

ASBESTOS STUDY
COMMITTEE - 1971

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Threshold Limit Values
of Airborne Contaminants
AND INTENDED CHANGES
Adopted By ACGIH
For 1970



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Documentation of Threshold Limit Values. A separate companion piece to the TLVs is issued by ACGIH under this title. This publication gives the pertinent scientific information and data with reference to literature sources that were used to base each limit. Each documentation also contains a statement defining the type of response against which the limit is safeguarding the worker. For a better understanding of the TLVs it is essential that the Documentation be consulted when the TLVs are being used.

Information concerning the availability of copies of the Documentation of Threshold Limit Values should be directed to the Secretary-Treasurer.

PREFACE

THRESHOLD LIMIT VALUES FOR 1970

Threshold limit values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit, a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness.

Simple tests are now available (J. Occup. Med. 9, 537, 1967; Ann. N.Y. Acad. Sci., 151 Art. 2, p. 968, 1968) that may be used to detect those individuals hypersusceptible to a variety of industrial chemicals (respiratory irritants, hemolytic chemicals, organic isocyanates, carbon disulfide). These tests may be used to screen out by appropriate job placement the hyperreactive worker and thus in effect improve this "coverage" of the TLVs.

Threshold limit values refer to time-weighted concentrations for a 7 or 8-hour workday and 40-hour workweek. They should be used as guides in the control of health hazards and should not be used as fine lines between safe and dangerous concentrations. (Exceptions are the substances listed in Appendices A and E and those substances designated with a "C" or Ceiling value, Appendix C.)

Time-weighted averages permit excursions above the limit provided they are compensated by equivalent excursions below the limit during the workday. In some instances it may be permissible to calculate the average concentration for a workweek rather than for a workday. The degree of permissible excursion is related to the magnitude of the threshold limit value of a particular substance as given in Appendix C. The relationship between threshold limit and permissible excursion is a rule of thumb and in certain cases may not apply. The amount by which threshold limits may be exceeded for short periods without injury to health depends upon a number of factors such as the nature of the contaminant, whether very high concentrations - even for short periods - produce acute poisoning, whether the effects are cumulative, the frequency with which high concentrations occur, and the duration of such periods. All factors must be taken into consideration in arriving at decision as to whether a hazardous condition exists.

Threshold limits are based on the best available information from industrial experience, from experimental human and animal studies, and, when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance or other forms of stress may form the basis for others.

The committee holds to the opinion that limits based on physical irritation should be considered no less binding than those based on physical impairment. There is increasing evidence that physical irritation may initiate, promote or accelerate physical impairment through interaction with other chemical or biologic agents.

In spite of the fact that serious injury is not believed likely as a result of exposure to the threshold limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.

These limits are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person trained in this discipline. They are not intended for use, or for modification for use, (1) as a relative index of hazard or toxicity, (2) in the evaluation or control of community air pollution or air pollution nuisances, (3) in estimating the toxic potential of continuous uninterrupted exposures, (4) as proof or disproof of an existing disease or physical conditions, or (5) for adoption by countries whose working conditions differ from those in the United States of America and where substances and processes differ.

Ceiling vs Time-Weighted Average Limits. Although the time-weighted average concentration provides the most satisfactory, practical way of monitoring airborne agents for compliance with the limits, there are certain substances for which it is inappropriate. In the latter group are substances which are predominantly fast acting and whose threshold limit is more appropriately based on this particular response. Substances with this type of response are best controlled by a ceiling "C" limit that should not be exceeded. It is implicit in these definitions that the manner of sampling to determine compliance with the limits for each group must differ; a single brief sample, that is applicable to a "C" limit, is not appropriate to the time-weighted limit; here, a sufficient number of samples are needed to permit a time-weighted average concentration throughout a complete cycle of operations or throughout the work shift.

Whereas the ceiling limit places a definite boundary which concentrations should not be permitted to exceed, the time-weighted average limit requires an explicit limit to the excursions that are permissible above the listed values. The magnitude of these excursions may be pegged to the magnitude of the threshold limit by an appropriate factor shown in Appendix C. It should be noted that the same factors are used by the Committee in making a judgment whether to include or exclude a substance for a "C" listing.

"Skin" Notation. Listed substances followed by the designation "Skin" refer to the potential contribution to the over-all exposure by the cutaneous route including mucous membranes and eye, either by airborne, or more particularly, by direct contact with the substance. Vehicles can alter skin absorption. This attention-calling designation is intended to suggest appropriate measures for the prevention of cutaneous absorption so that the threshold limit is not invalidated.

Mixtures. Special consideration should be given also to the application of the TLVs in assessing the health hazards which may be associated with exposure to mixtures of two or more substances. A brief discussion of basic considerations involved in developing threshold limit values for mixtures, and methods for their development, amplified by specific examples are given in Appendix B.

Nuisance Dusts. In contrast to fibrogenic dusts which cause scar tissue to be formed in lungs when inhaled in excessive amounts, so-called "nuisance" dusts have a long history of little adverse effect on lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. The nuisance dusts have also been called (biologically) "inert" dusts, but the latter term is inappropriate to the extent that there is no dust which does not evoke some cellular response in the lung when inhaled in sufficient amount. However, the lung-tissue reaction caused by inhalation of nuisance dusts has the following characteristics: 1) The architecture of the air spaces remains intact. 2) Collagen (scar tissue) is not formed to a significant extent. 3) The tissue reaction is potentially reversible.

Excessive concentrations of nuisance dusts in the work-room air may seriously reduce visibility (iron oxide), may cause unpleasant deposits in the eyes, ears and nasal passages (Portland Cement dust), or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by the rigorous skin cleansing procedures necessary for their removal.

A threshold limit of $10\text{mg}/\text{M}^3$, or 30 mppcf, of total dust $< 1\%$ SiO_2 , whichever is less, is recommended for substances in these categories and for which no specific threshold limits have been assigned. This limit, for a normal workday, does not apply to brief exposures at higher concentrations. Neither does it apply to those substances which may cause physiologic impairment at lower concentrations but for which a threshold limit has not yet been adopted. Some "inert" particulates are given in Appendix D.

Simple Asphyxiants - "Inert" Gases or Vapors. A number of gases and vapors, when present in high concentrations in air, act primarily as simple asphyxiants without other significant physiologic effects. A TLV may not be recommended for each simple asphyxiant because the limiting factor is the available oxygen. The minimal oxygen content should be 18 percent by volume under normal atmospheric pressure (equivalent to a partial pressure, $p\text{O}_2$ of 135 mm Hg). Atmospheres deficient in O_2 do not provide adequate warning and most simple asphyxiants are odorless. Several simple asphyxiants present an explosion hazard. Account should be taken of this factor in limiting the concentration of the asphyxiant. Specific examples are listed in Appendix E.

Physical Factors. It is recognized that such physical factors as heat, ultraviolet and ionizing radiation, humidity, abnormal pressure (altitude) and the like may place added stress on the body so that the effects from exposure at a threshold limit may be altered. Most of these stresses act adversely to increase the toxic response of a substance. Although most threshold limits have built-in safety factors to guard against adverse effects to moderate deviations from normal environments, the safety factors of most substances are not of such a magnitude as to take care of gross deviations. For example, continuous work at temperatures above 90°F or over-time extending the workweek more than 25%, might be considered gross deviations. In such instances judgment must be exercised in the proper adjustments of the threshold limit values.

"Notice of Intent." At the beginning of each year, proposed actions of the Committee for the forthcoming year are issued in the form of a "Notice of Intent." This Notice provides not only an opportunity for comment, but solicits suggestions of substances to be added to the list. The suggestions should be accompanied by substantiating evidence. The list of Intended Changes follows the Adopted Values in the TLV booklet.

As Legislative Code. The Conference recognizes that the TLVs may be adopted in legislative codes and regulations. If so used, the intent of the concepts contained in the Preface

should be maintained and provisions should be made to keep the list current. These values are reviewed annually by the Committee on Threshold Limits for revision or additions, as further information becomes available.

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ADOPTED VALUES
(In Alphabetical Order)

Substance	ppm ^{a)}	mg/M ³ b)
Abate	--	15
Acetaldehyde	200	360
Acetic acid	10	25
Acetic anhydride	5	20
Acetone	1,000	2,400
Acetonitrile	40	70
Acetylene	E	--
Acetylene dichloride, see 1, 2-Dichloroethylene	--	--
Acetylene tetrabromide	1	14
Acrolein	0.1	0.25
Acrylamide-Skin	--	0.3
Acrylonitrile-Skin	20	45
Aldrin-Skin	--	0.25
Allyl alcohol-Skin	2	5
Allyl chloride	1	3
**C Allyl glycidyl ether (AGE)	10	45
Allyl propyl disulfide	2	12
Alundum (Al ₂ O ₃)	--	D
2-Aminoethanol, see Ethanolamine	--	--
2-Aminopyridine	0.5	2
** Ammonia	50	35
Ammonium sulfamate (Ammate)	--	15
n-Amyl acetate	100	525
sec-Amyl acetate	125	650
Aniline-Skin	5	19
Anisidine (o, p-isomers)-Skin	--	0.5
Antimony & compounds (as Sb)	--	0.5
ANTU (alpha naphthyl thiourea)	--	0.3
Argon	E	--
Arsenic & Compounds (as As)	--	0.5
Arsine	0.05	0.2
Azinphos-methyl-Skin	--	0.2
Barium (soluble compounds)	--	0.5
C Benzene (benzol)-Skin	25	80
Benzidine-Skin	--	A1
p-Benzquinone, see Quinone	--	--
Benzoyl peroxide	--	5
Benzyl chloride	1	5
Beryllium	--	0.002
Biphenyl, see Diphenyl	--	--
Bisphenol A, see Diglycidyl ether	--	--
Boron oxide	--	15
Boron tribromide	1	10
C Boron trifluoride	1	3
Bromine	0.1	0.7
* Bromine pentafluoride	0.1	0.7
Bromoform-Skin	0.5	5
Butadiene (1, 3-butadiene)	1,000	2,200
Butanethiol, see Butyl mercaptan	--	--
2-Butanone	200	590
2-Butoxy ethanol (Butyl Cellosolve) - Skin	50	240
Butyl acetate (n-butyl acetate)	150	710

a) Parts of vapor or gas per million parts of contaminated air by volume at 25°C and 760 mm. Hg pressure.

b) Approximate milligrams of particulate per cubic meter of air.

** See Notice of Intended Changes
Capital letters refer to Appendices.

Substance	ppm ^{a)}	mg/M ³ b)
sec-Butyl acetate	200	950
tert-Butyl acetate	200	950
Butyl alcohol	100	300
sec-Butyl alcohol	150	450
tert-Butyl alcohol	100	300
C Butylamine-Skin	5	15
C tert-Butyl chromate (as CrO ₃) - Skin ..	--	0.1
n-Butyl glycidyl ether (BGE)	50	270
* Butyl mercaptan	0.5	1.5
p-tert-Butyltoluene	10	60
Cadmium (Metal dust and soluble salts)	--	0.2
*C Cadmium oxide fume (as Cd)	--	0.1
Calcium carbonate	--	D
Calcium arsenate	--	1
Calcium oxide	--	5
** Camphor (Synthetic)	2	--
Carbaryl (Sevin ®)	--	5
Carbon black	--	3.5
Carbon dioxide	5,000	9,000
Carbon disulfide-Skin	20	60
Carbon monoxide	50	55
Carbon tetrachloride-Skin	10	65
Cellulose (paper fiber)	--	D
Chlordane-Skin	--	0.5
Chlorinated camphene-Skin	--	0.5
Chlorinated diphenyl oxide	--	0.5
* Chlorine	1	3
Chlorine dioxide	0.1	0.3
C Chlorine trifluoride	0.1	0.4
C Chloroacetaldehyde	1	3
α-Chloroacetophenone (phenacyl- chloride)	0.05	0.3
Chlorobenzene (monochlorobenzene) ..	75	350
o-Chlorobenzylidene malononitrile (OCBM)	0.05	0.4
Chlorobromomethane	200	1,050
2-Chloro-1, 3-butadiene, see Chloroprene	--	--
Chlorodiphenyl (42% Chlorine) - Skin ..	--	1
Chlorodiphenyl (54% Chlorine) - Skin ..	--	0.5
1-Chloro, 2, 3-epoxypropane, see Epichlorhydrin	--	--
2-Chloroethanol, see Ethylene chlorohydrin	--	--
Chloroethylene, see Vinyl chloride ...	--	--
C Chloroform (trichloromethane)	50	240
1-Chloro-1-nitropropane	20	100
Chloropicrin	0.1	0.7
Chloroprene (2-chloro-1, 3-butadiene) -Skin	25	90
Chromic acid and chromates (as CrO ₃)	--	0.1
Chromium, sol. chromic, chromous salts as Cr	--	0.5
Metal & insol. salts	--	1
Coal tar pitch volatiles (benzene soluble fraction) anthracene, BaP, phenanthrene, acridine, chrysene, pyrene)	--	0.2

* 1970 Addition

** See Notice of Intended Changes

Substance	ppm ^{a)}	mg/M ^{3 b)}
Cobalt, metal fume & dust	--	0.1
Copper fume	--	0.1
Dusts and Mists	--	1
Corundum (Al ₂ O ₃)	--	D
Cotton dust (raw)	--	1
Crag [®] herbicide	--	15
Cresol (all isomers) - Skin	5	22
Crotonaldehyde	2	6
Cumene-Skin	50	245
Cyanide (as CN)-Skin	--	5
* Cyanogen	10	--
Cyclohexane	300	1,050
Cyclohexanol	50	200
Cyclohexanone	50	200
Cyclohexene	300	1,015
Cyclopentadiene	75	200
2, 4-D	--	10
DDT-Skin	--	1
DDVP, see Dichlorvos	--	--
Decaborane-Skin	0.05	0.3
Demeton [®] -Skin	--	0.1
Diacetone alcohol (4-hydroxy- 4-methyl-2-pentanone)	50	240
1, 2-Diaminoethane, see Ethylene- diamine	--	--
Diazomethane	0.2	0.4
Diborane	0.1	0.1
C 1, 2-Dibromoethane (ethylene dibromide)-Skin	25	190
Dibutyl phosphate	1	5
Dibutylphthalate	--	5
*C Dichloroacetylene	0.1	0.4
C o-Dichlorobenzene	50	300
p-Dichlorobenzene	75	450
Dichlorodifluoromethane	1,000	4,950
1, 3-Dichloro-5, 5-dimethyl hydantoin	--	0.2
1, 1-Dichloroethane	100	400
1, 2-Dichloroethane	50	200
1, 2-Dichloroethylene	200	790
C Dichloroethyl ether-Skin	15	90
Dichloromethane, see Methylene- chloride	--	--
Dichloromonofluoromethane	1,000	4,200
C 1, 1-Dichloro-1-nitroethane	10	60
1, 2-Dichloropropane, see Pro- pylenedichloride	--	--
Dichlorotetrafluoroethane	1,000	7,000
Dichlorvos (DDVP)-Skin	--	1
Dieldrin-Skin	--	0.25
Diethylamine	25	75
Diethylamino ethanol-Skin	10	50
**C Diethylene triamine-Skin	10	42
Diethylether, see Ethyl ether	--	--
Difluorodibromomethane	100	860
C Diglycidyl ether (DGE)	0.5	2.8
Dihydroxybenzene, see Hydroquinone	--	--
Diisobutyl ketone	50	290
Diisopropylamine-Skin	5	20

* 1970 Addition

** See Notice of Intended Changes

Substance	ppm ^{a)}	mg/M ³ b)
Dimethoxymethane, see Methylal	--	--
Dimethyl acetamide-Skin	10	35
Dimethylamine	10	18
Dimethylaminobenzene, see Xylidene .	--	--
Dimethylaniline (N-dimethylaniline)- Skin	5	25
Dimethylbenzene, see Xylene	--	--
Dimethyl 1, 2-dibromo-2, 2-di- chloroethyl phosphate, (Dibrom) ...	--	3
Dimethylformamide-Skin	10	30
2, 6-Dimethylheptanone, see		
Diisobutyl ketone	--	--
1, 1-Dimethylhydrazine-Skin	0.5	1
Dimethylphthalate	--	5
Dimethylsulfate-Skin	1	5
Dinitrobenzene (all isomers)-Skin	--	1
Dinitro-o-cresol-Skin	--	0.2
Dinitrotoluene-Skin	--	1.5
Dioxane (Diethylene dioxide)-Skin	100	360
Diphenyl	0.2	1
Diphenyl amine	--	10
Diphenylmethane diisocyanate (see Methylene bisphenyl isocyanate (MDI)	--	--
Dipropylene glycol methyl ether-Skin .	100	600
Di-sec, octyl phthalate (Di-2- ethylhexylphthalate)	--	5
Emery	--	D
* Endosulfan (Thiodan ®)-Skin	--	0.1
Endrin-Skin	--	0.1
Epichlorhydrin-Skin	5	19
EPN-Skin	--	0.5
1, 2-Epoxypropane, see Propylene- oxide	--	--
2, 3-Epoxy-1-propanol, see Glycidol .	--	--
Ethane	E	--
Ethanethiol, see Ethylmercaptan	--	--
Ethanolamine	3	6
2-Ethoxyethanol-Skin	200	740
2-Ethoxyethylacetate (Cellosolve acetate)-Skin	100	540
Ethyl acetate	400	1,400
Ethyl acrylate-Skin	25	100
Ethyl alcohol (ethanol)	1,000	1,900
Ethylamine	10	18
Ethyl sec-amyl ketone (5-methyl- 3-heptanone)	25	130
Ethyl benzene	100	435
Ethyl bromide	200	890
Ethyl butyl ketone (3-Heptanone)	50	230
Ethyl chloride	1,000	2,600
Ethyl ether	400	1,200
Ethyl formate	100	300
Ethyl mercaptan	0.5	1
Ethyl silicate	100	850
Ethylene	E	--
Ethylene chlorohydrin-Skin	5	16

* 1970 Addition

** See Notice of Intended Changes

Substance	ppm ^{a)}	mg/M ³ b)
Ethylenediamine	10	25
Ethylene dibromide, see 1, 2-Dibromoethane	--	--
Ethylene dichloride, see 1, 2-Dichloroethane	--	--
C Ethylene glycol dinitrate and/or Nitroglycerin-Skin	0.2 ^{d)}	--
Ethylene glycol monomethyl ether acetate, see Methyl cellosolve acetate	--	--
Ethylene imine-Skin	0.5	1
Ethylene oxide	50	90
Ethylidene chloride, see 1, 1-Dichloroethane	--	--
N-Ethylmorpholine-Skin	20	94
Ferbam	--	15
Ferrovandium dust	--	1
Fibrous glass	--	D
Fluoride (as F)	--	2.5
Fluorine	0.1	0.2
Fluorotrichloromethane	1,000	5,600
**C Formaldehyde	5	6
Formic acid	5	9
Furfural-Skin	5	20
Furfuryl alcohol	50	200
Gasoline	--	A ³
Glycerine mist	--	D
Glycidol (2, 3-Epoxy-1-propanol)	50	150
Glycol monoethyl ether, see 2-Ethoxyethanol	--	--
Graphite, (Synthetic)	--	D
Guthion,® see Azinphosmethyl	--	--
Gypsum	--	D
Hafnium	--	0.5
Helium	E	--
Heptachlor-Skin	--	0.5
Heptane (n-heptane)	500	2,000
Hexachloroethane-Skin	1	10
Hexachloronaphthalene-Skin	--	0.2
Hexane (n-hexane)	500	1,800
2-Hexanone	100	410
Hexone (Methyl isobutyl ketone),.....	100	410
sec-Hexyl acetate	50	300
Hydrazine-Skin	1	1.3
Hydrogen	E	--
Hydrogen bromide	3	10
C Hydrogen chloride	5	7
Hydrogen cyanide-Skin	10	11
Hydrogen fluoride	3	2
Hydrogen peroxide	1	1.4
Hydrogen selenide	0.05	0.2
Hydrogen sulfide	10	15
Hydroquinone	--	2
* Indene	10	45

d) An atmospheric concentration of not more than 0.02 ppm, or personal protection may be necessary to avoid headache.

* 1970 Addition

** See Notice of Intended Changes

Substance	ppm ^{a)}	mg/M ³ b)
Indium and compounds, as In	--	0.1
C Iodine	0.1	1
Iron oxide fume	--	10
Iron salts, soluble, as Fe	--	1
Isoamyl acetate	100	525
Isoamyl alcohol	100	360
Isobutyl acetate	150	700
Isobutyl alcohol	100	300
Isophorone	25	140
Isopropyl acetate	250	950
Isopropyl alcohol	400	980
Isopropylamine	5	12
Isopropylether	500	2,100
Isopropyl glycidyl ether (IGE)	50	240
Kaolin	--	D
Ketene	0.5	0.9
Lead	--	0.2
Lead arsenate	--	0.15
Limestone	--	D
Lindane-Skin	--	0.5
Lithium hydride	--	0.025
L. P. G. (Liquified petroleum gas)	1,000	1,800
Magnesite	--	D
Magnesium oxide fume	--	15
Malathion-Skin	--	15
Maleic anhydride	0.25	1
C Manganese and compounds, as Mn	--	5
Marble	--	D
** Mercury-Skin	--	0.1
** Mercury (organic compounds)-Skin ...	--	0.01
Mesityl oxide	25	100
Methane	E	--
Methanethiol, see Methyl mercaptan ..	--	--
Methoxychlor	--	15
2-Methoxyethanol, see Methyl cellosolve.....	--	--
Methyl acetate	200	610
Methyl acetylene (propyne).....	1,000	1,650
Methyl acetylene-propadiene mixture (MAPP).....	1,000	1,800
Methyl acrylate-Skin.....	10	35
Methylal (dimethoxymethane)	1,000	3,100
Methyl alcohol (methanol)	200	260
Methylamine	10	12
Methyl amyl alcohol, see Methyl isobutyl carbinol.....	--	--
* Methyl isoamyl ketone	100	475
Methyl (n-amyl) ketone (2-Heptanone) .	100	465
C Methyl bromide-Skin.....	20	80
Methyl butyl ketone, see 2-Hexanone .	--	--
Methyl cellosolve-Skin	25	80
Methyl cellosolve acetate-Skin	25	120
**C Methyl chloride	100	210
Methyl chloroform	350	1,900
Methylcyclohexane	500	2,000
Methylcyclohexanol	100	470

* 1970 Addition

** See Notice of Intended Changes

Substance	ppm ^{a)}	mg/M ³ b)
o-Methylcyclohexanone-Skin	100	460
Methyl ethyl ketone (MEK), see 2-Butanone	--	--
Methyl formate	100	250
Methyl iodide - Skin	5	28
Methyl isobutyl carbinol-Skin	25	100
Methyl isobutyl ketone, see Hexone ..	--	--
Methyl isocyanate - Skin	0.02	0.05
* Methyl mercaptan	0.5	1
Methyl methacrylate	100	410
Methyl propyl ketone, see 2-Pentanone	--	--
C Methyl silicate	5	30
C α Methyl styrene	100	480
C Methylene bisphenyl isocyanate (MDI) .	0.02	0.2
Methylene chloride (dichloromethane) .	500	1,740
Molybdenum (soluble compounds)	--	5
(insoluble compounds) ...	--	15
Monomethyl aniline-Skin	2	9
C Monomethyl hydrazine-Skin	0.2	0.35
Morpholine-Skin	20	70
Naphtha (coal tar)	100	400
Naphthalene	10	50
β-Naphthylamine	--	A ¹
Neon	E	--
Nickel carbonyl	0.001	0.007
Nickel, metal and soluble cmpds, as Ni	--	1
Nicotine-Skin	--	0.5
Nitric acid	2	5
Nitric oxide	25	30
p-Nitroaniline-Skin	1	6
Nitrobenzene-Skin	1	5
p-Nitrochlorobenzene-Skin	--	1
Nitroethane	100	310
Nitrogen	E	--
C Nitrogen dioxide	5	9
Nitrogen trifluoride	10	29
Nitroglycerin-Skin	0.2	2
Nitromethane	100	250
1-Nitropropane	25	90
2-Nitropropane	25	90
N-Nitrosodimethylamine (dimethyl- nitrosoamine)-Skin	--	A ¹
Nitrotoluene-Skin	5	30
Nitrotrichloromethane, see Chloropicrin	--	--
Nitrous oxide	E	--
Octachloronaphthalene-Skin	--	0.1
* Octane	400	1,900
* Oil mist, particulate	--	5h
* Oil mist, vapor	i) A ³	--
Osmium tetroxide	--	0.002
Oxalic acid	--	1
Oxygen difluoride	0.05	0.1
Ozone	0.1	0.2
Paraquat-Skin	--	0.5

h) As sampled by method that does not collect vapor.

i) According to analytically determined composition.

