.

PRACTICAL CONTROL

Yes, the total picture is complex, yet there are a lot of practical things that can be done. We can measure the chemical substances, physical energies and biological organisms in the occupational environment. We can control them through good engineering and good operation. We can and must obtain the understanding and cooperation of the employee in order that our environmental control may be effective. We can compare our findings with the acceptable limits suggested by various groups. With an understanding of the basis of these limits and the significance of our findings, we can judge the effectiveness of our control. We must recognize the possible impact of both occupational and nonoccupational factors.

The most effective use of our present knowledge should be made. We need to make an effort to increase that knowledge through toxicological, environmental and clinical research. We should recognize the complexity of the whole ecological system. This complexity should not discourage us from the effective application of the good practical knowledge which is available. With the practical application of all the factors discussed and the understanding and cooperation of the workers, our efforts can have a very favorable effect on health and well-being.