CHAPTER 35

PRINCIPLES FOR CONTROLLING THE OCCUPATIONAL ENVIRONMENT

Jack E. Peterson, Ph.D.

INTRODUCTION

Hazards and potential hazards in the occupational environment can be purely mechanical in nature, or they can take the form of materials which are capable of causing fire or explosion, or of producing injury by inhalation, skin or eye contact, or by ingestion. Physical forms of energy such as noise, non-ionizing and ionizing radiation, and heat are also potential hazards. Most basic to the control of any hazard is the concept that it can be controlled. Once the hazard is defined properly and the need for and the degree of necessary control is determined, then the only requirements are imagination, trained personnel and money to put the control methods to work.

The basic principles for controlling the occupational environment consist of substitution, isolation and ventilation. Not all basic control principles are applicable to every form of hazard, but all occupational hazards can be controlled by the use of at least one of these principles. Ingenuity, experience and a complete understanding of the circumstances surrounding the control problem are required in choosing methods which will not only provide adequate control, but which will consider installation, operating and maintenance costs and personal factors such as employee acceptance, comfort and convenience. Furthermore, hazards, costs and benefits can change with time so that hazard control systems need continuous review and updating. The aim, then, must be not only to devise efficient hazard control methods, but to evaluate the effectiveness of those methods at regular intervals.

SUBSTITUTION

Usually, when one thinks of controlling a hazard he thinks automatically of adding something to do the controlling. For example, an engineer is more likely to think of controlling a vapor hazard by ventilation than by substituting a less hazardous material for the one which is causing the problem. Yet, substitution of less hazardous materials or process equipment, or even of a less hazardous process, may be the least expensive as well as the most positive method of controlling an occupational hazard.

Unfortunately, substitution is not a technique easily taught. No one can sit down with a slide rule, pencil and paper and decide how to best use substitution to eliminate an occupational hazard. Instead, the principle of substitution is demonstrated best with examples so that by analogy the student may apply what he has learned to his particular problem.

Process

One of the main hazards to our atmospheric environment results from the use of gasoline-powered internal combustion engines in nearly all of our automobiles.[1] Control of this source of air pollution is being attempted in many ways, from the passage of laws to the modification of gasoline to the substitution of a less hazardous process. Substitute processes range from diesel engines to electric motors, and even include the greatly increased use of mass transit systems. That there is no agreement on the best "less hazardous process" (or in fact, that process substitution is necessary) indicates that more study is needed and problem solutions may be political as well as scientific.

Choosing a substitute process is not always difficult. For instance, dipping an object into a container of paint almost always creates much less of an inhalation problem than does the process of spraying that object. Cutting is usually less noisy than breaking or snapping; mechanical stirring causes less material to become airborne than does sparging; generating electric power from nuclear energy causes less air pollution than does the use of fossil fuel, but hydroelectric power is less polluting than either; and distillation usually causes fewer problems than does crystallization.

After considering many examples of process substitution, one principle appears to stand out: the more closely a process approaches being continuous (as opposed to intermittent), the less hazardous that process is likely to be. This principle is a fairly general one and applies to energy hazards such as noise, as well as to the more familiar material hazards. This principle is not always useful, but its application should be considered whenever hazard control by process substitution is attempted.

Equipment

Where the process itself does not need to be changed to reduce hazards, the needed control often can be achieved by substituting either equipment or materials handled, or both. Substituting equipment is nearly always less expensive than substituting processes and often can be done "on the job." On the other hand, finding a substitute material may be easy or may require extensive research and/or process changes. For these reasons, equipment is substituted more often than either processes or materials.

Equipment substitution is often the "obvious" solution to an apparent hazard. An example might be the substitution of safety cans for bottles to store or contain flammable solvents, or the substitution of safety glass for regular window glass in the sash of a "fume" hood. Examples such as these can be multiplied indefinitely because they are obvious on inspection.