* 1970 Addition

** See Notice of Intended Changes

Substance	ppm ^{a)}	mg/M ^{3 b)}
Parathion-Skin	--	0.1
Pentaborane	0.005	0.01
Pentachloronaphthalene-Skin	--	0.5
Pentachlorophenol-Skin	--	0.5
Pentaerythritol	--	D
* Pentane	500	1,500
2-Pentanone	200	700
Perchloroethylene	100	670
Perchloromethyl mercaptan	0.1	0.8
Perchloryl fluoride	3	13.5
* Petroleum Distillates (naphtha)	i) A ³	--
Phenol-Skin	5	19
p-Phenylene diamine-Skin	--	0.1
Phenyl ether (vapor)	1	7
Phenyl ether-Biphenyl mixture (vapor)	1	7
Phenylethylene, see Styrene	--	--
Phenyl glycidyl ether (PGE)	10	60
Phenylhydrazine-Skin	5	22
Phosdrin (Mevinphos ®)-Skin	--	0.1
Phosgene (carbonyl chloride)	0.1	0.4
Phosphine	0.3	0.4
Phosphoric acid	--	1
Phosphorus (yellow)	--	0.1
Phosphorus pentachloride	--	1
Phosphorus pentasulfide	--	1
Phosphorus trichloride	0.5	3
Phthalic anhydride	2	12
Picric acid-Skin	--	0.1
Pival ® (2-Pivalyl-1, 3-indandione) ...	--	0.1
Plaster of Paris	--	D
Platinum (Soluble Salts) as Pt	--	0.002
Polytetrafluoroethylene decomposition products	--	A ²
Propane	E	--
β Propiolactone	--	A ¹
Propargyl alcohol-Skin	1	--
n-Propyl acetate	200	840
Propyl alcohol	200	500
n-Propyl nitrate	25	110
Propylene dichloride	75	350
Propylene imine-Skin	2	5
Propylene oxide	100	240
Propyne, see Methylacetylene	--	--
Pyrethrum	--	5
Pyridine	5	15
Quinone	0.1	0.4
RDX-Skin	--	1.5
Rhodium, Metal fume and dusts, as Rh	--	0.1
Soluble salts	--	0.001
Ronnel	--	10
Rotenone (commercial)	--	5
Rouge	--	D
Selenium compounds (as Se)	--	0.2
Selenium hexafluoride	0.05	0.4
Silicon carbide	--	D

i) According to analytically determined composition.

Capital letters refer to Appendices.

* 1970 Addition

** See Notice of Intended Changes

Substance	ppm ^{a)}	mg/M ³ b)
Silver, metal and soluble compounds .	--	0.01
Sodium fluoroacetate (1080)-Skin	--	0.05
Sodium hydroxide	--	2
Stibine	0.1	0.5
Starch	--	D
* Stoddard solvent	200	1, 150
Strychnine	--	0.15
**C Styrene monomer (phenylethylene) ...	100	420
Sucrose	--	D
Sulfur dioxide	5	13
Sulfur hexafluoride	1, 000	6, 000
Sulfuric acid	--	1
Sulfur monochloride	1	6
Sulfur pentafluoride	0.025	0.25
Sulfuryl fluoride	5	20
Systox, see Demeton ®	--	--
2, 4, 5 T	--	10
Tantalum	--	5
TEDP-Skin	--	0.2
Teflon ® decomposition products	--	A ²
Tellurium	--	0.1
Tellurium hexafluoride	0.02	0.2
TEPP-Skin	--	0.05
C Terphenyls	1	9
1, 1, 1, 2-Tetrachloro-2, 2-di- fluoroethane	500	4, 170
1, 1, 2, 2-Tetrachloro-1, 2-di- fluoroethane	500	4, 170
1, 1, 2, 2-Tetrachloroethane-Skin ...	5	35
Tetrachloroethylene, see Per- chloroethylene	--	--
Tetrachloromethane, see Carbon tetrachloride	--	--
Tetrachloronaphthalene-Skin	--	2
Tetraethyl lead (as Pb)-Skin	--	0.100 j)
Tetrahydrofuran	200	590
Tetramethyl lead (as Pb)-Skin	--	0.150 j)
Tetramethyl succinonitrile-Skin	0.5	3
Tetranitromethane	1	8
Tetryl (2, 4, 6-trinitrophenyl- methylnitramine)-Skin	--	1.5
Thallium (soluble compounds)-Skin as Tl	--	0.1
Thiram	--	5
Tin (inorganic cmpds, except SnH ₄ and SnO ₂)	--	2
Tin (organic cmpds)	--	0.1
Tin oxide	--	D
Titanium dioxide	--	D
Toluene (toluol)	200	750
C Toluene-2, 4-diisocyanate	0.02	0.14
o-Toluidine-Skin	5	22
Toxaphene, see Chlorinated camphene	--	--
Tributyl phosphate	--	5
1, 1, 1-Trichloroethane, see Methyl chloroform	--	--
1, 1, 2-Trichloroethane-Skin	10	45

j) For control of general room air, biologic monitoring is essential for personnel control.

* 1970 Addition

** See Notice of Intended Changes

Substance	ppm ^{a)}	mg/M ³ b)
Trichloroethylene	100	535
Trichloromethane, see Chloroform ..	--	--
Trichloronaphthalene-Skin	--	5
1, 2, 3-Trichloropropane	50	300
1, 1, 2-Trichloro 1, 2, 2-tri- fluoroethane	1,000	7,600
Triethylamine	25	100
Trifluoromonobromomethane	1,000	6,100
* Trimethyl benzene	25	120
2, 4, 6-Trinitrophenol, see Picric acid	--	--
2, 4, 6-Trinitrophenylmethylnitramine, see Tetryl	--	--
Trinitrotoluene-Skin	--	1.5
Triorthocresyl phosphate	--	0.1
Triphenyl phosphate	--	3
Tungsten & compounds, as W		
Soluble	--	1
Insoluble	--	5
Turpentine	100	560
Uranium (natural) sol. & insol. compounds as U	--	0.2
C Vanadium (V ₂ O ₅ dust)	--	0.5
(V ₂ O ₅ fume)	--	0.1
Vinyl benzene, see Styrene	--	--
**C Vinyl chloride	500	1,300
Vinylcyanide, see Acrylonitrile	--	--
Vinyl toluene	100	480
Warfarin	--	0.1
Xylene (xylol)	100	435
Xylidine-Skin	5	25
Yttrium	--	1
Zinc chloride fume	--	1
Zinc oxide fume	--	5
Zirconium compounds (as Zr)	--	5

Radioactivity: For permissible concentrations of radioisotopes in air, see U.S. Department of Commerce, National Bureau of Standards, Handbook 69, "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure," June 5, 1959. Also, see U.S. Department of Commerce National Bureau of Standards, Handbook 59, "Permissible Dose from External Sources of Ionizing Radiation," September 24, 1954, and addendum of April 15, 1958.

* 1970 Addition

** See Notice of Intended Changes

MINERAL DUSTS

Substance	m.p.p.c.f. ^{e)}
SILICA	
Crystalline	
** Quartz, Threshold Limit calculated from the formula	$\frac{250 f)}{\%SiO_2 + 5}$
** Cristobalite " " "	
Amorphous, including natural diatomaceous earth	20
SILICATES (less than 1% crystalline silica)	
** Asbestos, all types	5
Mica	20
Portland Cement	50
Soapstone	20
Talc (non-asbestiform)	20
Talc (fibrous), use asbestos limit	--
Tremolite, see asbestos	--
Graphite (natural)	15
** "Inert" or Nuisance Particulates	50 (or 15 mg/M ³ whichever is the smaller) of total dust < 1% SiO ₂
see Appendix D	

Conversion factors

mppcf x 35.3 = million particles per cubic meter
= particles per c. c.

5 million particles / cu ft

e) Millions of particles per cubic foot of air, based on impinger samples counted by light-field technics.

f) The percentage of crystalline silica in the formula is the amount determined from airborne samples, except in those instances in which other methods have been shown to be applicable.

** See Notice of Intended Changes for Mineral Dusts.

NOTICE OF INTENDED CHANGES (for 1970)

These substances, with their corresponding values, comprise those for which either a limit has been proposed for the first time, or for which a change in the "Adopted" listing has been proposed. In both cases, the proposed limits should be considered trial limits that will remain in the listing for a period of at least two years. During this time, the previously Adopted Limit will remain in effect. If, after two years no evidence comes to light that questions the appropriateness of the values herein, the values will be placed in the "Adopted" list. Documentation is available for each of these substances.

Substance	ppm	mg/M ³
2-Acetylaminofluorene-Skin	--	A ¹
+ Allyl glycidyl ether	5	22
4-Aminodiphenyl-Skin	--	A ¹
+ Ammonia	25	18
+ Ammonium chloride fume	--	10
Asphalt (petroleum) fumes	--	5
+ Butyl lactate	1	5
+ Camphor (synthetic)	2	12
+ Diazinon-Skin	--	0.1
+ 2-N Dibutylamino ethanol-Skin	2	14
Dichlorobenzidine-Skin	--	A ¹
+ Diethylene triamine-Skin	1	4
4-Dimethylaminoazobenzene	--	A ¹
Fibrous glass	g) --	D
+ C Formaldehyde	2	3
+ Iron pentacarbonyl	0.01	0.08
+ Mercury (Alkyl compounds) - Skin	--	0.01
+ Mercury (all forms except alkyl)	--	0.05
+ Methyl chloride	100	210
Methyl 2-cyanoacrylate	2	8
+ Methylcyclopentadienyl manganese tricarbonyl (as Mn)	0.1	0.2
Methyl demeton-Skin	--	0.5
Methyl parathion-Skin	--	0.2
Phenothiazine-Skin	--	5
+ Rosin Core Solder, pyrolysis products	--	0.1 (as aldehyde)
Styrene	100	420
+ C Subtilisins (Proteolytic enzymes)	--	0.0003 (as 100% pure crystal- line en- zyme)
+ Vanadium (V ₂ O ₅ Fume) as V	--	0.05
Vinyl acetate	10	30
+ Vinyl chloride	200	770
+ Wood dust (non allergenic)	--	5

+ 1970 Revision or Addition
Capital letters refer to Appendices
g) < 5-7 μ Diameter. No TLV for coarse fibrous glass has yet been set.

NOTICE OF INTENDED CHANGES (Cont'd) **MINERAL DUSTS**

<u>SUBSTANCE</u>	<u>TLV</u>
+ Asbestos (All types)	5 fibers/ml > 5 μ in length ^k
+ Coal dust (bituminous)	2 mg/m ³ (respirable dust) ^m
Cristobalite	Use one-half the value calculated from the count or mass formulae for quartz.
+ 'Inert' or Nuisance Particulates	10 mg/M ³ or 30 mppcf (whichever is the smaller) of total dust < 1% SiO ₂ ⁿ
+ Quartz	TLV in mppcf: $\frac{300}{\%SiO_2 + 10}$
	TLV for respirable dust in mg/m ³ : $\frac{10 \text{ mg/M}^3 \text{p)}}{\% \text{ Respirable quartz} + 2}$
	TLV for "total dust", respirable and nonrespirable: $\frac{30 \text{ mg/M}^3}{\% \text{ quartz} + 3}$
Silica, fused	Use quartz formulae
Tridymite	Use one-half the value calculated from formulae for quartz.

+ 1970 Revision or Addition

- k) As determined by the membrane filter method at 430 X magnification phase contrast illumination. Concentrations > 5 fibers/ml, but not to exceed 10, may be permitted for 15-minute periods each hour up to five times daily.
- m) "Respirable" dust as defined by the British Medical Research Council Criteria (1) and as sampled by a device producing equivalent results (2).
 - (1) Hatch, T.E. and Gross, P., Pulmonary Deposition and Retention of Inhaled Aerosols, p. 149. Academic Press, New York, New York, 1964.
 - (2) Interim Guide for Respirable Mass Sampling, AIHA Aerosol Technology Committee, AIHA J. 31, 2, 1970, p. 133.
- n) This automatically reduces all particulate substances in Adopted list with TLV of 15 mg/M³ to 10 mg/M³.
- p) Both concentration and per cent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics:

<u>Aerodynamic Diameter (μ)</u> <u>(unit density sphere)</u>	<u>% passing selector</u>
< 2	90
2.5	75
3.5	50
5.0	25
10	0

APPENDIX A

- A¹ Because of the high incidence of cancer, either in man or in animals, no exposure or contact by any route, respiratory, oral or skin should be permitted for the compounds:

2-Acetylaminofluorene	beta-Naphthylamine
4-Aminodiphenyl	4-Nitrodiphenyl
Benzidine & its salts	N-Nitrosodimethylamine
Dichlorobenzidine	beta-Propiolactone
4-Dimethylaminoazobenzene	

Because of the extremely high incidence of bladder tumors in workers handling beta-naphthylamine and the potential carcinogenic activity of the other compounds, the State of Pennsylvania prohibits the manufacture, use and other activities that involve human exposure without express approval by the Department of Health.

- A² **Polytetrafluoroethylene* decomposition products.** Thermal decomposition of the fluorocarbon chain in air leads to the formation of oxidized products containing carbon, fluorine and oxygen. Because these products decompose in part by hydrolysis in alkaline solution, they can be quantitatively determined in air as fluoride to provide an index of exposure. No TLV is recommended pending determination of the toxicity of the products, but air concentrations should be minimal.
- A³ **Gasoline and/or Petroleum Distillates.** The composition of these materials varies greatly and thus a single TLV for all types of these materials is no longer applicable. In general, the aromatic hydrocarbon content will determine what TLV applies. Consequently the content of benzene, other aromatics and additives should be determined to arrive at the appropriate TLV (Elkins, et al. A.I.H.A.J. 24, 99, 1963).

* Trade Names: Algoflon, Fluon, Halon, Teflon, Tetran

APPENDIX B

B.1 THRESHOLD LIMIT VALUES FOR MIXTURES

When two or more hazardous substances are present, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of

information to the contrary, the effects of the different hazards should be considered as additive. That is, if the sum of the following fractions,

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots + \frac{C_n}{T_n}$$

exceeds unity, then the threshold limit of the mixture should be considered as being exceeded. C_1 indicates the observed atmospheric concentration, and T_1 the corresponding threshold limit, (See Example 1A.a.).

Exceptions to the above rule may be made when there is good reason to believe that the chief effects of the different harmful substances are not in fact additive, but independent as when purely local effects on different organs of the body are produced by the various components of the mixture. In such cases the threshold limit ordinarily is exceeded only when at least one member of the series ($\frac{C_1}{T_1}$ or $\frac{C_2}{T_2}$ etc.) itself has a value exceeding unity, (See Example 1A.b.).

Antagonistic action or potentiation may occur with some combinations of atmospheric contaminants. Such cases at present must be determined individually. Potentiating or antagonistic agents are not necessarily harmful by themselves. Potentiating effects of exposure to such agents by routes other than that of inhalation is also possible, e.g. imbibed alcohol and inhaled narcotic (trichloroethylene). Potentiation is characteristically exhibited at high concentrations, less probably at low.

When a given operation or process characteristically emits a number of harmful dusts, fumes, vapors or gases, it will frequently be only feasible to attempt to evaluate the hazard by measurement of a single substance. In such cases, the threshold limit used for this substance should be reduced by a suitable factor, the magnitude of which will depend on the number, toxicity and relative quantity of the other contaminants ordinarily present.

Examples of processes which are typically associated with two or more harmful atmospheric contaminants are welding, automobile repair, blasting, painting, lacquering, certain foundry operations, diesel exhausts, etc., (Example 2.)

THRESHOLD LIMIT VALUES FOR MIXTURES EXAMPLES

1A. General case, where air is analyzed for each component

- a. Additive effects. (note: It is essential that the atmosphere be analyzed both qualitatively and quantitatively for each component present, in order to evaluate compliance or noncompliance with this calculated TLV.)

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \dots = 1$$

Example No. 1: Air contains 5 ppm of carbon tetrachloride (TLV = 10 ppm) 20 ppm of ethylene dichloride (TLV = 50 ppm) and 10 ppm of ethylene dibromide (TLV = 25 ppm)

Atmospheric concentration of mixture =

$$5 + 20 + 10 = 35 \text{ ppm of mixture}$$

$$\frac{5}{10} + \frac{20}{50} + \frac{10}{25} = \frac{25 + 20 + 20}{50} = 1.3$$

Threshold Limit is exceeded. Furthermore, the TLV of this mixture may be calculated by reducing the total fraction to 1.0; i.e.

$$\text{TLV of mixture} = \frac{35}{1.3} = 27 \text{ ppm}$$

Example No. 2: Air contains 200 ppm of hexane (TLV = 500 ppm) 100 ppm of methylene chloride (TLV = 500 ppm) and 20 ppm of perchlorethylene (TLV = 100 ppm)

Atmospheric concentration of mixture =

$$200 + 100 + 20 = 320 \text{ ppm of mixture}$$

$$\frac{200}{500} + \frac{100}{500} + \frac{20}{100} = \frac{200 + 100 + 100}{500} = \frac{400}{500} = 0.8$$

Threshold Limit is not exceeded. The TLV of this mixture = $\frac{320}{0.8} = 400 \text{ ppm}$

- 1B. Special case when the source of contaminant is a liquid mixture and the atmospheric composition is assumed to be similar to that of the original material; e.g. on a time weighted average exposure basis, all of the liquid (solvent) mixture eventually evaporates.

a. Additive effects (approximate solution)

1. The percent composition (by weight) of the liquid mixture is known, the TLVs of the constituents must be listed in mg/M³.

(NOTE: In order to evaluate compliance with this TLV, field sampling instruments should be calibrated, in the laboratory, for response to this specific quantitative and qualitative air-vapor mixture, and also to fractional concentrations of this mixture; e.g., 1/2 the TLV; 1/10 the TLV; 2 X the TLV; 10 X the TLV; etc.)

$$\text{TLV of mixture} = \frac{1}{\frac{f_a}{\text{TLV}_a} + \frac{f_b}{\text{TLV}_b} + \frac{f_c}{\text{TLV}_c} + \dots + \frac{f_n}{\text{TLV}_n}}$$

Example No. 1: Liquid solvent contains (by weight) 50% heptane (TLV = 2000 mg/M³) 30% methylene chloride (TLV = 1740 mg/M³) 20% perchlorethylene (TLV = 670 mg/M³)

$$\begin{aligned} \text{TLV of mixture} &= \frac{1}{\frac{0.5}{2000} + \frac{0.3}{1740} + \frac{0.2}{670}} = \frac{1}{.00025 + .00017 + .0003} \\ &= \frac{1}{.00072} = 1390 \text{ mg/M}^3 \end{aligned}$$

Of this mixture: 50% or 695 mg/M³ is heptane, 30% or 417 mg/M³ is methylene chloride and 20% or 278 mg/M³ is perchlorethylene

These values can be converted to ppm as follows:

heptane: $2000 \text{ mg/M}^3 = 500 \text{ ppm}$
 $1 \text{ mg/M}^3 = 0.25 \text{ ppm}$
 $695 \text{ mg/M}^3 = 174 \text{ ppm}$

methylene chloride: $1740 \text{ mg/M}^3 = 500 \text{ ppm}$
 $1 \text{ mg/M}^3 = 0.287 \text{ ppm}$
 $417 \text{ mg/M}^3 = 119 \text{ ppm}$

$$\begin{aligned}\text{perchloroethylene: } 670 \text{ mg/M}^3 &= 100 \text{ ppm} \\ 1 \text{ mg/M}^3 &= 0.15 \text{ ppm} \\ 278 \text{ mg/M}^3 &= 42 \text{ ppm}\end{aligned}$$

The TLV of this mixture = $174 + 119 + 42 = 335 \text{ ppm}$.

1B.b. General Exact Solution for Mixtures of N Components With Additive Effects and Different Vapor Pressures.

$$(1) \frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots + \frac{C_n}{T_n} = 1;$$

$$(2) C_1 + C_2 + \dots + C_n = T;$$

$$(2.1) \frac{C_1}{T} + \frac{C_2}{T} + \dots + \frac{C_n}{T} = 1.$$

By the Law of Partial Pressures,

$$(3) C_1 = ap_1,$$

and by Raoult's Law,

$$(4) p_1 = F_1 p_1^0.$$

Combine (3) and (4) to obtain

$$(5) C_1 = aF_1 p_1^0.$$

Combining (1), (2, 1) and (5), we obtain

$$\begin{aligned}(6) \quad & \frac{F_1 p_1^0}{T} + \frac{F_2 p_2^0}{T} + \dots + \frac{F_n p_n^0}{T} = \\ & \frac{F_1 p_1^0}{T_1} + \frac{F_2 p_2^0}{T_2} + \dots + \frac{F_n p_n^0}{T_n}\end{aligned}$$

and solving for T,

$$(6.1) \quad T = \frac{\frac{F_1 p_1^0}{T_1} + \frac{F_2 p_2^0}{T_2} + \dots + \frac{F_n p_n^0}{T_n}}{\frac{F_1 p_1^0}{T} + \frac{F_2 p_2^0}{T} + \dots + \frac{F_n p_n^0}{T}}$$

$$\text{or } \sum_{i=1}^n F_i p_i^0$$

$$(6.2) \quad T = \frac{\sum_{i=1}^n F_i p_i^0}{\sum_{i=1}^n F_i p_i^0}$$

$$i = 1 \quad \frac{F_1 p_1^0}{T_1}$$

T = Threshold Limit Value in ppm.
 C = Vapor concentration in ppm.
 p = Vapor pressure of component in solution.
 p^0 = Vapor pressure of pure component.
 F = Mol fraction of component in solution.
 a = A constant of proportionality.

Subscripts 1, 2, . . . n relate the above quantities to components 1, 2, . . . n, respectively.

Subscript i refers to an arbitrary component from 1 to n.

Absence of subscript relates the quantity to the mixture.

- 1B.c. Solution to be applied when there is a reservoir of the solvent mixture whose composition does not change appreciably by evaporation.

Exact Arithmetic Solution of Specific Mixture

		Mol. wt.	Density	TLV	p^0 at 25°C	Mol fraction in half-and- half solution by volume
Trichloro- ethylene	(1)	131.4	1.46g/ml	100	73mmHg	0.527
Methylchloro- form	(2)	133.42	1.33g/ml	350	125mmHg	0.473

$$F_1 p_1^0 = (0.527) (73) = 38.2$$

$$F_2 p_2^0 = (0.473) (125) = 59.2$$

$$TLV = \frac{38.2 + 59.2}{\frac{38.2}{100} + \frac{59.2}{350}} = \frac{(97.4) (350)}{133.8 + 59.2} = \frac{(97.4) (350)}{193.0} = 177$$

TLV = 177 ppm (Note difference in TLV when account is taken of vapor pressure and mol fraction in comparison with above sample where such account is not taken.)

2. A mixture of one part of (1) parathion (TLV, 0.1) and two parts of (2) EPN (TLV, 0.5).

$$\frac{C_1}{0.1} + \frac{C_2}{0.5} = \frac{C_m}{T_m} \quad C_2 = 2C_1$$

$$C_m = 3C_1$$

$$\frac{C_1}{0.1} + \frac{2C_1}{0.5} = \frac{3C_1}{T_m}$$

$$\frac{7C_1}{0.5} = \frac{3C_1}{T_m}$$

$$T_m = \frac{1.5}{7} = 0.21 \text{ mg/M}^3$$

1C. TLV for Mixtures of Mineral Dusts.

For mixtures of biologically active mineral dusts the general formula for mixtures may be used.

For a mixture containing 80% talc and 20% quartz, the TLV for 100% of the mixture is given by:

$$TLV = \frac{1}{\frac{0.8}{20} + \frac{0.2}{2.5}} = 8.4 \text{ mppcf}$$

Essentially the same result will be obtained if the limit of the more (most) toxic component is used provided the effects are additive. In the above example the limit for 20% quartz is 10 mppcf.

For another mixture of 25% quartz, 25% amorphous silica and 50% talc:

$$TLV = \frac{1}{\frac{0.25}{2.5} + \frac{0.25}{20} + \frac{0.5}{20}} = 7.3 \text{ mppcf}$$

The limit for 25% quartz approximates 8 mppcf.

APPENDIX C

PERMISSIBLE EXCURSIONS FOR TIME-WEIGHTED AVERAGE (TWA) LIMITS

The Excursion TLV Factor in the Table automatically defines the magnitude of the permissible excursion above the limit for those substances not given a "C" designation; i.e., the TWA limits. Examples in the Table show that nitrobenzene, the TLV for which is 1 ppm, should never be allowed to exceed 3 ppm. Similarly, carbon tetrachloride, TLV 10 ppm, should never be allowed to exceed 20 ppm. By contrast, those substances with a "C" designation are not subject to the excursion factor and must be kept below the TLV.

These limiting excursions are to be considered to provide a 'rule-of-thumb' guidance for listed substances generally, and may not provide the most appropriate excursion for a particular substance. Efforts are being made to develop such specific excursions, when indicated to be significantly different from that recommended by the present excursion factors.

