Rachel's Environment & Health News

#415 - The Scientific Basis Of Chemical Safety -- Part I: Limits On Workplace Chemical Exposures

November 08, 1994

In 1990, the American Public Health Association (APHA) estimated that each year 50,000 to 70,000 Americans die of diseases developed from toxic exposures on the job. Furthermore, APHA estimated that 350,000 new cases of occupational disease develop each year from toxic exposures.[1]

The federal government established standards for chemicals in workplace air for the first time in 1971, as required by the Occupational Safety and Health Act [OSH Act] of 1970. Prior to 1971, the U.S. had no enforceable federal standards for workplace air; instead, guidelines (which could be voluntarily adopted, or not) were set by a private organization called the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH is a private group composed of industrial hygienists from state and local governments, plus academics and industry consultants.

In 1946 the ACGIH established a Committee on Threshold Limits, charged with developing "threshold limit values" (TLVs) for chemical exposures in the workplace. A threshold is an amount below which no damage is evident. The ACGIH says TLVs are average concentrations in air for an 8-hour workday, 40 hours per week, to which "nearly all workers may be repeatedly exposed, day after day, without adverse effect."[2]

In 1971 the U.S. government adopted all the ACGIH's TLVs as official government standards for workplace air. Since 1950, the ACGIH's TLVs have also been used to set government standards in Belgium, West Germany, Austria, Italy, the Netherlands, Portugal, Denmark, Sweden, Finland, Norway, Spain, Switzerland, England, Japan, and probably elsewhere.

Furthermore, during the 15 years after 1971, at least 37 of 50 states in the U.S. used the TLVs as the basis for setting ambient air pollution standards --not workplace standards, but standards for the general outdoor air. ("Ambient" means "surrounding" or "enveloping.") Often states have taken the TLVs, reduced them by some arbitrary "safety factor" like 100, and declared them "safe" for ambient air. Reasons for reducing TLVs by a "safety factor" are: (a) TLVs are established for only 40 hours of exposure each week, not continuous exposure 168 hours per week; (b) workers are assumed to be young, healthy, male, and employed (therefore, probably eating well, with access to health care) whereas the general population includes pregnant women, infants, the elderly, people with chronic ailments, people with special sensitivity to particular chemicals, and poor people who can't afford to eat well and rarely, if ever, see a doctor; (c) TLVs are set based on exposure to a single chemical, but in the real world everyone is exposed to numerous chemicals simultaneously. Since the "safety factor" is an arbitrary number, any "safety" in TLV-based ambient air standards must rely upon the safety of the underlying TLV itself. There is evidence that the role of TLVs is now being extended in the U.S., to setting standards for indoor air, standards for groundwater contamination, and standards for cleanup at Superfund [contaminated dump] sites.

For nearly 5 decades, no one critically examined the scientific data underlying the TLVs. Even the TLV Committee itself seems to have relied solely on the advice of individual Committee members who took responsibility for setting a TLV for a particular chemical. Those individual Committee members, it was revealed in 1988, were often employed by the same corporations that were the major producers of the chemicals having their TLVs set. For example, a Dow Chemical Company representative took responsibility for setting TLVs for at least 30 of Dow's halogenated hydrocarbons, pesticides, and other industrial chemical products. Furthermore, in 1988 it was learned that at least 104 TLVs had been set based, in whole or in part, on data that appeared in unpublished corporate communications. Those corporate communications were not available from the ACGIH, from the corporations themselves, or from individual members of the TLV committee.[3] Thus the basis of those TLVs was secret and not available for scientific peer review. (The Reagan administration's Occupational Safety and Health Administration [OSHA] responded to this information in 1989 by once again formally adopting all 600 of the TLVs, wholesale, as federal regulations. The OSH Act of 1970 had required the federal government to conduct its own research and set its own workplace air standards, but between 1971 and 1989 OSHA was able to set only 12 such standards of its own. Since there are roughly 60,000 chemicals now in commercial use, at this rate, OSHA would take 90,000 years to set standards for all chemicals.)

