Improved communication — hygienic standards for daily inhalation*

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Experience convinces us that we humans are unique in the universe. Because of our ability to communicate, we may be well on the way toward emerging into a new level of biological existence. Each individual may eventually share completely all past and present experiences of the species. Each may act in concert with his fellows toward common ideals and goals, still retaining his own individuality. Real progress in this direction has been made during the past ten thousand years through developments of recording, duplicating and retrieval techniques. Despite brief back-sliding, there has furthermore been real spiritual progress, and an increase in the proportion of men of good will. The next ten thousand years should bring substantial achievements in communication upon higher levels, perhaps even through inarticulate contact of mind with mind. There are hints that what some have called the world mind may come into being before the present human species evolves physically into whatever new species its body is tending toward.

However, until the world mind develops, we are forced to depend upon more prosaic means of communication. Not so many generations ago, a natural philosopher like Roger Bacon, whom today we call a scientist, could live a full life investigating the secrets of nature, feeling no need and finding no opportunity to communicate his discoveries and his conclusions to a living soul. He could bury his achievements in code, making them difficult for posterity to unravel. We do not have such people and such situations today. Each one of us benefits from current division of labor, of experience, and of knowledge. Each one of us is a unique specialist, depending upon a multitude of other unique specialists for the achievement of our aims, for our very existence. If nothing else motivates us, simple self-interest should dictate that each one of us ought to make public all that he has learned, in order that his fellow specialists may use it to help us all.

Communication

A year ago Sterner[1] expressed the situation in more concrete terms. We comprise persons separately trained in highly specialized fields, led after training to cooperate in the common aim of providing means by which technological developments in occupation may be utilized in a manner compatible with complete health. He said,

> "We must provide a fluid and effective means of communication between the *chemist,* the engfneer, the physicist, the toxicologist, the physician, and the other specialists brought into industrial hygiene. There must result from this interchange *of ideas* not *only* an appreciation *of* each team member's *contribution,* but an ability actually to bridge the ***gap*** between the disciplines, to synthesize, *from* the offerings *of* each *of* the fields, the solutions to the *ever* more *complicated problems.* Each memberspeclalist *must* not only contribute *the* information he *is* most *qualified* to give, but also must *encourage sympathetic,* intelligent, and mutual understanding."

In this matter of mutual understanding, we are very much like the inhabitants *of* Looking Glass laid. You remember that the White Queen told Alice, "Now here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that." With the entry of new people into our profession and the recognition of new constituent specialties such as health physics and atmospheric pollution control, each with a tendency to keep to itself, are we running fast enough

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even to stay in the same place? We all feel there are too many conferences and too many committees to leave us time to do our daily work. On the other hand, if we are to do our work as well as it can be done, we must be in constant communication with related specialists, because each one of us fully knows only one facet of his own problems.

Communication is not a simple process. It requires an informed speaker or writer who can express himself at the level of comprehension of his audience. It requires an audience which wishes to receive communication. It must be carried on with words, those abstract symbols for reality, each of which has a different meaning to each individual, shaded by his entire past experience. Only a newly coined word is free from ambiguity, and it remains new for only a brief interval. Most important of all, successful communication requires what is today known as feed-back. By this, the speaker hears his audiences' impressions. He can correct and amptify his words until he thinks his audience truly perceives his meaning. A leisurely conversation can be effective communication through feed-back; an article in a journal is likely to be poor communication because feed-back is inadequate.

The relatively new specialty of industrial toxicology has already contributed to the equally new profession of industrial hygiene by means of communication. The toxicologists are doing an acceptable job for those people who recognize their need for toxicological information and opinion. The job could be done better, but it is at least acceptable. Success is by no means as great in helping those people who do not recognize their need for help. Once more communication cannot succeed unless the audience desires to receive communication.