One of the main requirements for efficient equipment substitution is the awareness of alternates. Persons concerned with hazard reduction must familiarize themselves with all kinds of "safety" equipment as well as with the processes and process equipment in their jurisdiction. For example, sideshield safety glasses are unlikely to be substituted for regular spectacles unless someone knows the need for, as well as the existence of, the side-shield glasses. Unless someone knows that neoprene gloves are being ruined by contact with chlorinated hydrocarbons, and also knows that polyvinyl alcohol gloves are available and impervious to this kind of attack, a substitution is unlikely.

Realistic suggestions for process equipment substitution are often based on a background in both engineering and industrial hygiene, but even without an extensive background, a fresh look at an old process or problem can pay large dividends. The man who gets out and around within a plant, a company, a city or a nation is likely to observe new solutions to problems and thus is likely to be able to apply them elsewhere. Good equipment substitution is based on common sense, ingenuity, keeping up with the state of the art, and the experience of working with people, processes, and the equipment used by both.

Material

After equipment substitution, material substition is the technique most often used to reduce or to eliminate hazards in the occupational environment. Examples abound. The substitution (forced by a tax law in 1912) of red for white phosphorus in matches drastically reduced both an industrial and a "general" hazard. Substitution of perchloroethylene for petroleum naphtha in the dry cleaning industry essentially eliminated a serious fire hazard. Using tritium-activated phosphors instead of radium-based paint for watch and instrument dials has reduced the hazards associated with the manufacture of the dials, and in addition has reduced by a small amount the background radiation experienced by the general public. Removing beryllium phosphors from fluorescent lamps not only eliminated a hazard to the general public, but also eliminated a more serious hazard to the men manufacturing such lamps.

Many years ago the principal cold cleaning solvent was petroleum naphtha. Because of its fire hazard, a substitute material was sought. Carbon tetrachloride appeared to be ideal because of its low flammability, good solvent power, and low price. Experience and a great deal of research, however, showed that a serious fire hazard had been traded for a perhaps even more serious vapor inhalation hazard. Today, carbon tetrachloride is being supplanted by several other chlorinated hydrocarbons, notably 1, 1, 1-trichloroethane, trichloroethylene, perchloroethylene and methylene chloride. Each of these substitutes is far less toxic and far less hazardous to handle than is carbon tetrachloride, although each has its own hazards. In addition, the fluorinated hydrocarbons are being used more and more despite their expense, mainly because their inhalation and fire hazards are so low.

The principle of material substitution carries with it the same type of reward and the same potential hazards as other kinds of substitution. Substitution of a different material can reduce or eliminate hazard, but one hazard can be substituted for another inadvertently. A careful watch must be kept for unforeseen hazards that may crop up when any kind of substitution is used. An excellent source of information about the toxic properties and hazards of materials and their substitutes is the Hygienic Guide series published by the American Industrial Hygiene Association.

ISOLATION

Isolation is the term applied when a barrier is interposed between a hazard and those who might be affected by that hazard. The barrier may be physical, or distance or time may provide the isolation considered necessary.

Stored Material

Stored material rarely poses an overt hazard, and therefore, whether it is raw material or finished product, those concerned are likely to take it for granted and to assume that it poses no threat. This assumption can be dangerous.

When flammable liquids are stored in large tanks above ground, common practice is to group the tanks on a "tank farm" but to isolate each tank from the others by means of a dike made of earth or concrete. If a major spill does occur, the (possibly flaming) liquid is restrained by the dike from coming close enough to other storage tanks to affect them. For more positive protection, tanks are buried to interpose an even more formidable barrier between their contents and the general environment. A further example is to restrict the volume of material stored in a single container. This exemplifies the use of isolation to reduce a hazard by imposing many small barriers rather than one large one between the contents and the environment.

