Hygienic Standards for Workroom Air

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HYGIENIC STANDARDS, particularly those for contaminants in the air, are often misused and many, possibly a great majority, are based on inadequate data. However, the future of our civilization depends, among other things, on discovering before it is too late the extent to which we can safely pollute the air, water, and soil with chemical, biological, and radioactive wastes and pesticide residues.

Hygienic standards for work places, more commonly called threshold limits or maximum allowable concentrations, vary considerably from those applicable to the general public. They affect only a minority of the population; yet the segment of the population to which they do apply is far more important economically than all the others combined. Although these standards apply to less than 25 percent of the workers' time, the periods for which they are in effect are the most critical in the life of the average wage earner. Most individual standards, however, affect only a minute fraction of the total working force.

In some cases work places are used as proving grounds in that they provide data for extrapolation of workroom standards to standards for the general public, in much the same way that the workroom standards may result from the extrapolation of data obtained from animal test chambers.

Groups Concerned

The three groups of persons (workers, employers, and suppliers) who are mainly concerned with standards for contaminants of air in workrooms have diverse interests in them.

The cumulative probability curve in figure 1 shows broadly the percentage of persons in each group who will be affected by a given concentration of contaminant. A considerable range of concentration does not injure anyone. Eventually, however, a point is reached at which a small percentage of persons will be affected. As the concentration is increased, the percentage affected increases rather rapidly up to the halfway mark, and then the rate of increase falls off. Finally, a few persons will not be affected by concentrations that are quite high relative to those which elicit unfavorable responses in the most susceptible persons. The difference between the highest concentrations that will not affect any workers and the lowest concentrations that will affect all varies greatly, depending on the substance and the effect being considered. Sometimes the concentration may be as little as twofold, but often it may be tenfold or even more.

As the concentration is increased, not only are more persons affected but the severity of the effect on those who have already shown some response is also steadily intensified. It is not unknown for some persons to have severe and eventually even fatal effects at concentrations which cause no observable response in others. Examples may be found in the reports of beryllosis, benzene poisoning, and cancer of industrial origin. Obviously, unless quite trivial effects are being considered, the standards should be set along the lower end of the curve.

The first group to be affected by standards consists of the workers, and this group's pri-

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mary interest is that these standards be sufficiently low to prevent ill health. To provide a safety factor, a standard near the point "workers" (fig. 1) would be in the interest of the worker.

The second group, the employers in whose work places the standards are to be applied, prefers a higher standard than the first group, perhaps at point "employers." A primary concern of employers is that standards be uniform throughout the country, and, if possible, internationally. The employer is more willing to bear the expense of meeting low standards if his competitors are required to do likewise than if more liberal standards are in effect elsewhere. For example, the presently accepted standard for beryllium (2 micrograms per cubic meter) is so low that it adds materially to the cost of processing. (In some beryllium facilities, however, a large part of the cost of control does not result directly from the low standard.) If this standard is too low, as some authorities hold, it is of considerable comfort to the processor in Massachusetts to know that a similar standard is in effect in California and that his competitor must bear a similar expense to maintain the unnecessarily low standard.

On the other hand, if the standard for beryllium is actually too high or if a new standard were set which was too high, workers in Massachusetts who contracted berylliosis would find little solace in the knowledge that their counterparts in California were similarly afflicted.

The third group, the producers or suppliers of substances for which standards are set, is primarily interested in insuring that the standards are not too low, because a low value may make their products less acceptable in the marketplace. Suppliers prefer a standard around the point "suppliers," which protects the average worker but not those who are even mildly susceptible.

If the standard is set at the point "workers" or at the point where the curve begins or even at point "employers," exposure of a small number of workers to concentrations in excess of the standard would not necessarily be expected to result in ill effects. Only if a large number of workers are exposed to concentrations well above the standard can it be established that the value set is too low and, as indicated later, the time of exposure must also be considered. On the other hand, if the standard set is too low but universally adhered to, it will be impossible to discover that the standard is at a level lower than necessary.

The committees which make recommendations for standards consider first the health of the employee. But they are not unmindful of the interests of the employer and the supplier. They therefore attempt to set the standard at the highest level compatible with the employee's health if the standard requires expenditures by the employer for control measures. When dealing with easily controlled substances, however, many committee members are less concerned with monetary considerations, because the extra margin of safety can be provided at little or no cost to industry.