Acceptable concentrations

The most important communication within industrial hygiene, and between our profession and others, may be the collection of judgments upon acceptable concentrations of contaminants in working atmospheres. During what may be called the age of chaos, every experienced industrial hygienist had a few values uniquely his own, drawn from his own experience. For less familiar substances, he borrowed more or less judiciously from the values cherished by his professional colleagues. Some degree of unanimity was brought about when the United States Public Health Service values, based on its long-time collective experience in industrial hygiene, were published in a manual.[2] Further unanimity followed publication of the values collected and extended by Cook.':" In 1947 the American Conference of Governmental Industrial Hygienists published its first list in the *Industrial Hygiene Newsletter*.[4] In the next two years revised lists were privately circulated to the members of the Association.[5,6] Then publication took place in a scientific journal,[7] and each year thereafter a revised list of threshold limit values has appeared in the scientific literature, and has been generally accepted.[8-12]

The contributions of Cook[3] in unifying opinion, and in weighing threshold limit values then in use, judging new data and proposing a list of 129 values, are worthy of high regard. Among the ***238*** values for substances other than mineral dusts in the current list[13] of established and tentative threshold limit values are 54 of those which were first proposed in Cook's list, some as definitely established, others to be used cautiously until verified by actual experience.

Not since Cook has anyone published a summary of the data which serve as bases for the selection of specific threshold limits. The privately circulated documents[14-16] which give some of these data cannot be considered to be publication, although they are freely available to any person.

Threshold limits are, and must continue to be the products of judgment, important if true. Some few truly represent their definition and are approximations of the maximum concentrations which can be inhaled continuously and repeatedly without injury to health. These may possibily be fit parameters for incorporation into codes and regulations. Many of the threshold limits are well below concentrations which can injure health. They represent current judgment as to concentrations to which, good practice dictates, men may be expected to subject themselves. These do not seem fit parameters for regulations. In a particular operation, if possible, it is desirable to maintain concentrations below the bench-mark by reasonable ventilation and precaution. It is always best to reduce exposure to chemicals to the lowest practical level.

Previous suggestions for improvement

During the Ninth Annual Congress on Industrial Health, the writer was chairman of the Committee on Chemical Agents. The report of the 16-man committee[17] devoted considerable attention to praising the development of threshold limits, and to suggesting ways in which their presentation could be made more useful. Since that report, two developments have taken place along lines desired by the Committee. The annual table of the Threshold Limits Committee of the American Conference of Governmental Industrial Hygienists is now published in the Archives of Industrial Health, removing the earlier implication of quasi-legal status arising from its appearance in the Industrial Hygiene *Newsletter* of the Division of Industrial Hygiene, U.S. Public Health Service. In 1954, the Committee on Threshold Limits of that Association began to supplement its table of accepted values with a list of tentative values.

Three other suggestions of the Committee on Chemical Agents deserve reiteration and discussion. It was urged that the bases for the selection of each value should be published, that the name should be changed to hygienic standard, and that the particular concept of permissible human response behind each value should be clearly indicated.

There is such a multitude of factors involved in the protection of health in our complex civilization that no one person or group of persons is competent to weigh them all with assurance. No oracular or ex cathedra statement on health deserves serious attention. Only when the facts upon which a decision are based are furnished for general scrutiny and evaluation can the decision be considered even tentatively sound, and only after there has been adequate opportunity for criticism and modification can it be considered established. All toxicological facts should be published, and all decisions upon the facts should be accompanied by a summary of the reasoning under which they were derived, before anyone should be expected to act upon the decisions. Any publication of standards for maintenance of health ought to include reference to the underlying data.

The second suggestion referred to the name by which the values are **known.** Semantics is more than a sport for the idle. No matter how thoroughly a concept is originally presented, it always becomes known and referred to by a brief name, a catch-word. Most persons who learn of the concept hear the catch-word name, and do not go back to the original presentation. The meaning they attach to the name comes from their previous experience with the particular words. It may be, but is usually not, exactly what the originator of the idea intended. The more carefully one chooses the name he assigns to a concept, the more likely are others to interpret the concept as he himself does.