Despite the absence of open scientific process underlying many TLVs, many other TLVs had been set based on published literature, and in those cases, the TLVs were still assumed to be valid. However, in 1990, independent researchers compared many TLVs to the scientific reports upon which these TLVs are supposedly based.[4] They found that, in numerous cases, the TLVs had been set at levels higher than the levels shown to cause effects in humans, ranging from eye and nose irritation to permanent changes in bodily structure and outright disease. (They also found TLVs based on data that was 50 years old; TLVs based on examination of as few as 3 individuals; and TLVs set to protect against hearing loss, based on studies of eyes, noses and throats but not ears.)

The 1990 report on the scientific underpinnings of the TLVs is worth reading. Using a uniform format, it contrasts the effects that the TLV is supposed to prevent, against the actual scientific study of those effects in humans which the TLV Committee says it relied upon. Here we reprint excerpts from that 1990 report readers can see for themselves the way scientific information has been used in setting many TLVs. We are quoting the 1990 report verbatim, including material both inside and outside quotation marks, and including the original use of ... to indicate omissions; our only editing has been to remove italics from some words. (In what follows, the notation m**3 means "cubic meter of air.")

Acetaldehyde: EFFECT. "The TLV, 100 ppm, is recommended to prevent excessive eye irritation and potential injury to the respiratory tract." [ACGIH, 1976]

VALIDATION? "Several of 12 volunteers objected... strenuously even at 25 ppm... A majority... experienced... eye irritation at 50 ppm." [Silverman and others, 1946]

Benzene: EFFECT. "A TLV of 25 ppm is believed low enough to prevent serious blood changes." [ACGIH, 1976]

VALIDATION? In "a study... of the benzene exposure of workers in the rubber coating industry... the measured benzene vapor concentrations averaged 18 ppm and 6 of 47 employees showed a lowered hemoglobin of below 13.5 grams." [Pagnotto and others, 1961]

Butyl Alcohol: EFFECT. "In view of the apparent potential of n-butyl alcohol to increase hearing loss in the younger age group of workers and to impair vestibular [ear] function at levels somewhat below 110 ppm, a TLV of 50 ppm as a ceiling value is recommended." [ACGIH, 1976]

VALIDATION? "Butyl alcohol, at 25 ppm irritated the eyes, nose, and throat of the majority of 10 volunteers... At 50 ppm there was a unanimous feeling of pronounced throat irritation, in 10 volunteers." [Nelson and others, 1943]

Chlorine dioxide: EFFECT. "The recommended limit of 0.1 ppm is... to prevent irritation and possible bronchitis." [ACGIH, 1976]

VALIDATION? "At a factory for the production of sulfite-cellulose... extensive investigations... showed the occurrence of slight bronchitis in 7 of 12 workers exposed to chlorine dioxide... at concentrations lower than 0.1 ppm." [Gloemme and Lundgren, 1957]

Chlorodiphenyl--42% chlorine: EFFECT. "It is believed that this limit, 1 mg/m**3, will offer reasonably good protection against

systemic intoxication but may not guarantee complete freedom from chloracne [a disfiguring skin disease]." [ACGIH, 1976]

VALIDATION? "In a chemical plant concerned with organic chemical production where the chlorinated diphenyls in the actual breathing zone of the workers were 0.1 mg/m**3 of air... seven cases of mild to moderate chloracne of the face and head occurred among 14 chemical operators exposed..." [Meigs and others, 1954]

Ethyl Ether: EFFECT. "Regular exposure at this concentration (400 ppm, the TLV) should cause no demonstrable injury to health nor produce irritation or signs of narcosis among workers." [ACGIH, 1976]

VALIDATION? "Complaints of nasal irritation began at 200 ppm in the majority of 10 volunteers." [Nelson and others, 1943]

Fluoride as F [Fluorine]: EFFECT. "The limit, 2.5 mg/m**3, is sufficiently low to prevent irritative effects and to protect against disabling bone changes." [ACGIH, 1976]

VALIDATION? At a factory where the concentration of fluorides ranged from 0.14 to 3.13 mg/m**3, "radiological [x-ray] examination revealed signs of osteosclerosis [abnormal hardening of bone] in 48 of 189 workers." [Largent, 1961]

Isopropyl acetate: EFFECT. "The limit, 250 ppm,... is considered adequate to prevent significant irritation of the eyes and respiratory passages." [ACGIH, 1976]

VALIDATION? "We found that at 200 ppm, the majority of... twelve subjects of both sexes... experienced some degree of eye irritation." [Silverman and others, 1946]