<u>Substance</u>	<u>TLV</u>	<u>Excursion Factor</u>	<u>Max. Conc. Permitted for short time</u>
Nitrobenzene	1 ppm	3	3 ppm
Carbon tetrachloride	10 ppm	2	20 ppm
Carbon monoxide	50 ppm	1.5	75 ppm
Acetone	1000 ppm	1.25	1250 ppm
Boron trifluoride	C 1 ppm	-	1 ppm
Butylamine	C 5 ppm	-	5 ppm
Styrene monomer	C 100 ppm	-	100 ppm

For all substances:

TLV = 0 - 1 (ppm or mg/m ³),	Excursion Factor	= 3
TLV = 1 - 10 "	" "	= 2
TLV = 10 - 100 "	" "	= 1.5
TLV = 100 - 1000 "	" "	= 1.25

BASIS FOR ASSIGNING LIMITING "C" VALUES

By definition in the Preface, a listed value bearing a "C" designation refers to a 'ceiling' value that should not be exceeded; all values should fluctuate below the listed value. This, in effect, makes the "C" designation a maximal allowable concentration (MAC). In general, the bases for assign-

ing or not assigning a "C" value rest on whether excursions of concentration above a proposed limit for periods up to 15 minutes may result in a) intolerable irritation, b) chronic, or irreversible tissue change, or c) narcosis of sufficient degree to increase accident proneness, impair self-rescue or materially reduce work efficiency.

APPENDIX D

Some "Inert" or Nuisance Particulates q)

Alundum (Al_2O_3)	Kaolin
Calcium carbonate	Limestone
Cellulose (paper fiber)	Magnesite
Portland Cement	Marble
Corundum (Al_2O_3)	Pentaerythritol
Emery	Plaster of Paris
Glycerine Mist	Rouge
Graphite (synthetic)	Silicon Carbide
Gypsum	Starch
Vegetable oil mists	Sucrose
(except castor, cashew	Tin Oxide
nut, or similar irritant	Titanium Dioxide
oils)	

q) When toxic impurities are not present, e. g. quartz <1%.

APPENDIX E

Some Simple Asphyxiants - "Inert" Gases and Vapors

Acetylene	Hydrogen
Argon	Methane
Ethane	Neon
Ethylene	Nitrogen
Helium	Nitrous Oxide
	Propane

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Brake Lining Decomposition Products

Jeremiah R. Lynch*

ABSTRACT

A number of investigators have found asbestos bodies in the lungs of urban residents who were not occupationally exposed to asbestos. A relationship between the carcinogenic properties of asbestos and the urban excess of lung cancer has been suggested. The decomposition products of brake linings have been described as a possible source of these fibers. Brake testing laboratory methods were used to test fiber emission from a variety of friction products. Only a very small fraction of the asbestos escaped as free fiber while the remainder was transformed into some other, non-fibrous, mineral. A significant release of free fiber occurred only under conditions extreme enough to produce brake failure.

*U. S. Public Health Service - Department of Health, Education and Welfare
Bureau of Disease Prevention and Environmental Control
National Center for Urban and Industrial Health
Occupational Health Program
1014 Broadway, Cincinnati, Ohio 45202

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Brake Lining Decomposition Products

Jeremiah R. Lynch*

Introduction

The occurrence of coated fibers referred to as "asbestos bodies" in the lungs of urban populations not occupationally exposed to asbestos has been noted by several investigators. The results of several autopsy series, as summarized by Cooper,⁽¹⁾ are shown in Table 1.⁽¹⁻⁶⁾ Thompson,⁽⁷⁾ in suggesting possible modes of exposure that could account for these bodies, stated "The average private motor vehicle wears out three or four sets of brake linings and one or two clutch linings in its lifetime, and commercial and public transport vehicles wear out many more. These linings consist largely of asbestos which is ground to dust as the linings wear, and most wear occurs in built-up areas. This alone in most cities would involve the discharge of many tons of asbestos dust and fibers in the streets each year". Since asbestos has been implicated as a carcinogen⁽⁸⁾ and lung cancer has a higher incidence⁽⁹⁾ among urban populations, the fate of the asbestos work from brake linings becomes significant.

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Table 1

Asbestos Bodies in Human Lungs

<u>Location</u>	<u>Year</u>	<u>% Positive</u>
Cape Town (2)	1963	26
Miami (2)	1965	27
Pittsburgh (3)	1965	41
Johannesburg (4)	1965	39
Finland (5)	1966	58
Montreal (6)	1966	48
San Francisco (1)	1966	42

Brake Lining Composition

The average composition of typical brake linings of the type tested is shown in Table 2. Individual mixes may vary considerably from these averages.

Table 2

Brake Lining Composition

<u>Ingredient</u>	<u>Automobile</u>	<u>Truck</u>
Asbestos	55	33
Resins and Polymers	28	48
Oxides and pigments	9	16
Metals	3	2
Carbon, graphite, etc.	<u>5</u>	<u>1</u>
	100%	100%

Each of these ingredients performs a particular function. The asbestos provides strength, heat resistance and selective decomposition under stress. The resins and polymers hold the other ingredients together. Various oxides are added as pigments and to improve the grip of the lining on the drum. Soft metals such as lead and brass improve wear while carbon and graphite serve as friction modifiers.

Brake lining quality depends to a large extent on the type of binder used. Linseed oil, which begins to decompose at about 450F, is used for light service brakes. More demanding service requires brakes made from cashew type resins or oil modified phenolic resins. These ingredients are mixed, either dry or with a solvent added, formed into shape and cured

in an oven. The hardened lining is then cut, ground and sanded to the precise dimensions of the finished linings. The dust produced by the abrading operations in asbestos friction product factories (Figure 1) contains free asbestos fibers that are similar to those in industries where cancer is known to be in excess⁽¹⁰⁾. The question to be resolved, therefore, is whether the dust produced by the normal wear of brake linings contains this same type of free asbestos fiber.

Test Methods

In an initial exploratory survey, the dust obtained from inside automobile brake drums removed for brake relining was examined by electron micrograph. Figure 2, which is typical of the series, does not reveal any free fibers. However, this finding did not eliminate the possibility that free asbestos fibers were released and that they had escaped into the atmosphere. To examine this hypothesis a series of experiments was devised to permit sampling decomposition products of the lining under simulated operating conditions. The tests (Table 3) were performed with the brake testing machines in the laboratory of a major brake lining manufacturer. Most of the tests were performed on a friction-testing machine which used one-inch-square samples of the test lining. Heating and cooling apparatus permitted control of drum temperature from those encountered with intermittent brake use to the maximum temperature which occurred only in extremely rapid or "panic" stops from high speed. Other tests were performed on a brake-testing dynamometer which subjected a complete

brake assembly to a series of stops and starts from different speeds and at different deceleration rates to simulate actual driving conditions.

In these tests the drum temperatures varied according to the driving condition simulated. During each run at a test condition, a sample was collected on an 0.8 ~~µ~~ pore size membrane filter. Electron micrographs of these filters were examined to determine the presence of free asbestos fibers and to quantify these fibers when more than a few occurred.

Table 3

Test Results by Electron Micrograph

Product	Brand	Test Method	No. of Samples	Conditions of Test-F	Presence of Free Fibers	% Free Fiber*
1. Automobile drum brakes	A	Friction	6	300-800	Few	<1
2. "	B	Friction	6	250-800	None	0
3. "	C	Friction	5	300-700	Few	<1
4. "	C	Friction	1	700-900	Numerous	~10
5. "	D French	Friction	5	300-800	Few	<1
6. "	E	Friction	5	300-700	Few	<1
7. "	F German	Friction	5	300-800	Few	<1
8. "	G	Friction	2	100-500	Few	<1
9. "	G	Friction	1	600-700	Numerous	~15
10. "	H	Friction	2	100-600	Few	<1
11. Automobile clutch	J	Dynamometer	1	normal driving	None	0
12. Automobile disk brake	K	Dynamometer	1	normal driving	Few	<5
13. Bus drum brake	L	Dynamometer	1	city driving	None	0
14. "	M	Friction	2	450-550	None	0
15. Truck drum brake (light)	F	Friction	10	300-800	Few	<1

*Weight estimated from fiber volume.

Results

The object of the tests was to determine what proportion of the asbestos known to be present in the lining appeared as free fiber in the decomposition product. No attempt was made at a mass balance between the material worn from the lining and the decomposition product since it was not possible to collect all of the decomposition product. However, the percentages obtained in the fraction of decomposition product examined are applicable to the total material worn from the brake and may be compared to the percentage of asbestos originally present.

In all but a few tests the automobile drum brake linings showed less than 1% free fiber in the decomposition product as compared to about 50% in the lining. An electron micrograph of the decomposition product obtained from a typical test in this group is shown in Figure 3. In those tests where a significant mass of free fiber was released (Figure 4), the temperature was in an extremely high range for the lining in question as evidenced by rapid drop in the coefficient of friction. Had these linings been subjected to like conditions in a vehicle, the brakes would have failed.

Similar results were obtained in the bus and truck drum brake tests and in the clutch test. The experimental model disk brake tested did release some (> 5%) free fibers, but no conclusion can be drawn from a single sample.

DISCUSSION

Except in all but the most extreme driving conditions, only a very small fraction of the 30 to 50% asbestos present in a brake lining escapes into the atmosphere as free fiber. The question remains: What happened to the asbestos? A prevalent theory of brake operation holds that wear occurs not by abrasion of the lining by the drum but by the production of minute areas of intense heat at the points of contact between the drum and the lining. Decomposition, not only of the binder but of the asbestos as well, occurs at these locations since the breakdown temperature of asbestos, about 900F, is exceeded. The decomposition products will thus include not free asbestos fibers, but a different mineral resulting from the thermal metamorphosis of the asbestos.

Some independent experiments done at a brake lining research laboratory⁽¹¹⁾ have shown that all of the magnesium present in the chrysotile asbestos originally in the lining can be accounted for in the decomposition products. However, the characteristic X-ray diffraction pattern of chrysotile asbestos had vanished. Thus, it is apparent that under conditions in which asbestos is worn from the lining of a brake, the asbestos is destroyed.

CONCLUSION

Only a very small proportion of the asbestos worn from brake linings is released as free fiber; the remainder is converted into some other mineral as a result of the extreme temperatures generated at small spots on the lining surface. Thus, although urban air contains a few free fibers as a result of brake lining wear, they represent a very small proportion of the total asbestos used in the manufacture of brakes. Many sources of respirable fibers not associated with asbestos products have been identified⁽¹²⁾ and the free fibers from brake lining wear appear to be an inconsequential health factor in urban air pollution.

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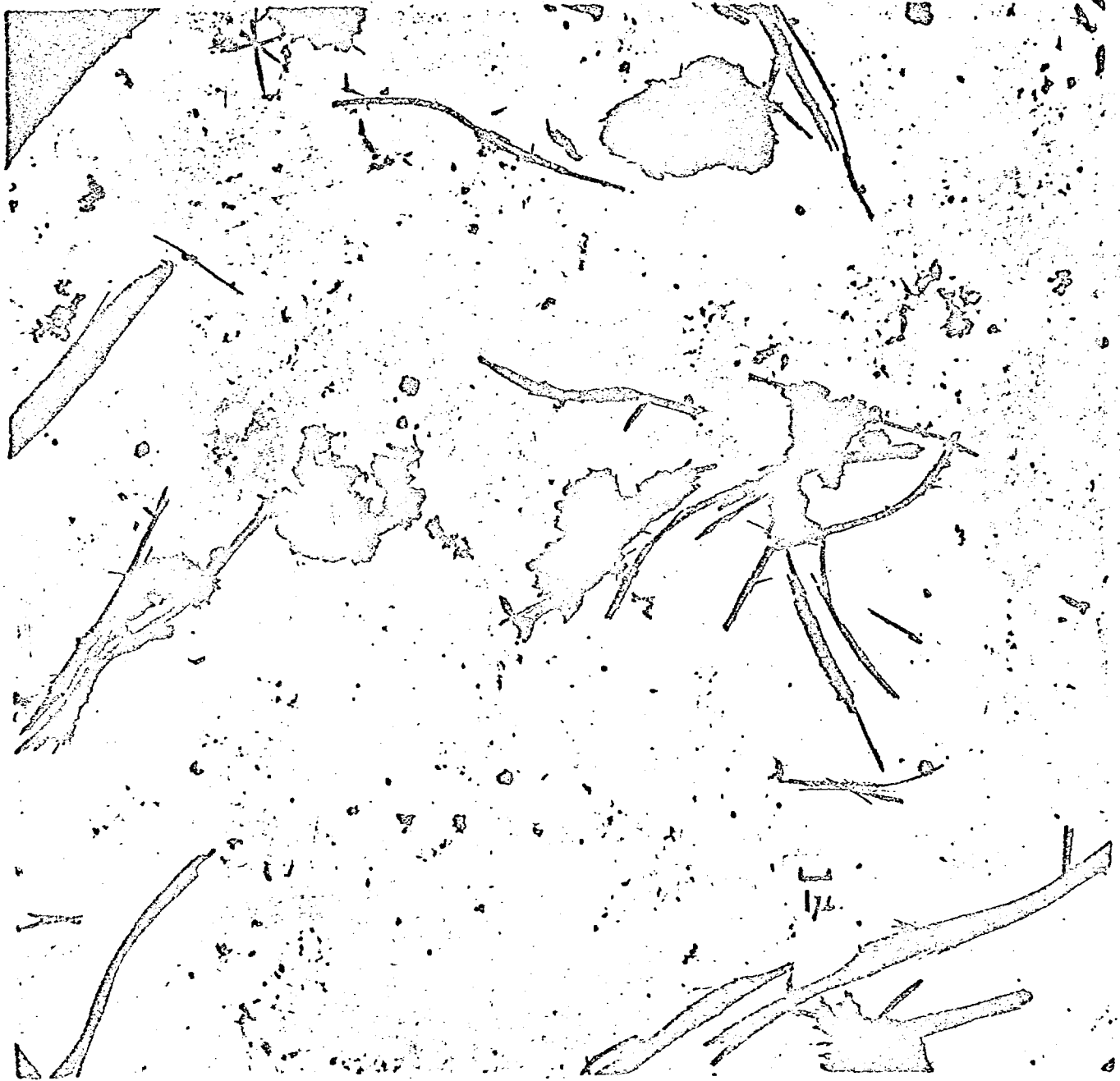


Figure 1. Brake lining factory dust.

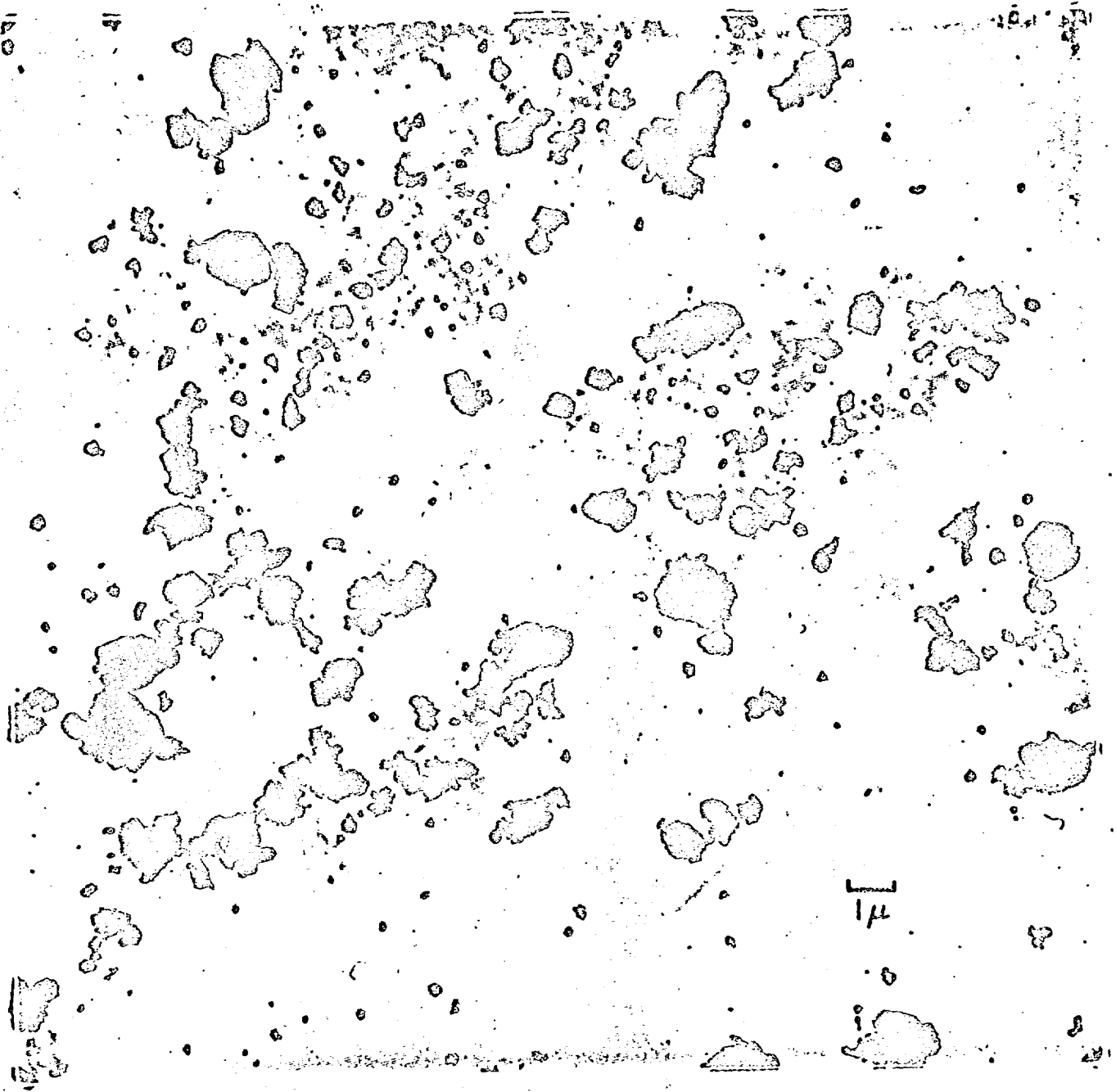


Figure 2. Dust removed from brake drum.

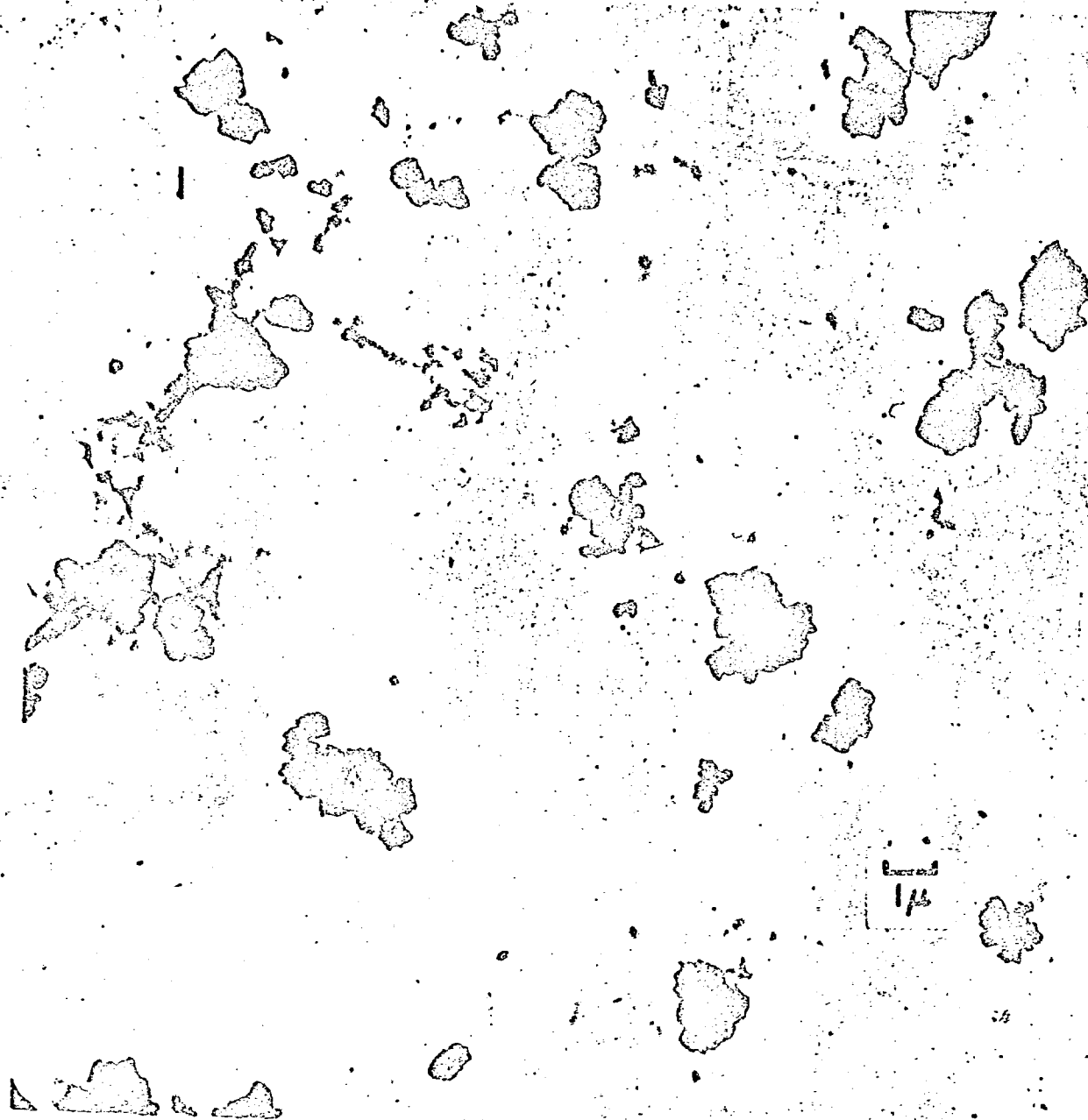


Figure 3. Decomposition product from normal wear of brake lining.

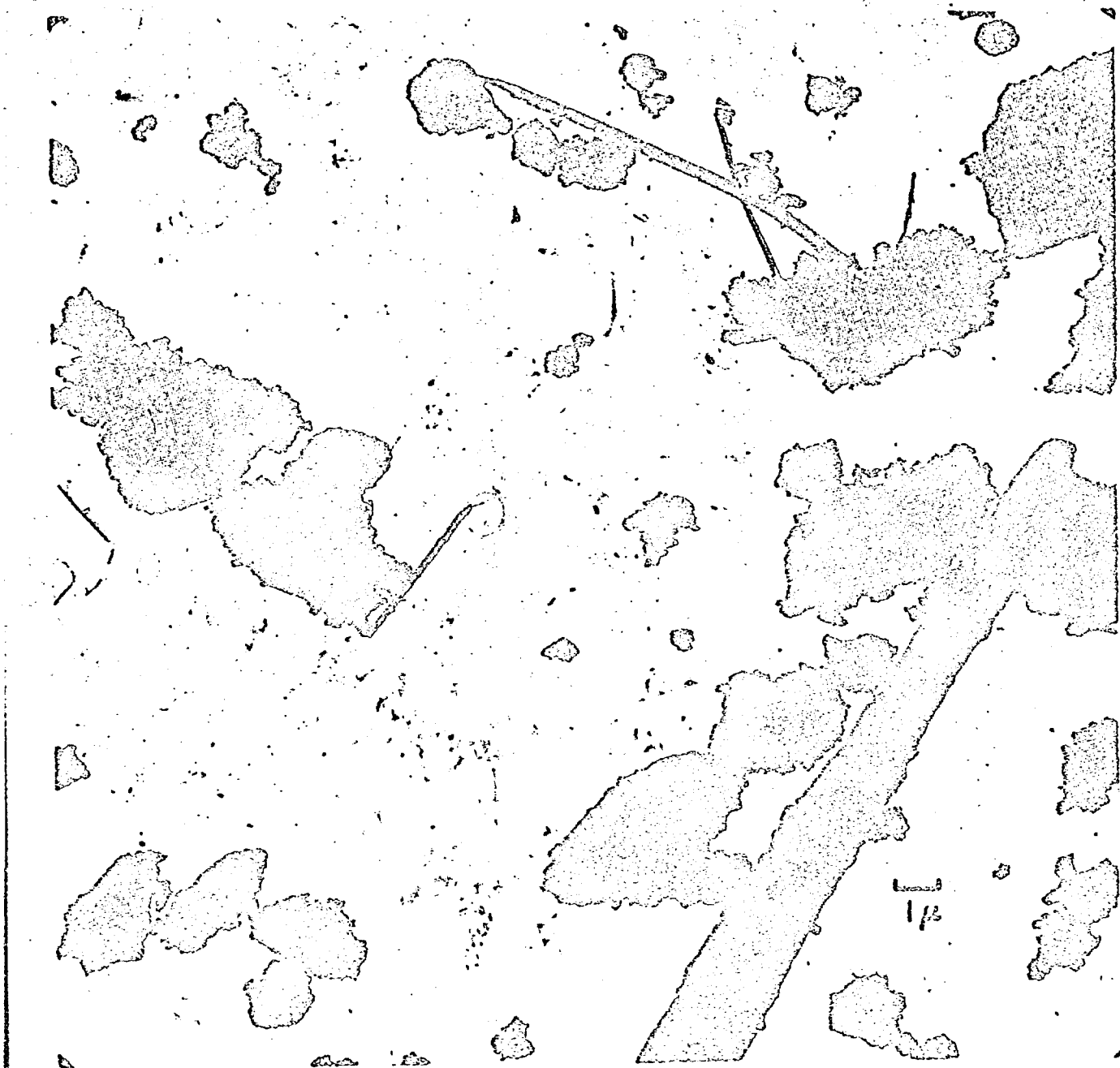


Figure 4. Decomposition product from
brake lining at failure.