Objectives

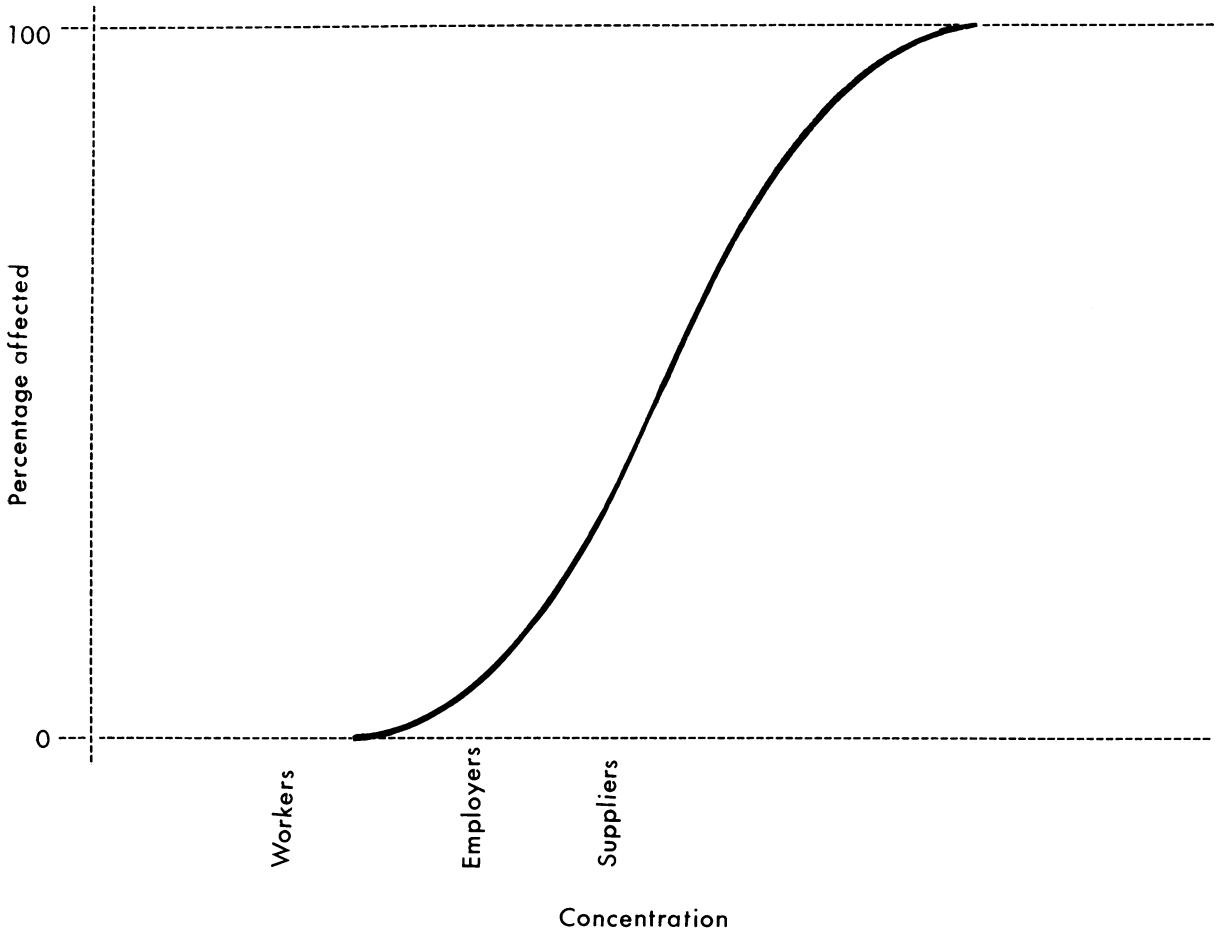
Obviously, the primary objective of standards is to protect the employee; not only from acute, fatal poisoning or a possibly fatal chronic disease, such as benzene poisoning or severe silicosis, but also to prevent a shortening of his lifespan. These standards must be set on the assumption that the worker will be exposed 40 hours a week, 52 weeks a year, and possibly for his entire working career—which can be as long as 50 years.

