Here's an update on asbestos . . .

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There has always been an attempt on the part of scientists to establish a hygienic standard for asbestos that is biologically most appropriate in limiting the hazard. However, since asbestos was established as a human carcinogen, it has been difficult to establish a no-risk level, either for occupational exposure or non-occupational exposure. There is always some small risk to health as long as there is any airborne dust in the environment.

Nevertheless, an allowable exposure level must be set and defined by an index based on the theory that exposure up to certain levels can be tolerated without incurring undue risks. This article will offer a critical review of the existing and proposed occupational and non-occupational standards for asbestos.

OCCUPATIONAL STANDARDS The occupational or work-environment level is normally referred to as a Threshold Limit Value (TLV) or Time-Weighted Average (TWA). These values refer to time-weighted concentrations for a 7- or 8-hour work day and 40-hour work week. They refer to airborne concentrations under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect.

In 1946, the American Governmental Industrial Hygienists proposed that the TLV for asbestos dust be set at 5 mppcf (million particles per cubic foot), as determined from impinger samples.[1] This value was recommended by Dressen, Dallavalle, Edwards, Miller and Sayers after a study of 541 employees in three asbestos textile plants using chrysotile asbestos.[2]

In 1960 an occupational standard for asbestos was published in the U.K. by the Minister of Labour.[3] This was taken from the annual list of TLV's published by the ACGIH. In 1965 The British Occupational Hygiene Society (BOHS) formed a Hygiene Standard Committee.[4] This committee, after critical examination of the ACGIH standards, recommended the use of the ACGIH standard for asbestos for the time being, until they have established their own standard.

In 1967, Cooper[5] observed that the TLV of 5 mppcf for asbestos rests on shakier evidence than most TLV's. His chief argument was that a large proportion of asbestos fibres have diameters below the resolving power of the light microscope used for impinger counts and are therefore not counted at all. He further reported that asbestosis appeared in insulation workers who were exposed to concentrations much below the time-weighted average of 5 mppcf. Leathart and Sanderson[6] also considered the TLV of 5 mppcf to be too high. In January of 1968 the ACGIH issued the following statement:

> "A limit to 5 mppcf, based on impinger samples counted by light-field techniques is satisfactory to control exposures to most forms of asbestos: Crocidolite, however, has been shown to produce mesotheliomas in addition to the common asbestotic inflammations. Since no safe limit can be established for this form of asbestos at this time, until more definitive data are obtained, it is recommended that workers exposed to crocidolite be equipped with air-

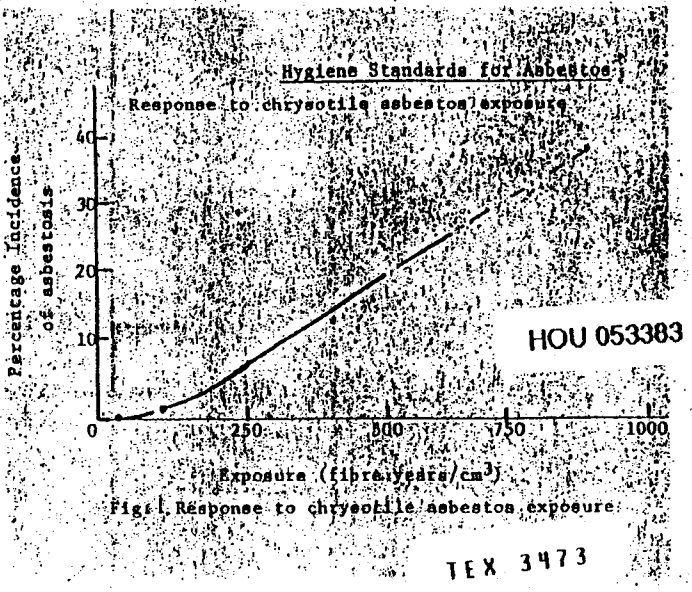

Fig. 1. Response to chrysotile asbestos exposure.

supplied helmets."

