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Lowering threshold limit values (TLVs) has additional benefits*

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Abstract

A brief accounting is given of early attempts to develop limits on the levels of volatile industrial substances to which workers could be exposed. The progression of events leading to the formation of the American Conference of Governmental Industrial Hygienists (ACGIH) and its Airborne Contaminants Committee, later to be the Threshold Limit Value (TLV) Committee, is explained. Currently, the TLV Chemical Substances Committee has four subcommittees which review the data for different types of industrial substances. As the TLVs are lowered to prevent evidence of toxicity in exposed workers, the possibilities for fire/explosion due to reaching flammable limits are also decreased.

1. Introduction

The term threshold limit value or TLV generally refers to a level in air of an industrial solvent or intermediate that can be present in the workplace air without causing adverse effects to the worker over the usual work week. Although this term is usually associated with the ACGIH, one of the earliest efforts along these lines was made by Rudolf Kobert in 1912, a time when horseless carriages were beginning to appear. In one of his many books on toxicology, Kobert published a list entitled "The Smallest Amounts of Noxious Industrial Gases Which Are Toxic and the Amounts Which May Perhaps be Endured". Twenty compounds were mentioned; for many the values were not much different from values accepted 30 to 40 years later (Table 1) [1, 2].

As industrial use and production of chemicals increased in the period of 1920–1940, the development of industrial hygiene followed. Accordingly, the number of people engaged in this activity more than doubled [3]. The need for developing standards for safe exposures became apparent; thus in 1939 and 1940 lists of levels for chemical exposures were prepared as a concensus

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TABLE 1

Comparison of Kobert, MAC and current TLV values

Substance	Kobert value (% or mg)	1942 MAC value (ppm)	1991–1992 value (ppm)
Inorganic			
Ammonia	0.1	100	25
Carbon dioxide	20–30	—	5000
Carbon monoxide	0.2	100	50
Chlorine/bromine	0.001	1	0.5/0.1
Hydrogen chloride	0.01	10	5
Hydrogen cyanide	0.02–0.04	20	10
Hydrogen sulfide	0.1–0.15	20	10
Iodine	0.0005–0.001	—	0.1
Phosphine	—	2	0.3
Phosphorous trichloride	0.004 mg	—	0.2
Sulfuric acid	0.02–0.03	5 mg/m^3	1 mg/m^3
Organic			
Aniline/toluidine	0.1–0.25 mg	5	2/2
Benzene	about 5 mg	100	10
Carbon disulfide	1–1.2 mg	15	10
Carbon tetrachloride	about 10 mg	100	5
Chloroform	about 10 mg	—	10
Gasoline	5–10 mg	1000	300
Nitrobenzene	0.2–0.4 mg	5	1

opinion by the American Standards Association and a number of industrial hygienists [4]. However, the situation was somewhat uncertain for maximum allowable concentrations differed from state to state. As an example, California, Colorado, Connecticut, Pennsylvania, and South Carolina allowed 100 ppm of benzene, Kansas had a standard of 75–100 ppm, but Kentucky, Maryland, Massachusetts, Michigan, Ohio, Oklahoma, and Wisconsin considered 75 ppm to be the maximum. For manganese there was a ten-fold difference in the limits between certain states, namely from 5 mg/m^3 in Kentucky to 50 mg/m^3 in California and Colorado [5]. Clearly, there was a need for more uniform standards [6].

2. Threshold limit values

The United States Public Health Service began to sponsor summer seminars in 1936 and 1937 to provide additional training for industrial hygienists from different State health departments. By 1938, the ACGIH was organized to continue these training courses and to provide more uniformity in practices between the States. Within three years ACGIH had a subcommittee on technical standards and a second on threshold limits. By 1944 this second subcommittee had become independent and it was now the Airborne Contaminants Committee [7]. After World War II, the TLV Committee was reactivated and published lists of allowable concentrations for various substances. In 1961 the ACGIH began to publish the TLV list in a separate booklet, in a size and form which could easily be carried in a shirt pocket.

The form of these booklets is still the same, and well over 100,000 copies are sold each year. Besides TLVs for approximately 700 chemicals, the booklets also contain other information on TLVs for mixtures, biological exposure indices, and TLVs for physical agents in the work environment. Included in this latter category are: sonic and ultrasonic radiation, cold and heat stress, ionizing radiation, lasers, light and near-infrared radiation, radiofrequency/microwave and ultraviolet radiation, noise, vibration, magnetic and static electric fields [8].