Where the principal hazard of a liquid arises from inhalation rather than from fire, the imposition of a physical barrier becomes much more difficult than simply building a dike. When the quantities are relatively small (up to a few tens of gallons, perhaps) the best storage technique uses both isolation and ventilation. An example of this practice is the more and more common use of ventilated storage cabinets in laboratories.[2] Such cabinets are usually made of fire resistant material and air is drawn through them constantly by means of a fan which discharges out-of-doors. This type of arrangement interposes both a physical and a ventilation barrier between the contents of storage vessels and the laboratory environment and in addition, may free much valuable hood space for other than storage use.

Solids usually are stored either in original containers (bags, cans, or drums), bins, or simply in piles which may even be out-of-doors. Except in unusual cases, solids rarely pose problems in storage which compare in magnitude with those of liquids and gases. Outside storage piles can be unsightly and can be the source of air pollution problems; in such cases a physical barrier is the usual answer. The barrier may be as simple as a tarpaulin or as complex as a storage building with several kinds of materials handling equipment.

Equipment

Most equipment used in processing operations is designed to be safe if it is used properly. On the other hand, there are times and cases where this is far from true. Equipment that is operated under very high pressure, for instance, may well pose a severe hazard even when operated correctly. In such cases, the proper action to take is to isolate the equipment from the occupational environment. Usually physical barriers are used and the barriers may be very formidable ones, indeed. Extensive use may be made of armor plate as well as reinforced concrete, mild steel, and even wood. Viewing the work area may be done by remote controlled television cameras, simple mirrors or periscopes.

Equipment isolation may be the easiest method of preventing hazardous physical contact, for instance with hot surfaces. Insulating a hot water line may not be economical from a strictly monetary standpoint, but may be necessary simply because that line is not sufficiently isolated from people by distance.

Inhalation hazards can often be reduced markedly by equipment isolation. One example is that of isolating pumps. Nearly all pumps used in industry can leak and will do so, at least occasionally. Proper planning should take this fact into consideration, perhaps by arranging vessels and piping so that pumps handling hazardous materials can all be located in one area. That area, then, can be isolated physically from the remainder of the process equipment. If, then, the pump room (and/or each pump) is ventilated properly, minor leaks will be of no consequence, and major ones will be repairable without a serious inhalation hazard to the mechanic.

Process

Process isolation is usually thought to be the most expensive of the isolation methods of hazard control, and thus is probably the least used. Nevertheless, with today's space-shot-perfected techniques, some extremely complex processes and equipment have been shown susceptible to remote control, and in principle there is probably no process which cannot be operated remotely if the expense of remote operation is justified.

Process isolation techniques were given great impetus when men sought ways in which to handle radioisotopes safely. They found that the hazard from external radiation sources could be attenuated with shielding and distance, but both of these techniques required the development of very sophisticated methods of remote operation. Master-slave manipulators were designed to allow direct "handling" of equipment from very remote locations and this, in turn, accelerated the development of different viewing methods, complex electronic systems, and the theory and philosophy of remote operation.

The modern petroleum processing plant is an example of the use of remote processing. Many of the newer plants are based almost completely on centralized control with automatic sampling and analysis, remote readout of various sensors, on-line computer processing of the data, and perhaps actual computer control of process equipment. These techniques were not developed with hazard control uppermost in mind; instead, economy of operation was the spur, but safety was a by-product.

Computer-controlled processing also appears to be gaining acceptance in the chemical industry. For the most part, this change has been in response to economic pressures because, despite their high initial costs, computer-controlled continuous processing plants can be operated with much less expense than that associated with manual operation, and at the same time produce a superior product. Such plants enjoy the advantages of remote operation and also those of continuous processing with attendant relatively low volumes of materials actually being handled. This combination can result in a very low hazard potential.

Process isolation, however, by its very nature can pose some rather extreme hazards. That is, when human intervention is required, the potential hazard may rise abruptly from near zero to near certainty. In such cases, full use must be made of techniques of isolating the man from his environment.

