

ENCLOSURE 3

PATTY'S INDUSTRIAL HYGIENE AND TOXICOLOGY

Fourth Edition

Volume I, Part A
General Principles

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Editors

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The Industrial Hygiene Survey and Personnel

James O. Pierce, Sc.D.

1 INTRODUCTION

In today's industrial society, with the advent of numerous health and safety regulations, many of which are contradictory and overlapping, the industrial hygienist finds that what was once considered to be the industrial hygiene survey has now taken on new ramifications. In the past, these surveys were regarded as scientific investigations using all of the skill, experience, and art of the professional industrial hygienist to recognize, to evaluate, and eventually to devise methods of controlling exposure to potentially harmful substances in the workplace. The results of these efforts were intended to provide a safe and healthy work environment, to prevent undue stress on the worker, and to prevent injury or illness resulting from the workplace environment.

Prior to the passage of the Occupational Safety and Health Act of 1970 (OSHA), the accomplishment of these aims was considered to be a fundamental moral obligation on the part of the employer because few health and safety regulations existed and there was little or no enforcement at the federal level, although enforcement authority existed under statute authority such as the Walsh-Healy Act (see Chapter 2).

One of the primary industrial health professional groups in the country, the U.S. Public Health Service, was instrumental in establishing policy and procedures that would eventually result in the formation of the Bureau of Occupational Health

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(BOSH) and, finally, the National Institute of Occupational Health and Safety (NIOSH), which is the premier research and training arm of the federal government in occupational health and safety.

The changes brought about by the act and the resulting emphasis, especially in later years, on industrial hygiene practices and procedures, have been significant. Abetted by increased concern of employer, employee, and society in general, along with a changing definition of societal well-being, today's industrial hygiene practice has taken on a new meaning and direction, and what was once considered the industrial hygiene survey has now been upgraded to include many new skills and requirements. No longer is the practice of industrial hygiene viewed as one based upon the investigation of acute episodes and events with the long-term goal of reducing exposures to potentially toxic substances, but one based upon the new regulatory mode of having to comply not only with complex regulations promulgated by the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), and the Consumer Product Safety Commission, but also with a myriad of regulations from federal, state, and community agencies.

One highly recognized and respected expert in the field (1) has recently described the progression of industrial hygiene as characterized by six distinct periods of time:

1950-1960	Benign neglect of occupational safety and health
1960-1970	The environmental counterpart and stimulus
1970-1975	OSHA—start-up: early childhood patterns
1975-1980	Adolescence
1980-1988	Deregulation and "down-scaling"
1989-1990	Adulthood

To this impressive analysis up to the 1990s must be added a prediction for 1990-1995, and to the year 2000 and beyond, which will be characterized by a different kind of work force and by more concern for limiting the risks associated not only with the workplace, but with society in general.

In 1994, when there no longer exists a mandatory retirement age for most employees, we will see a much more aging work force, and statistics prove that industrial accidents increase with the age of the work force. Thus the industrial work site will be the focus of increased vigilance to provide for a safe and totally healthful environment. In addition, in future years more intensive automation and emphasis on robotics will continue to develop. The major employers of the future will be in the service-related industries. Furthermore, the continued trends of stress-related health effects and disorders will rise and cause us further to evaluate our approach to the field of preventive health. All of these factors, including our continuing dependency upon computers and computer-controlled work sites, will change our approach to the industrial hygiene survey. The field of industrial hygiene must change to meet and accommodate these future challenges.

However, we must be practical and realize that change comes about slowly and, although we must look toward the future and try to prepare adequately for its

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eventualities, we must still face the realities of the 1990s. We must look toward the leaders of today to cope with the realities of what we must accomplish.

The industrial hygiene era of 1980-1988, Corn (1) points out, is one of deregulation accompanied by the shock of early OSHA childhood. He cites the following parameters as the primary factors responsible for this era:

1. Reduced effort of federal OSHA
2. State programs facing budgetary constraints
3. Improved cost effectiveness of control methods
4. Pressure to abandon "hierarchy of controls"
5. Trimming of corporate staffs ("decentralization") and increased utilization of consultants
6. Employee and community "right-to-know" laws
7. Comparative risks utilized for priority setting
8. International coordination at the professional level
9. University programs in occupational safety and health

Corn views the 1990s and beyond as having reached "adulthood" and as characterized by increased regulations, increased employee and community knowledge, increased worker/employer joint safety and health programs, increased presumption of risk in absence of data, increased concern with stress and ergonomics, and increased litigation.

These factors among others directly affect today's industrial hygienists and the duties and responsibilities they face in a modern society. These factors play an important role in the industrial hygiene survey because no longer is such a survey the personal province of the industrial hygienist and management; the results and all data thus obtained can now be construed to be in the public domain.