DR. W. J. NICHOLSON TESTIMONY
IPCB HEARING
CHICAGO, OCT. 15, 1971

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Thank you very much for the opportunity to appear in support of your regulations controlling the use and production of asbestos materials and spray insulation.

For purposes of identification, my name is William J. Nicholson. I am Assistant Professor of Community Medicine at the Mount Sinai School of Medicine of the City University of New York. As a physicist, I have served as coordinator of several projects undertaken by the Environmental Sciences Laboratory of Mount Sinai to evaluate the effects of asbestos exposure. These include an industrial hygiene research program designed to identify and control asbestos hazards in the insulation industry, the development of analytical techniques for the quantitation of asbestos in ambient air, and a study of asbestos air pollution in New York City and throughout the United States. Additionally, I am engaged in several epidemiological studies of disease associated with occupation or environmental exposures to various substances. Two of these studies involve the effects of asbestos on defined populations.

The justification is strong for controlling the use of asbestos on basis of the health effects produced by its use in the past. The evidence that heavy occupational exposure to asbestos is associated with pulmonary disease dates from 1900 when massive fibrosis was found at post mortem in the lungs of a man who was the last survivor of a group of 10 men who worked since 1886 in the carding room of an asbestos textile mill. Cases of asbestos-induced scarring of the lungs, asbestosis, were seen with increasing frequency in subsequent years as the use of asbestos increased. However, a hint of additional disease risk from occupational asbestos exposure was seen in 1935. Two cases of lung cancer were found in individuals having asbestosis. This portent was grimly verified in

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later studies. In 1947, the Chief Inspector of Factories in Britain found lung cancer in 13 per cent of deaths in which asbestosis was present.

To bring us up to date, 70 years after the first knowledge of asbestos disease, and to complete the picture of occupational risk from exposure to asbestos, let me present some data obtained by Dr. Irving J. Selikoff, Director of the Environmental Sciences Laboratory, Mount Sinai School of Medicine. He has followed since January 1, 1943 the 632 members of the New York and New Jersey Locals of the asbestos workers union, the International Association of Heat and Frost Insulators and Asbestos Workers. These men apply the insulation to high temperature pipes and boilers in apartment, office building and individual plants. Some of the material they use contains a small amount of asbestos -- 7 to 15 per cent, usually. Often it contains none. In comparison to the factory exposures during early decades of this century, their exposures are relatively light.

Knowing their ages in 1943 and using standard tables, it was possible to calculate the expected mortality experience of these 632 workers. This was done by Dr. E. Cuyler Hammond, Chief Epidemiologist of the American Cancer Society, and the results, along with those actually seen, are given in Table I for the years 1943 through 1962.

From all causes, 203 deaths were expected of those who had worked 20 years. In fact, there were 255. More than 50 men who died should not have died. Looking at the table, we can see the causes of these "excess death": 45 died of cancer of the lung, trachea and pleura where only six or seven were expected; 12 died of asbestosis although none

should have died; three times as many died of cancer of the G. I. tract as were expected.

Results of continued observation of the group through June 30, 1971 are shown in Tables II and III. They represent a catastrophe. Over half of the deaths were from some form of cancer or asbestosis. Nearly 40% could be termed "occupational" deaths.

In these latter data, special reference should be made to the high death rate from mesothelioma. Twenty-seven cases of this, as yet, incurable disease were seen. A diffuse cancer of the lining of the chest or abdomen, it is so rare that it has yet to be separately classified in the International Classification of Causes of Death. Its occurrence in the general population may be so infrequent as to cause only one death in 10,000. Here, it was the cause of death in one of every 16 individuals. Moreover, in other studies, its appearance in increased amounts has always been associated with asbestos exposure.

Two other aspects of the research by Doctor Selikoff are important. The first is the evidence of the long lapsed period between onset of asbestos exposure and the incidence of disease. Lung cancer usually appears between 20 and 40 years after first exposure to asbestos, and mesothelioma most often after a 35-year lapsed period.

The second aspect is the strong synergism found between asbestos exposure and cigarette smoking in the incidence of lung cancer. By personal interview in 1962, the smoking habits of 370 of the 632 men were established. By following the mortality experience of these 370 men, a special risk of cigarette smoking was established. From January 1, 1963 through February 1, 1971, in 283 men with a history of cigarette smoking, 40 lung cancers were observed. This is nearly ten times the number ex-

pected in an equivalent cigarette smoking population. In 87 non-smokers, only one lung cancer was seen. Thus, it is not asbestos alone, or cigarette smoking alone, but the combination of the two that produced these grim data. In fact, it is calculated that asbestos workers who smoke run more than 90 times the risk of dying of lung cancer than men who neither smoke cigarettes nor work with asbestos.

These data I have presented to you were from occupational exposures to asbestos. At most, 200,000 men and women in the United States have such exposures. Hopefully, 70 years after the first awareness of asbestos disease, working conditions will be improved to reduce their risk of disease. But were this the only risk of asbestos exposure, it would not be germane to the regulations under consideration here. Unfortunately, in recent years the evidence has accumulated that the problem of asbestos disease has disseminated from the occupational area into the general environment.

Evidence is accumulating that mesothelioma is rapidly increasing among men who worked in the vicinity of asbestos application. Recall that mesothelioma is virtually nonexistent in people who have had no exposure to asbestos. In Holland, 22 cases were found during a 6-year period in workers of the de Shelde shipyard. These cases occurred, however, not in asbestos workers, but in members of other trades, welders, carpenters, or painters, all of whom only worked in an area where asbestos insulation was applied or removed. Similar data have appeared from Great Britain. Here, 80 cases of mesothelioma were found in a survey of the material in the pathology departments of Scottish hospitals and medical schools from the years 1950 through 1967. An investigation of the occupational background of these cases revealed a strong association

with shipbuilding or marine work. Here again, however, the cases were not often found in insulators but in other trades working near the application or removal of asbestos. A further disconcerting feature of the Scottish data is the rapid rise in the rate of occurrence of mesothelioma; 51 of the 80 cases were seen in the years 1964-67, approximately 30 years after the extensive shipbuilding undertaken during World War II.

The spectrum of disease associated with asbestos now extends even to environmental exposures. In 1960, Wagner, Sleggs and Marchand described 47 cases of mesothelioma found during a four-year period in the northern Cape province of South Africa, an area with extensive crocidolite asbestos mines. None were seen in the neighboring Transvaal Province or in 10,000 autopsy cases of workers who had died with known exposures to silica. Of the 47 cases, approximately half were found to have had either industrial or mining exposures to asbestos. Virtually all of the remaining cases were in individuals who simply lived or worked in the vicinity of the asbestos mines or mills.

Confirmation of the possibility of environmental asbestos-associated disease soon appeared. Newhouse and Thompson reviewed all mesothelioma cases at the London Hospital. They corroborated the close association with asbestos, 31 of the 76 cases having had documented occupational exposure. Of the remainder, 11 had lived, decades before, within one-half mile of an asbestos factory. A similar distribution of cases was found by Lieben and Pistawka in Pennsylvania. One insidious form of indirect asbestos exposure is that of families of asbestos workers. In the previously mentioned studies, 9 of the London mesotheliomas were in family members, as were 3 of the 46 Pennsylvania cases.

Unfortunately, these data on the incidence of mesothelioma from environmental or indirect occupational exposure to asbestos are severely limited. The exposures in question took place beginning 20, 30, 40 or more years ago. No knowledge exists of the associated asbestos dust exposure levels. Thus, we have no dose-response information on low-level asbestos exposure. We only have knowledge of a potential risk of cancer, at exposures much below occupational ones. Obviously, additional research and continued surveillance are highly desirable.

Let us now turn to specific items in your regulations. Firstly, the general requirements of Section 2 are excellent, particularly with regard to responsibility and education. We find a great problem to be the ignorance of a potential hazard among marginal users of asbestos. Such ignorance can easily result in lax procedures.

Secondly, the banning of asbestos in spray insulation is entirely appropriate. In New York City we have found this to be a major contributor to ambient air asbestos levels. For the past 10 years, during which spray fireproofing came to be extensively used, it was not uncommon to see extensive snowfalls of asbestos-containing material over widespread areas of New York and other metropolitan centers. In some cases, the fireproofing was even done with no attempt to enclose the spray area by tarpaulins or other means.

To verify that such fireproofing operations were a significant source of respirable asbestos fiber, air sampling was conducted in lower Manhattan about construction sites where extensive spraying of asbestos-containing fireproofing was taking place. This work was done by our Laboratory in conjunction with the Department of Air Resources of New York City. The results demonstrated that spray fireproofing can indeed con-

tribute significantly to asbestos air pollution.

Up to $\frac{1}{4}$ mile away, levels exceeding 0.1 micrograms per cubic meter were observed, which exceeds by 100 times background levels found in urban areas distant from construction sites. While 0.1 micrograms may appear to be a small amount, it could represent more than 10 million minute fibers of asbestos. Moreover, the large clumps of asbestos-containing material covering the sidewalk serve as a continuing source to be dispersed by passersby.

As I mentioned earlier, lacking a dose-response relationship, we cannot state that environmental exposure levels from this practice are certain to produce disease. However, it is hard to imagine factory emissions, even 40 years ago, being more excessive. Since the extensive spraying of asbestos-containing fireproofing material has only existed in the construction industry for the last 10 years, disease caused by the exposure resulting from this practice is 10 or 20 years away. However, continuing the uncontrolled spraying practices of the past decade in the face of the mounting evidence of risk to all metropolitan residents would be playing asbestos roulette with the lives of millions of people.

This method of fire protection for high rise buildings presents an additional, continuing risk to the occupants of those buildings. Often, the space between the false room ceiling and the under side of the floor above, which has been sprayed with asbestos, serves as a return plenum for the air supply system. After filtration, inadequate to remove most asbestos fibers that may have eroded into the air stream, this return air is recirculated throughout the building. The magnitude of this problem has yet to be defined. Until recently in New York City, we have not been allowed to analyze the air in buildings that has been in direct contact

with asbestos-containing insulation.

Finally, this spray procedure leaves a legacy of potential risk to future generations. The lifetime of modern office buildings is short and the procedures for the safe future demolition of buildings that could contain more than 100 tons of asbestos as fireproofing have yet to be developed. Perhaps these procedures will be found and perhaps they will be followed but we have no such assurance at this time.

Unfortunately, safe procedures developed for the spray application of asbestos-containing materials have not been followed either voluntarily or under control regulations by contractors. Because of this failure and because alternative procedures or materials are available, action banning this use of asbestos is indeed appropriate.

Moreover, because of uncertain knowledge of the health effects of exposure to mineral fibers other than asbestos, it is entirely appropriate that strict control be exercised over other spraying of such substitute materials. While some forms of "mineral wool" and other mineral fibers have been in use since the 1930s there are still no definitive studies on exposed populations that would, at this time, provide assurance that respirable mineral fibers, other than asbestos, are biologically inert in humans. In the absence of such assurance, caution is warranted and I support, in its entirety, Section 3 of your regulations.

On the other items, in Section 4, you might wish to add a qualifying statement that when there is potential release of asbestos to the air, a special enclosure shall be used. Many asbestos products used in construction can be installed with no release of fiber. Asbestos-vinyl floor tile is one example. In fact, with proper procedures, even asbestos cement can be applied with minimal release of fiber.

I cannot emphasize too strongly the need for stringent controls during demolition. Those listed here may not be adequate and close surveillance should be maintained to verify their adequacy. For example, I am not sure that any asbestos should be transported via chutes to trucks. It is hard to imagine that the debris would be completely wetted.

In reference to Section 6 A, I would like to raise some of the problems associated with air monitoring which may be severe. In ambient air samples, it is difficult, and often impossible, to identify asbestos fibers by optical microscopy alone. There are many birefringent fibers with a similar appearance. Even the sampling of stacks containing only asbestos has its problems. Such sampling does not evaluate any emissions from windows, room exhausts or uncontrolled sources. Moreover, the use of optical microscopy can misestimate actual concentrations, even assuming accurate counting of all fibers longer than 5 microns. Often as many as 100 times more fibers shorter than 5 microns may be present. If those counted were a constant fraction of the total present, this would be no problem. However, such is not the case. In different uses of chrysotile we have found the ratio of the number of fibers longer than 5 microns to the total number to vary from 1/250 to 1/20. Since bag houses have a size dependent efficiency, the results obtained by optical analysis may be misleading and not comparable to other samples analyzed by similar means.

The only way to accurately assess environmental exposures is by electron microscopy. Here, however, an analysis may cost \$200 - \$300 and be very time-consuming. You may wish to consider procedural controls with the requirement of no visible emissions of asbestos from any building or site. If the facility inspected questions the judgement of an inspector they could pay for adequate air analysis by electron microscopy.

I enclose in Table IV data from our work analyzing samples of ambient air from nearby 50 U. S. cities. These data show that a background of some asbestos fiber is found in all cities, but occasional peaks appear. From this occasional occurrence and from the fiber size distribution on high samples, it appears that the contribution of some specific source is important in these high levels.

Finally, one comment on the proposed ban of asbestos in brake linings after 1975. The problem here is there is a dearth of information. We have some very preliminary information that asbestos air levels near sites of extensive braking may be 3 times higher than background. Since wind conditions are highly variable, much more analysis of this question is required. All our data really show is that brakes are not as obvious a problem as asbestos-containing fireproofing spray in New York City. Perhaps you may wish to qualify 7 B by the words "Unless evidence of safety is demonstrated the use of asbestos...."

In summary, your regulations in general are excellent, your intent is proper, and I am pleased to support you.

Table I

Observed and Expected Number of Deaths
Among 632 Asbestos Workers Exposed to
Asbestos Dust 20 Years or Longer, 1943-1962

Cause of Death	Years				Total, 1943- 1962
	1943- 1947	1948- 1952	1953- 1957	1958- 1962	
Total, all causes.....					
Observed (asbestos workers)	28	54	85	88	255
Expected (US white males)..	39.7	50.8	56.6	54.4	203.5
Total cancer, all sites.....					
Observed (asbestos workers)	13	17	26	39	95
Expected (US white males...)	5.7	8.1	13.0	9.7	36.5
Cancer of lung and pleura....					
Observed (asbestos workers)	6	8	13	18	45
Expected (US white males)..	0.8	1.4	2.0	2.4	6.6
Cancer of stomach, colon and rectum.....					
Observed (asbestos workers)	4	4	7	14	29
Expected (US white males)..	2.0	2.5	2.6	2.3	9.4
Cancer of all other sites com- bined.....					
Observed (asbestos workers)	3	5	6	7	21
Expected (US white males)..	2.9	4.2	8.4	5.0	20.5
Asbestosis.....					
Observed (asbestos workers)	0	1	4	7	12

Death rates as reported annually by the U.S. National Office of Vital Statistics. A five year average is given here for each period.

Death rates include cancer of lung, bronchus, pleura, mediastinum and trachea, assigned to international list code No. 47b-f prior to 1949 and to No. 160-164 thereafter.

Table II

Expected and observed deaths among 370 asbestos
insulation workers, Jan. 1, 1963 - June 30, 1971.

	<u>Observed deaths</u>	<u>Expected deaths*</u>
Total cancer (all sites)	92	15.1
Cancer of lung, pleura, trachea, bronchus	47	4.5
Lung cancer	43	+
Pleural mesothelioma	4	+
Peritoneal mesothelioma	19	+
Cancer of stomach, colon and rectum	12	3.0
Cancer all other sites	14	7.6
Asbestosis	20	+
All other causes	51	63.5
Total deaths	163	78.6

*Expected deaths are based upon age-specific rates for U.S.
white males in 1967. Smoking habits are disregarded.

+United States data not available but figure should be only
slightly less than 4.5.

+United States data not available but these are rare causes
of death in general population.

Table III

Mortality experience of 632 members of IAHFIAW, Locals 12 and 32
January 1, 1943 to June 30, 1971

Cause of Death	Number	Per Cent
Lung cancer	85	20.0
Pleural mesothelioma	7	1.6
Peritoneal mesothelioma	20	4.8
Gastro-intestinal cancer	40	9.3
All other cancers	36	8.4
Total cancer = 188		
Asbestosis	32	7.7
All other causes	205	48.2
	425	100.0

Table IV

Asbestos Air Levels in United States Cities

Analysis of 187 Quarterly Composite Samples

Asbestos Air Levels (10^{-9} grams/ m^3)	Number of Samples With Given Vaule
0.0-0.9	61
1.0-4.9	103
5.0-9.9	12
10.0-19.9	8
20-49	2
50-99	1

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Vice President

ENVIRONMENTAL HEALTH UNIT

August 27, 1971

✓
Dr. E.P. Stefl
Vice President
Raybestos-Manhattan
205 Middle Street
Bridgeport, Conn. 06603

Dear Gene:

Bill Raines has asked me to send you the enclosed packet of materials dealing with brake linings to help in preparations for your meeting with Illinois Pollution Control Board personnel. For a quick rundown on what the scientific papers contain I am attaching to each of them a copy of the Summary and Evaluation sheets prepared at the time they were received in this office.

The papers enclosed are:

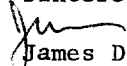
Bentley, M.L., "Control of the Use of Asbestos-Containing Friction Materials"
Hatch, D., "Possible Alternatives to Asbestos as a Friction Material"
Hickish, D.E. and Knight, K.L., "Exposure to Asbestos During Brake Maintenance"
Knight, K.L. and Hickish, D.E., "Investigations into Alternative Forms of Control for Dust Generated During the Cleaning of Brake Assemblies and Drums"
Lee, G.L., "Removing Dusts from Brake Assemblies During Vehicle Servicing -- Alternative Cleaning Methods"
Luxon, S., "Technical Implementation of the New Asbestos Regulations"
Roach, S.A., "Hygiene Standards for Asbestos"
Smither, W.J., "Asbestos and Asbestosis"

Although you probably have it, I am also enclosing a copy of the Lynch paper on brake linings. In addition you will find a selection of pages from a document, "National Inventory of Sources and Emissions: Cadmium, Nickel, and Asbestos - 1968. Asbestos, Section III," that deal with friction materials.

This report was prepared for the old Air Pollution Control Administration and was presented to them in February 1970. It has only recently become available to the public through a printing by the U.S. Department of Commerce Clearinghouse.

If we can be of any further help, please let us know.

Sincerely,


James D. Callaghan

JDC:rm1
Enc.
cc: W.P. Raines

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FMSI 02970

SUMMARY AND EVALUATION

Subject: Brief discussion of the various forms of asbestos and their effects on health. Of some interest.

Evaluation: This very short paper, running to three printed pages, was presented to provide background information to a conference on possible asbestos exposure to maintenance workers on auto brakes and clutches in Britain. The author points out that currently disc brake pads, brake linings and clutch facings contain 50 percent chrysotile asbestos. However, newer developments indicate that the percentage of asbestos in the mix is likely to decline, perhaps down to a minimum of 30 percent asbestos. Disc brakes require less asbestos fiber than drum brake linings, and it is estimated that more and more passenger cars produced in the U.K. will be equipped with disc brakes.

• Author: Smither, W. J. (Group Medical Adviser, Cape Asbestos Company).

Journal: Annals of Occupational Hygiene (British), January 1970.

Title: "Asbestos and Asbestosis."

Summary: As given above.

-XXX-

ASBESTOS AND ASBESTOSIS*

W. J. SMITHER

Group Medical Adviser, Cape Asbestos Company, 114 Park Street, London W.1.

THE FORMS AND USES OF ASBESTOS

COMMERCIALY important asbestos fibres fall into two main groups. The first of these is chrysotile, and the second comprises the amphiboles. Both groups are fibrous silicates, but they differ in geological origin, in chemical composition, in molecular structure, in fibre size and strength, and in other characteristics. Chrysotile, white asbestos, comes from many different places. There are slight chemical and physical variations in the fibres from different sources, but basically all have the same molecular structure. On the other hand, the amphiboles comprise at least three separate types, whose molecular structure is very similar, but whose chemical and physical properties differ more widely. Amosite (amber) and crocidolite (blue) are of commercial importance in this country, whereas anthophyllite is a Finnish fibre not used here.

The relative amounts of each fibre in world production is shown in Fig. 1 and the areas of main use in Fig. 2.

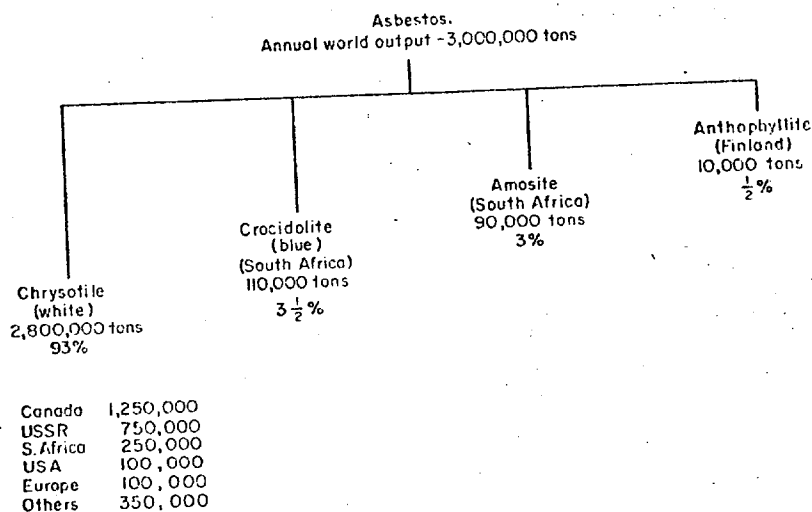


FIG. 1. World production of asbestos.

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

Asbestos
Annual consumption-3,000,000 tons

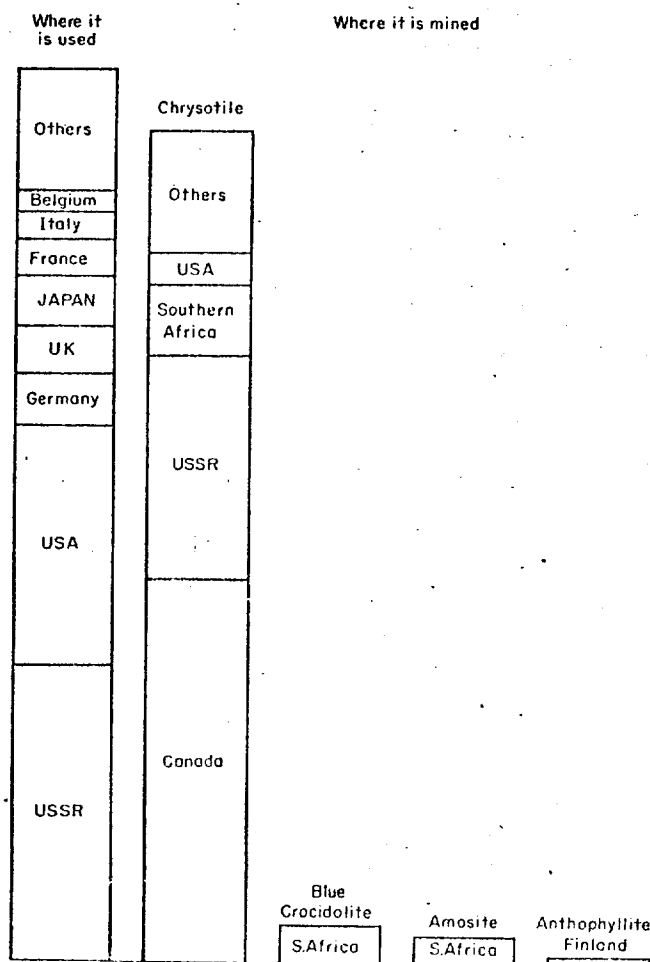


FIG. 2. Areas of use of asbestos.

The different characteristics of asbestos fibres dictate their uses, their applications and their mode of packing and handling. For example, amosite can be pressure packed and palletized, whereas chrysotile lends itself more readily to containerization. By far the greatest use of chrysotile is in the asbestos cement industry. Amosite is used mainly in insulation and building products. Crocidolite, due to its excellent acid resistance, finds its major application in the manufacture of battery boxes in this country. It is added to the pitch mixture in unopened dissoluble bags.

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Very broadly it can be said that current friction materials, whether they be disc brake pads, passenger car and commercial vehicle brake linings or clutch facings, contain 50 per cent chrysotile asbestos. The new trends of development, particularly in the fields of disc brake pads and commercial vehicle brake linings, indicate that the percentage of asbestos included in the mix is likely to decline. Some new materials now contain approximately 40 per cent asbestos, and newer mixes can be foreseen with an even lower percentage, probably down to a minimum of 30 per cent. The pads for disc brakes require less asbestos fibre than conventional drum brake linings. It is estimated that more and more passenger cars produced in the U.K. will in future be equipped with disc brakes, particularly on the front wheels.