This may seem like a severe requirement, since few workers stay on the same job for half a century. In many instances, however, workers are employed in similar occupations or in occupations with similar exposure throughout their lifetimes. Even this requirement may not protect the man who works overtime, or the man who holds two jobs at one time, or the man who has been previously overexposed.

Information is not available, on most substances, which indicates conclusively that exposure throughout his working career at the recommended standard does not affect the lifespan of an employee. From our knowledge of toxicology and more limited experience, however, we can make a fair estimate of whether or not the objective is met, at least in a large number of cases.

The next objective is to prevent disabling disease—disease that will not only impair the ability of the employee to perform his job but

Figure 1. Percentage of persons who will be affected by a given concentration of air contaminant



also to carry out other normal functions. It is well known that a major symptom of chronic mercury poisoning is a tremor of the extremities. In the hat industry, where in the past the major incidence of mercurialism has occurred, workers with severe tremor were reported to be able to carry out their daily tasks in the factory without apparent impairment of their skill. Nevertheless, they could not write legibly nor could they readily perform other tasks requiring a steady hand, such as lacing their shoes (*1*). A standard for mercury in air which permitted this condition to develop would obviously be too liberal according to our philosophy.

A third objective relates to certain stigmas of occupation. Some chemicals produce conditions which can be characterized as stigmas without impairing the health. Examples are tellurium, which imparts an unpleasant odor to the breath, and silver, which causes a marked discoloration of the skin. These conditions are produced by absorption of the particular element in amounts so small that the normal functions or health of the person are not affected. Nevertheless, these conditions can cause great mental anguish. Consequently, the standards for these elements in the air should be set to prevent such conditions. Incidentally, I believe that the standard for tellurium (0.1 milligram per cubic meter of air) fails to meet this requirement. The newly suggested standard for silver (10 micrograms per cubic meter) probably does.

In addition, certain conditions may be considered hidden stigmas. For example, the so-called benign pneumoconiosis may result from the inhalation of iron oxide dust or fumes, the dusts of tin compounds, barium sulfate, and

other inert substances. This condition is detectable by X-ray, but the consensus is that it does not impair lung function nor does it produce other adverse effects. However, the presence of this condition may be detrimental to a worker seeking employment, because his chest X-ray indicates some form of lung abnormality.

In my opinion, regardless of whether a condition is detectable by chest X-ray, there should be a limit to the amount of foreign material a worker is required to accumulate in his lungs or in other storage areas of his body. The commonly accepted standard for inert substances is 15 milligrams per cubic meter of air. If a worker inhales 8 cubic meters of air during a workday and retains one-fifth of its dust or fumes, he accumulates 25 milligrams per day if the concentrations equal the standard for inert dust. This amounts to 1 gram in about 2 months or a total of 300 grams during a work lifetime of 50 years. To my knowledge, such a quantity of dust has never been found in a worker's lungs. The highest values reported in the literature were about 100 grams, and these were in men who died of pneumoconiosis (*2*).

The fourth objective is prevention of undue discomfort either on or off the job. A certain amount of discomfort can be accepted during working hours, just as other disagreeable features of work are accepted. But this discomfort should not be tolerated when it is caused by inhalation of fumes or dust and it persists after working hours. Irritation from some gases, such as formaldehyde, usually stops when exposure ends. A headache from carbon monoxide may persist after work is concluded. Metal fume fever ordinarily occurs during the night following exposure. The standard for zinc fumes was recently reduced from 15 to 5 milligrams per cubic meter. A number of men in the industry objected. They admitted that sensitive workers contract metal fume fever at 15 milligrams, but claimed that such workers would be affected by even 5 milligrams. The curve shown in figure 1 indicates that the new standard is at "employers" and the old at "suppliers." It seems highly unlikely, therefore, that reducing the level from 15 to 5 milligrams does not materially decrease the number of workers affected as well as lessen the severity of symptoms in those who are sensitive.