Workmen

Isolating workmen from their occupational environment has been used since antiquity, and will continue to be necessary in the foreseeable future. The first blacksmith to don an apron of hide was using this principle just as certainly as is the present day radioisotope handler with his plastic airsupplied sealed suit and its connecting "tunnel."[3] Pliny, the Elder, wrote about the use of pig's bladders by miners to reduce the amount of dust inhaled[4] and today advertising men extol the virtues of masks made of polyurethane foam to accomplish the same thing.

Using personal protective equipment of any sort exemplifies the principle of isolating man from his occupational environment. Protective equipment for workers should usually be designed for emergency or temporary use, but this does not always hold true. Experts in the safety field stress the continual use of some sort of eye protection if only because loss of vision is such an extreme penalty to pay for a moment's inattention. Hard hats and safety shoes with steel toecaps are other examples of protective equipment designed to be cheap insurance against severe loss. Some kinds of personal protective equipment are so ubiquitous as to be almost a badge of the trade. The butcher's apron, the chef's tall hat, the welder's helmet, the first baseman's glove, the logger's boots and the fullback's shoulder pads are all devices designed to help isolate man from his occupational environment.

Today it is possible to isolate anyone from practically any environment for nearly any length of time. We can send men through the vacuum of space to the moon, for instance, or send them to the depths of the sea, completely protected from rather extreme environments. Nevertheless, even though essentially complete protection is possible, it is rarely used.

Completely isolating a man from his occupational environment is difficult and expensive; therefore, when worker isolation is necessary, it is usually partial rather than complete. Even partial isolation can result in discomfort (consider wearing a gas mask all day, for instance), and in such cases other techniques of controlling the environment should be considered seriously. Face shields, ear plugs, rubber gloves and the like should always be available if their use is warranted, but the aim of the engineers and planners should be to make their continual use unnecessary. Furthermore, all emergency protective equipment should be inspected periodically and tested if necessary to assure that it will perform its intended function in use.

Testing of protective equipment and planning for its proper use (see Chapter 36) are both very complex fields. By its nature, most equipment of this type is designed for use at times when all of the hazards are not delineated readily — where, in fact, the real hazards may never be known. For instance, canister-type gas masks have been regarded as suitable for respiratory protection in emergencies provided that the air still contains enough oxygen to sustain life. Chemical reactors, tanks, sewers and buildings on fire don't always provide enough oxygen to sustain life, and therefore, injuries do occur from asphyxiation. Furthermore, the canister on the mask may not be designed to protect against the air contaminant(s) actually present and again people are injured despite their gas masks. While the traditional gas mask still has uses, in many cases it should be replaced by one of the supplied-air type which can be worn in an oxygen-deficient atmosphere which contains unknown concentrations of unknown gases, vapors and particulates. This type of mask will do a good job in such atmospheres provided that it fits,[5] that the reservoir contains sufficient air for the necessary time, and that the regulator is functioning properly.

Gas masks are not the only pieces of protective equipment that actually may not protect in the emergency where they are used, but they exemplify the idea that obtaining equipment for protection is no guarantee that the equipment will be effective. Judicious testing of equipment designed to isolate man from his occupational environment is a necessity.

VENTILATION

Ventilation (see Chapters 39 and 42) can be used to insure thermal comfort as well as to keep dangerous vapors from the breathing zone of a worker. It can be misused in an attempt to blow away radiant heat or used properly to control the dust hazard from a grinder. Ventilation equipment is found everywhere, much of it designed, engineered, and used improperly, even though a similar expenditure of time, effort and money could well have resulted in adequate or better-than-adequate control of the occupational environment.[6]

From the point of view of the engineer, ventilation systems can be either local or general in nature, and they can attempt control mainly by exhausting or supplying air properly. These designations cannot, of course, be absolute because, for instance, local supply for one area is general supply for any other part of that room or building. Nevertheless, the intention of the planner will control this discussion.