THE BIOLOGICAL EFFECTS OF ASBESTOS

The variation existing in the biological effects of the different types of asbestos is the subject of considerable interest and research, and the extent to which the physical and chemical characteristics of the asbestos itself influence biological effects is being investigated. The role of trace elements and contaminants associated with the fibres has also to be considered.

The chief biological effects of asbestos are confined to the lung and the pleura, or lining of the lung and chest cavity, and to the peritoneum, or lining of the abdominal cavity. A few cases of skin corns have occurred in asbestos workers, but these are becoming much less common.

All types of asbestos, if inhaled in fairly high concentrations over a considerable period of time, may cause fibrosis of the lungs. This disease, called asbestosis, consists of thickening of the lung membranes with resultant stiffening of the tissues and interference with oxygen uptake. The interference with gas transfer is the reason for the shortness of breath which causes the disability associated with asbestosis.

- The amount of exposure required to produce fibrosis of the pleura, with or without calcium deposition in the scars, is more debatable. It may be that shorter, less concentrated exposures, particularly in youth, leave this mark upon the pleura. In any event this particular effect of asbestos inhalation causes little or no disability in itself.

Exposure to asbestos may lead to further complications, e.g., heart failure, cancer of the lung, or, rarely, to malignant changes in the pleura or peritoneum, known as mesothelioma. Cancer of the lung has been shown to be more common in asbestos workers who smoke, just as it is in the general population. Mesotheliomas are very uncommon throughout the world, but in some areas they have been associated more frequently with exposure to crocidolite than to chrysotile, amosite or anthophyllite. The reasons for this are at present obscure, but are being sought intensively by investigators in many different countries.

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SUMMARY AND EVALUATION

Subject: Asbestos dust control standards in Britain and the U.S. and their relationship to occupational health. Of some interest.

Evaluation: This paper is essentially identical with the one presented by the author at the Conference on "The Control of Asbestos in the Working Environment," sponsored by the British Occupational Hygiene Society and the Asbestosis Research Council, London, June 18, 1969. That paper has previously been evaluated and distributed. The author is president of the British Occupational Hygiene Society.

Author: Roach, S. A. (London School of Hygiene and Tropical Medicine).

Journal: Annals of Occupational Hygiene (British), January 1970.

Title: "Hygiene Standards for Asbestos."

Summary: Hygiene standards of the BOHS are discussed and compared with those of the ACGIH. The British standards apply only to chrysotile, and recommend a lower TLV than the latest recommended by the ACGIH.

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HYGIENE STANDARDS FOR ASBESTOS*

S. A. ROACH

London School of Hygiene and Tropical Medicine, Keppel Street, London W.C.1.

AS LONG as there is any airborne asbestos dust in the work environment there may be some small risk to health. Nevertheless exposure up to certain limits can be tolerated for a lifetime without incurring undue risks.

A hygiene standard for asbestos was published in the U.K. by the Ministry of Labour in 1960 and was taken from the annual list of Threshold Limit Values of the American Conference of Governmental Industrial Hygienists (ACGIH) (Committee on Threshold Limits, Annually).

The British Occupational Hygiene Society formed a Hygiene Standards Committee in 1965 to advise on hygiene standards. This Committee recommends the use of the ACGIH list of standards and supplements this with critical examinations of ACGIH and other standards considered unsatisfactory by British workers. The Hygiene Standards Committee has expert Sub-Committees, each of which is concerned with a specific standard. There is a sub-committee on asbestos dust in air, one on trichloroethylene vapour and its urinary metabolites, one on airborne vegetable dusts in the textile industry, another on noise criteria for hearing conservation and two new ones are coming into being; on cadmium oxide fume and silica dusts in air.

It is important to take into account the economic consequences of any recommendations made as well as the benefits to health, and this is one reason why on each of these Hygiene Standards Sub-committees, scientific and medical experts from industry are included. The value of a standard rises in proportion to the number of people who become protected by it. A particular advantage of direct industrial representation on hygiene standards committees is that the industry more readily identifies itself with the standards recommended.

The Hygiene Standards Sub-committee on Asbestos, under the Chairmanship of Professor Lane, has developed new hygiene standards for airborne chrysotile dust (LANE *et al.*, 1968). These were based on the results from a medical and environmental study at an asbestos textile factory in England, in which investigations were made on 290 of the men employed at this factory in the period of 1933-1966.

The Sub-committee considered that the degree and nature of the risk associated with the standards should be specified and the method of the derivation of the standard from the data presented should be described in detail. It was also considered that the standards should give prominence to the gradually increasing risk in relation to the concentration rather than to the single figure threshold concept. Open recognition should be given to the possibility that people might be adversely affected, even

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

when the recommended standards of air cleanliness are maintained. It was recognised that to protect the hypersusceptible workers environmental control would have to be supplemented with medical examinations.

It was evident from the data made available to the Sub-committee, and from the earlier American experience, that when concentration is held constant the prevalence of asbestosis was highest among those with the greatest duration of exposure. Over a period of time, dust accumulates in the lungs and gives rise to asbestosis. However, some of the dust is removed from the lungs, for example, by being dissolved. Consequently, if it is assumed that none is removed and exposure is limited accordingly, a safety factor is thereby incorporated. The problem of relating prevalence 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.

The asbestos dust concentration had been measured at the textile factory concerned with several different instruments, including the membrane filter method, in which the number of fibres longer than 5μ was counted. The dust concentration to which different workers had been exposed varied from 1 fibre/cm³ to 27 fibres/cm³ over periods from 10 years to 33 years.

The exposure of an individual was expressed as fibre years/cm³, that is, the product of the average concentration to which he was exposed during working hours and his years of exposure to this average. A curve was developed relating the prevalence of asbestosis to exposure expressed in this way. The principles on which this was based may be explained as follows.

An individual's response to dose of any foreign substance can be expressed by a line (Fig. 1). There is a dose which produces no response whatsoever. This is marked by the threshold A. If the individual is given progressively higher doses, the response progresses correspondingly. The least positive response may be real but merely undesirable. A higher response may have sensory manifestations. A still higher response might be associated with observable physiological changes and overt clinical effects. The highest responses of all would perhaps be signified by loss of consciousness, or even death.

The degree of response may be conceived to be measurable objectively on a continuous scale starting at zero, and the scales of dose and response could be chosen to linearise the relationship between them, as in Fig. 1. The dose-response relationship could then be described by the slope of the line and the point where the line strikes the dose axis. The slope of the line expresses the rapidity with which increases in dose produce increases in response in this individual. The steeper the slope the greater the safety factor necessary in practice to allow for the inevitable occasional excursions of dose above the maximum desirable.

Doses which give zero response are never, in fact, known with absolute certainty since the sensitivity of measurements of response is limited. A response which can just be detected in a man corresponds to another and higher dose, shown as threshold B on Fig. 1. Also, one is not normally considering just one individual. As with all other characteristics of man, the position and slope of a dose-response line varies from one individual to another. Each man's dose-response line is different with a

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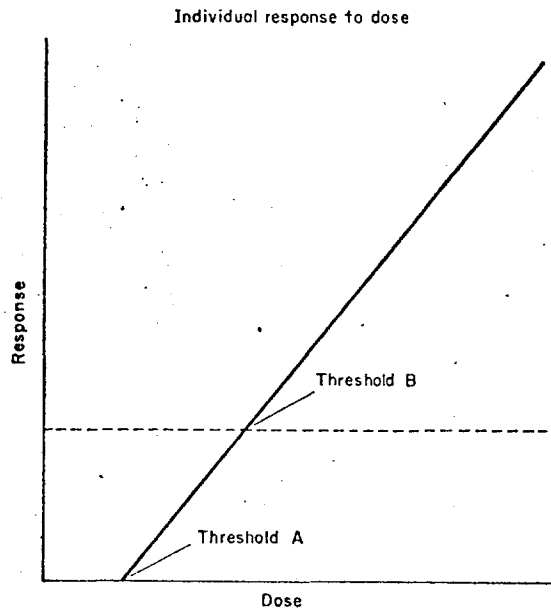


FIG. 1. Individual response to dose.

different threshold dose and a different slope. A particular population under study is represented by a family of dose-response lines centred around the line for the average man.

In a real population the threshold dose will vary from one individual to another about an average value, as in other medical norms. It is to be expected that the size frequency distribution of threshold doses would be a hump-shaped curve tailing away on either side of the central value, as shown in the Fig. 2a.

In a real field study it is established whether a man has or has not been affected. Exactly when or in what concentration he first developed the characteristic response is usually not known. A graph showing exposure against the total number of people affected by it would be a cumulative sigmoid curve, illustrated in Fig. 2b, derived from the size frequency distribution in Fig. 2a. This tails away down to zero response at zero exposure.

An air quality standard is still associated with a small but non-zero probability of men being affected by the contaminant in question. The risk of people being affected can be made as small as one wishes. Zero risk is the ultimate target and an air quality standard has to be a compromise between the costs of bearing a health risk and the costs of air contaminant control.

A curve was fitted to the data from the textile factory on asbestosis, detected clinically and the exposure in fibre years per year of all the individuals under study over their years of employment up to 1966. The bottom end of the fitted curve is shown in Fig. 3. The three points relate to three of the groups of workers studied. The exposure

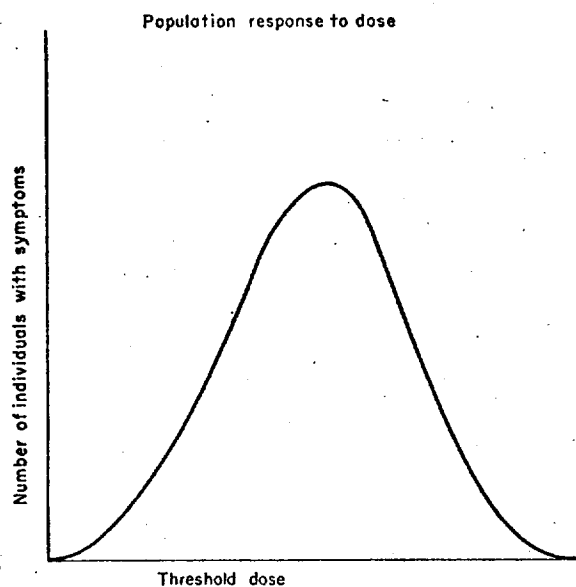


FIG. 2a. Population response to threshold dose.

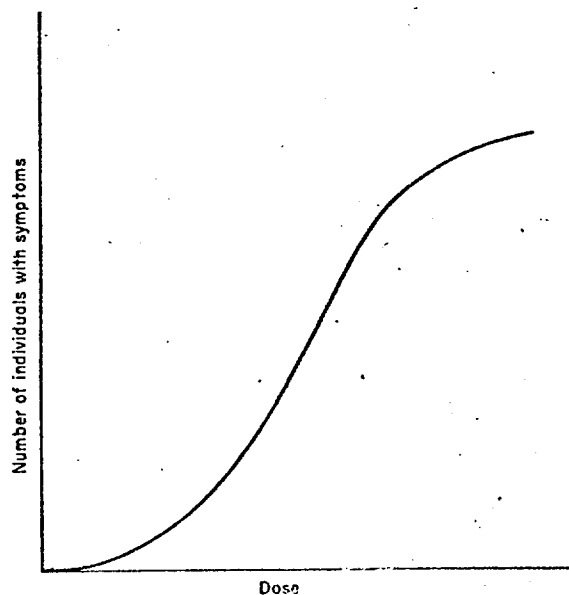


FIG. 2b. Population response to dose.

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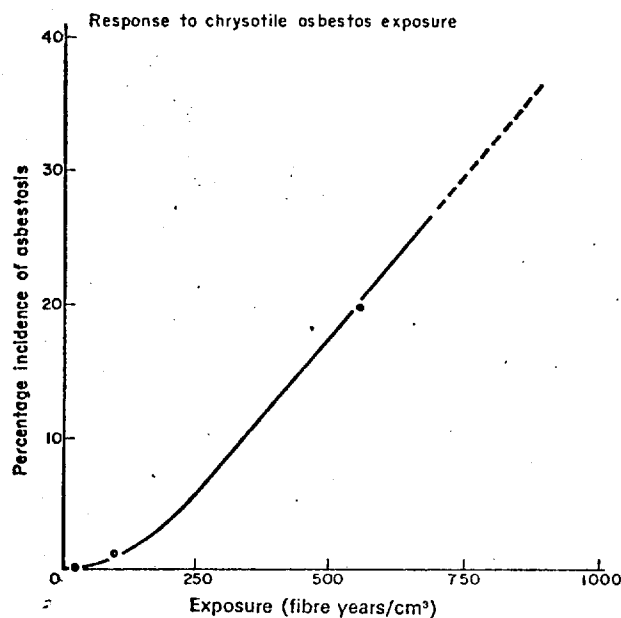


FIG. 3. Response to chrysotile asbestos exposure.

is shown on the horizontal axis, expressed in fibre years per cm^3 and the corresponding prevalence is on the vertical axis, showing the proportion of people with crepitant basal rales.

Basal rales is the earliest clinically demonstrable effect on the lung due to asbestos and there is a steadily increasing prevalence of basal rales with increase in dust exposure. Only groups with near zero dust exposure show zero prevalence of basal rales.

A problem arises when it is appreciated that there is no exposure which can be said to be absolutely free of risk. There is no single threshold exposure held in common by everyone. There is, consequently, this gradually increasing risk in relation to exposure. The application of dust control to meet a TLV, an MAC, MAK value, or other similar hygiene standard will limit and control the risk but is unlikely to reduce it to zero. It has to be remembered that asbestos is very widely used and brings real benefits to the community at large. A standard could be made so stringent that the cost of dust control is prohibitive, that the production and use of asbestos ceases to be economic, production and use is discontinued and the associated benefits are lost. The benefits gained by reducing the risk of asbestosis through reducing air contaminant exposure have to be weighed against the possible loss of direct and indirect benefits to the community from the use of the material.

One conclusion from the exposure-response curve fitted to the data was that for an accumulated exposure of 100 fibre years/ cm^3 , it is probable that the risk of being affected to the extent of having early clinical signs will be less than 1 per cent. That is, for example, a concentration of 2 fibres/ cm^3 for 50 years of such exposure while

at work, 4 fibres/cm³ for 25 years, or 10 fibres/cm³ for 10 years. The British Occupational Hygiene Society Hygiene Standards Sub-committee on Asbestos expressed the view that a proper and reasonable objective would be to reduce exposures to below this level and thereby reduce the risk of contracting asbestosis to less than 1 per cent of those who have a lifetime's exposure to the dust. For such workers, who may possibly work for 50 years, the long term average concentration to which they are exposed would need to be less than 2 fibres/cm³. For others, who will be exposed to asbestos dust in air for shorter periods, the long term average concentration need not be so low, as long as their exposure will amount to less than 100 fibre years/cm³.

The possibility was considered that short periods of very high concentration for a few weeks or less might be disproportionately important in determining the risk of asbestosis. However, the evidence for this was not conclusive and the committee were satisfied that the risk can be satisfactorily expressed with respect to an average concentration over 3 months and can safely be kept below 1 per cent by ensuring that a man's accumulated exposure does not rise above 100 fibre years/cm³.

The exposure measured by making fibre counts on membrane filter samples can be converted into exposure measured with an impinger, the American method, by examining the results of side-by-side comparisons of the two instruments. Such comparisons made by the United States Public Health Service in asbestos textile plants have shown that an accumulated exposure of 100 fibre years/cm³ corresponds to 15 million particle years/ft³ by standard impinger methods (AYER, LYNCH and FANNEY, 1965). The present American Threshold Limit Value is a concentration of 5 million particles/ft³ (mp/ft³) which, if it persisted, would result in an accumulated exposure of 250 million particle years/ft³ over 50 years.

These American hygiene standards, called Threshold Limit Values, are a system for summarising published information on air contaminants in a convenient form for the day-to-day practice of industrial hygiene. The present American standard for 8-hr averages is thus 17 times higher than the British standard for 3 monthly averages. However, there is a published intention to revise the American standard in view of recent knowledge.

However, the difference between the American and British standard is not primarily due to conflicting evidence on the adverse effects of asbestos. It is because of a different attitude now adopted over the degree of protection which ought to be given against asbestosis.

The American Threshold Limit Value of 5 mp/ft³ was recommended by Dreessen and his co-workers in 1938 after studying 541 employees in 4 asbestos textile plants where massive exposures to chrysotile occurred (DRESEN *et al.*, 1938). Only 3 doubtful cases of pneumoconiosis were found at the time of the study in those exposed to dust concentrations under 5 mp/ft³, whereas numerous well-marked cases were found above 5 mp/ft³.

A conference held in 1965 on the biological effects of asbestos called attention to the very real probability that the 5 mp/ft³ limit recommended by Dreessen is inadequate to give complete working-lifetime protection against all forms of asbestos (SCHALL, 1965). Medical data on which the limits had been based were inadequate; more than half of the asbestos workers studied by Dreessen and his co-workers were under 30 years of age and thus had insufficient exposure time for much asbestosis to

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develop. Of the 105 workers exposed to less than 5 mp/ft³, 82 had worked less than 5 years and only 4 had more than 10 years exposure. Moreover, it was a "point-in-time" study; many of the ill were missing, the dead uncounted, and were not considered in the over-all evaluation of the limit.

The British Hygiene Standards Committee finalised its views in November 1967 after studying the British data, and these views were immediately communicated to the ACGIH TLV committee. In May 1968 the ACGIH (Committee on Threshold Limits, 1968) proposed changes to its hygiene standard. The new asbestos limit, while taking into account the British views, had to be based on American experience and considerations applicable to the American industrial scene. Recent evaluation of the health experience in asbestos plants in the U.S.A. had, nevertheless, indicated that the 5 mp/ft³ limit was not sufficiently low to protect workers exposed for 30 years, a period rarely exceeded in America.

In accordance with these findings, the 5 mp/ft³ limit was made a ceiling value below which all concentrations should fluctuate. This corresponds to a time-weighted average concentration over a shift of 2 mp/ft³. Since the count by Impinger procedure often consists primarily of extraneous particulates, an alternative fibre count was recommended, using the membrane filter method in which fibres greater than 5 μ in length are counted as in Britain. On this basis, for a time-weighted 8-hr average limit by Impinger count of 2 mp/ft³, the corresponding limit based on the fibre count is 12 fibres/cm³. This limit is intended to reduce to an insignificant risk, the occurrence of asbestos disease among those exposed for 30 years to all forms of asbestos.

The intended changes in American TLVs give two years' notice and objections to them should be conveyed to the TLV committee of the ACGIH. All objections are given the most serious and sympathetic consideration and users are strongly advised to take advantage of this if they have reason to question the proposed changes.

The standards of the British Occupational Hygiene Society recommend that a person's accumulated exposure to chrysotile asbestos should not exceed 100 fibre years/cm³. It is probable that the risk of being affected to the extent of having early clinical signs of asbestosis will be less than 1 per cent if the conditions comply with these standards. It is believed that this is the first time a hygiene standard has been associated with such a specified degree of protection.

The standards refer essentially to an average concentration during working hours over 3 months of 2 fibres/cm³. In an environment where this 3 monthly average just equals 2 fibres/cm³, the concentration within this period will sometimes be above this value and sometimes below. The maximum 8-hr average will thus be somewhat higher than 2 fibres/cm³. The proposed change in the American TLV is to a maximum 12 fibres/cm³ 8-hr average, which if exceeded on a shift demonstrates non-compliance. Thus, there may be a rough degree of consistency between the hygiene standards from the two countries' organisations, so far as this is possible. The Factory Inspectorate in their work have often only a short time during a day to come to a judgment on conditions and are considering a development of this, applying a maximum for even shorter periods, of a few minutes, which if exceeded would indicate a probability that the Asbestos Regulations are not being complied with.

There is a growing body of information on chrysotile dust and other asbestos dusts from many countries, and it is hoped that in future the views from different

parts of the World will be sought so that standards for testing air cleanliness can, as far as possible, be held in common. Even so, the risks that may be tolerated can vary from country to country and from one situation to another within a country.

The air quality attained in industry in different countries does differ and, no doubt, will continue to differ. A wealthy country can afford to spend more money on air-contaminant control. Also, a country very conscious of the slightest risks to which its workers may be exposed through their occupation may be expected to have different standards from one which is not, where other health risks may be so much the greater.

The benefits to the community from the use of inexpensive asbestos products have in some measure to be weighed in the balance against the benefits to the health of the workers that would accrue by reducing asbestos dust exposure.

The British Occupational Hygiene Society Sub-committee on Hygiene Standards for Asbestos has not yet decided whether their chrysotile standards would be suitable for amosite or crocidolite dust, nor whether they give sufficient protection against lung cancer or mesotheliomas. The ACGIH, on the other hand, make no distinction between different types of asbestos in their standards. In this country it should be remembered that the Senior Medical Inspectors' Advisory Panel on Problems arising from the use of Asbestos considered that the evidence to date on balance indicated that a particular significance must be given to crocidolite as a cause of mesotheliomas (Ministry of Labour, 1967). That Panel recommended that other types of fibre should be substituted for crocidolite wherever possible and where this is at present impossible special precautions should be taken to reduce the risks of inhaling the material to the lowest possible level. Whatever measures may be adopted to control asbestos dust, the Panel urged that these be even more rigidly applied to crocidolite. The Factory Inspectorate is also developing procedures for testing hygiene standards in factories and is seriously considering the adoption of especially rigid requirements where crocidolite is used.

To derive hygiene standards for an air contaminant which provide a known degree of protection against a health hazard, it is necessary to have a body of data showing the amount of air contaminant to which people are exposed and the corresponding effects or lack of them in the people. It is also necessary to have a grasp of the consequences to industry and users of limiting and controlling emissions of the contaminant. Our present information is very imprecise, particularly in terms of the practical consequences of specific hygiene standards. In developing recommendations for a hygiene standard, the British Occupational Hygiene Society Sub-committee found that knowledge of the relationship between exposure and risk was not the greatest area of uncertainty. A much more difficult and contentious problem was to decide on what, in fact, was an acceptable level of dust control.

More information is needed, for example, on the expense of dust control. Where this is done by ventilation it is important to know what is the minimum amount and what kind of local exhaust ventilation and dilution ventilation is necessary to achieve a given degree of air cleanliness in a work place, since costs tend to climb as the cube of the air flow.

Research is needed to determine the balance between local and general ventilation which produces a specified degree of control at minimum cost. By setting down the capital cost, installation cost, running and maintenance costs, it becomes possible to

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grasp more firmly the consequences of adopting particular hygiene standards. This kind of information is needed throughout the field of asbestos dust control so as to be able to weigh up the costs of achieving high air cleanliness.

This does not reduce the choice of an air quality standard to a mathematical equation, nor does it avoid the need to exercise wise judgment in the choice of standard. However, the judgment can become a little less arbitrary than at present.

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SUMMARY AND EVALUATION

Subject: Study of asbestos dust exposure among British auto brake mechanics.

Of interest and importance.

Evaluation: This paper sheds additional light on the persistent speculation concerning brake linings and asbestos dust. The study was conducted among workers engaged in the repair and maintenance of brake drums "at the Service Bay of a Ford Main Dealer in the Greater London area." During the dustiest part of the operation, the preliminary cleaning of the brake drum, workers were exposed to an average of fewer than two fibers per cubic centimeter of air. According to the recommended dose-time limits established by the British Occupational Hygiene Society, this means that a brake-maintenance worker could work for 50 years at this job with less than a one percent risk of contracting asbestosis.

Authors: Hickish, D. E. and Knight, K. L. (Medical Services, Ford of Britain).

Journal: Annals of Occupational Hygiene (British), January 1970.

Title: "Exposure to Asbestos During Brake Maintenance."

Summary: Brake lining mechanics in an automobile service shop worked on two passenger cars and a truck, while two types of dust-measuring devices counted the amount of asbestos dust in the atmosphere. The personal exposure of the mechanics was below the limit corresponding to 50-year exposure, the hygiene standard of the British Occupational Hygiene Society. "Samples of drum dust were examined by Dr. S. Holmes, and his tests showed that chrysotile was present only in trace quantities, or at most at 1 per cent, compared with the original lining content of 40-60 per cent. These findings suggest that there is a change in the physical and/or chemical form of the asbestos during its use as a brake material."

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EXPOSURE TO ASBESTOS DURING BRAKE MAINTENANCE*

D. E. HICKISH and K. L. KNIGHT

Medical Services, Ford of Britain, Brentwood, Essex

EXPOSURE DURING CAR SERVICING

THERE is little maintenance of passenger vehicle brakes involved at the manufacturers' premises, and therefore an investigation was carried out at the Service Bay of a Ford Main Dealer in the Greater London area. This Dealer normally services 10-20 cars per day, but blowing-out of brake shoes and drums is not included in all routine services. It is the blowing-out procedure which is the subject of the study.