2.1. Decision making

The Chemical Substances TLV Committee sets values after study of all available toxicological and epidemiological data on the compounds under discussion. Effects on specific organ systems, functional changes, biochemical studies, teratogenesis, carcinogenesis, mutagenesis, neurotoxicity, and various other toxicological responses are all considered. Of special importance are data from human exposure experiences; reports of adverse effects may lead to revision of the TLVs. Moreover, the judgement of committee members is an essential part of the process [9, 10].

The TLV Committee itself has on the order of 15–20 members who have expertise in industrial hygiene, toxicology, medicine, chemistry, and epidemiology. Several industrial consultants attend the meetings of the Committee and participate fully in the work of the group. Their advice and expertise are valued highly, but under ACGIH rules they are not allowed to vote on TLV decisions.

Currently, the TLV Committee is composed of four subcommittees, namely Carcinogens, Dusts and Inorganics, HOC (Hydrogen, Oxygen, Carbon), and MISCO (Compounds containing other elements besides Hydrogen, Oxygen and Carbon). The Carcinogen subcommittee is reclassifying the compounds in the TLV booklet according to the following scheme:

A1 – known human carcinogen
A2 – suspected human carcinogen
A3 – animal carcinogen
A4 – not classifiable
A5 – not suspected as a human carcinogen

When it is considered that a change is needed in the TLV value for any compound, the substance is placed on the NIC (Notice of Intended Changes) list. These notices on the compounds and the intended changes are published in the ACGIH journal, *Applied Occupational and Environmental Hygiene*. Interested parties thus have an opportunity to present any data bearing on the compound of interest to the Committee.

2.2. Industrial substances

Besides toxicity, the possibility of the flammability of the material must be considered for many industrial substances [11, 12]. Table 2 gives the lower and upper explosive limits of some commonly used solvents and gases. Although the TLV Committee does not consider flammability in setting TLVs, such values are included in the documentation for a particular compound. Moreover, the trends toward lowering TLV values also decrease the possibilities for fire or explosion. Table 3 provides an overview of how TLVs for some flammable materials have been lowered over the years or are on the NIC list. These include: benzene, from 10 ppm (32 mg/m^3) to 0.1 ppm to avoid the risk of leukemia; dimethylamine, from 10 ppm (18 mg/m^3) to 5 ppm to avoid toxicity and irritation; formaldehyde, from 1 ppm (1.2 mg/m^3) to 0.3 ppm to reduce the possibility of irritation; hydrazine, from 0.1 ppm (0.13 mg/m^3) to 0.01 ppm because of general toxicity; methylhydrazine, from 0.2 ppm (0.38 mg/m^3) to

TABLE 2

Limits of flammability in air of some volatile substances[a]

Compound	Explosive limits (% v/v)	
	Lower	Upper
Acetone	2.6	12.8
Acetylene	2.5	82
Ammonia	16	25
Benzene	1.4	8.0
Butane	1.9	8.5
Carbon disulfide	1.3	50
Carbon monoxide	12.5	74.2
Dimethylamine	2.8	14.4
Ethane	3.0	12.5
Ethanol	3.3	19.0
Ethylene oxide	3.0	100
Formaldehyde	7	73
Gasoline	1.3	6.0
Hydrazine	4.7	100
Hydrogen	4.1	75
Hydrogen sulfide	4	46
Methane	5.3	15
Methylhydrazine	2.5	97 ± 2
Nitromethane	7.3	—
Pentane	1.5	7.8
Propane	2.3	9.5
Toluene	1.3	7
Trichloroethylene	8	10.5 (25°C)
	7.8	52 (100°C)

[a] Data from *Dangerous Properties of Industrial Materials*, N.I. Sax and R.J. Lewis, Sr. (Eds.), 7th Edn., 1989 [12].

TABLE 3

Decreases in TLV values (ppm)

Substance	Year											
	1946	1947	1948	1956	1957	1966	1971	1973	1980	1981	1985	1992 (NIC)
Benzene	100	50	35		25			10				0.1
Dimethylamine						10						5
Formaldehyde	10		5							2	1	0.3
Hydrazine				1					0.1			0.01
Methylhydrazine							0.2					0.01
Nitromethane	200	100										20
Toluene	200							100				50

0.01 ppm, also because of general toxicity; nitromethane, from 100 ppm (250 mg/m^3) to 20 ppm on the basis of general toxicity; and toluene, from 100 ppm (377 mg/m^3) to 50 ppm to avoid general toxicity [13].

Although the flammable limits for these compounds are above the TLV values, there seems to have been little effort on determining the flammability of mixtures of some of these substances. In essence, this may be an unknown quantity. Thus, overall, the trend to lower TLVs will have several benefits in that exposure to toxic materials will be less, and the possibility of fire or explosion due to compounds and/or mixtures of compounds will be decreased.

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