Magnesium oxide fume: EFFECT. "The limit, 10 mg/m**3, is recommended on the basis that this value represents a maximal desirable limit for dusts of relatively minor hazard." [ACGIH, 1976]

VALIDATION? In 1 of 4 subjects exposed to an average concentration of magnesium oxide at 5.8 mg/m**3 and in 2 of 4 subjects exposed to an average concentration of magnesium oxide of 4.1 mg/m**3 "was found... a leukocytosis [an abnormally large number of white blood cells] and a fever resembling those caused by the heavy metals." [Drinker and others, 1927]

Mercury: EFFECT. "Following a study of the chlorine industry it was concluded in general that exposure at 0.1 mg/m**3 [100 micrograms/m**3] produced no significant incidence of mercury poisoning but contained little or no margin of safety." [ACGIH, 1976]

VALIDATION? "Symptoms or signs of chronic mercury poisoning were found in 1 of 9 and in none of 3 men... engaged in repairing D.C. meters... where the concentration of mercury in the atmosphere averaged 19 and 40 micrograms/m**3, respectively." [Bidstrup and others, 1951]

Mica: EFFECT. "The limit of 20 mppcf [million particles per cubic foot of air]... should prevent disabling pneumoconiosis, but may not be sufficiently low to eliminate positive chest x-ray findings in workers with many years' exposure." [ACGIH, 1976]

VALIDATION? "In mica factories... the exposure to dust is limited to muscovite mica only... which contains less than 1% free silica. When the dust concentrations to which most workers were exposed ranged from 2 to 21 mppcf, with an average of 10 mppcf,... 27 of 61 workers examined had ground-glass 2 readings of their chest x-rays." [Heimann and others, 1953]

Selenium: EFFECT. "The limit of 0.2 mg/m**3 for elementary selenium and its common inorganic compounds is believed low enough to prevent systemic toxicity and to minimize irritation of eyes and respiratory passages." [ACGIH 1976]

VALIDATION? In the "manufacture of rectifiers... conjunctivitis and slight tracheo-bronchitis were present in 9 of 62 workers... The atmospheric concentrations at different stages of the process varied from 0.007 to 0.05 mg/m**3, nowhere reaching the recommended MAC [maximum allowable concentration] of 0.1 mg/m**3." [Note: 0.007 to 0.5 is 4 to 28 times smaller than 0.2, the TLV.] [Kinningkeit, 1962]

Turpentine: EFFECT. "A TLV of 100 ppm is... recommended to prevent chiefly irritative effects." [ACGIH, 1976]

VALIDATION? "Turpentine at 75 ppm caused nose and throat irritation in several of 10 volunteers." [Nelson and others, 1943]

[To be continued.]

--Peter Montague

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[1] Philip J. Landrigan, "Commentary: Environmental Disease--A Preventable Epidemic," AMERICAN JOURNAL OF PUBLIC HEALTH Vol. 82 (July 1992), pgs. 941-943.

[2] Barry I. Castleman and Grace E. Ziem, "Editorial: Toxic Pollutants, Science, and Corporate Influence," ARCHIVES OF ENVIRONMENTAL HEALTH Vol. 44, No. 2 (March/April, 1989), pgs. 68, 127.

[3] Barry I. Castleman and Grace E. Ziem, "Corporate Influence on Threshold Limit Values," AMERICAN JOURNAL OF INDUSTRIAL MEDICINE Vol. 13, No. 5 (1988), pgs. 531-559.

[4] S.A. Roach and S.M. Rappaport, "But They Are Not Thresholds: A Critical Analysis of the Documentation of Threshold Limit Values," AMERICAN JOURNAL OF INDUSTRIAL MEDICINE Vol. 17, No. 6 (1990), pgs. 727-753.

Descriptor terms: american public health association; osha; american conference of governmental industrial hygienists; committee on threshold limits; tlvs; belgium; west germany; austria; italy; netherlands; portugal; denmark; sweden; finland; norway; spain; switzerland; japan; great britain; air quality standards; clean air act; indoor air pollution; superfund remediation; groundwater; standards; ronald reagan; acetaldehyde; benzene; butyl alcohol; chlorine dioxide; chlorodiphenyl; ethyl ether; fluoride; fluorine; isopropyl acetate; magnesium oxide fume; mercury; mica; selenium; turpentine;