Air-sampling was carried out using membrane filters, the sampling and subsequent assessment being in accordance with the technique described in the *Hygiene Standard for Chrysotile Asbestos Dust*, published by the British Occupational Hygiene Society (1968).

Static samples were taken by the side of the car (Fig. 1) and composite samples were also taken in the dust-cloud during the blowing-out procedure, continuing by the side of the car for the remainder of the sampling period. Normally the mechanic takes care to blow the dust away from himself, so this sampling procedure should over-estimate exposure. Two sampling periods of 45 minutes were used, and during the first period one Cortina Estate and one Anglia Van received brake blow-outs, and during the second period one Cortina car was dealt with. The results are shown in Table 1.

TABLE 1. ATMOSPHERE SAMPLES DURING CAR BRAKE SERVICE

Location of samples	1st period	Fibres/cm ³	
		2nd period	Time-weighted average
By car	1.12	1.42	1.25
Dust cloud then by car	1.71	3.62	2.55

An estimate of the daily exposure of the mechanic engaged on brake cleaning was obtained by a series of personal samples (Fig. 2) covering an entire workshift, during which brake servicing was carried out on 11 vehicles. The results are shown in Table 2.

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Chutch Maintenance, held at Brentwood, Essex, March, 1969.

TABLE 2. PERSONAL SAMPLES DURING CAR BRAKE SERVICE

Sample	Concentration (fibres/cm ³)
1	0.63
2	1.12
3	0.21
4	0.96
5	0.38
6	0.79
Time-weighted average	0.68

EXPOSURE DURING TRUCK SERVICING

Maintenance of truck brakes involves a somewhat different type of operator exposure as the servicing is more complex, and therefore the number of vehicles dealt with is less. The larger size of wheels and drums, on the other hand, makes it difficult for the operator to avoid the dust cloud produced, and personal exposure could be higher than that during car maintenance. Further sampling was therefore carried out in a large fleet workshop with equipment similar to that used for the passenger car tests.

Static samples, each of approximately 3 hr duration, were collected during the morning and afternoon periods at three positions; at the bay adjacent to the one at which brake cleaning was carried out, at the next bay, and in the centre of the garage.

Brakes were blown out during the morning, but not during the afternoon. The results are given in Table 3.

TABLE 3. GENERAL ATMOSPHERE SAMPLES DURING TRUCK BRAKE SERVICE

Location of sample		Concentration (fibres/cm ³)
Adjacent bay	Morning	0.28
	Afternoon	0.07
2 Bays away	Morning	0.17
	Afternoon	0.07
Centre of garage	Morning	0.49
	Afternoon	0.11

Personal samples were obtained from two men—the man engaged on brake cleaning, and the man engaged on clutch repair work at the adjacent bay. The first period of 1.5–2 hr included the period of brake cleaning, and the second period of approximately 5 hr represented the remainder of the shift. The results are shown in Table 4.

TABLE 4. PERSONAL SAMPLES—TRUCK BRAKE SERVICE

Operator	Concentration (fibres/cm ³)
• Brake cleaner	
during cleaning	7.09
after cleaning	0.08
Time-weighted average	1.75
Clutch repair—adjacent bay	
during cleaning	2.25
after cleaning	0.11
Time-weighted average	0.79

SIGNIFICANCE OF EXPOSURE LEVELS

The Hygiene Standard suggests that exposure should not exceed an accumulated level of 100 fibre-years/cm³. On this basis, a man exposed for the whole of his working lifetime of 50 years, should not be exposed to concentrations exceeding 2 fibres/cm³. While an exposure to asbestos of this length is somewhat improbable in the case of motor mechanics, nevertheless the results have been interpreted against this value, and the findings are summarized as follows:

Car servicing

While the standard may be exceeded in the dust cloud during actual brake cleaning, the personal exposure of the operator studied was well below the standard.

Truck servicing

The standard is not exceeded during brake cleaning in the general atmosphere away from the immediate vicinity of the operation, but personal exposures in the vicinity do exceed the standard. On a daily basis, the personal exposure levels are below the standard, although that of the brake cleaner approaches it.

It should be noted, however, that in a fleet workshop, brake cleaning operations do not necessarily take place daily.

THE NATURE OF AIR-BORNE DUST

Brake lining materials contain 40–60 per cent of asbestos, and it was somewhat surprising to find that particles of a fibrous nature were scarce in the air samples collected. In a laboratory investigation, specimens of dust were obtained by filing brake lining material, and after sieving through a 200-mesh sieve, these were examined microscopically before and after incineration. Samples of dust were collected from brake drums during car servicing and examined in similar manner.

The results of the examination were expressed as the percentage of particles which were fibrous in nature, and are compared in Table 5, together with a result from an incinerated thermal precipitator sample obtained during brake cleaning.

TABLE 5. ASSESSMENT OF FIBROUS FRACTIONS OF DUST SAMPLES

Sample	Percentage of particles seen to be fibrous	
	Sample not incinerated	Sample incinerated
Brake lining material	28	12.3
Brake drum dust	0.6	1.6
Air-borne dust	—	1.3

It is clearly shown that the percentage of fibres in the drum dust and airborne dust is much lower than that in the dust formed from the original lining material.

Samples of drum dust were examined by Dr S. Holmes, and his tests showed that chrysotile was present only in trace quantities, or at most at 1 per cent, compared with the original lining content of 40–60 per cent. These findings suggest that there is a change in the physical and/or chemical form of the asbestos during its use as a brake material.

Enquiries were made of research workers in the UK and USA as to whether they had observed a similar effect. LYNCH (1968) reported that tests on brake testing dynamometers had shown the presence of few or no fibres in the dust produced from bus and automobile brakes, except under severe braking conditions. In the latter instance, the brake temperature reached 320–370°C, compared with the design maximum temperature of 290–320°C, and it appeared that, under these conditions, the binder decomposed and released part of the asbestos as free fibre. At lower bulk lining temperatures within the normal operating range, the binder behind the surface remains intact. However, the spot temperature at the point of contact between the lining and the drum may be higher than the decomposition temperature of asbestos. The decomposition product, therefore, includes not free asbestos fibres but a different mineral, resulting from thermal metamorphosis.

HOLMES (1967) in reporting the analyses described earlier in this paper, commented that the normal thermal decomposition product of chrysotile is forsterite, a non-fibrous crystalline magnesium silicate. However, our samples of brake drum dust contained very little forsterite, but rather were mainly comprised of an amorphous magnesium silicate, which is non-fibrous. Little was known at that time about the structure and composition of this substance. Whilst there was no evidence to suggest that the material was a health hazard, this possibility could not be dismissed, and animal experimentation has been commenced in the U.S.A.

CONCLUSIONS

Our investigations show that exposure to asbestos during brake maintenance is not as severe as was anticipated, and in the situations we examined, the personal exposure of the operators was below the limit corresponding to 50-year exposure.

It is however recommended that care should be exercised during brake cleaning to avoid inhalation of the dust produced, and the development of cleaning procedures which would reduce air contamination is desirable. The present trend towards the

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introduction of "flow-line" servicing at Dealers works, in which one individual may be engaged almost entirely on brake servicing, emphasises this point.

Our environmental studies have not included maintenance procedures which involve the filing or grinding of brake lining material, and we would envisage that these would give rise to considerably increased air contamination by chrysotile asbestos, with the attendant need for strict precautions to prevent the inhalation of fibres.

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SUMMARY AND EVALUATION

Subject: Brief discussion of the British Asbestos Regulations as applied to brake maintenance in auto repair shops. Of interest and importance.

Evaluation: This very short paper is important because the last paragraph confirms the American study by Lynch on the small amounts of asbestos in brake lining dust. The present author reports the results of tests performed in the Industrial Hygiene Laboratory of the British Ministry of Labour: "We have found that samples of dust from brake drums, when subjected to X-ray diffraction analysis, contained between 1 per cent and 3 per cent of chrysotile asbestos although the original lining material contained more than 40 per cent of asbestos. There seems little doubt that this is due to the considerable thermal degradation which occurs consequent on the high temperatures generated by friction at the interface between the lining and the drum."

Author: Luxon, S. (H.M. Factory Inspectorate, British Ministry of Labour).

Journal: Annals of Occupational Hygiene (British), January 1970.

Title: "Technical Implementation of the New Asbestos Regulations."

Summary: The levels of asbestos exposure for brake mechanics appear safe. However, the exposure of particular individual workers will be increased if brake overhauls are conducted on a production line basis, making the development of adequate precautionary measures even more important. "Certainly, we should not be blowing out brake dust, even if it contains only a few per cent of asbestos."

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that they indicate that the levels likely to be found in many sections of the industry engaged in this work are below the level of 2 fibres/cm³, which is considered, in the light of past knowledge, a safe one for chrysotile asbestos. Their highest figures for the time-weighted average concentration over 4 hr, however, clearly show that over a period of 10 min we may have concentrations exceeding substantially the level of 12 fibres which are quoted above.

I was interested to hear of the increasing tendency to carry out brake overhauls on a production line basis. This, clearly, must increase the exposure of particular individual workers, making the development of adequate precautionary measures even more important and, in this connection, I hope the devices which will be described later to-day can be improved and developed to the point where they become universally acceptable to the operator. Certainly we should not be blowing out brake dust, even if it contains only a few per cent of asbestos.

In regard to this latter statement, perhaps I should say that work at our Industrial Hygiene laboratory confirms the figures indicated in the previous paper. We have found that samples of dust from brake drums, when subjected to X-ray diffraction analysis, contained between 1 per cent and 3 per cent of chrysotile asbestos although the original lining material contained more than 40 per cent asbestos. There seems little doubt that this is due to the considerable thermal degradation which occurs consequent on the high temperatures generated by friction at the interface between the lining and the drum.

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TECHNICAL IMPLEMENTATION OF THE NEW ASBESTOS REGULATIONS*

S. LUXON

H.M. Factory Inspectorate, Department of Employment and Productivity, Chepstow Place,
Westbourne Grove, London W.2.

THE NEW Asbestos Regulations were signed by the First Secretary of State on May 13 1969, and will therefore come into operation on May 14 1970. They are based on the concept that asbestos dust must be so controlled as to be at a level which will not be liable to cause injury to health.

For the purposes of our discussion today, I believe we should take this to be a level of 2 fibres/cm³ and 0.1 mg/m³ for chrysotile asbestos. A fibre is taken as being 5 μ or over in length with an aspect ratio of at least 3:1. This is of course the standard proposed by the British Occupational Hygiene Society (1968) and is based on time-weighted average concentrations. There is a practical limit on the time over which samples can be taken if the exercise is not to become unnecessarily cumbersome and expensive. On this basis, a sample of 4 hr duration seems a reasonable compromise. If we accept this, as a practical sampling time then the overall standard becomes 2 fibres/cm³ over this four hour sampling period.

We cannot, however, afford to ignore entirely peak concentrations which will occur during this period, and it seems reasonable to expect that a concentration of, say 12 fibres/cm³ should not be exceeded during any period of 10 min, i.e. we might regard 12 fibres/cm³ as a ceiling value.

It must be remembered that we are using the fibre count not as an absolute measure of concentration but rather as a conveniently measurable parameter to indicate the total asbestos in the air. The work leading to the formulation of the BOHS Standard referred to above related to conditions in the textile industry and not enough information is yet available on the relationship between mass of asbestos and fibre counts in other industries. To further complicate the problem, it is not known what fibre sizes are biologically active and, even if this were known, appropriate elutriation (i.e. the rejection of material not biologically active) would be very difficult with a fibrous material such as asbestos. We, ourselves, are making both fibre counts and total mass determinations by X-ray diffraction analysis in industries, such as the motor industry, where degradation of the fibres may occur, resulting in a substantial change in size distribution.

HICKISH and KNIGHT (1969) have described conditions during the servicing of braking systems. The figures they have quoted are, to a large extent, reassuring in

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

SUMMARY AND EVALUATION

Subject: Discussion of the possible use of materials other than asbestos for auto brakes. Of interest and importance.

Evaluation: The conclusion of the author is that asbestos is practically indispensable for auto brakes at the present time. If asbestos were not available, we could "eventually find a substitute, but it could well be at the expense of a considerable loss in performance, and also at a considerable increase in cost." The author also emphasizes that there is no valid health reason why asbestos should be abandoned at the present time. He cites the tests demonstrating the very small percentage of asbestos fiber in brake lining dust and concludes that "the wear products from friction materials are probably no more dangerous to health than many other dusts and can be treated as 'merely dirty.'" He also mentions that technical developments have reduced the quantities of asbestos needed in the production of efficient brakes and clutches.

Author: Hatch, D. (Ferodo Company).

Journal: Annals of Occupational Hygiene (British), January 1970.

Title: "Possible Alternatives to Asbestos as a Friction Material."

Summary: As given above.

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POSSIBLE ALTERNATIVES TO ASBESTOS AS A FRICTION MATERIAL*

D. HATCH

Ferodo, Chapel-en-le-Frith, Derbyshire

INTRODUCTION

I HAVE been asked to talk on the possible alternatives to asbestos as a friction material. The facts are that if by "alternative" we mean a new or better fibre which might shortly be available as a replacement for asbestos in conventional friction materials, then I think the chances are so remote as to be not worth considering.

This is not to say that if the world supplies of asbestos dried up we would not eventually find a substitute, but it could well be at the expense of a considerable loss in performance, and also at a considerable increase in cost.

THE ROLE OF ASBESTOS IN FRICTION LININGS

Having started on what may appear to be a rather depressing note, let us examine the reasons why asbestos occupies the role of an almost universal constituent in friction materials at the present time.

The first automotive friction linings were made from cotton textile material impregnated with drying oils which were subsequently cured to form a strip of material which, while being flexible and conformable, still exhibited great mechanical strength. The main function of the drying oil was to protect the cotton from attack by atmospheric oxygen, which, even at the temperatures reached by early brakes, would have resulted in the cotton burning had its surface been exposed. A second function of the drying oil was to prevent the cotton from fraying under the influence of mechanical abrasion.

As brake operating temperatures increased, it was found that cotton started to degrade and lose its strength even though still protected from attack by oxygen. In other words, it suffered thermal degradation instead of oxidative degradation.

Around 1910, a technological break-through was achieved when it was discovered that textiles could be woven from asbestos and used to replace cotton, because asbestos neither burns nor loses its strength below about 500°C. However, as brake operating conditions became steadily more severe, a point was reached in about the middle 1940's when, despite the continual improvement of synthetic resins with which the asbestos textile was impregnated, further heat resistance was required, this time because the organic part of the composite was proving inadequate. The solution proved to be to mould brake linings from powdered resins, using short fibre unwoven

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

asbestos to maintain the necessary strength and flexibility. This made possible the inclusion of heavy loadings of mineral and metal fillers which imparted greater heat resistance than could be obtained from resin and asbestos alone, and did so at the expense of a reduction in asbestos content. The last point is important in the context of asbestos substitutes. The question is often asked, "why can't asbestos be replaced by something like glass fibre which, after all, must surely impart sufficient strength?" The answer is possibly "it can", if merely the performance of a textile lining is required, but at the temperatures commonly met in modern brakes, the glass fibre melts even in depth below the operating surface.

Furthermore, as a result of the embrittling effect of mineral and other fillers needed in today's brake lining, glass fibre is inadequate in imparting the necessary strength and flexibility. The same can be said to a greater extent, of the various types of rock wools and mineral fibres which have appeared on the market over recent years. It is interesting to note that not only is the ultimate strength of asbestos almost three times that of glass fibre, i.e. 550,000 lb/in.² but the modulus of rigidity is up to ten times as high, at a value of 30,000,000 lb/in.². Typical figures for other materials are say 100,000 lb/in.², for steel wool and down at 60,000 lb/in.² for mineral wool.

The current situation therefore, is that in drum brake linings of normal configuration used for passenger cars and commercial vehicles, there exists no substitute for asbestos which would not result in a deterioration of performance and strength.

DISC BRAKE PADS

Rates of energy dissipation continue to rise and we have now passed the point where moulded drum brake linings are adequate for a large percentage of passenger cars. In this country, nearly 50 per cent of the passenger car axles are equipped with disc brakes, and for the second time in nearly half a century, there seem to be technical possibilities of reducing the asbestos content of friction materials. It is purely fortuitous that the friction materials used in disc brakes are designed to a stronger shape, that is, more or less square or circular pads of considerable thickness, supported, furthermore, by a metal plate of adequate stiffness. The friction material, therefore, does not have to stand up to handling during assembly, does not have to withstand riveting, and could, from the point of view of bulk mechanical strength alone, be made without a high loading of fibrous reinforcement of any kind. There remains, however, thermal shrinkage and thermal shock, and in order to prevent the formation of tensile cracks normal to the operating surface, a percentage of asbestos fibre is still retained. Nevertheless, it cannot be said that the use of asbestos in disc brake pads remains a technical necessity, and it is in this field of friction materials that some departure from resin-asbestos based composites could occur in the next few years on technical and performance grounds.

FRICTION MATERIALS FOR CLUTCHES

As yet, I have confined my comments to brakes, but the development of friction materials for clutches has followed broadly similar lines. In recent years, however, we have seen the start of a growing replacement of manual clutches by automatic

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transmissions where the clutch packs are immersed in oil and therefore do not give rise to airborne contamination. The friction materials used are, in any case, made from sintered metals or paper based facings in which the fibre is largely cellulose. This feature is made possible by the low operating temperatures, due in turn, to the fact that the materials are immersed in oil.

Clutches for heavy duty manual shift gear boxes are, in the U.S.A., being superseded at a significant rate by the spider clutch. This is a type of clutch in which the friction material, instead of being in the form of a thin annulus, consists of a number of buttons rather like disc brake pads, and these again could be made from asbestos-free material such as sintered metals or cermeis (ceramic-metallic compositions).

Summarizing the situation at the present time therefore, it can be seen that there is a drift towards the use of smaller quantities of asbestos in friction materials as a result of a number of purely performance considerations and design changes, that is, reduced amounts of asbestos in some disc brakes, and replacement by other materials in automatic transmissions and some dry clutches.

OTHER FACTORS AFFECTING EXPOSURE TO ASBESTOS

There are, however, several other factors which enter the equation when considering the exposure to asbestos during brake and clutch maintenance, which is the subject of this meeting.

The first is that the durability of friction materials is increasing, as is the temperature at which they will operate satisfactorily. I mention these facts not only because they tend to offset the adverse effect of increase in vehicle miles per year, but because they affect the whole chemistry of asbestos in friction materials. The second important point is that the type of asbestos used in friction materials is chrysotile or white asbestos, and is different from blue asbestos or crocidolite, not only in colour, but in chemical composition and also in chemical decomposition. The third important point is that under the influence of heat alone, chrysotile asbestos decomposes by loss of water of crystallization at a temperature of around 600°C. The process is rather slow, taking well over an hour to convert 50 per cent of the asbestos to its degradation products. These form a series of iron magnesium silicate materials known as olivine, the end member of which is forsterite. The olivine series of minerals are quite unlike asbestos, both physically and chemically, being non-fibrous, and in fact, widely occurring as the major part of many common rocks (basic and ultramafic igneous). One would not expect that a significant amount of asbestos would be converted to olivine during braking except under conditions of very severe duty such as a fade test, but in fact it is exceedingly difficult to detect asbestos in friction material wear products. It has only on rare occasions been possible to detect asbestos in wear products by X-ray diffraction methods, and one has to resort to electron diffraction, selecting occasional individual small fibres to show its existence. This rather surprising fact has been known for several years and current theory suggests that it is accounted for by very high temperatures which are said to exist at the points of real contact between the lining and drum or disc, even at bulk temperatures as low as 100°C.

Whether this explanation is correct or not, it remains a fact that very little asbestos survives in the wear products after brakes or clutches have been used under normal

operating conditions. As the durability of brakes improves, further reductions will occur in the percentage of asbestos which survives the wear process, because each particle of asbestos is then subjected to more heat treatment. Of the approximately 1 per cent of asbestos remaining in wear products, a large proportion is ground down during the wear process to much less than the 5μ length at which particles are judged to be fibres. This is easy to understand when one considers that under normal conditions a lining will lose about one-millionth of an inch of thickness for every 20 ft of sliding.

Over recent weeks I have had regular tests performed in which employees' private cars, and trucks from the Company fleet have been brought into the garage for brake cleaning. The drums have been removed and in a garage with no forced ventilation, all loose dust has been removed from the drums and back plates by the use of a compressed air jet. As each brake was cleaned, instantaneous atmospheric samples were rapidly taken by a hand-pump from the centre of the dust cloud. Several of the dust clouds were visibly filthy, and would, in my view, be avoided by the operator; the dust counts taken at the point of maximum dust density were as given in Table 1.

TABLE 1. DUST COUNTS DURING BRAKE CLEANING BY
COMPRESSED AIR-JET

Test No.	Non-fibrous above 2μ	Fibre count $2-5 \mu$	Fibre count Above 5μ
Samples			
1	2000+	306	5.4
2	109	11	2.1
3	402	17	2.5
4	607	21	3.7
5	475	37	5.3
6	1513	49	8.2
7	628	35	3.2
10 min average	181	5.0	0.8

The interesting points from this exercise are, firstly, the ratio of the number of particles of asbestos to the total dust particles of a similar size, showing a very small percentage of asbestos, and, secondly, the distribution of size of the fibrous element, suggesting that those particles over 5μ must have been only just over.

I am not suggesting for a minute that the practice of blowing out brake drums with a compressed air line is to be recommended, merely that an intense dust cloud of this composition is a lot less harmful than one might think.

Unfortunately, at the present time, no corresponding data is available from clutches but one would expect the situation to be better than in brakes rather than worse, because on the one hand, surface rubbing speeds are higher, giving rise to higher point contact temperatures, and on the other hand, wear rates are very much lower resulting in an even finer subdivision in the wear products.

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POSSIBLE ALTERNATIVES TO ASBESTOS

I have confined my comments to an account of changes which are taking place in friction materials at the present time in the normal course of technical development, in the belief that, although the use of raw asbestos must be tightly controlled, the wear products from friction materials are probably no more dangerous to health than many other dusts and can be treated as "merely dirty". If further evidence comes to hand to suggest that a substitute for asbestos must be found, then under the pressure of necessity, a list of possible replacements could be drawn up as follows:—

Glass fibre	Low strength—low melting point—severe frictional instability.
Steel wool	Low availability—high cost—low strength—damage to drums.
Mineral wool	Very low strength—brittle to the extent of limiting mixing processes.
Carbon fibres	£100/lb currently forecast to fall to £1/lb in several years' time. Still ten times too expensive.
Sintered metals and cermets	Probably the best possibility eventually, but cost will always be relatively high.

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SUMMARY AND EVALUATION

Subject: Brief account of the work of the British Asbestosis Research Council in setting hygiene standards in asbestos friction products plants. Of some interest.

Evaluation: This paper runs only two pages, of which the first is devoted to the background and organization of the ARC. A Working Group on Friction Materials has been conducting studies of dust exposure in factories making brake linings. The studies are not yet complete, and there is no report as to preliminary findings.

Author: Bentley, M. L. (Mintex Company).

Journal: Annals of Occupational Hygiene (British), January 1970.

Title: "Control of the Use of Asbestos-Containing Friction Materials."

Summary: As given above.

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CONTROL OF THE USE OF ASBESTOS-CONTAINING FRICTION MATERIALS*

M. L. BENTLEY

Mintex, Cleckheaton, Yorks

INTRODUCTION

This paper outlines the measures taken by the asbestos-using industry to find out the nature and causes of asbestosis, and the work it has carried out on environmental control. Particular reference is made to dust created during the manufacture and subsequent handling and machining operations of friction materials containing asbestos.

It is rather less than 40 years ago that the need for control of asbestos dust in large quantities was first recognised and the Government Regulations which became law in 1933 have resulted in a considerable improvement in the health record of people employed in asbestos factories.

In the 1950's, however, it became apparent that although the improvement had been dramatic, cases of asbestosis were occurring in people who had joined the industry since the dust control measures were introduced and it was also apparent that certain users of asbestos products, such as thermal insulation engineers or ladders were also being affected.

As a result of this the three leading Companies in the asbestos industry, B.B.A. Group, Cape Asbestos and Turner & Newall, decided that further investigation into the nature and causes of asbestosis was necessary and they financed and set up the Asbestosis Research Council with this objective. Since then the Asbestosis Research Council (ARC) has continuously sponsored research at Cambridge, Reading and other centres and has co-ordinated the work of its own research, medical and engineering teams concerned with this problem.

Much of the increased awareness of health problems connected with asbestos stems from these research projects and the industry's own experts are acknowledged, and have been consulted regularly, by Government Departments and other organisations both in this country and overseas. The ARC has drawn up some Codes of Practice on the handling of asbestos in those areas where the control of asbestos dust was thought advisable at that time. The ARC has also played an active part in the formulation of the new Asbestos Regulations which are expected to become law in about 12 months.

Because of its considerable experience in using asbestos and asbestos products itself and its concern that these products should be used without risk, it set up an additional committee last year with the principal object of intensifying the study of problems arising in the working environment, dealing with those areas where it had only

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

recently become apparent that some control might be necessary and helping those concerned with satisfying the requirements of the new regulations.