The values now known as threshold limits are usually identified by phrases containing the words allowable or *permissible.* These two words have connotations of legal regulations. Such connotations cannot properly attach to the judgment of a voluntary professional association. The identifying phrases may also contain the words *maximum*, threshold and limit. These words all imply that below the concentration specified, human response is negligible, above the concentration it is dangerous. Actually, it is more than an implication. It is definitely stated. In the introduction to its 1956 list the Committee on Threshold Limits says, "Values are *given* . . . for the maximum average atmospheric concentrations *of* contaminants to *which* workers may be exposed for an eight-hour working day without *injury* to *health.*"[13] Careful study of the data which support the currently accepted values suggests that no such description can be truthfully attached to most of them. Industrial hygienists recognize this. They are accustomed to empnasize that the values should be regarded simply as bench-marks, guides to good practice. Indeed, the Threshold Limits Committee itself confusingly warns "Threshold *limits* . . . should not be regarded as fine lines between *safe* and dangerous *concentrations.*"[13]

The term maximum acceptable concentration being used in revisions of standards by the American Standards Association 2-37 Committee is objectionable only because it will be abbreviated M.A.C. Many will interpret this abbreviation as *maximum* allowable concentration, and nothing will have been gained by the change from allowable to acceptable.

I conclude that the names *maximum allowable concentration* and *threshold limit* are misleading. They convey a wrong impression to those who are not already familiar with the concepts behind the values. The name suggested in 1949, *hygienic*

standard, is not misleading. Standards of good practice are familiar to all of us in many fields. Looking toward the future provision of a variety of hygienic standards, a series of values should be selected, to be known as hygienic ***standards*** for daily inhalation.

The third suggestion is more far-reaching. The Committee on Chemical Agents pointed out that there has been no simple or uniform relation between the effects of a substance and the numerical value chosen for tabulation.[17] The Committee concluded that concentrations have been selected on the basis of one of four concepts of the level best suited to hygienic control of inhalation, the choice having been governed by the nature of the toxic response and by the degree of organoleptic response. The Committee's four concepts follow

a. *Plus or minus:* The maximal time-weighted average concentration which produces only minor injury, and that in a very small proportion of exposed workmen.

b. Safe: The maximal time-weighted average concentration which sound evidence leads one to believe will cause no demonstrable illness or other symptom of toxic effect in any workman during a lifetime of industrial exposure.

c. Bench-mark: A concentration based on the belief that any unnecessary exposure is undesirable — a concentration lower than that of a or b, one as low as is consistent with practical engineering control.

d. Comfort: A concentration lower than a or *b,* representing the maximum which in a short time is not objectionable to 9 out of 10 of a group of persons not accustomed to inhalation of the substance.

Note well that these four concepts were judged to be those already used for the selection of hygienic standards for daily inhalation. All four were judged consistent with the goals of industrial hygiene.

Hygienic standards for daily inhalation

The subject of hygienic standards for daily inhalation should be re-examined, the concepts represented by the values should be restated in more realistic toxicological terms, and more consistent and more informative standards should be prepared. Such a step will not undo any of the accomplishments of the profession of industrial hygiene or of any organization. Rather, it will supply informative standards to supplement the accumulation of naked numbers now accepted, some of which have not been critically re-examined for a decade.

It is certainly imperative that the inhalation of substances during the working'day shall not be allowed to result in any injury to the physical well-being of workmen. It is furthermore imperative that inhalation shall not increase the probability of accidents through the mental distress occasioned by objectionable eye, nose or throat irritation, transient though it may often be, nor through the impaired judgment and delayed reaction time of light narcosis. It is desirable that inhalation shall result in no degree of discomfort whatsoever. On the other hand, when it is impractical to avoid all discomfort, then such inhalation is certainly justified, provided there results no injury to workmen and no increase in the probability of accidents.