However, the industrial hygiene survey is affected not only by OSHA regulations, but also by the proliferation of health-related regulations being promulgated by a wide variety of federal and state programs. These include those regulations that require complicated record-keeping systems ranging from SARA Title III to the emerging legislative activity at the state level, requiring risk management and prevention programs (RMPPs). These regulations are a direct result of tragic events such as Bhopal, the Union Carbide disaster, and the asbestos episodes.

In addition, we now are faced with overlapping legislations such as AHERA (Asbestos Hazard Emergency Response Act, 1986); SARA (Superfund Amendments and Reauthorization Act, 1986); TSCA (Toxic Substances Control Act, 1976); CERCLA (Comprehensive Environmental Response Compensation and Liability Act, 1980); and numerous other state and federal regulations related to health and safety. All these affect the field of industrial hygiene and further complicate the importance and significance of the industrial hygiene survey. Today's hygienist must have thorough knowledge of all such related regulations in order to function in our complex society of the 1990s and beyond.

If I were to attempt to predict the future of the industrial hygiene survey, I

would look toward a model of risk assessment/computer enhanced procedures. A recent article on risk assessment by Renshaw (2) states:

Techniques for assessing risks to the health of employees and property in the occupational setting are evolving at a rapid pace. These techniques embrace a wide variety of risks including chronic disease from repeated exposures to toxic substances and fatalities from vapor cloud releases. An understanding of these techniques by the industrial hygiene manager is necessary to provide insight into the effective allocation of resources and to make sound decisions on control measures which minimize risks. An understanding of basic terms related to risk assessment is necessary in order to apply these techniques and, more importantly, to determine where such techniques are worthy of application.

In defining the future role of the industrial hygiene survey, one needs to address the emerging proliferation of computer software programs that are coming out with increasing frequency. Separate reference books are being published on computer systems for occupational safety and health management. Record-keeping programs for tabulating industrial hygiene exposures and records are readily available. It is undeniable that computers and advanced software programs will play an integral part in the future of industrial hygiene and will have a direct impact on the future performance of industrial hygiene surveys. Also, owing to the complexities involved, the "team" personnel will change, requiring new disciplines to be integrated into this already complex field. Industrial hygiene is fast becoming less of an art and more of a science.

In summary, I believe the industrial hygiene survey and the type of personnel required to meet the needs of the year 2000 and beyond will be dramatically different from today's, requiring changes in the traditional education of industrial hygienists and occupational health and safety personnel to equip them with the advanced techniques and knowledge necessary to meet the challenges of the future. Of increasing importance will be innovative educational curricula that will address these needs, including new approaches that will include risk assessment, risk management, and management techniques.

The role of the industrial hygienist will continue to increase in the industrial management structure of the future; it will also require more skills. The role of the industrial hygiene technician or associate industrial hygienist, discussed below, will also change dramatically and will eventually assume the role of what has in the past been the assumed role of the primary industrial hygienist. In the interim, we must still rely upon a modified approach to the traditional industrial hygiene survey, a basic tool that all such professionals must still be adept at using.

2 TYPES OF SURVEY

In the current practice of industrial hygiene there are three types of survey:

1. The reconnaissance or observational survey
2. The investigational or appraisal survey
3. The combined industrial hygiene and medical survey

The second type has as its chief purpose the evaluation and control of potentially harmful situations, and the third type integrates the investigational survey with medical examinations of the work force. It must be noted that this approach is becoming much rarer because the reporting structures of many current and future corporate entities separate the occupational health and safety component from the traditional medical department and have put the latter group into a direct line reporting organization. A number of corporations still follow the older, traditional approach, but the future is clear: industrial hygienists have become corporate managers and, as such, must be prepared to enter this more rarefied atmosphere. New computer software programs automatically correlate medical and toxicology data and nowadays even the results of genetic screening into highly sophisticated programs that will individually characterize work stations with exposure data.

2.1 The Preliminary Industrial Hygiene Survey

The preliminary or observational industrial hygiene survey is usually the immediate forerunner of a survey employing technical instruments. In this survey, experience and familiarity with industrial processes are a *must*.

This survey is of paramount importance, especially when familiarizing oneself with a new plant or workplace: it is done for the purpose of selecting locations in a plant where exposures or hazards are later to be evaluated by analytical studies, to determine whether additional control is necessary. During this survey pertinent data should be collected, such as the number of male and female workers employed at various operations or processes; safety and systems management practices, emergency response programs, and medical services; availability of accident and illness records; the different types of operations conducted; raw materials, processing aids, products, and recognized by-products; measures employed for dust, fume, and vapor or gas control; and methods of solid, liquid, or gas waste disposal.

Detailed notes, preferably a tape-recording followed by a typewritten transcription, may prove invaluable, as will also discussions with workers involved with the actual performance of the work in progress.