Local Exhaust and Supply

Localized ventilation systems nearly always attempt to control a hazard by directing air movement. The velocity of the moving air may also be a consideration, but except in high velocity-low volume systems, it is used only to assure that the direction of movement is the correct one.

There are two main principles governing the correct use of local exhaust ventilation to control airborne hazards. The first is to enclose the process or equipment physically as much as possible. The second is to withdraw air from the physical enclosure (hood) at a rate sufficient to assure that the direction of air movement at all openings is always **into** the enclosure. All other considerations are secondary. If these principles are followed, no airborne material will escape from the enclosure so long as the enclosure is intact and the ventilation system is operating properly.

There are times where no enclosure is possible and where control of airborne hazards must be accomplished simply by the direction and velocity of air movement. These cases are not exceptions to the basic principle because, at the point where control must be assured, if the direction of air movement is always into the hood there will be control of materials suspended in that air. Similarly, if an air-tight enclosure were to be used, then no air need be moved to assure control of a vapor or an aerosol, but the principles have not been violated.

Three of the problems associated with local exhaust systems stand out. First, and most obvious, is that of poor design. All too many ventilation systems appear to have been laid out by someone who has no knowledge of how to handle air properly. These systems abound in abrupt expansions and contractions, in right-angle entries, in the overuse of blast gates to attenuate problems, and so on. Since the advent of the ACGIH Ventilation Manual,[7] poor exhaust or supply system design has had no excuse because good technique is so easily available.

The second problem is that of inadequate exhaust. It is exemplified by the exhaust system which has been added to from time to time, until nothing associated with the system works at all well. The solution is simply to make sure that **all** systems, old as well as new, are well engineered.

The third problem of local exhaust systems is that of inadequate supply. People who are willing to install extra hoods at the drop of a hat (probably adding them to an already overloaded exhaust system) almost uniformly seem to feel that adequate supply air is a luxury or frill which they can do without. This tendency is accentuated by the widespread knowledge of a "rule of the thumb" which states that so long as the number of air changes per hour in the building is less "X" there is no need for a separate supply system. (The value of "X" varies from thumb to thumb, but is likely to be from 2 to 4.) This rule assumes that the building isn't "tight" and that infiltration of air will equal or exceed that exhausted.

Almost all buildings "leak" a little, and some leak a lot of air. Nevertheless, another principle of controlling the occupational environment by local exhaust is "always supply at least as much air as will be exhausted." A mechanical air supply system can and will do many things that infiltration cannot. A mechanical system can supply air that is filtered (and thus clean), tempered (warmed or cooled as necessary) and in the proper location to eliminate drafts and to avoid excessive disturbance of air at the faces of local exhaust hoods. None of these benefits can be gained by counting on infiltration for supply.

Local supply in itself is used occasionally to effect control or to assist in control of local exhaust. A combination of supply and exhaust, for instance, is sometimes used as a "push-pull" system to control vapors from large open tanks,[8] the supply air being used to "push" vapors into the exhaust system. If properly engineered, such systems can work well and can effect control by the movement of much less air than would be necessary if only exhaust were used.

The main use of local supply systems is not, however, to control hazardous vapors but, instead, to reduce heat stress problems. For this application, air is usually supplied on an individual basis and each man is allowed to control the direction and/or the velocity of air impinging on his work station. The air used is not cooled, but is supplied at high velocities (up to 500 fpm); it cools by sweat evaporation and by convection, if its temperature is below the man's skin temperature (as is usually the case).

General Exhaust and Supply

General exhaust and supply systems attempt to control the occupational environment by dilution. This principle can be used for many types of problems, ranging from hazardous vapors to locker room odors to problems of dust, humidity and temperature. A principle of general ventilation is that it be used to control problems that inherently are widespread. That is, it makes sense to use general exhaust and supply ventilation to control the temperature and humidity of all the air in an office building, but it does not make sense to try to control the fume generated by one welder with an exhaust fan located in the opposite wall. General ventilation is almost always unsuccessful when used to control "point" sources of airborne contaminants, and in addition, is very wasteful of air when used for such purposes.