TEXTILE STUDY However, by this time, the Hygiene Standards Committee of the BOHS under the chairmanship of Professor Lane had already completed an environmental and medical study at an asbestos textile factory in England, in which investigations were made of 290 of the men employed in the period of 1933–1966.[7] The asbestos dust concentrations to which different workers had been exposed varied from 1 fibre/cc to 27 fibres/cc measured by the membrane filter (MF) technique in which the number of fibres greater than 5u in length were counted.

The problem of relating prevalence of asbestosis with concentration and with duration of exposure was resolved by assuming that the cumulative amount of asbestos remaining in the lungs from a given exposure is equally dependent on the dust concentration and on the duration of exposure to that concentration. Thus, the exposure of an individual was expressed as fibre-years/cc, that is the product of the average concentration during working hours and his years of exposure. Exposure expressed in this way was compared to the prevalence of asbestosis and a curve was developed.[8] *(Fig. 1)*

One criticism of this curve was the use of a continuous scale starting at zero. Doses which give zero response are never, in fact, known with absolute certainty since the sensitivity of a measuring instrument is limited. However, the main conclusion from the curve was that for an accumulated exposure of 100 fibre-years/cc, it is probable that the risk of being affected, to the extent of having the earliest clinically demonstrated signs, is less than 1%. That is, 2 fibres/cc for 50 years, 4 fibres/cc for 25 years or 10 fibres/cc for 50 years, 4 fibres/cc for 25 years or 10 fibres/cc for 10 years.

ACGIH In 1969 the ACGIH proposed a TLV of 12 fibres greater than 5 um in length per cc by the MF technique or 2 mppcf by the impinger technique. This was probably based on the work of Lynch, Ayer and Johnson[9] in asbestos textile plants where 1 mppcf (impinger) was shown to be equal to 5.9 fibres/cc. In 1970[10] the ACGIH proposed a lower asbestos dust limit of 5 fibres/cc by the MF technique and eliminated the impinger standard. However, this TLV remained on the intended changes list until 1973 when it was first adopted as the TLV and continues to be the one today. This TLV, if continued, would result in an accumulated exposure of 250 fibre-years/cc over 50 years and an extrapolation of the curve shown above would indicate that this would result in more than 2% risk of contracting asbestosis.

In 1972 NIOSH recommended the following criteria for asbestos dust.[11]

"Occupational exposure to airborne asbestos dust shall be controlled so that no worker shall be exposed to more than 2.0 asbestos fibres per cubic centimeter (cc) of air based on a count of fibres greater than 5 micrometers (> 5 um) in length determined by the membrane filter method at 400-450× magnification (4 mm objective) phase contrast illumination, as described in Appendix I, determined as a time-weighted average (TWA) exposure for an 8-hour work day, and no peak concentration of asbestos to which workers are exposed shall exceed 10.0 fibres/cc greater than 5 um as determined by a minimum sampling time of fifteen minutes."

Along with the above recommendation the NIOSH also issued several other statements:

TABLE I

Category	Dust Concentration f/cc
Negligible	0-0.4
Low	0.5-1.9
Medium	2-10.0
High	over 10.0

(1) The standard is amenable to techniques that are valid, reproducible and available to 'industry' and governmental agencies. It will be subject to review and will be revised as necessary.

(2) The recommended standard is designed primarily to prevent asbestosis. For other diseases associated with asbestos, there is insufficient information to establish a standard to prevent such diseases including asbestos-induced neoplasms by any all-inclusive limit other than one of zero. Nevertheless, a safety factor has been included in arriving at the concentration level that will reduce the total body burden and should more adequately guard against neoplasms.

LATENCY A ceiling value of 10.0 fibres/cc that was not to be exceeded was included to reduce the possibility of the short-term heavy exposures to asbestos that have been reported to cause mesotheliama. In addition, this should reduce the likelihood of diseases (malignant and non-malignant) resulting from exposure in excess of 30 years with very long latent periods. The U.S. Government published the following in the Federal Register, Vol. 36, No. 234, December 7, 1971."