If a plant layout showing the location of the operations or process equipment in the industrial establishment is immediately available or can be obtained in a short time, it will be invaluable in helping to orient the industrial hygienist to the complexities of an industrial situation. The preliminary survey will also determine the field survey equipment necessary for the investigational survey.

Depending on the size and complexity of the operations, the time required for the preliminary survey may vary from one day in a small shop to a week or more in large industrial plants. In a small plant the preliminary survey may immediately precede the investigational survey, and both may be accomplished on the same

day by the same individual, although care must be taken if the necessary goals are to be achieved.

2.1.1 *The Industrial Hygiene Survey and Personnel*

The preliminary survey is usually made with no equipment for measurement purposes other than those portable pieces of equipment that can be conveniently carried on the person, such as a sound level meter. This survey relies heavily upon experience and expertise in the field.

This survey should be made by an individual who is familiar with the type of industry involved, especially the chemistry of its products and by-products, and one who is well grounded in the field of industrial hygiene. This individual may or may not be the person who is to make the final technical analysis, but he or she should be at least equally familiar with the problems involved in recognizing and evaluating exposures to potentially harmful materials. Also, a complete familiarity with local, state, and federal regulations pertaining to the workplace and to the outside environment should be taken into account and notes appropriately made, along with references to pertinent regulations.

This survey is best accomplished by following the industrial process through the plant from raw materials to finished products. The industrial hygienist should be accompanied by the production superintendent, or some other qualified plant employee, to explain any process or steps in manufacture that are not evident to the surveyor. Among the plant personnel who are best suited to the role of guide for the investigator are the production superintendent, the chief process engineer, the plant chemist, the foreman of the department under investigation, and the safety director. Consultation with the medical department may also be of help in attempting to identify potential exposures with physiological effects. Familiarity with industrial processes is a *must*.

As a part of this type of survey, which draws upon the expertise of the trained and experienced industrial hygienist, he or she must rely upon a well-developed and trained sense of smell along with other senses that tend to detect and recognize potentially hazardous exposures. The person should be able to recognize and identify all the common gases and vapors that possess characteristic odors, tastes, or irritant effects, as well as to judge qualitatively whether the concentration of a substance may be exceeding permissible levels or recommended levels of exposure. This highly unobjective evaluation must of course then be followed by a full evaluation employing "state-of-the-art techniques" for quantifying atmospheric workplace exposures.

The industrial hygienist should also be alert to any signs in the personal appearance of the workers that may indicate adverse occupational exposures. Of course, interviews with individual workers are a primary source of information for the industrial hygienist evaluating potential problems in the workplace. In this way it may be possible to identify a serious exposure that might otherwise be overlooked because of the intermittent or obscure nature of its cause. Interviews with such workers can often reveal health problems resulting from workplace exposures that

can easily be overlooked by any qualitative or even quantitative evaluation of the workplace.

Frequently there are contributory or intermittent operations not in evidence at the time of the survey. These may include preliminary treatment of raw materials, disposal of by-products or waste products, "turn-around" or periodic maintenance and rebuilding, and warehouse operations. The industrial hygienist may learn of these through experience in the industry, from a knowledge of similar operations, or by an extended discussion with potentially affected employees.

One should always determine the presence of control measures and provide an opinion about:

1. The probable need for, or effectiveness of, control
2. The type of personnel, in terms of training, skill, or knowledge of the potential hazards in the workplace
3. The attitude of management, supervising staff, and the personnel employed at the work site toward health and safety practices, along with the control measures currently in effect and proper maintenance procedures

At the end of the preliminary survey it may be desirable to give the management a report of findings and plans.

Having completed the preliminary survey, and having decided where all investigations are to be made, the industrial hygienist now selects the necessary equipment and undertakes the technical analysis. However, all findings and observations made during the preliminary survey should be fully documented in writing and forwarded to the appropriate supervisor for the record.

2.2 The Investigational Industrial Hygiene Survey

2.2.1 Surveying the Plant

The investigational survey, or the technical industrial hygiene analytical survey, involves the evaluation of all exposures to potentially harmful situations and the development of control measures. This is what is ordinarily referred to in the profession as an industrial hygiene survey. If no previous survey of the plant has been made, it is best to leave any equipment in a safe place and conduct a preliminary survey before undertaking the detailed investigation.

It is now necessary to evaluate exposures by exact measurements owing to the necessity for legal documentation. When control is the only objective, and it is obvious to the investigator that contaminants are excessive, it is not prudent to devise satisfactory controls without the benefit of quantitative measurements. Nowadays one must document all such situations to protect against future liability claims.

When there is any question about the necessity of control, however, or when facts are desired for the record because of medical, legal, or other needs, samples of the atmosphere must be collected and evaluated by chemical or instrumental methods.