Even local systems must have air to exhaust, and usually that air is supplied by a general system — one that is not associated with any particular hood or exhaust port. Some dilution of air contaminants will take place because of the general supply system, but its main purpose is simply to provide air to be thrown away by the exhaust system.

Air moving equipment can be expensive, and air filtering and tempering equipment can be even more so. Therefore, some engineers attempt to save money by recirculating some exhaust air back into the supply system. While this practice is standard in office buildings, it is rarely applicable in factories and shops because the air handled by the exhaust system cannot usually be cleaned adequately. Once-through systems, therefore, are standard except where the contaminant in the exhausted air is an easily handled particulate with a low inhalation toxicity. Sawdust, for example, is usually low in toxicity (although some woods are sensitizers), and the particles may be large enough to be removed easily from an air stream. In such a case, recirculation of some part of the exhaust air could be considered.

Inadvertent recirculation of exhausted air is a growing occupational health problem. When exhaust stacks and supply inlets are not separated adequately, part of the exhaust air will be captured by the inlet and recirculated to the building. This problem is prevalent in buildings designed by architects who are more concerned with the appearance of a roofline than they are with the health of those who will work in the building.[9] The problem also occurs between buildings, especially when roof elevation differences are not great, and elsewhere when little or no attention has been paid to the possibility of recirculation.

Recent work has shown that the best way to prevent recirculation is to discharge exhaust air in such a manner that all of it will escape from the "cavity" which forms as a result of wind moving over and around buildings.[10, 11] The intake can then be located at any convenient place, usually close to the roof, with assurance that recirculation will be negligible. Unfortunately, the prediction of cavity height above a roof is not yet an exact science, but enough is known so that intelligent decisions can be made. The recirculation problem must be considered whenever highly toxic, highly hazardous, or highly odorous materials are discharged by an exhaust system, whether or not a mechanical supply system is present.

EDUCATION

The first and most basic principle of almost any discipline is that knowledge is needed in order to apply that discipline to practical problems. Some knowledge comes with experience, but experience can be a poor teacher. More or less formal education can supplement experience and can direct it into the most productive channels. Nearly all people with line responsibility in industry, and many with staff responsibility, can become involved with controlling the occupational environment. All of these people can profit from education in this area.

Management

Few managers become involved directly in the practical aspects of hazard control, yet very little hazard control is done without management backing. Managers exist mainly to motivate people (or to allow people to motivate themselves), but even expert motivators cannot channel activity into areas of which they are ignorant. Education of management should deal much more with the "why" of hazard control than with the how, when, where or whom.

There has been very little effort to formalize the education of managers in most industries; usually they are taught about hazards in meetings, conferences and personal chats by men who work for them. Informal education is better than no education at all, but the present best hope is the recent proliferation of short courses prepared and presented for representatives of high echelon management. A short course is the easy way to obtain quite a lot of valuable information with a small expenditure of time. This approach has been used successfully in the field of hazard control and much more use of it should be made in the future.

Short courses for managers should identify hazards in broad areas; details should be reserved for examples. The courses should concentrate particularly on the costs and benefits of controlling the environment, but should not completely neglect humanitarian aspects. Legal requirements which must be met should also be a part of the course content, but where a "carrot" exists, its use will almost always produce better results than will a club. Particularly for managers, the carrots (rewards) should be searched out, found and emphasized.

Engineers

At least a portion of the work of every industrial hygienist can be traced to equipment and/or process design failure. In many "failure" cases the person who designed the equipment or process simply was not aware of the potential consequences of the failure, or that such a failure was possible. Examples range from the purchase of equipment noisy enough to be hazardous, to the use of carbon tetrachloride or benzene as solvents, to the specification of gasoline-powered lift trucks for an enclosed warehouse, to the omission of a necessary fire door. In general, these failures arise from ignorance rather than from malice or from a "devil-may-care" attitude. Furthermore, the decision which resulted in a failure probably was made by someone quite far removed from the consequences of the decision — a planner, perhaps, or an engineering designer.