> "The 8-hour time-weighted average airborne concentration of asbestos dust to which employees are exposed shall not exceed 5 fibers per milliliter greater than 5 microns in length, as determined by the membrane filter method at 400-450× magnification (4 millimeter objective) phase contrast illumination. Concentrations above 5 fibres per milliliter but not to exceed 10 fibres per milliliter, may be permitted up to a total of 15 minutes in an hour for up to 5 hours in an 8-hour day."

On June 7, 1972[12] the OSHA promulgated a standard which limits the worker exposure to an 8-hour time-weighted average (TWA) of five asbestos fibres per cc of air; and the ceiling limit of 10 fibres/cc. They also mentioned that effective July 1, 1976, the 1972 rule would reduce the exposure limit to an 8-hour exposure limit of 2 fibres/cc. Selikoff et al[13] criticized the standard on the basis that the fibres are made of fibrils 300 to 350 Angstroms in diameter and cannot be seen with the optical microscope, being far below the limits of its resolution.

In 1973 the Hygiene Standard Committee reviewed the 1968 BOHS standard for chrysotile and recommended that no changes be made at the present time, but the standard be kept under review.[14] They also reviewed the information on the results of human exposure to airborne amosite asbestos with animal experiments. They recommended that the standards for amosite be the same as those for chrysotile.

It was further recommended that the following table (Table I) be used to designate certain ranges of dustiness.

On October 9, 1975 the Federal Register[15] proposed a standard of 0.5 fibres per cc for an 8-hour TWA (or 500,000 fibres per cubic meter) and likewise a reduced ceiling of 5 fibres per cc (or 5 million fibres per cubic meter) for any period not exceeding 15 minutes.

IHPR The proposed standard did not apply to the construction industry and separate rulemaking to revise the asbestos standard for construction

industry was planned. The Insulation Hygiene Progress Report[11] critically reviewed the proposed OSHA standard and issued the following statement:

"This recognition that the construction industry is unique is highly desirable. Earlier data on the effectiveness of monitoring in the construction industry (see Insulation Hygiene Progress Reports, Summer 1973), have shown that few dust counts are ever taken in this segment of the Industry. Thus, specification of procedures is of much greater importance here. Individual workers must be able to judge whether or not they are working in a safe environment on the basis of materials and methods rather than dust counts.

"As much of insulation is now asbestos-free, work practices for installation of new material can be developed that would lead to a time-weighted average exposure less than that proposed in the new standard. With care, even ripout can be done safely, but special precautions must be taken. Wetting techniques have now been developed that would allow removal of asbestos to be accomplished within the proposed regulations."

2 FIBRE OSHA invited comments on appropriateness and feasibility from the asbestos industry. On February 4, 1976[11] some 65 representatives from companies and trade associations representing manufacturers and processes of asbestos products in the United States participated in a meeting held in Washington, D.C. and overwhelmingly endorsed that the "2 fibre" level has been or can be attained by application of engineering technology but the proposed "0.5 fibre" level is unnecessary, impracticable and lacks medical justification.

In a letter dated December 15, 1976[11] to the OSHA, Dr. Finklea of the NIOSH recommends that the OSHA reduce the standard for occupational exposure to asbestos to 0.1 fibres per cc. Dr. Finklea said the previous recommendation of a 2 fibres/cc was designed primarily to prevent asbestosis since insufficient information then existed to establish a standard to prevent asbestos-related diseases such as pulmonary, pleural and peritoneal neoplasms. The 0.1 fibre per cc recommendation is based on lowest concentration at which asbestos fibres can be monitored reliably using phase contrast microscopy. Our study[11] indicates that it is not possible to monitor the levels at 0.1 fibres/cc reliably.

CANADA In Canada there is no uniform standard, all provinces have their own asbestos standards. An attempt is made here to summarize the provincial standards.