This Committee is the Environmental Control Committee of the Asbestosis Research Council and it consists of a number of working groups concentrating on the special problems of particular areas. One of these Working Groups is being devoted to the field of friction materials, and has, as its constituent members, Small & Parkes (makers of Don materials), Ferodo and Mintex. This Group, which has been formed recently, is concerned with the users of friction materials, both at its major customers—the brake, clutch and car manufacturers—and also in the replacement and service field.

Its concern has been, first of all, to establish whether or not a problem exists and, if so, how big a problem it is. To this end dust counts have been taken both in premises where friction materials are handled and serviced, and at customers' premises, by the three Companies principally involved. These tests have been taken by their own dust counting teams who have many years' experience in accurate dust measurement. This work is continuing and a picture is being built up of dust counts likely to be encountered whilst carrying out typical operations during brake and clutch maintenance. Analysis of the dust found in brake drums is being carried out also to determine whether all the fibrous dust is asbestos or not.

In addition to gathering and collating information on a large number of dust readings in various types of service premises, the Working Group is preparing two codes of practice for users of asbestos-based friction materials which will be issued by the Asbestosis Research Council. One of these is for the guidance of bulk users in factory premises carrying out, in some cases, operations similar to those carried out in our own factories, such as drilling and grinding, and the other is for the guidance of those engaged in servicing of brakes and clutches.

The purpose of these Codes of Practice or Notes for Guidance will be to remind users of the principal requirements of the new Asbestos Regulations to recommend the action that they should take to meet their requirements. The aim is to achieve what is, after all, the whole purpose of the Asbestos Regulations and the Asbestosis Research Council's work—to reduce concentrations of asbestos dust to a safe level. The long experience of the manufacturers of friction materials in dust control over a wide variety of operations will enable them to recommend measures and types of equipment to help the users to comply with the Regulations and protect the health of their employees.

A further line of study is being followed to see whether a satisfactory surface-sealing agent can be found in order to cut down the amount of dust given off in handling a new lining, even though this amount is already small.

It is not possible for us to take dust counts in every service garage in the country and the work of the Friction Materials Group has been directed to dealing with, and giving advice on, situations which are likely to be typical of those found in service garages. It is, however, the intention to give as much help and advice as possible with the facilities that are available and requests for help or advice directed to the Asbestosis Research Council will be passed on to the Working Group for action.

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SUMMARY AND EVALUATION

Subject: Comparative study of methods used for cleaning auto brakes during servicing. Of some interest.

Evaluation: In British auto repair shops it has apparently be common practice to clean the dust from brake assemblies by blowing it out with a compressed air hose. The natural assumption that this process releases most dust into the air was confirmed by comparative tests using a vacuum cleaner, two types of brushes and rag wiping. However, it is noteworthy that the dust concentrations, measured by sampling devices, included relatively few fibers, which would presumably be asbestos. The author comments: "The results of fibre counts showed that the numbers of fibres present in the high total dust concentrations obtained when an air line was used were of a low order of magnitude and hence the total dust concentration was used as a relative method to describe the dustiness of the environment."

Author: Lee, G. L. (British Leyland Company).

Journal: Annals of Occupational Hygiene (British), January 1970.

Title: "Removing Dusts from Brake Assemblies During Vehicle Servicing -- Alternative Cleaning Methods."

Summary: "Vacuum cleaning provides a useful contribution towards obtaining satisfactory dust control when brake assemblies are cleaned."

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REMOVING DUSTS FROM BRAKE ASSEMBLIES DURING VEHICLE SERVICING— ALTERNATIVE CLEANING METHODS*

G. L. LEE

British Leyland, Longbridge, Birmingham

PRELIMINARY CONSIDERATIONS

WHATEVER the criticisms may be from an occupational health point of view, few would deny that the operation of removing brake dusts with an air line is efficient in that the total time to perform the task is extremely short. The time required to perform an operation is of vital importance in industry and any process changes will always be judged relative to the time scale. In addition, the effort required from an operative in using the method should be minimal and it is easy to see that the chances of developing a technique of cleaning which will reduce dust emissions but at the same time require no more time and effort are extremely slim. Quite clearly, we must concede from the very beginning that some increase in time and effort involved is inevitable.

When viewed under normal lighting conditions, the result of applying a compressed-air line to remove brake dusts is very dramatic. Unfortunately, mere dramatisation alone is not adequate to describe the emission of dust from a process; more objective methods are needed. The conventional method of evaluating an environmental condition is the measurement of the appropriate parameter (in this case—fibre counts), referring the results to hygiene standards. In experimental work to evaluate dust control methods, simpler, "relative" techniques of measurement have considerable advantages and part of this work is concerned with applying a fairly simple method to define certain environmental conditions which prevail when brake dusts are removed by blowing out with a compressed air line and comparing these with the conditions obtained when a dust control technique is applied. Because the method is a relative one, care to prevent errors from extraneous sources of variation is important. These sources of error are discussed later.

METHODS USED TO EXAMINE ENVIRONMENTAL CONDITIONS

When dusts are released in relatively small quantities it is often impossible to see the clouds under normal lighting conditions. They can be made visible using the Tyndall Beam effect and this has been employed extensively during the experimental work.

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

Mass concentrations of airborne brake dusts were determined at two positions by sampling through tared membrane filters. In the first position, a static sampler was placed close to the sources of dust emission. Generally, this sampling position was chosen to be in the area where the results of Tyndall Beam examinations had indicated that the highest dust concentrations were likely to be obtained. Secondly, a personal air sampling device was worn by the operative in such a manner that the sampling head was attached to the wearer's lapel, as near as practicable to the breathing zone.

Samples for particle counting were taken, again in the operative's breathing zone, using a Konimeter, and membrane filter samples were also taken for subsequent fibre counts by microscopy, using the method described by ADDINGLEY (1966). Possible weighing errors due to static charges on membrane filters were prevented by weighing in a field of ionising radiation, as described by HIGGINS and DEWELL.

The results of fibre counts showed that the numbers of fibres present in the high total dust concentrations obtained when an air line was used were of a low order of magnitude and hence the total dust concentration was used as a relative method to describe the dustiness of the environment.

The location selected for the experiments was in a workshop area, behind a glazed partition, and well away from access doors, so that comparisons of cleaning methods were not affected by variations in local air movement. Smoke tests were carried out at each sample period to confirm this point.

CONDITIONS OBTAINED WHEN A COMPRESSED AIR LINE WAS USED TO REMOVE BRAKE DUSTS

A commercial vehicle brake assembly, after removal of the brake drum preparatory to cleaning, is shown in Fig. 1. In this particular case, the hub had also been removed for bearing replacement which facilitated cleaning operations. It should be noted that this is not always so and for the majority of our tests the inconvenience of the hub being present had to be contended with.

A series of Konimeter samples were taken during typical operations and also after the process had ceased. The counts for these samples are summarized in Table 1.

TABLE 1. RESULTS OF KONIMETER SAMPLES DURING BLOW-OFF

Sample	Number of brake dust particles/5 cm ³
Taken at beginning of operation	5000
Taken approx. 20 sec later	4500
Taken approx. 60 sec later	4000
Taken approx. 30 sec later	1800
Taken approx. 30 sec later	580

It is seen that there is a progressive fall in count as the local dust cloud disperses. The first three figures are approximate only, the numbers of particles collected being too high for accurate counting.

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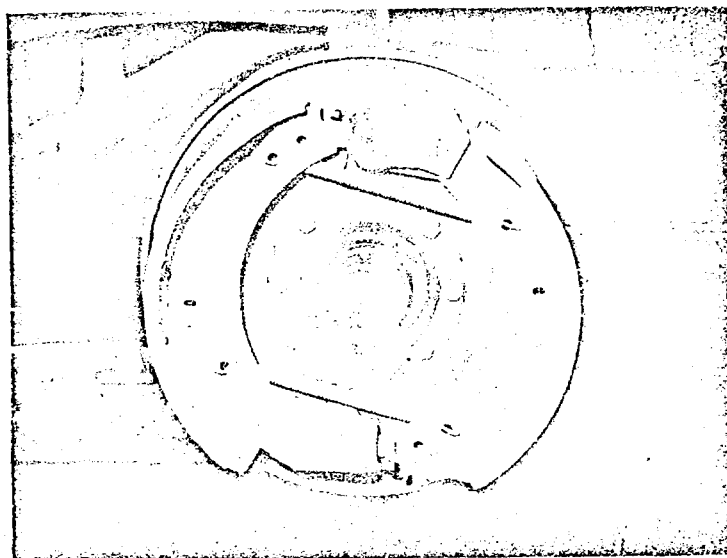


FIG. 1. Brake assembly before cleaning.

(facing p. 34)

A fixed sampling period of some 5 min was chosen for the determination of mass concentrations—this being longer than required for the blowing operation but sufficient to cover that required for the alternative cleaning methods. The dust collected by the static sampler close to the brake assembly gave an equivalent concentration of 114 mg/m³ and that for the personal air sampler 42 mg/m³. It is probable that many of the particles included were larger than respirable size. The few asbestos fibres counted on membrane filter samples gave a concentration of the order 3–5 fibres/cm³.

ALTERNATIVE CLEANING METHODS

Initial approaches were to try the use of fixed and hand-held extractors to collect the dust particles removed by hand-brushing with a small paint brush. Fixed extractors, although reasonably efficient, were rejected because of restrictions which these placed upon the work by confining it to one area. Both operatives and supervision were unhappy about being confined to one work area—preferring to retain flexibility and carry out the work as they had previously done, wherever the vehicle happened to be. Portable extraction equipment was clearly required and after some preliminary enquiries, a BVC industrial vacuum cleaner was selected for use in experimental work. It is of fairly conventional type, powered by a $\frac{3}{4}$ h.p. motor and supplied with disposable paper bags in addition to the normal cloth bag. The paper bags are fitted in a manner which allows them to be sealed fairly easily before removal. To trap any particulates which might pass through the paper and cloth bags, an external, multi-layer filter was provided for fitting to the air outlet end of the cleaner. Preliminary experiments established that some brake dust particles were passing the paper and cloth bags but these were trapped by the externally fitted filter. Sampling at the exit side of the filter established that no particles passed the filter.

CONDITIONS OBTAINED USING THE VACUUM CLEANER AS A SOURCE OF EXTRACTION

The first technique tried was to use the nozzle of the cleaner, hand-held as a source of local extraction whilst the dust deposits were disturbed with a small paint brush held in the other hand. The Tyndall Beam showed that some dust was escaping into the environment. Objective measurements are summarized in Table 2.

TABLE 2. RESULTS OF KONIMETER SAMPLES DURING BRUSHING AND
WITH LOCAL EXTRACTION

Sample	Number of brake dust particles/5 cm ³
Taken at start of process	1070
Taken about 1 min later	404
Taken about 2 min later	426
Taken at end of process	446

The fixed sampler in the area of the highest concentration gave a dust concentration of 21 mg/m³ and the personal sampler, 2.7 mg/m³.

An improvement in controlling the release of dust had been obtained but was not considered completely satisfactory and an alternative approach was sought.

CONDITIONS OBTAINED USING A MODIFIED TECHNIQUE

After some preliminary experiments, the following general technique was devised. Firstly, the loose deposits of dusts inside the brake drum and on readily accessible surfaces of brake shoes and the brake assembly were removed, using the smallest brush supplied with the cleaner—the equipment being used as a vacuum cleaner. A much narrower, tubular brush, made from available materials was then used to remove deposits from less accessible surfaces. Finally, a rag, soaked in water and wrung fairly dry, was used to remove adherent deposits. No visible emissions of dust were observed but a few particles were detected by the objective methods, as shown in Table 3.

TABLE 3. RESULTS OF KONIMETER SAMPLES DURING MODIFIED TECHNIQUE

Sample	Number of brake dust particles/5 cm ²
Brushing with standard brush	16-25
Brushing with tubular brush	20-25
Rag wiping	1-5

No fibres were detected and the mass concentrations involved were too low to determine.

CONCLUSIONS

The objective measurements made seem to confirm that vacuum cleaning provides a useful contribution towards obtaining satisfactory dust control when brake assemblies are cleaned. The design of the particular cleaner chosen prevents the discharge of particles back into the environment and the collection in a paper bag enables suitable disposal methods to be adopted. This work was completed in the early part of 1968 and subsequently the method described was recommended for use until such time as the results of studies being carried out elsewhere in the Motor Industry were known and detailed requirements subsequently formulated.

Acknowledgements—The assistance of Mr D. Smith of the Industrial Hygiene Department and Mr Young, Works Engineers, is gratefully acknowledged.

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INVESTIGATIONS INTO ALTERNATIVE FORMS OF CONTROL FOR DUST GENERATED DURING THE CLEANING OF BRAKE ASSEMBLIES AND DRUMS*

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INTRODUCTION

THE MOST usual method of removing the accumulated dust from brake drums and assemblies is by "blowing off" with a compressed air stream. This, of course, generates a dust cloud in which the operator works, proportionate in size to the drum/assembly being cleaned. We therefore investigated two alternative methods of controlling dust generated at a maintenance operation on commercial vehicles, as representing maximum likely exposure.

Enquiries at the beginning of the investigation indicated that the removal of dust is to allow inspection of the mechanism, rather than being a maintenance procedure in itself. Our efforts were, therefore, directed towards the removal of loose dust from the parts of the brake mechanism which needed inspection, rather than achieving total cleanliness.

The criteria for evaluating the two methods devised were firstly, that the alternative method did not take significantly longer than the method already in use, secondly, that it was not more difficult to carry out, and thirdly, that very little extra equipment was needed.

ALTERNATIVE METHODS EXAMINED

The alternative methods examined were a vacuum funnel, and a vacuum brush.

Vacuum funnel

The funnel (see Fig. 1) comprised a steel cone with a connection point at its apex for an industrial vacuum cleaner; a flexible skirt, with a draw string attached at its periphery; and a small-bore side-entry for the injection of compressed air. In use, the funnel was secured over the backplate of the brake assembly or over the drum and compressed air was injected to dislodge dust while the vacuum cleaner extracted dust-laden air. The assembly was rotated around the total circumference to complete the cleaning operation.

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

Vacuum brush

The vacuum brush shown in Fig. 2 consisted of a circular nylon bristle brush mounted on an angled handle and fitted via the handle to the same vacuum cleaner. In use, the brush was used to remove dust from drums and assemblies under vacuum.

EXPERIMENTAL PROCEDURE

In order to determine which of these two methods was the better, the performance of each was compared with the traditional blow-off method, in two separate experiments shown in Table 1.

TABLE 1. EFFECT OF CLEANING METHODS ON DUST CONCENTRATIONS

Hour		1	2	5	6	6
Activity		Back-ground	Blow-off	Back-ground	Funnel cleaning	Brush cleaning
Personal sampler	particles/cm ³	116	422	107	415	
	fibres/cm ³	0.96	5.35	0.95	3.5	
Static sampler	particles/cm ³	161	72	162	210	
	fibres/cm ³	0.45	0.52	0.41	0.75	
Peak sample	particles/cm ³		41750		759	
	fibres/cm ³		87		1.04	
Personal sampler	particles/cm ³	125	635	140		158
	fibres/cm ³	0.16	0.84	0.09		0.22
Static sampler	particles/cm ³	129	155	110		122
	fibres/cm ³	0.10	0.16	0.20		0.18
Peak sample	particles/cm ³		41750			310
	fibres/cm ³		87			0.57

During the first hour of the day air samples were collected to determine background concentrations; during this period the near side front road wheel was removed. In the second hour samples were collected during dust removal from the near side brake assembly by blow-off. Further background samples were taken during the fifth hour while the off side front road wheel was removed; and during the sixth hour dust determinations were made while either the funnel or the brush cleaning methods were used.

The personal samples were collected from the breathing zones of mechanics engaged in the work and static samples were collected concurrently to simulate exposure of mechanics working in an adjacent repair bay. Short duration samples were also collected by means of a Dräger pump from the operator's breathing zone at the peak period of dust generation.

All the samples were subsequently analysed for fibres in accordance with the technique laid down in the *Hygiene Standard for Chrysotile Asbestos* published by the British Occupational Hygiene Society (1968). Particle counts were limited to particles greater than 1 μ dia.

DISCUSSION

The results for the vacuum funnel vs. blow-off experiment and for the vacuum brush versus blow-off are shown in Table 1. It can be seen that the background concentrations during the fifth hour had re-established at the original level after a 2 hr latent period and therefore the blow-off operation carried out during the second hour did not affect the concentrations observed in the vacuum funnel samples collected in the sixth hour. The funnel appears to reduce personal exposure by 2 per cent for particles and 40 per cent for fibres; concentrations observed in the adjacent bay are increased and a reduction in peak concentrations of about 80:1 was achieved.

During the second experiment there was more variability in the background concentrations between the first and fifth hours but the effect of blow-off on the vacuum brush test may be discounted. Personal exposure by use of the brush is reduced by 75 per cent for both particles and fibres and the static samples show a reduction of 20 per cent for particles but an increase of 12 per cent for fibres. A reduction of 80:1 in peak concentrations was again observed.

CONCLUSION

The experiments demonstrated that the vacuum brush was better in reducing operator's exposure; it had the added advantages over the funnel of being easier to handle, consisted of fewer, simpler parts and was much quicker than the vacuum funnel.

There are three major reasons for the relative inefficiency of the funnel; its use increased brake cleaning time (and thus exposure time) by a factor of 8, it was difficult to obtain a good seal at the skirt, and imbalance occurred between the necessary air input and the capacity of the available exhaust system, with resulting leakage of dust.

REFERENCE

COMMITTEE ON HYGIENE STANDARDS, BRITISH OCCUPATIONAL HYGIENE SOCIETY (1968) *Hygiene Standards for Chrysotile Asbestos Dust*. Pergamon Press, Oxford.

SUMMARY AND EVALUATION

Subject: Discussion of the preferred type of vacuum cleaner to use in cleaning auto brakes during servicing. Of some interest.

Evaluation: Having determined that blowing the dust out of brake assemblies with a compressed air hose releases the most dust into the air, the authors investigated the use of vacuum cleaning equipment with two types of pick-up heads. It was determined that a brush on the end of the vacuum hose is more efficient than a funnel attachment.

Authors: Knight, K. L. and Hickish, D. E. (Medical Services, Ford of Britain).

Journal: Annals of Occupational Hygiene (British), January 1970.

Title: "Investigations into Alternate Forms of Control for Dust Generated During the Cleaning of Brake Assemblies and Drums."

Summary: As given above.

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National Center for
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Brake Lining Decomposition Products

A number of investigators have found asbestos bodies in the lungs of urban residents who were not occupationally exposed to asbestos. A relationship between the carcinogenic properties of asbestos and the urban excess of lung cancer has been suggested. The decomposition products of brake linings have been described as a possible source of these fibers. Brake testing laboratory methods were used to test fiber emission from a variety of friction products. Only a very small fraction of the asbestos escaped as free fiber while the remainder was transformed into some other, nonfibrous, mineral. A significant release of free fiber occurred only under conditions extreme enough to produce brake failure.

Table I. Asbestos bodies in human lungs.

Location	Year	% Positive
Cape Town (2)	1963	26
Miami (2)	1965	27
Pittsburgh (3)	1965	41
Johannesburg (4)	1965	39
Finland (5)	1966	58
Montreal (6)	1966	48
San Francisco (1)	1966	42

Table II. Brake lining composition.

Ingredient	Automobile	Truck
Asbestos	55	33
Resins and polymers	28	48
Oxides and pigments	9	16
Metals	3	2
Carbon, graphite, etc.	5	1
	100%	100%

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The occurrence of coated fibers referred to as "asbestos bodies" in the lungs of urban populations not occupationally exposed to asbestos has been noted by several investigators. The results of several autopsy series, as summarized by Cooper,¹ are shown in Table I.¹⁻⁶ Thompson,⁷ in suggesting possible modes of exposure that could account for these bodies, stated:

The average private motor vehicle wears out three or four sets of brake linings and one or two clutch linings in its lifetime, and commercial and public transport vehicles wear out many more. These linings consist largely of asbestos which is ground to dust as the linings wear, and most wear occurs in built-up areas. This alone in most cities would involve the discharge of many tons of asbestos dust and fibers in the streets each year.

Since asbestos has been implicated as a carcinogen⁸ and lung cancer has a higher incidence⁹ among urban populations, the fate of the asbestos worn from brake linings becomes significant.

Brake Lining Composition

The average composition of typical brake linings of the type tested is shown in Table II. Individual mixes may vary considerably from these averages.

Each of these ingredients performs a particular function. The asbestos provides strength, heat resistance, and selective decomposition under stress. The resins and polymers hold the other ingredients together. Various oxides are added as pigments and to improve the grip of the lining on the drum. Soft metals such as lead and brass improve wear while carbon and graphite serve

as friction modifiers.

Brake lining quality depends to a large extent on the type of binder used. Linseed oil, which begins to decompose at about 450°F, is used for light service brakes. More demanding service requires brakes made from cashew type resins or oil modified phenolic resins. These ingredients are mixed, either dry or with a solvent added, formed into shape, and cured in an oven. The hardened lining is then cut, ground, and sanded to the precise dimensions of the finished linings. The dust produced by the abrading operations in asbestos friction product factories (Figure 1) contains free asbestos fibers that are similar to those in industries where cancer is known to be in excess.¹⁰ The question to be resolved, therefore, is whether the dust produced by the normal wear of brake linings contains this same type of free asbestos fiber.

Test Methods

In an initial exploratory survey, the dust obtained from inside automobile brake drums removed for brake relining was examined by electron micrograph. Figure 2, which is typical of the series, does not reveal any free fibers. However, this finding did not eliminate the possibility that free asbestos fibers were released and that they had escaped into the atmosphere. To examine this hypothesis a series of experiments was devised to permit sampling decomposition products of the lining under simulated operating conditions. The tests (Table III) were performed with the brake testing machines in the laboratory of a major brake lining manufacturer. Most of the tests were performed on a

Table III. Test results by electron micrograph.

	Product	Brand	Test Method	No. of Samples	Conditions of Test-F	Presence of Free Fibers	% Free Fiber*
1.	Automobile drum brakes	A	Friction	6	300 - 800	Few	<1
2.	Automobile drum brakes	B	Friction	6	250 - 800	None	0
3.	Automobile drum brakes	C	Friction	5	300 - 700	Few	<1
4.	Automobile drum brakes	C	Friction	1	700 - 900	Numerous	~10
5.	Automobile drum brakes	D French	Friction	5	300 - 800	Few	<1
6.	Automobile drum brakes	E	Friction	5	300 - 700	Few	<1
7.	Automobile drum brakes	F German	Friction	5	300 - 800	Few	<1
8.	Automobile drum brakes	G	Friction	2	100 - 500	Few	<1
9.	Automobile drum brakes	G	Friction	1	600 - 700	Numerous	~15
10.	Automobile drum brakes	H	Friction	2	100 - 600	Few	<1
11.	Automobile clutch	J	Dynamometer	1	Normal driving	None	0
12.	Automobile disk brake	K	Dynamometer	1	Normal driving	Few	<5
13.	Bus drum brake	L	Dynamometer	1	City driving	None	0
14.	Bus drum brake	M	Friction	2	450 - 550	None	0
15.	Truck drum brake (light)	F	Friction	10	300 - 800	Few	<1

* Weight estimated from fiber volume.

Some independent experiments done at a brake lining research laboratory¹¹ have shown that all of the magnesium present in the chrysotile asbestos originally in the lining can be accounted for in the decomposition products. However, the characteristic X-ray diffraction pattern of chrysotile asbestos had vanished. Thus, it is apparent that under conditions in which asbestos is worn from the lining of a brake, the asbestos is destroyed.

Conclusion

Only a very small proportion of the asbestos worn from brake linings is released as free fiber; the remainder is converted into some other mineral as a result of the extreme temperatures generated at small spots on the lining surface. Thus, although urban air contains a few free fibers as a result of brake lining wear, they represent a very small

proportion of the total asbestos used in manufacture of brakes. Many sources of respirable fibers not associated with asbestos products have been identified,¹² and free fibers from brake lining wear seem to be an inconsequential health factor in urban air pollution.