Educating engineers in regard to environmental hazards has, in the past, taken place mainly on the job by association with more experienced people. In recent years a few short courses have been given to supplement on-the-job training, but all too often any remedy applied is both too little and too late.

The logical place for engineers to be exposed to the knowledge that the environment abounds with hazards is when they are students at the undergraduate level. What is necessary then is not a program designed to turn these people into industrial hygienists or safety engineers, but instead, a course or courses which tend to open their eyes to the consequences of decisions they may make in their professional capacity. Undergraduate engineers (and most graduate engineers, for that matter) simply are not aware that it is perfectly possible to write noise specifications for much equipment; that carbon tetrachloride and benzene have excellent, much less hazardous, substitutes; that LPG fueled lift trucks generate much less carbon monoxide than do gasoline-powered lift trucks, that electric lift trucks are available and entirely suitable for most lift truck tasks; or when and where to install fire doors. The hazard gamut is so large that the typical short course can only scratch the surface, and a semester-long exposure stands a much better chance of getting the idea across.

Several colleges and universities already offer one or more courses surveying the fields of industrial hygiene for undergraduates especially in engineering curricula. With such courses as the foundation, short courses later in professional life should be able to keep engineers reasonably well up to date on environmental hazard control provided, of course, that they regularly read the literature related to the field.

Supervisors

In most circumstances, the further a supervisor is from actual control of a process, the more he deals with men and the less he deals with things. Supervisors usually work only through other people and consequently, they become aware of most environmental hazards from other people, or through their actions. In the case of an obvious hazard within his jurisdiction, a supervisor either can deal with the hazard with his own resources or he can solicit aid from others. Generally, which action to take is rather obvious, but some of the hazards posed by the occupational environment are subtle rather than obvious, and most supervisors are not equipped to deal with the subtle variety at all.

Education of supervisors usually should be process and process equipment oriented. The aim of the education should be to teach them about the subtle hazards that may be found in the environment of their employees and when and under what circumstances to request aid in solving the problems those hazards pose. Supervisors who are knowledgeable and well informed about hazardous processes, operations and materials are often able to control hazards early enough so that outside aid is not necessary except for periodic checks or reviews.

Workmen

Traditionally, little effort has been made to teach workmen about either the equipment or the materials that they handle. In the past few decades, safety engineers have shown over and over again that there are direct benefits to be gained from teaching workmen about the physical hazards in their environment and how to avoid those hazards. More recently, industrial hygiene engineers have begun, usually in periodic safety meetings, to teach workmen about the hazards of materials and energies and, perhaps not surprisingly, have found similar benefits.

Hazards associated with the occupational environment impinge first on the men who work directly with materials, process equipment and processes. As these men are the first affected, they may well be the first to recognize adverse effects, and if so, if they are knowledgeable about the effects of the materials and energies they work with, they may be able to pinpoint problems before those problems become severe.

The main arguments against educating workers about the real and potential hazards of the materials and energies to which they are exposed have been that such knowledge would create apprehension, cause malingering, and give the unions another club to hold over the head of management. Where worker education has been used, however, groundless fears have evaporated, attendance has improved, and unions have been more cooperative, especially in matters concerning the health and safety of workmen.

An aware workman can often anticipate and circumvent hazards before they become serious to him, his fellow workers, or to the physical facilities. Furthermore, once the source of a hazard has been found, workmen, rather than supervisors or engineers, quite often have the best ideas of how to eliminate the problem with the least effort and expense. And finally, aware workmen often can be used to assist in industrial hygiene surveys,[12] thereby freeing the industrial hygiene engineer for perhaps more productive tasks.

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