In surveys to determine the merits of a claim for compensation for injury allegedly arising from harmful exposures in industry, it is essential to obtain quantitative information about exposures, in order to ensure the establishment of facts, rather than the recording of opinions, even though it may be obvious to the experienced industrial hygienist that the exposures are either insignificant or excessive. In a system handling a potentially harmful chemical, even though the investigator is completely satisfied that control is ample, sampling may be desirable for its psychological effect; it eliminates personal factors and gives the uneasy employees assurance of a safe environment.

Under the requirements of OSHA, records of periodic analyses of atmospheric contamination are required when the concentration of a chemical agent is borderline with respect to the threshold limit value for an 8-hour daily exposure. More frequent analyses are required when control measures are to be installed to reduce the air contamination to acceptable levels. The detailed regulatory requirements of the act with respect to chemical air contaminants are still being developed, and some of the procedures specified for air sampling, work practices, and other administrative matters are subject to dispute. However, there is still room for the knowledgeable hygienist to exercise judgment in evaluating exposures and creating a safe working environment, as long as this judgment decision is fully documented. Again, caution is advised.

2.2.2 The Industrial Hygiene Survey and Personnel

The analytical survey can be accomplished with the cooperation of the production superintendent, the safety director, or the foremen of the particular departments in which investigations are to be made. If the results are to be representative, air sampling or other quantitative measurements should be made during normal, as well as the most unfavorable, operating conditions, and over a period of time long enough to yield the complete exposure picture. The foremen can assist in maintaining the normal conditions as well as in simulating abnormal conditions if such are required for a true evaluation. It is good policy to visit the physician or nurse on duty, if there is one, to establish cordial cooperation and to review any records of ill health. The plant physician may wish to accompany the hygienist during the survey of the plant, and this may prove advantageous to both; but it is an exceptional physician who can supply needed information about plant processes.

In the present social climate, it is a rare employee indeed who has no inkling of the possible occupational health hazards of a particular industry or a specific workplace.

Both worker and management are constantly bombarded by articles on industrial health hazards that appear in the daily newspapers, union periodicals, trade journals, and scientific literature. Some of the information is factual and straightforward, whereas some articles have an inflammatory tone. In addition to such educational efforts, some of the regulations promulgated by OSHA require that employee representatives be informed of the nature and purpose of an industrial hygiene survey and be granted the opportunity to observe air sampling, instrumental

measurements, and other procedures carried out during the survey by the employer, the employer's agent, or a regulatory officer. Furthermore, during the inspection or survey made by an OSHA compliance officer, the inspector has the legal right to interrogate employees in private concerning their knowledge of adverse working conditions and complaints of ill health due to alleged occupational exposure.

In view of these unsettling influences, how should professional industrial hygienists carry out their responsibilities without creating any friction between the workers and their employer or without contributing to any further apprehension among the workers concerning the healthfulness of their occupation?

It is advisable for management to explain the purpose of the survey to the employees and/or the union, thereby creating a feeling of partnership with the workers in their health protection efforts. At the same time, the element of apprehension due to the presence of strangers or relatively unfamiliar persons making unfamiliar measurements will have been removed. A request can be made for management to assign a temporary guide to answer workers' questions at the different locations surveyed in the establishment. The normal exchange of greetings and courtesies between the fellow employees and the hygienist should be maintained. The plant escort can be useful in answering questions regarding the survey. Although all possible sources of friction between humans cannot be prevented, a friendly attitude will have a calming influence on many hostile situations.

Air samples may be taken at one or several locations to determine individual exposures, general room air conditions, and sources of contamination. Many variable factors should be considered at the time of sampling, in relation to normal, adverse, and optimal conditions. Single samples, though not to be scorned, should not be accepted as true indications of existing conditions because the concentration of contaminants vary from minute to minute, day to day, and season to season.

The more samples taken, the more evident will be the reasons for any variance in results, trends, peak concentrations, and other factors, versus the single extended-time sample. Here again, the trained observer, from the senses of smell, taste, or feeling, may be able to evaluate an exposure accurately enough to establish either the necessity for its control or its insignificance. In large measure, this depends on previous observations of known amounts and similar magnitudes of the material to be evaluated, or a calibration of individual sensitivity, so to speak, because there is some variation among persons in sense of smell.

Three is the minimum number of samples to be taken to evaluate any one operation in a series of successive steps of a process or job assigned to a worker. If the job consists of four different tasks successively repeated, 12 air samples should be collected if confidence in the results is to be had.

All shifts of a similar process should be observed, for a night shift may present an exposure during some operation that the day shift conducts safely, or vice versa. A survey was made many years ago in which an unusual night operation created a very high overexposure to toxic substances. The process involved the smelting of zinc sulfide ore in gas-fired retorts, and the molten zinc metal was collected in cylindrical clay condensing units. A certain number of condensers were removed and replaced each night, successively. This was a hot and dirty job that was rotated

among all smelter employees. Tests for employee exposure to airborne heavy metal contaminants, such as lead, antimony, arsenic, and cadmium, were below acceptable levels during the day and "graveyard" shifts. However, the night shift workers who performed this special operation for 4 to 5 hours had very high exposures to these agents, which offered an explanation for the subjective symptoms and clinical signs of illness among the employees.