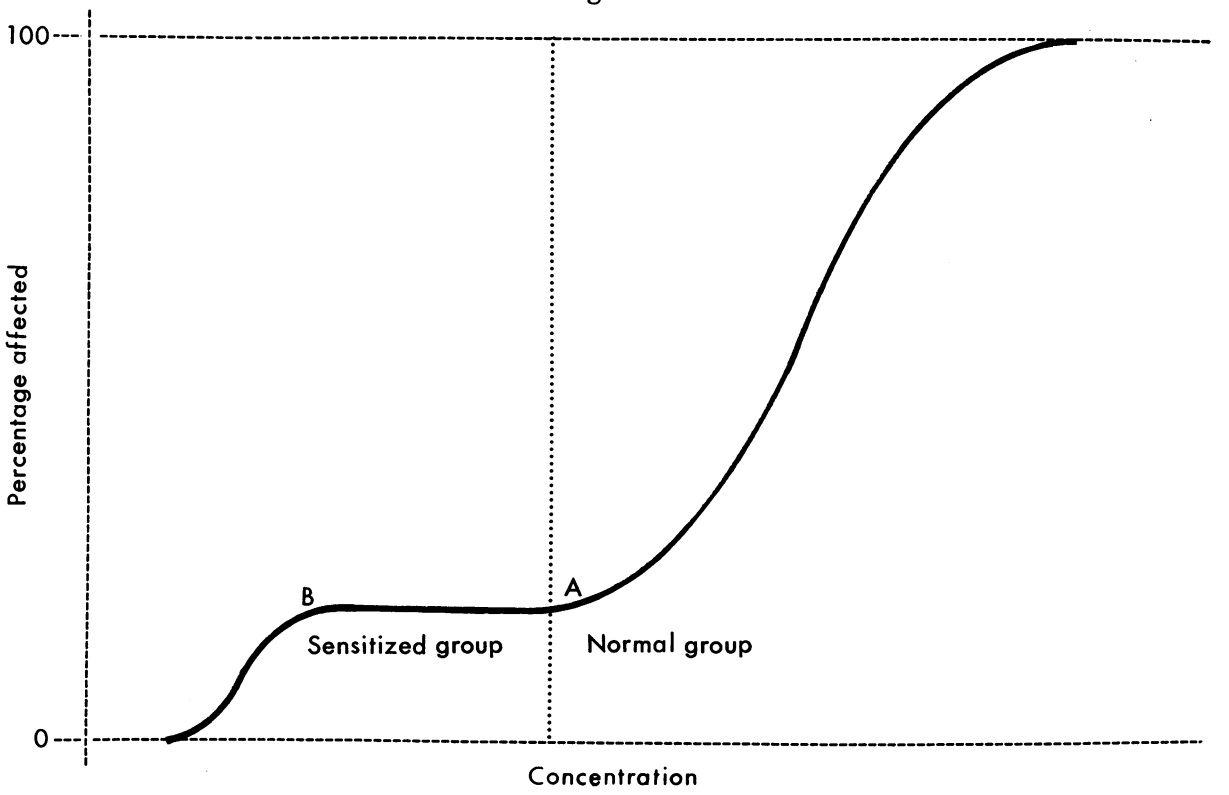
Two somewhat similar but extremely difficult problems to solve occur when there are great variations in the susceptibility of different persons. The first problem arises when a number of workers apparently become readily accustomed to an exposure. Formaldehyde is a good example, and other lachrymatory agents behave similarly. The average person experiences considerable discomfort from exposure to concentrations of formaldehyde at 1 to 3 ppm of air. Many persons rapidly become inured to such concentrations, and they can likely tolerate levels in excess of 5 ppm. As far as known, there is no substantial evidence that the process of becoming inured creates permanent injury, although conceivably this may occur. The current standard for formaldehyde is 5 ppm, a concentration definitely irritating to many persons but to which a majority can become accustomed. However, there is considerable sentiment in favor of reducing this limit.

The second problem concerns sensitized persons who become suspectible to much lower concentrations than those which affect the average person. An example is toluene diisocyanate, for which concentrations ranging from 0.01 to 0.02 ppm are needed to produce reactions in normal persons. But the concentrations required to affect sensitized persons are probably at least tenfold or more lower.

