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Various Methods Of Controlling In-Plant Inhalable Contaminants

After identifying contaminants and determining exposure severity, article tells how to control contaminants within the plant

by William E. McCormick
Mgr., Dept. of Industrial Hygiene and Toxicology
B. F. Goodrich Company

PROVIDING A HEALTHFUL working environment for employees has long been an accepted fact of American industry. It is also accepted that the responsibility for providing this is that of management. As a result of this recognition, industrial hygiene personnel have become necessary adjuncts to most corporate management staffs, and it becomes the primary function of these personnel to provide the many skills needed in the control of in-plant contaminants.

Because of the extent of the problem of "in-plant contaminants" some restriction of the subject is necessary. Consequently, this article shall be confined to *inhalable* contaminants only; i.e., gases, vapors, dusts, fumes, mists.

Is the Contaminant Hazardous?

In our attempts to define and elucidate the problem of in-plant contaminate control, we need to be particularly aware of this basic philosophy: atmospheric contaminants are ever present and whether control is needed must be determined on an individual problem basis.

For in-plant operation, the question must always be answered on the basis of degree of exposure—is there "too much?" Is there a hazard to health or well-being? In order to answer these questions, four things must first be done:

1. The contaminant must be identified. The identity of the atmospheric contaminant may appear to present little or no problem. After all, we should know what is being used and, therefore, immediate identity can be made. Actually, this first phase of our four-part effort is often the most difficult. Identity is relatively simple if a single compound, with no resulting chemical reactions, is the contaminant. However, with multiple compounds, some or all of which may react—or with compounds producing decomposition products—the problem becomes extensive and perhaps insurmountable. Years of time and millions of dollars have been expended in attempts to accurately identify the contaminant(s) in smog, notably that occurring in Los Angeles, but without complete success. Many examples of in-plant problems of similar complexity can be cited, requiring the best analytical skills and tools for their solution.

2. Some knowledge about the physiological effect(s) of the contaminant must exist. To be most meaningful, this should be data gained from wide experience with humans. Often this is unlikely or impossible, particularly with materials of new or recent origin. Therefore, certain compromises have to be made. Reliable data, derived from animal experimentation, and properly interpreted, can be very useful in providing sound bases for judgment on the expected effects on humans. This is the function of the industrial toxicologist. With the knowledge so developed, materials can be put into industrial use and reasonably reliable controls established. In general, these uses occur only after adequate factors of safety have been "built into" the controls and after careful regimens of medical observance of exposed personnel have resulted.

3. The severity of the exposure must be quantitated. Whether a contaminant is a hazard to health or well-being can only be determined after adequate evaluations of the working environment have been made to provide a sound basis for judgment. These evaluations may be relatively simple or quite complex, depending upon the material(s) involved and the manner of use. They may require only the simple use of direct reading instruments in the hands of a skilled technician, or they may tax the ingenuity of several scientific disciplines, possessing highly refined techniques. In any event, they must be so designed as to represent actual conditions of exposure on both a *severity* and a *time* basis.

Many commercial devices are now available to assist the industrial hygienist in these efforts. Let no one assume, however, that these devices can be used indiscriminately, or by untrained personnel. Many of them *are* simple to use, but adequate training on the part of the evaluator must exist in order that time exposure

conditions are simulated, as well as the realization of the device's limitations.

4. The results of the quantitation must be interpreted. Reference has been made earlier to one of the basic tenets of industrial hygiene: the decision regarding the existence of a hazard, rests not on the basis of the presence or absence of a contaminant, but, rather, on the quantity and time of exposure to it.

The presence of some atmospheric contamination is a practical necessity, not only of all industrial operations, but of all everyday living. It becomes simply a matter of deciding whether the exposure to which a human is subjected is "too much" without affecting his health or well-being.

Fortunately, relatively good guidelines have been developed through research and experience whereby this judgment can be made for a large number of materials. These guidelines are referred to under various names: maximum allowable (or sometimes acceptable) concentrations, hygienic standards, threshold limit values. These terms may or may not be synonymous. The values most widely in use today are those published annually by the American Conference of Governmental Industrial Hygienists and are suggested maxima for eight-hour, five-day week exposure on a time-weighted basis. Some of the more common values are shown in Tables I and II.

It should be appreciated that these values are suggested guides and are not intended as hard and fast boundaries between "hazard" and "no hazard." Sound professional judgment is needed in their interpretation. Unfortunately, many previous TLV's of the ACGIH have been transferred into governmental codes and have become "legal" values.

The use of a single value as a guideline leaves much to be desired. For this reason, the American Standards Association has recently reactivated its Z 37 Sectional Committee to develop standards of safe atmospheric exposure. These will be multiple values and will fill a long-felt need. Regardless, however, of the value used, or its source, the proper interpretation of it and the assessment of the severity of hazard requires professional industrial hygiene knowledge.

How Can the Contaminant Be Controlled?

Four basic methods exist for the control of atmospheric contaminants. It is not unusual to use two or more in combination.

1. *Replacement or substitution:* frequently, a less hazardous material may be used. For instance, the insiduous health hazards of benzene and carbon tetrachloride are well known. Because of this, their use as industrial-type solvents has been supplanted to a large degree by less hazardous ones—particularly, by toluene and methyl chloroform, respectively. Obviously, the degree to which this method of control can be used is determined by chemical and physical requirements, fire hazards, costs, etc. and although it is one of the less widely applicable control methods, it should always be considered.