Quebec[11]—The standard to be applied is 5 fibres/cc but the Beaudry commission has suggested a reduction to 2 fibres per cc or the equivalent.

Ontario[11]—They followed the ACGIH recommendation until 1972 and then they lowered the standard to 2 fibres/cc for chrysotile mainly due to the following:

(1) The U.K. has been using this standard since 1971.

(2) The NIOSH criteria document recommended this limit.

(3) The toxicities of various types of asbestos is not well understood and hence a built-in safety factor was needed.

TABLE 2

REGULATING AGENCY	TA ASBESTOS CONCENTRATION STANDARD
CALIFORNIA	
Air and Industrial Hygiene Laboratory, California State Department of Health	Total fibre count downwind of an asbestos emission source must not exceed 10 times the total fibre count upwind of that source.
CONNECTICUT	
Department of Environmental Protection, State of Connecticut	50 ng/m³ (based on 30-day average sample)
ONTARIO	
Ontario Ministry of the Environment Air Resources Branch	Interim guideline of 5 µg/m³

For crocidolite the standard is 0.2 fibres/cc. They also have a ceiling value of 10 fibres per cc for a 15-minute exposure.

Alberta[11]—On April 15, 1975 Alberta officially promulgated the following occupational health standards:

(A) For asbestos dust or fibre, all forms, the time-weighted average airborne concentration shall not exceed 2 fibres greater than 5 micrometers in length per cubic centimeter of air, as determined by the membrane filter method of evaluation at 400-450× magnification using phase contrast illumination.

(B) For asbestos dust or fibre, all forms, the maximum (ceiling) airborne concentration shall not exceed 10 fibres greater than 5 micrometers in length per cubic centimeter of air as determined by the membrane filter method of evaluation at 400-500× magnification using phase contrast illumination.

British Columbia[11]—The B.C. Government have had a standard of 5 mppcf (impinger) for a long time. However, they have now their standard and recommended a TLV of 2 fibres per cc greater than 5 um in length for chrysotile and 0.2 fibres/cc for crocidolite in the Second Draft Amendments, Workmen's Compensation Board, Industrial Health and Safety Regulations, February, 1976. They have also mentioned a ceiling of 5 fibres/cc for 15-minute exposure. This is ¼ the ceiling level of 10 fibres/cc recommended by Ontario.

Saskatchewan[11]—The province has a TLV of 2 fibres/cc for all asbestos varieties.

Nova Scotia[11]—At present, the standard is 5 fibres/cc but new facilities will be required to meet the standard of 2 fibres/cc.

The Working Group on Asbestosis[11] recognized the documented and suspected health hazards associated with asbestos exposures and recommended a uniform early acceptance of a maximum tolerable level of 2 fibres/ml., time-weighted average. The practical objective, however, should be to reduce asbestos dust in the workplace to the lowest possible level.

Feasibility of 2 fibres/cc Standard

A standard should not be promulgated on whether it is feasible to meet it or not. Almost anything is feasible if it is necessary. However, it is a worthwhile exercise to analyse if the standard is feasible. It should also be realized that 2 fibres/cc is a TWA over an 8-hour period. In other words some excursion during the period can be permitted, but the excursion is limited to 10 fibres/cc. Now, if one supposes

that a worker is exposed to 10 fibres/cc for 15 minutes he could be exposed to 1.7 fibres/cc for the rest of his shift, i.e. $5 \times 10.465 \times 1.7 = 480 \times 2$.

Lemen et al[24] showed that more than 50% of the operations in textile operations were able to meet the 2 fibres/cc limit and control technology to meet the 2F/cc level existing in all operations in the friction product industry. A study has been carried out in Ontario to determine the technological feasibility of the 2 f/cc standard[31] as is the Beaudry Commission in Quebec.[32] The Ontario report[32] shows that the level of 2 fibres per milliliter is technologically feasible in the five major plants studied.