The opportunity for employee exposure to airborne chemical contaminants is low in the chemical and petroleum processing industries, because the processing is carried out in closed systems. When such systems are shut down for periodic safety inspections, or cleaning and replacement of worn equipment, gross exposure to chemicals may occur unless the work is planned and safety precautions followed. During these periods, exposures can occur to the process chemicals, cleaning agents, and air contaminants arising from such construction activities as welding in confined spaces.

During the course of the technical survey it may be desirable to trace the air contaminants from their origin to the point or points of dispersion.

Because of the possible synergistic effect of exposures to combined aerial contaminants or the enhancing influence of abnormal temperatures on chemical exposures, the industrial hygienist should also search for the unusual circumstances or combinations of factors that may give rise to adverse physiological responses.

Up to this point this discussion has centered on a survey designed to quantify aerial contaminants and evaluate employee exposure to these agents. However, associated matters such as the types of emergency respiratory protective device issued for use against a specific air contaminant also should be examined.

The survey should determine that the device conforms with the NIOSH approval schedules, making sure that it will provide protection against the concentration of contaminant that may be encountered. No respiratory protective device is presently permitted to be used for continuous protection against air contaminants in lieu of engineering control, although regulatory enforcement may differ on this aspect. Nevertheless, certain devices—namely, mechanical filter-type respirators and chemical cartridge-type respirators—may be used temporarily over protracted periods while engineering controls are being installed.

2.2.3 Developing Control Procedures

If the industrial hygienist or associates have knowledge and skills in the design of mechanical ventilation systems that may be suitable for controlling or reducing the dispersion of a chemical agent from a certain operation, advice and assistance in the form of elementary design specifications can be offered to the plant management.

To be more specific, the hygienist should at least choose between general ventilation and exhaust at the source of contamination, the size, shape, and face velocity requirements of hoods, type of ventilating fan, necessity of a dust collector, suitable types of dust collector, location of dust collector inside or outside, and possibility of recirculation of the air. The judicious use of a smoke tube or Velometer to

locate and measure air currents and cross-drafts may demonstrate to the plant engineer the ineffective control of a present exhaust system. In today's environment, the effective industrial hygienist should rely upon competent outside consultants to provide the expertise in designing such advanced systems.

At the end of this investigational survey, the hygienist possesses many accumulated facts that must be correctly applied; otherwise they become of academic interest only and serve little purpose in the promotion or control of health. The hygienist should develop methods or procedures for controlling overexposures and should have such ideas sufficiently crystallized to present to the plant management, albeit they must also be able to survive outside and regulatory scrutiny.

Any unusual hazards found during the plant survey should be pointed out and discussed with the physician or nurse, to ensure that by cooperation and knowledge of the complete picture, both the industrial hygienist and the plant medical department are aided in their work. It is important that the medical advisors have knowledge of all information developed as a result of the survey.

At the end of the survey, if not before, the plant manager, personnel director, production superintendent, safety engineer, and maintenance engineer should be acquainted with all significant findings, along with recommendations or suggestions for control. Objections may be raised; some of them can be overcome, whereas others may indicate that alternatives to some of the original proposals are more practical. It is obviously desirable that any major control program be discussed in detail and its merits carefully explained. Because federal law requires preventing excessive exposure to potentially harmful agents, it is not a matter of "selling" the need for a control program but rather "selling" a system that is most effective and most economic for the specific situation. The professional industrial hygienist should not attempt to coerce management to undertake any corrective action nor allow any negative management attitudes to discourage reporting adverse findings or to color the conclusions and recommendations that are made.

2.2.4 Records and Reports

A written confirmation report of the survey, complete with findings and recommendations, should be delivered to plant management and other appropriate levels of a corporate establishment. The report should contain the results of all measurements in tabulated form. Interpretation of the findings in each table should be presented in an adjacent narrative, along with the surveyor's conclusions and any necessary recommendations for improving the working environment. A summary of the findings, conclusions, and recommendations should be located in the beginning of the report to draw the reader's attention to information of special importance.

The report may vary from a brief, unbound set of written pages to a voluminous manuscript in an attractive and expensive binding. The report is more likely to be read when brief, but it should always be sufficiently detailed to establish the necessity for the accompanying recommendations.

The industrial hygienist may wish to use prepared forms to accommodate per-

sonal needs to record each sample collected and all environmental and work information pertinent to the sample. Calculated air concentration of the chemical agent derived from the laboratory analysis of the sample can also be recorded on such a form. Many new and emerging computer software programs are available for recording and permanently storing such data. Many software programs are specifically tailored to meet regulatory requirements and can save much time and effort.