Tables of hygienic standards do not now carry indications of the nature and of the magnitude of the effects to be expected from inhalation of greater concentrations. It is only by a rather thorough study of the available data that one can decide whether or not a particular substance can safely be inhaled at a greater concentration. With most substances, it is quite practical to set **two** standards, one an inoffensive level, another a concentration which cannot safely be exceeded under any pressure of practicality.

Administrative expediency may be served by a table of numbers which constitute a part of official regulations. Regulations need not be defended, they need not cite justifications. However, it is a minority of the profession of industrial hygiene who have regulatory responsibilities. Most **of** our colleagues act through obtaining voluntary cooperation with their judgments. They would be aided by a greater degree of explanation in a tabulation of standards. They could then show that their recommendations are quite defensible, that they are not arbitrary decisions having no regard for the realities of competitive industrial existence.

A hygienic standard for daily inhalation should specify **two** concentrations, together with a description of the human response to be expected from

inhalation of each. One concentration should be low enough so that no injurious effect can be expected in any workman, but it may cause a detectable odor, it may cause a detectable eye, nose or throat irritation. The second concentration should produce somewhat more severe, but still reversible and non-progressive effects. From these two concentrations, one can at once see how strictly the standard should be observed, the steepness of the dosage-response curve, the breadth of the plateau of non-injurious concentrations. Despite the wide range in individual susceptibilities of workmen, such values can be selected for most, if not all, substances.

Adequate data for preparing this sort of standard consist of appropriate human experience, or repeated medical examinations of workmen in atmospheres whose concentration has been frequently estimated. Sterner'" discussed this point in detail. Experiments upon animals, verified by biochemical and physiological studies in humans, may demonstrate conclusively that a substance has an effect during one period of inhalation which does not progress during off-repeated inhalation. For such a substance, satisfactory data can be obtained from objective study and secretly recorded subjective effects of a group of humans inhaling known concentrations for substantially eight hours. Any lesser body of data should result in a hygienic standard being designated a s tentative.

Categories of objectionable action

Judgments should be made to determine which hygienic standards for daily inhalation must be carefully observed, and which may be exceeded when it is impractical to observe them. These judgments will be most consistent if we first decide for each substance what objectionable action we are guarding against by the standard. Every toxicologist will realize that the action at a low concentration which it is most important to guard against, may not be the same as the menace to life to be expected at a high concentration. In a tentative fashion, the writer has made these decisions for the 238 substances, exclusive of the mineral dusts, included in the 1956 tables of proposed accepted and tentative standards."" The decisions can be divided into the following nine categories on the basis on the nature of human response.

Chronic toxicity

The most dangerous effect of some substances is a progressive systemic injury, increasing in severity with continuing inhalation. Benzene, carbon disulfide, carbon tetrachloride and lead are the most familiar examples. The lower standard for these substances should be a concentration believed not to produce any effect in any workman, and no considerations of practicality are sufficient to justify inhalation in excess of the standard. Close medical supervision is required for safe use of these toxic substances. The standard for chronically toxic substances should refer to the time-weighted average concentration throughout a working day. Brief peaks of a few times the standard have no significance, save as they increase the average.

Acute toxicity

Some substances do not produce an injury progressing with repeated inhalation. Such systemic injury as they may cause takes place as the result of one excessive inhalation, or not at all. Familiar examples are carbon monoxide and hygrogen cyanide. The standards for acutely toxic substances should be interpreted in the same light as those for chronically toxic substances.

Narcosis

The most dangerous effect of some substances is narcosis, which becomes anesthesia in its extreme state. At a rather low concentration they induce accidents by impairing judgment and delaying reaction time. Familiar examples are ethyl alcohol, ethyl ether and gasoline. The lower standard for a narcotic substance should be a concentration which produces no detectable effect upon judgment and reaction time after eight hours inhalation. It should refer to the average concentration existing during some appreciable period of time, the length of which can be estimated from absorption and elimination data. No considerations of practicality can justify exceeding the standard for a narcotic substance.