COSTS Our studies in Ontario would seem to indicate that the industry is well able to bear significantly increased control costs without enormous dislocations in the industry. We enforce asbestos standard as strict as that presently used anywhere in the world. At the present time, it would seem that our asbestos using industries are economically healthy and perfectly capable of working under the necessary constraints imposed upon them.

Other Occupational Standards

(1) The BOHS has recommended a level of 0.2 fibres/cc for crocidolite.

(2) The BOHS also gives the following alternative indices for chrysotile asbesots.[26] Respirable mass:

- ~0.03 mg magnesium/m³
- ~0.04 mg SiO_2/m³
- ~0.10 mg ash/m³
- ~0.12 mg asbestos/m³

Thermal Precipitator: 25 ppcc greater than 1 um after incineration.

Impinger: 10 ppcc

Royco Particle Counter: 2 ppcc greater than 4 um.

It should, however, be realized that the above standards refer to conditions in textile factories using chrysotile asbestos and the equivalents may not be applicable in other places.

The joint ACGIH–AIHA Aerosol Hazards Evaluation Committee[24] after reviewing various standards including the mass concentration concluded that "at present the only practical way to determine fibre concentration is by counting fibres which have been mounted on a suitable substrate so that they can be identified as individual fibres."

ENVIRONMENTAL STANDARDS In 1971 the Environmental Protection Agency, U.S. Government proposed emission standards concerning the following:

(1) Emissions shall not exceed those which would be emitted from operations if proper engineering control had been installed (i.e. fabric filter, cyclone gas cleaning devices).

(2) Visible emissions of particulate.

(3) Spraying of asbestos.

(4) Use of asbestos for surfacing or resurfacing of roads.

The use of procedural standards and visible emissions as the basis for evaluation for compliance with the standard are designed to minimize emission to the atmosphere. At about the same time the USA, through the Air and Industrial Hygiene Laboratory, California State Department of Health, asks that the total fibre count downwind of an asbestos source not exceed 10 times the total fibre count upwind of that source. The Department of Environmental Protection, State of Connecticut U.S. Environmental Protection Agency, had the problem under study, and required only that there be no visible emission or certain specified control equipment must be used, e.g. a baghouse, high energy scrubber, etc.

Ontario has an emission guideline which is 5 micrograms per cubic metre averaged over a half hour at point of impingement. This guideline ... to

the maximum concentration of asbestos averaged over a half hour resulting from the plume from any source, stack or vent, impinging on any receptor, a school, shopping centre, ground, etc., at the time when the wind is blowing from the source directly toward the receptor.

Since wind direction is variable and since more than one source may impinge on a given receptor at one time, the emission guideline is developed to encompass these variables in such a way that, if every source meets the emission guideline, the ambient air quality guideline will not be exceeded. Thus, there is no direct numerical relationship between the emission guideline and the ambient air quality guideline. The ambient air quality guideline is the maximum concentration, averaged over 24 hours, to be found anywhere in the community.

Table II summarizes some of the air quality standards in force today.

The Final National Emission Standards for Hazardous Air Pollutants—Asbestos and Mercury, promulgated by the U.S. Environmental Protection Agency, were published in the Federal Register of October 14, 1975[5] and are effective as of that date. Initially the standards appeared in the Register of April 6, 1973." The amendments thereto were proposed October 25, 1974.

The following are some of the highlights of this new document as it concerns asbestos.

(1) The "no visible emissions" clause for the waste disposal of asbestos materials remains in effect.

(2) Asbestos mills are exempt from the requirement to wet tailings when disposal site temperatures are below 15°F.

(3) Only asphalt concrete manufacturing plants that use commercial asbestos are affected.

(4) Local exhaust ventilation systems may be used during certain renovation operations.

(5) Containers of asbestos waste may display either an EPA or an OSHA warning label.

(6) Clarification is given of the definitions for "planned renovation" and "emergency renovation" operations.

(7) Wastes generated by operations that use sprayed-on materials containing less than 1% of asbestos by weight to insulate or fireproof buildings, structures, pipes and conduits are not covered by the new ruling. OHAS

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