A permanent record of observations made during the course of the survey should be entered into a field notebook on the job for reference during preparation of the report; these notes will also serve as admissible evidence in any possible court action. The surveyor should not jot down random bits of information on loose pieces of paper that may be lost. Details that are not recorded on the spot are often forgotten. If management permits, snapshots of specific operations taken with a camera that uses self-developing film are extremely helpful for refreshing memory in report preparation. A decision to include photographs in a report should be made after crucial consideration for their need, but only with prior approval of management.

It is important that the report of a survey reach the plant management while the situation is fresh in mind, never later than 30 days after the survey and preferably within 2 weeks.

The value of the report is enhanced if it is delivered in person by the surveyor, or this effect may be achieved by a personal call as soon as the management has read the report, in time to explain or support any findings or recommendations that may be questioned. Even though a recommendation was agreed on at the time of the survey, if it arrives at an inopportune time—or so late that it has been forgotten or interest has waned—management may assume an antagonistic attitude, necessitating another personal contact. Reports or copies of reports should never be presented to anyone other than the person requesting the survey without the knowledge and permission of that person.

The written report should be delivered personally by the chief industrial hygienist, to ensure that the findings are discussed at the appropriate management level. A report sent by mail, or delivered by someone with little experience, detracts from the importance of the survey and can also lead to misinterpretation of the recommendations.

2.3 The Combined Industrial Hygiene and Medical Survey

The combined industrial hygiene and medical survey is a comprehensive study of the environment and of the health status of the workers. Its purpose is to determine any relationship between exposure to atmospheric contaminants and the workers' health. Depending on the size of the plant and the number of different kinds of agent to which the employees may be exposed, this type of survey may require a week to several months or even longer to complete. In addition to in-depth studies of the various environmental factors, this kind of investigation includes examination of individual workers by physicians and medical technicians. It includes tests to

observe the various organs of the body and to measure their physiological functions by microscopic and chemical examination of the blood and urine as well as X-ray and vital capacity tests of the pulmonary tract. Other special examinations such as the electrocardiogram or an electroencephalogram may be required.

The interpretation and evaluation of medical information belong in the field of medicine and call for the services of physicians qualified by training to evaluate the tests just mentioned. Likewise, the environmental findings should be handled by persons technically trained in the scientific principles of industrial hygiene, preferably with long experience in this field.

Because the purpose of the combined survey is to determine any possible relation of exposure to the environmental factors and any detectable adverse effects among the workers, another important professional, namely, the statistician or epidemiologist, completes the survey team.

In years past such studies evolved from the discovery of unexplained illnesses in certain occupations, but at present they are more likely to originate from a desire to learn whether the known presence of air contaminants with ill-defined or low toxic properties may exert little known or obscure adverse effects among occupational exposed workers. Many of the maximum permissible concentrations of exposure for atmospheric contaminants, notably free-silica-bearing dusts, mercury vapor, lead dust and fume, and carbon monoxide, were derived from such classical, comprehensive industrial hygiene studies (5-9) carried out in the 1920s and 1930s by the Division of Industrial Hygiene of the U.S. Public Health Service. The standards or "safe limits" established by these studies have been modified in recent years because of new evidence based on advances in analytical techniques and more sensitive clinical test procedures.

For that reason, in all reports proposing safe working standards, the environmental and clinical methods of analysis should be explained and documented. At some later time, more accurate or sensitive analytical test methods may reveal new findings that show an accepted figure to be erroneous.

3 THE INDUSTRIAL HYGIENE UNIT OR ORGANIZATION

3.1 Recent Pattern of Growth

For a span of about 30 years, beginning in the middle 1930s, the centers of industrial hygiene activity were concentrated in the governmental units of about 25 states. The federal industrial hygiene activity was located in the Public Health Service in its Division of Industrial Hygiene, which provided leadership in research, grants in aid, and loans of personnel to the various states. The size of these industrial hygiene units in the states varied from one or two persons up to a dozen or more. At the zenith of its field investigational activity, from about 1942 to about 1955, the Industrial Hygiene Division of the Public Health Service had a staff of several hundred technical persons.

Obviously the smaller organizational units could not accomplish a great deal in

the way of technical surveys, and much of their time was devoted to educational efforts and the investigation of complaints.

During the same period there was a slow but steady growth of industrial hygiene activity in private industry, primarily among larger corporations. These units ranged from one to three or four persons and, in a few instances, as many as 10 hygienists. Most of the units were staffed by experienced industrial hygienists who had "won their spurs" in state or federal employment. Many of these companies made notable advances in researching areas of potential hazard to their employees and initiating corrective action to protect workers against adverse effects to their health. All industrial hygiene units in private industry have environmental evaluation and control as their primary objective, but their activities vary greatly depending on the views of management and the size of the establishment. Several types of industrial hygiene consulting organizations were also created during this period. The Industrial Health Foundation (formerly the Industrial Hygiene Foundation) is an organization having a general, educational, and investigational interest, whereas the industrial hygiene units of insurance companies were principally engaged in investigational surveys and individual control programs for their insurance clients.