2. *Enclosure or isolation:* this method of control is widely used, especially in the chemical and petroleum industries. An example of it is reactors used in the manufacture of SBR polymer. The method has wide application and enables industrial handling of a great number of hazardous materials.

3. *Ventilation:* perhaps the most widely practiced method of control is the use of ventilation. This may be of two basic types: *general* (provided by natural or mechanical means) and *process* (in nearly all cases requiring the use of mechanical air-moving equipment).

The literature is extensive on the design techniques of process ventilation, both in a general way and for specific industrial operation. In spite of this, it is often poorly designed and fails to accomplish the required control, or if it does, at greater cost than it should. From the standpoint of costs, it is poor business to overdesign. All air exhausted must, of course, be replaced, and heat losses, especially in northern climates, become significant. As an example, approximately 450 Btu are lost for each 1000 cu. ft. of air, with removal at 70°F and makeup at 40°F, 50% rh. If we assume a heating cost of 60 cents per million Btu, the exhausting of each 1000 cfm over a 24-hour period will cost 40 cents. Correct design becomes, therefore, doubly important: for adequate control and lowest cost.

General ventilating, whether it be produced by natural draft through room openings or from mechanically driven fans, has limited use for industrial hazards. It can only be used with contaminants of low hazard and where good air mixing of the working area can be attained. Considerably more air must be removed than with local process ventilation, although the initial cost of the equipment for general ventilation is usually considerably less. An approximation of the amount of general ventilation required for a volatile solvent can be calculated from the equation:

$$V = \frac{6.45\ W}{MC} \times 10^6$$

Where V = volume in cfm
W = weight, in pounds per hour, of solvent lost by evaporation
M = molecular weight of solvent
C = TLV of solvent in ppm

4. *Personal protective equipment:* there is available today a wide variety of well-designed equipment, to be worn by the individual, for protection against hazards to or via the respiratory organs. These devices are an important

ABOUT THE AUTHOR

William E. McCormick received his B.S. and M.S. degrees in physical chemistry from Pennsylvania State University. Prior to establishing the Dept. of Industrial Hygiene and Toxicology at The B. F. Goodrich Co. in 1946, Mr. McCormick served as an industrial hygienist for the U. S. Public Health Service and the Georgia State Health Dept. Earlier, he was engaged in development and research activities pertaining to respiratory protective devices for Willson Products Co., Inc.

Table I—TLV—Dusts

Toxic		Mineral	
Substance	Mg/M³*	Substance	m.p.p.c.f.**
Antimony (as Sb)	0.5		250
Beryllium	0.002	Silica, crystalline quartz	
Cadmium oxide fume	0.1		$\%SiO_2+5$
Chromic acid and chromates (as CrO_3)	0.1	Silica, amorphous,	
Lead	0.2	including diatomaceous earth	20
Lead Arsenate	0.15	Asbestos	5
Magnesium oxide fume	15.	Mica	20
Mercury	0.1	Soapstone	20
Nicotine	0.5	Talc	20
Titanium dioxide	15.		

*Milligrams per cubic meter of air. **Million particles per cubic foot of air.

means of contaminant control. Their principal disadvantage lies in discomfort through prolonged use. They find their greatest asset in providing protection against a wide number of materials during emergency-type, or short-term exposure. Of course, there are a few special situations where, because of the high degree of hazard, *practical* control of a contaminant can only be achieved through the combined use of respiratory protective devices and either ventilation or enclosure, and in these circumstances their continuous wearing is necessary.

To be assured that the quality of the respiratory protective device is satisfactory, only those bearing the seal of approval of the U.S. Bureau of Mines should be used. It is, of course, elemental that the correct type of device for the specific hazard be selected, that it be fitted properly, and that it be satisfactorily maintained.

Need for Professional Know-How

The control of industrial air contaminants is a complex procedure, requiring the skills of many disciplines. It is paramount that personnel, properly trained in these disciplines, make the judgments required, which become in a very real sense, judgments dealing with the lives of humans.

Industrial hygiene holds that any material can be used in industry—the only problem is to devise the necessary controls for its safe use. ▲▲

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Table II—TLV—Vapors

	Substance	ppm*		Substance	ppm*
	Acetone	1000		Isophorone	25
	Acrylonitrile	20		Methyl acrylate	10
	Ammonia	50		Methyl alcohol	200
	Aniline	5		Methyl chloroform	
C	Benzene	25		(1, 1, 1, trichloroethane)	350
	Butadiene	1000		Methylene chloride	500
	2-Butanone (methyl ethyl kitone)	200		Naphtha (petroleum)	500
	Carbon disulfide	20		Nitrobenzene	1
	Carbon monoxide	100	C	Nitrogen dioxide	5
	Carbon tetrachloride	10		Ozone	0.1
	Chlorine	1		Perchloroethylene	100
	1, 2 Dichloroethane			Phenol	5
	(ethylene dichloride)	50		Prophyl alcohol (iso-)	400
	Ethyl acetate	400		Propylene dichloride	
	Ethyl alcohol	1000		(1, 2 dichloropropane)	75
	Ethyl bromide	200		Stoddard solvent	500
	Fluorine	0.1		Sulfur dioxide	5
C	Formaldehyde	5		Tetrahydrofuran	200
	Gasoline	500		Tolune	200
	Heptane (n-)	500		Trichloroethylene	100
	Hexane (n-)	500		Turpentine	100
	Hydrogen bromide	3	C	Vinyl chloride	500
	Hydrogen chloride	5		Xylene	200
C	Iodine	0.1			

*Parts of substance per million parts of air. Note: "C" indicates ceiling rather than time-weighted values.