A hypothetical curve for the response to substances which may cause sensitization is shown in figure 2. The sensitized group will be affected by quite low concentrations, beginning at level B. The number affected as the concentration increases does not change appreciably, however, until point A where effects on normal persons become apparent. The question arises as to whether the standard should be set at A or B. At point A, a number of workers will be excluded from employment in the area. These workers, however, presumably have been previously overexposed. This situation is somewhat similar to that of the overexposed radiation worker who is barred from further work with radiation until his cumulative exposure is within permissible limits.

A most difficult problem occurs when there is considerable controversy as to whether or not

Figure 2. Percentage of persons who will be affected by a given concentration of air sensitizing agent



serious ill effects may result from certain substances. Two such substances are oil mist and fiber glass. Pulmonary diseases have occurred in workers exposed to these substances (unpublished records of the Massachusetts division of occupational hygiene and *3*), but the cause and effect relationship has been disputed for most of these cases. Some persons feel that because of this doubt the limits for these substances should be set at the nuisance level of 15 milligrams per cubic meter of air. It seems to me, however, that the data on such materials are far from adequate, and if there is any suspicion of serious ill effect a standard should be set below the nuisance level.

To digress briefly from occupational hazards, an innumerable number of persons have been heavily exposed to cigarette smoke for the better part of their adult lives. Also, an enormous number of persons have suffered respiratory or heart conditions, which many attribute in part to cigarette smoke. Nevertheless, whether or not cigarette smoking is really injurious is still controversial.

It would seem, therefore, that surveys of a few dozen or even hundreds of workers exposed to such contaminants as oil mist and fiber glass for a few years would not be adequate to establish definitely whether or not exposure causes significant injury.

The effects of some contaminants may be of greater importance to the employer than to the employee: levels of carbon monoxide well below the accepted standards diminish the sensitivity of the eye to light and impair the ability to think clearly and quickly (*4*). Probably, low concentrations of narcotic vapors produce somewhat similar effects. Some persons believe that such conditions are undesirable because they increase the possibility of accidents. From the employer's standpoint, it seems likely that they would affect the quality of production. If the effects were rapidly reversible so that they did not exist after the workday, a liberal standard for such an agent might be more objectionable to the employer than to the worker.

If the standard is properly established and maintained, respirators should not be needed.

I have experienced situations where industrial hygienists objected to standards which they considered too low, yet they recommended that workers in the area where the standard was not exceeded be required to wear respirators. In such cases, respirators should be necessary only for sensitized workers.

Briefly, as to the permanence of standards for impurities in workroom air, I believe that standards for units of measurement should be changed as infrequently and as little as possible. On the other hand, many of the standards for concentrations of gases and fumes have been proved wrong; in most cases, they were too high. When this occurs, there should be no hesitation about changing the standard. Also, another standard—the standard of living of the worker—is steadily being improved. Is it unreasonable to require that the air he breathes at work be of a higher degree of purity than may have been the case when he was expected to spend long hours at backbreaking labor to obtain the bare necessities of life?

Conclusions

Standards for contaminants in workroom air should be set at a level at which exposure does not reduce the lifespan of the employee, cause a disability, produce significant stigmas, result in serious pain or discomfort during the work period or mild pain or discomfort at other times, or seriously impair ability to work efficiently.

Except for instances where a worker is sensitized and responds immediately to very low concentrations, standards should be set to protect the most susceptible workers.

When enforcement of standards entails cost to the employer, the standards should not be lower than necessary to protect the worker. However, when effects of long-term exposure are doubtful, the health of the worker rather than the financial interest of the employer or supplier should be given primary consideration.

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Mid-Missouri Mental Health Center

A $691,000 grant, the first construction grant under the Community Mental Health Centers Act of 1963, was awarded recently to the Mid-Missouri Mental Health Center in Columbia, Mo., to cover 49.9 percent of the center's construction costs.

Affiliated with the University of Missouri Medical School, the Mid-Missouri center is part of a $3.2 million medical facility already under construction. The center is designed to serve 9 counties with a population of 197,072.

To be eligible for Federal assistance under the act, a center must be part of a program providing "at least the essential elements of comprehensive mental health services," which include inpatient and outpatient services, partial hospitalization, emergency services 24 hours a day, and consultation and education services to community agencies and professional personnel.