OSHA has exerted great influence on the field of industrial hygiene and its centers of activity. At present, governmental activity in industrial hygiene is primarily centered in the organizational structure of OSHA, in the U.S. Department of Labor, and in NIOSH, in the U.S. Department of Health and Human Services. The continued existence of most state units is problematic for many reasons, including lack of financing, personnel, and legislative interest. The federal industrial hygiene activities are divided into two broad objectives: the inspection and compliance activities of OSHA and the research and investigational activities of NIOSH. Each of these organizations employs about the same number of industrial hygienists, with a total of about 150 technically trained personnel.

Unquestionably, the largest current employer of industrial hygienists is private industry, and its need for workers will continue. The number of industrial hygienists required for an individual plant or company depends on a number of factors: the number of employees, the number of different chemical agents and physical factors providing opportunity for exposure, the number of such physical or chemical agents that may require periodic evaluation during the year, and the physical dimensions of the plant.

Plants with 350 to 500 employees where there may be opportunity for exposure to three or four chemical agents or factors requiring semiannual evaluation may be able to utilize one professional industrial hygienist on a full-time basis. Larger plants may require a proportionate number of professional industrial hygiene personnel, including one experienced in the analysis of industrial hygiene air samples. Multiplant corporations may have an industrial hygiene staff of six or more professional persons providing services from a central location, or they may be located in selected company regions from which they can best serve their employers' needs.

Insurance carriers each employ at least one industrial hygienist and usually several, located in regional areas, to advise their clients on the hazards of various chemical agents and to provide minimum services. A client with 50 to 150 workers

usually finds it necessary to employ a private consultant to obtain adequate evaluation of exposures in his establishment.

A number of competent, private consulting organizations devoted to industrial hygiene and air pollution activities have been in existence for 30 or more years.

These organizations are generally staffed with professional industrial hygienists of long experience who carry out industrial hygiene evaluations and may supervise the work of younger, less experienced technical people.

Consultants in this category provide complete in-house services and are prepared to undertake a job of any magnitude. Newer organizations, equally competent in industrial hygiene, have been started in more recent times and may not be as well known in their field. Since 1970, the number of industrial hygiene consultants has mushroomed. Many are retired professional industrial hygienists who operate privately and obtain analytical services from special consulting laboratories. Among this large group of capable consultants are a few organizations with little knowledge of industrial hygiene and no professional abilities or judgment. Employers seeking to utilize the services of consultants for industrial hygiene purposes should inquire into their qualifications just as they would ask about the qualifications of a product research organization or other types of management service.

3.2 Administrative Location in Organizational Structure

The administrative location of an industrial hygiene unit in the organizational structure of an establishment can exert a marked influence on its effectiveness and accomplishments. Private firms, entirely engaged in providing consulting services in industrial hygiene, air and water pollution control, and similar environmental matters, integrate such functions into a cohesive body, to utilize all available talents.

In governmental units, industrial hygiene has attained equal status with other preventive health and safety functions that are necessary in today's society. The activity and effectiveness of such units depends on the needs of the public and the support of the legislative entity. At this writing, governmental activity in industrial hygiene is rapidly becoming centralized in the federal sphere, with laboratory and field research located in NIOSH, whereas authority for the framing of regulatory standards and enforcement activities resides in OSHA.

The industrial hygiene functions in industry show the widest variation in their location within the organizational structure and thus are reflected in their functioning.

Some units may report directly to the head of manufacturing, and may or may not be combined with safety and fire protection. Frequently such a unit serves no function beyond monitoring employee exposures for in-company compliance purposes. The industrial hygiene function may be located in the central engineering department of a large establishment, and its obvious focus of attention is on measuring the effectiveness of control systems. In large corporations, especially those with multiplant activities, industrial hygiene generally is structured within the corporate headquarters.

However, branch units may be found in individual large plants or may be located

to serve a number of smaller plants in regional areas of the corporation. Even the research departments of several large corporations have successfully accommodated the centralized industrial hygiene functions of their company. Among the corporate industrial hygiene units that have been operating for 15 years and longer, units tend to be located in the medical department of the establishment. Although there are honest differences of opinion regarding the most desirable administrative location of the industrial hygiene unit, the success of the large number of such units in medical departments appears to favor this location.