Irritation

The most dangerous effect of some substances is irritation. Eye, nose and throat are irritated at a low concentration, the bronchi at a higher concentration, and fatal lung edema may be the result of inhaling an extreme concentration. The aldehydes,

halogens and acids are familiar examples. Highly odorous substances may also be considered in this catagory. The lower standard for an irritant substance should be a concentration which is detectable, but is not objectionably irritating to the majority of unhardened subjects who are exposed for a substantial part of a working day. The higher standard should be set at a concentration which is well under one injuring bronchi or lungs, and which is justifiable when it is impractical to keep concentrations at the lower standard. Standards for irritating substances should refer to concentrations existing for even a brief period during a work day.

Asphyxiation

Some substances are inert in the body and can injure only by asphyxia at extremely high concentrations, excluding the oxygen of the atmosphere. Familiar examples are the fluorochloro refrigerants. The lowcr standard for these asphyxiants should be a nominal bench-mark of good engineering practice, such as the 1000 ppm concentration now quoted. The inert nuisance dusts like iron oxide might well be placed in this same catagory, and the currently used bench-mark of 15 mg./cu.m. seems an appropriate level. The standard should refer to the concentration existing during any brief period, but it should be recognized that higher concentrations are justified when it is impractical to keep below the standard.

Fume fever

The most important effect of some substances is a transient influenza-like condition known as fume fever. A familiar example is zinc oxide fume. The lower standard for a fume fever producer should be a concentration which will not produce that distressing but not menacing condition in any workman, and it should apply to an appreciable period, such as half an hour. No considerations of practicality can justify exceeding the standard for fume fever producing substances.

Eye pigmentation

The most important effect of two substances, quinone and hydroquinone, appears to be a slowly developing pigmentation of the sclera, which may reduce visual acuity, or even lead to blindness. The lower standard for these substances should be a concentration which produces no pigmentation after years of exposure, and it should refer to the time-weighted average concentration throughout the day. For a few days at a time, conditions of practicality should justify exceeding the standard.

Cancer

One substance is reasonably well established as a cause of respiratory tract cancer. This is nickel carbonyl. It appears probable that the minimum cancerigenic exposure will never be defined. At this time it is prudent to set the standard for a cancerigenic substance substantially at zero, as has already been done for nickel carbonyl, and no considerations can justify allowing the inhalation of any concentration which is avoidable.

Allergy

Some substances are known to sensitize an appreciable proportion of exposed workmen. They may produce distressing and menacing asthma-like attacks when a sensitized person inhales a low concentration. Examples are ethylene diamine and the diisocyanates. At this time there is no rational experimental basis for defining a concentration which will not sensitize a susceptible workman, or one to which no previously sensitized workman will respond. Control of exposure to allergenic substances must rely heavily upon industrial medicine. After experience has allowed withdrawal of workmen susceptible to sensitization, the remaining resistant individuals can be protected by a hygienic standard for daily inhalation based upon irritation or systemic injury. Until it has been demonstrated that a particular group includes no susceptible workmen, no considerations can justify allowing inhalation of any concentration which is avoidable.

(Editor's note **The table which lists the 238 values as well as the discussion that followed this portion of Dr. Smyth's paper is not reproduced in this publication due to space** limitations. The **interested reader may find the table along** with the **discussions and references cited on pp.** 136-185 of the *Am. Ind. Hyg. Assoc.* **Q.,** Vol. **17. The 1956 recommended threshold** limit **values appear in this volurnc. The** *Documentation of the Threshold Limit Values,* **4th ed.. provides more up to date information regarding the predicted effects of a given substance. This publication** is available **from** ACGIH, **Publications Office, 6500** Glenway Ave., **Bldg. D-5, Cincinnati, OH 45211.)**

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