It provides flexibility in functions, helps bridge normal departmental barriers, and provides access for communicating with top management. Functionally, this location permits the unit to engage in comprehensive medical-industrial hygiene studies, environmental surveys, training of plant personnel in monitoring techniques, research in sampling and measurement of exposures, and other activities. Traditionally, the physician who is trained and experienced in occupational medicine considers industrial hygiene and occupational health and safety to be an important and equal partner in the integrated occupational health team.

4 QUALIFICATIONS AND TRAINING OF PERSONNEL

4.1 Director of Industrial Hygiene

The qualifications specified here for the administrator of an industrial hygiene unit represent opinions molded from the observations and experience of numerous persons who have served in this capacity in the field of industrial hygiene during the past 25 years. The director should have at least a master's degree from an accredited college or university and a basic education in science, preferably in physical chemistry or chemical engineering. The graduate training should include courses in physiology, toxicology, biochemistry, ventilation and air conditioning, and the practical application of statistical parameters to numbers obtained in scientific measurements.

Certification as a diplomate by the American Board of Industrial Hygiene should be a consideration for the administrator's position. A prerequisite to certification is five years of practical field experience followed by passing a comprehensive written examination.

Although these are the basic requirements, the administrator should have at least 10 additional years of broad experience in industry, including involvement with the type of manufacturing over which he will maintain environmental supervision.

In the process industries, the absence of such experience would be a serious obstacle to successful performance of the administrative function.

Directors should be able to understand and discuss all phases of industrial hygiene and toxicology and should be interested in public health and industrial relations. They should be able to set up systems for keeping records of results achieved

and for planning future activities. They should be avid readers and should devise a systematic bibliography of references covering the field of their interests and activities. Directors should be able to locate the cause of cases of industrial ill health presented by a physician, to make comprehensive analyses of health conditions in industries, to draw adequate conclusions, and to prepare clear and informative reports for publication.

Tact, good judgment, and courage of personal convictions are also important assets. The director must do sufficient fieldwork to keep the viewpoint of the worker in the field, and it is necessary to maintain a wide personal acquaintance with the men and women active in promoting industrial health.

The administrator should support and attend public meetings where current problems in the field are discussed, and should develop the ability to address a group of peers as well as the public.

4.2 Associate Industrial Hygienists

The industrial hygienists reporting to the director should have received basic education in the scientific disciplines similar to that of the administrator. A degree in chemistry or chemical engineering is desirable, and a degree in mechanical engineering provides greater knowledge in the disciplines required for designing control measures. A graduate degree that includes training in illumination, ventilation and air conditioning, energy conservation, principles of air sampling, and the toxicology of the commonly used industrial chemicals is essential. As indicated earlier, the role of the associate industrial hygienist is rapidly changing as newer and more administrative responsibilities fall upon the industrial hygiene administrator.

The position of associate has become more technical and field-oriented and thus will require more involvement with the design of sampling schemes and quantitative evaluation of the workplace environment.

If the unit is so large that one of the industrial hygienists acts in the capacity of a supervisor, this person should be certified by the American Board of Industrial Hygiene or should possess sufficient experience to command respect of the junior members.

Depending on their individual experience, the associates must be able to recognize and evaluate a potentially harmful situation, to judge the necessity for carrying out a specific study, and, of course, conduct a survey.

The knowledge required for developing a control measure varies directly with experience and the type of basic education. However, one of the most important abilities required of industrial hygienists is that of preparing a clear report of the survey findings, bearing a definitive conclusion. Because so much of their time is spent in studying plant situations, industrial hygienists must have the ability to communicate their ideas and thoughts to production personnel, safety engineers, maintenance supervisors, and plant physicians.

4.3 Other Unit Personnel

To operate effectively an industrial hygiene unit may find it desirable to add such specialists to its staff as an industrial toxicologist, an industrial hygiene analytical chemist, a ventilation engineer, a statistician, a health physicist, and perhaps survey monitors; each one will have a personal set of qualifications, and each will make special contributions to the output of the unit. Occasionally, a person may start out as a specialist and by close association broaden the scope of his or her activities and interests, to be able to claim properly the title of industrial hygienist. With today's utilization of increasingly sophisticated computer hardware and software for both record-keeping and reporting purposes, an additional resource would be a technician skilled in the use and application of computers.

Many young persons are now being graduated from recognized colleges with bachelor's degrees in environmental health, air and water conservation, ecology, and other general fields relating to the biosphere in which humans live.

On examining numerous employment applications of persons with such degrees, one finds that many of their studies have emphasized the social aspects of environmental conservation with relatively brief exposure to the basic sciences.

These young persons can be trained as technicians or scientific aides to carry out routine procedures such as exposure monitoring, sample collection, and other uncomplicated assignments.

It could be a serious error for an employer to place the responsibility of a new industrial hygiene program in the hands of an inexperienced person on the basis of a degree with an attractive sounding title. Helpful advice and assistance in seeking competent industrial hygienists can be obtained from the office of the manager of the AIHA (10).

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