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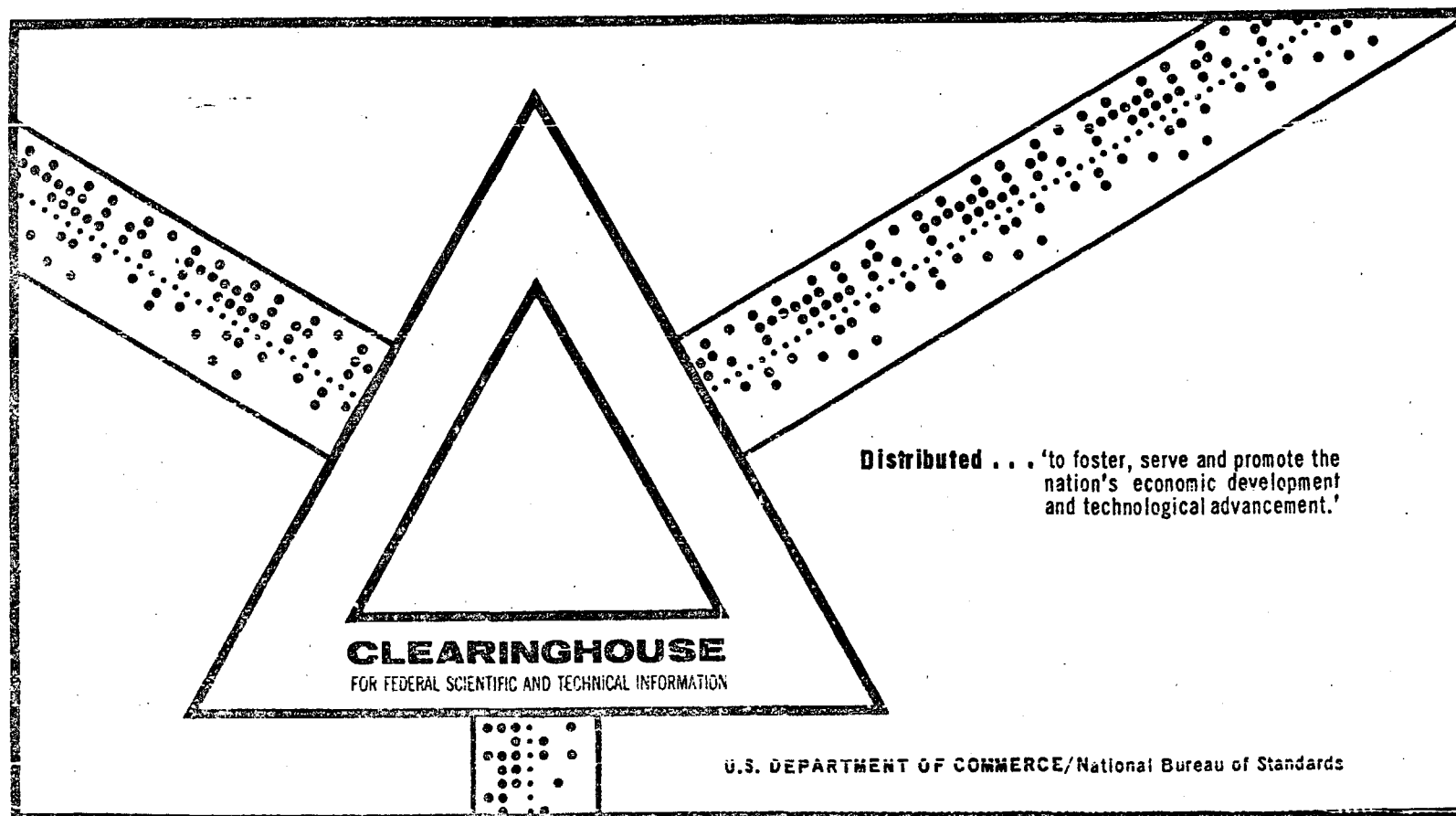
BRAKE LINING DECOMPOSITION PRODUCTS

In recent years, some individuals have pointed at brake lining wear as a probable source of asbestos contamination of the ambient air. In this paper, Jeremiah R. Lynch of the National Center for Urban and Industrial Health, HEW, refutes this theory by showing that in all but a few extremely severe automobile braking tests, less than one percent asbestos fiber could be found in the collected dust. He concludes that brake lining wear is "an inconsequential health factor in urban air pollution."

NATIONAL INVENTORY OF SOURCES AND EMISSIONS: CADMIUM,
NICKEL, AND ASBESTOS - 1968. ASBESTOS, SECTION III

David (W. E.) and Associates
Leawood, Kansas

February 1970



FMSI 03016

ASBESTOS IMPORTS

During 1968, asbestos imports were 737,909 short tons. Approximately 94 percent of the import total was from Canada and 5 percent was from the Republic of South Africa.^{1/}

ASBESTOS EXPORTS

Asbestos exports, during 1968, were 41,236 short tons.^{2/}

1-2- Bureau of Mines Minerals Yearbook - 1968

REPROCESSING

The apparent consumption of asbestos in the United States, during 1968, has been reported at 817,363 short tons.^{1/}

FRICTION MATERIALS

Asbestos is regarded as indispensable in most types of friction materials. It is used as the primary constituent in brake linings and clutch facings for motor vehicles, and other commercial and industrial equipment.

Brake linings are of two principal types. In the early days of the automobile, virtually all brakebands were of woven asbestos fabrics but now the molded type is used extensively. Molded linings consist of asbestos fibers bonded with an organic matrix. Metallic reinforcing is commonly added, and the shaped products are thoroughly cured. Chrysotile asbestos is required, ranging in fiber length from the very short grades to those just under spinning grades.

In the United States the use of asbestos in friction materials during 1968 was about 104,000 short tons.^{2/} Reprocessing plants producing friction materials are listed in Appendix A.

1- Bureau of Mines Minerals Yearbook - 1968

2- Estimate based on reports from reprocessing companies and data from the 1967 Census of Manufacturers.

REPROCESSING

An outstanding characteristic of the asbestos industry is that a very large proportion of the fiber is mined, imported, processed, and re-processed by a relatively few companies. Very little of the finished product is sold to the consumer trade.

The original use of asbestos was based on its heat resistance properties, but the current use is more often as a binder; such as in asbestos cement products.

The asbestos fibers are usually sold in 100 pound bags which are paper bags or jute bags which sometimes have a plastic liner. The disposal of these bags seems to present a problem to the industry. A few are able to use the paper bags in the product being produced, but many more are still seeking a satisfactory solution.

FRICTION MATERIALS

One of the largest uses of the friction material is in brake linings of the molded type. The molded linings, consisting of asbestos fibers bonded with an organic matrix, contain approximately fifty percent asbestos. As a part of the manufacturing process, the linings must be shaped and finished by grinding after they are formed. This

creates a substantial loss of asbestos, as much as thirty percent. With such a grinding procedure an adequate exhaust and collection system is essential.

A large manufacturer of brake linings reported 4000 tons of asbestos collected in bag filters at one plant during 1968 and described his collection system. He estimated overall atmospheric emissions of asbestos to be 0.25 to 0.50 percent, based on the efficiency of his collection equipment. Other manufacturers provided some information regarding the type of collection equipment in operation, but not data or estimates of asbestos emissions.

On the basis of information obtained an emissions factor of 6 pounds per ton of asbestos processed is estimated, and asbestos emissions to the atmosphere during 1968 are 312 short tons.

fiber, were sold to a contractor during 1968 for use on roads.

It is reported that an appreciable amount is used in Vermont for roads.¹ This could not be confirmed, since permission to visit the mine and mill was denied.

Construction

Workmen in all trades in the construction industry come in contact with asbestos. Heating ducts are often insulated with asbestos, and steam piping is nearly always covered with a material containing asbestos. Electricians strip asbestos insulation from wires, and the carpenter saws asbestos siding, wallboard, and shingles. As a result, there is asbestos released to the air around the construction sites.

Asbestos emissions to the atmosphere at construction sites are estimated at 61 short tons for 1968.

Brake Linings

Motor vehicle travel during 1968 totaled one trillion miles, and replacement brake linings were required for about 25 to 30 million vehicles. It is the usual practice, when installing new brake linings,

1- May-Timothy C.; Asbestos; Mineral Facts and Problems; Bureau of Mines Bulletin 630 - 1965

to fit the linings to the drums by grinding, and the amount of grinding required varies depending on the condition of the brake drum.

Data concerning motor vehicle brake linings:

Vehicle miles during 1968	1,010,000,000,000
Mileage life of brake linings	27,500
Brake lining sets on new vehicles	10,718,000
Pounds of asbestos per set of brake linings	3
Assumed loss to atmosphere during grinding and fitting - percent	0.5

Based on the above, the emissions factor is 10 pounds per ton of asbestos processed, and the asbestos emissions to the atmosphere during 1968 were 190 tons.

Steel Fireproofing

Several spray-on materials that contain asbestos are used extensively on steel columns and other structures as a fire protection measure. The application of such materials is often required by code. Even though the building frame may be covered by a temporary enclosure when the material is sprayed, the workmen are exposed to an atmosphere that is virtually saturated with asbestos fiber.

Asbestos emissions to the atmosphere, due to the use of spray-on fireproofing during 1968, are estimated at 15 short tons,

based on an emissions factor of 10 pounds per ton of asbestos applied.

Motor Vehicle Use

It is obvious that there are substantial particulate emissions from the wear of motor vehicle brake linings and clutch facings. This has been reported as a primary source of asbestos emissions to the atmosphere; however, there are conflicting reports indicating that the asbestos fiber has been destroyed by the heat of friction.

In this report the estimate of emissions does not include an amount for the wear of motor vehicle brake linings and clutch facings.

Insulating Cement

Insulating cement that contains asbestos is used extensively in all types of boilers. It is used for pointing up joints and cracks in stack and breeching linings, and for surfacing block insulation that is installed inside breechings, ducts and economizers.

During the boiler operation, as the flue gas passes through the boiler some of the insulating cement is worn away and carried along through the dust collector, up the stack, and into the atmosphere.

Based on the following assumptions, an emissions factor of 33

pounds per ton of asbestos applied is calculated for the use of insulating cement.

- 1 - Fifteen percent of the insulating cement worn away during use,
- 2 - Dust collector efficiency - 89 percent (average)

Asbestos emissions to the atmosphere during 1968 due to the use of insulating cement are estimated at 25 short tons.

ASBESTOS MINES IN THE UNITED STATES

ARIZONA

Asbestos Manufacturing Company
Jaquays Mining Corporation
Metate Asbestos Corporation

LOCATION

Gila County
Gila County
Gila County

CALIFORNIA

Atlas Minerals Corporation
Coalinga Asbestos Company (1)
Pacific Asbestos Corporation (2)
Union Carbide Corporation

Fresno County
Fresno County
Calaveras County
San Benito County

NORTH CAROLINA

Powhatan Mining Company

Yancey County

VERMONT

GAF Corporation

Orleans County

(1) - Owned by Johns-Manville Corporation

(2) - Acquired by H. K. Porter Company, Inc. during 1968.

REPROCESSING PLANTS PRODUCING ASBESTOS FRICTION MATERIALS

CALIFORNIA

H. Krasne Manufacturing Company
Silver Line Brake Lining Corporation
Lasco Brake Products Corporation, Ltd.

LOCATION

Los Angeles
Los Angeles
Oakland

CONNECTICUT

H. K. Porter Company, Inc.
Raybestos-Manhattan, Inc.

Middletown
Stratford

ILLINOIS

Gatke Corporation
Grizzly Brake Division of Mar Pro Inc.
The L. S. Miley Company
Johns-Manville Corporation

Chicago
Chicago
Chicago
Waukegan

INDIANA

Raybestos-Manhattan, Inc.
H. K. Porter Company, Inc.
World Bestos Company
(sub. of Firestone Tire & Rubber Co.)

Crawfordsville
Huntington
New Castle

KENTUCKY

H. K. Porter Company, Inc.

Richmond

MASSACHUSETTS

Auto Friction

Lawrence

MICHIGAN

American Brakeblock - Division Ambes Corp.
American Brake Shoe Company

Birmingham
Troy

NEW JERSEY

Johns-Manville Corporation
Reddaway Manufacturing Company, Inc.
Raybestos-Manhattan, Inc.
H. K. Porter Company, Inc.

Manville
Newark
Passaic
Trenton

NEW YORK

Bendix Corporation

Troy

NORTH CAROLINA

Southern Friction Materials Company

Charlotte

OHIO

American Brake Shoe
General Motors Corporation
Maremont Corporation

Cleveland
Dayton
Paulding

PENNSYLVANIA

Raybestos-Manhattan, Inc.
H. K. Porter Company, Inc.

Manheim
Pittsburgh

TEXAS

Standco Brake Lining Company

Houston

TENNESSEE

Bendix Corporation

Cleveland

VIRGINIA

American Brake Shoe

Winchester

(Thomas Register, Dec., 1968 Ed., Fortune-1966 Plant & Product
Directory of the 1000 Largest U.S. Industrial Corporations; U.S.
Department of Commerce.)

REPROCESSING PLANTS PRODUCING ASBESTOS CEMENT PRODUCTS

ALABAMA

U. S. Cast Iron Pipe Company
GAF Corporation
Cement Asbestos Products Company

LOCATION

Anniston
Mobile
Woodward

CALIFORNIA

Southern Pipe & Casing Company
Johns-Manville Corporation
Johns-Manville Corporation
Certain-Teed Products Corporation
Certain-Teed Products Corporation
Johns-Manville Corporation

Azuza
Long Beach
Pittsburgh
Riverside
Santa Clara
Stockton

CONNECTICUT

Tile Roofing Company

Stratford

GEORGIA

Uniroyal, Inc.
GAF Corporation

Hogansville
Port Wentworth

ILLINOIS

Acme Asbestos Covering & Flooring Company
Asbestos & Magnesia Materials Company
Flintkote Company
Western Slate Company
Fel-Pro, Inc.
Johns-Manville Corporation

Chicago
Chicago
Chicago
Elmhurst
Skokie
Waukegan

INDIANA

U. S. Gypsum Company

East Chicago

GHQ
December 3, 1971

TO: JOHNS-MANVILLE ENVIRONMENTAL HEALTH TASK FORCE
AIA/NA MEMBER COMPANIES
AIA/NA ADMINISTRATIVE SUB-COMMITTEE

CC: Dr. Joseph L. Goodman Frank Zimmerman
Ike Weaver Bradley Walls
Ed Drislane
C. R. Wikel
R. F. Winkworth
H. J. Roesch

ILLINOIS POLLUTION CONTROL BOARD REGULATIONS ON ASBESTOS

Attached is the "Proposed Final Draft" of the State of Illinois Pollution Control Board regulations on asbestos. Substantial changes of a positive nature have been made in nearly every section of the regulations as compared with the draft published last summer.

Among the most important changes are the following:

1. The section banning the use of asbestos-containing brake linings after 1975 has been eliminated. While it might appear from the comments in the "Explanation" section of the regulations on page 10-11 that this question is not completely settled, it is our belief that the Board will take no further action against brake linings unless the Federal Government does first, in which case any action taken by the state would be rather academic.
2. The plant emission standard has been raised from a level of .5 fibers per cc to a more acceptable level of 2 fibers per cc. In addition, the standard of .05 fibers per cc at the boundary line of a plant has been eliminated completely.
3. A "no visible emissions" standard has been included in various sections of the regulations where enforcement of a stricter standard would have been a problem, if not impossible.
4. The segment of the regulations requiring "total enclosure" of a structure under demolition before toppling of walls could begin has been altered to a more-or-less "do the best you can" standard.

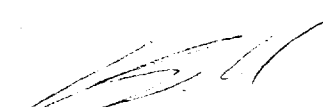
FMSI 03023

5. The section requiring the use of a sealant on all "fibrous" materials used inside ducts or plenums has been changed to "asbestos-containing" materials only.
6. The section prohibiting the discharge of asbestos-containing process waste water into the rivers, streams and sewers of the state has been changed to permit such discharge if the waste water "is given the best available treatment consistent with technological feasibility and economic reasonableness."
7. Under the Proposed Final Draft, only manufacturing plants will be required to obtain a permit from the state. The first draft required permits for any operation or activity involving asbestos.

The vast majority of the above and other positive changes in the regulations reflect specific recommendations and corroborative evidence presented to the Board by Dr. F. L. Pundsack of Johns-Manville and Dr. Joseph L. Goodman of Raybestos-Manhattan on behalf of the AIA/NA at the public hearing on the regulations held October 15 in Chicago, and by Dr. George W. Wright and an industry team at a meeting held with Board staff representatives in September. Also participating in the overall cooperative industry effort were NIMA and the Friction Materials Standards Institute.

Attached is a copy of the specific changes submitted by the AIA/NA at Board request following the Chicago hearing. Because of the many changes in the final draft, the section and sub-section numbers on the AIA/NA recommendations do not correspond to those in the final draft. However, as you can see, the basic changes recommended by the AIA/NA have been adopted by the Board.

It is indeed an encouraging sign to find that, in this era of national environmental panic, a well-documented and well-presented industry case can produce results as fair and reasonable as those obtained in the state of Illinois. Much credit must go to the responsible yet fair attitude of the Illinois Pollution Control Board, and to all those in the industry who worked long and hard on this project.



W. P. Raines

Asbestos dust called killer

By STEVE ROTHMAN
Staff Writer

"There is no doubt about it... asbestos dust is a killer if it gets into your lungs."

The man who was speaking was James Middleton, business representative for the International Chemical Workers Union, Local 60, in Waukegan.

Some 25 environmental experts, concerned citizens and representatives of the Johns-Manville Company plant in Waukegan sat and listened.

Samuel T. Lawton Jr., Illinois Pollution Control Board member, eyed the wiry union executive with interest.

"There is a long hard road ahead to improving conditions (in the Waukegan plant)," added Middleton, "but we are looking toward the day when we can pull off our respirators and work without them."

Middleton's testimony came at

the end of three days of hearings before the IPCB, which is creating regulations to protect the public and workers from asbestos-related ailments.

Hearings also were held in Granite City and the Field Museum in Chicago.

"We read a great deal about emission control standards," said Middleton, "but we seldom come in contact with the people working with the products."

Middleton brought employee problems to the attention of News-Sun reporter Steve Rothman last June.

He provided death certificates on two workers, who died of ailments caused by long exposure to asbestos dust in the plant.

A series of News-Sun articles led to a promise by J-M officials to clean up the four plants it operates in Waukegan and to create a union-

management environmental team to work out methods of dust control. It also led to a special asbestos dust hearing in Waukegan.

J-M officials termed the series the work of a "local busy-body troublemaker trying to muddy up J-M's good name," according to an IPCB investigator.

But the investigator added the investigation indicated J-M had a great deal more to do even though it was a leader in the field of environmental protection for asbestos workers.

Middleton said workers were exposed to dust when unloading railroad cars of asbestos material and making pipe in the transite pipe division, as well as in its block-making process.

"The company has showed us where it is making improvements in the plant," he said, "but the problem has not been solved."

"Asbestos dust will get into the lungs some way, if it is not controlled," he added, "and we feel the respirator (used by employees) is not good."

Middleton said the union has adopted a wait-and-see attitude to see how far the committee can go in cleaning up the plant.

The danger not only is in the handling of asbestos, said Middleton.

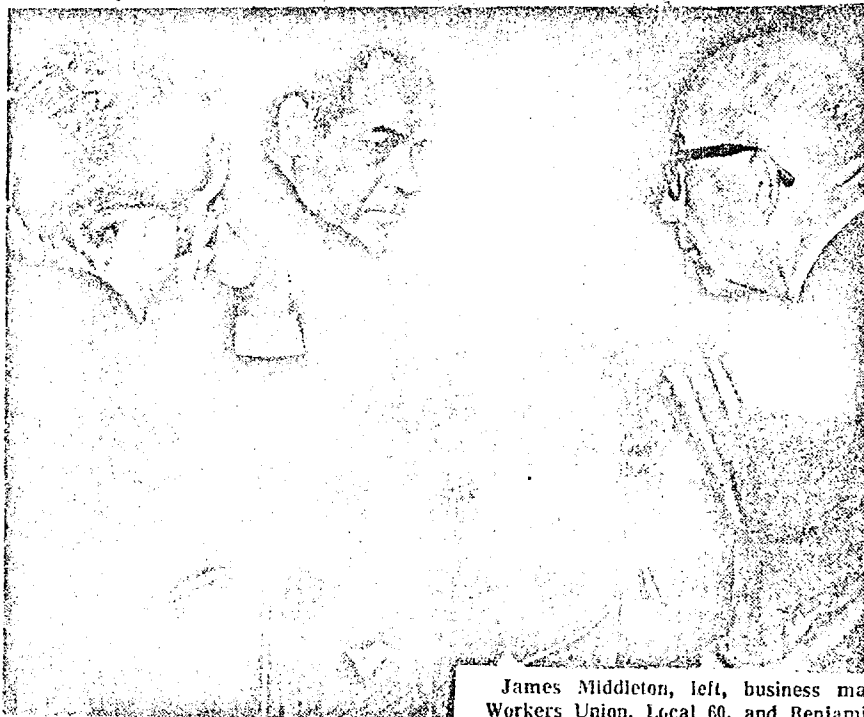
"Workers leave the plant with dust on their clothes," he said. "They carry it into their cars, into the stores where other people buy products and home."

"Their children come in contact with the dust and get it in their lungs, when they play on the couch where their fathers sit to rest," he added.

Middleton said he felt workers should be provided clothes which would be left in the plant at the end of the day, or some means of cleaning the dust from their clothing before they went home.

Gaddam N. Reddy, an Illinois Environmental Protection Agency environmental engineer, said he felt regulations should stop all commercial activity where asbestos was used (Continued on Page 4A, Col. 6)

WAUKEGAN, ILL., WEDNESDAY, OCTOBER 20, 1971



Plant problems

James Middleton, left, business manager for the International Chemical Workers Union, Local 60, and Benjamin Fout, union president, discuss conditions at the Johns-Manville complex in Waukegan with Charles Wikel, one of the company's plant managers. (Staff photo)

Asbestos dust called killer at hearing

(Continued from Page 1)

unless the person in charge complies with regulations.

"We want to stop dust from getting into the atmosphere not just those who violate the regulations," he said.

Reddy said the agency was recommending that mechanical exhaust of dust into the atmosphere be prohibited.

"Any factory, plant or enterprise should have to enclose its asbestos facilities so all exhaust air is filtered," he said.

Reddy said he felt the spraying of asbestos fibers should be regulated so that the fibers are confined to the area being treated.

But he did not feel that all spraying of asbestos fibers should be prevented.

IPCB is proposing that all asbestos spraying be halted.

But Benjamin Fout, president of Local 60, urged the board not to halt use of asbestos spraying.

"Handled properly, asbestos is a good fire protection material," he said, pointing to the disastrous McCormick Place fire of several years ago.

McCormick Place had not been protected from fire by flame resistant materials and all steel girders melted under the intense heat.

Howard Ayer, National Institute for Occupational Safety and Health of the U.S. Public Service, said that in-plant testing for dust concentrations can be set up for about \$1,100.

He said filters which employees could wear cost about 60-cents a piece.

He said it takes one day to train a man who knows how to use a microscope in testing techniques.

A man of average intelligence can learn the process in one week where he first must learn to handle a microscope.

"Our primary concern is with the workers," he said. "Asbestos is related to lung cancer and we aim to see these people protected because of the danger from long exposure."

Ayer said that protection must come at the "source" of exposure.

Ayers said the concern is not with the dust which you see, "but the dust which you cannot see because it is too small but can make it into your lungs."

Fred Engelking, a Caterpillar Tractor Co. research expert, said that the company had made its own test of brake linings and felt the evidence inconclusive to pass regulations covering them.

"Caterpillar... questions whether the intent of the... regulations is actually accomplished by the proposed ban of asbestos brake linings," he said referring to the 1975 cut-off date for use of asbestos in brake linings.

He said if testing indicates a danger exists, the regulations should be qualified to allow asbestos use in a totally enclosed brake compartment system. This would prevent asbestos particles from getting into the air.

If testing indicates that asbestos brakes are harmful then a reasonable threshold limit of the danger should be established, he added.

"Place the burden on the manufacturer to design his product to meet reasonable, attainable standards," he said. "Don't just prohibit the use of asbestos in brakes."

But Colin F. Harwood, an Illinois Institute of Technology Institute research chemist, said brake linings have asbestos dust in them and that many people have asbestos deposits in their lungs although they don't work with the product.

Harwood, who testified at earlier hearings, told The News-Sun "asbestos spraying" should be stopped.

"Building sites are essentially messy places and are hard to clean up," he said. "Spraying increases the number of airborne particles."

While J-M took no active part in the Waukegan hearings, officials later backed the position of Dr. Fred L. Pundsack, a company vice president who represented the Asbestos Information Association of North America in Chicago.

Pundsack said while the danger to the general public had not been defined...

"We believe it is prudent

and feasible to establish reasonable emission controls that will protect the public and ensure that hazardous levels of asbestos will not develop in the community air in the future."



Dust dangers

Samuel T. Lawton Jr., IPCB board member, reads over submitted testimony dealing with the dangers of asbestos dust. (Staff photo)

October 20, 1971

ILLINOIS POLLUTION CONTROL BOARD HEARING ON ASBESTOS
WAUKEGAN, ILLINOIS - OCTOBER 19, 1971

This hearing was presided over by Board Member Samuel Lawton and was also attended by his Assistant, Timothy Harker. Others in attendance included representatives of the Johns-Manville Local 600 of the International Chemical Workers Union, Dr. Colin Harwood, of Illinois Institute of Technology Research Institute, Reporter Steve Rothman of the Waukegan "News-Sun", the newspaper that blasted J-M on the asbestos and health issue last summer, and a representative of the Illinois Department of Labor.

Johns-Manville was represented by Plant Manager Chuck Wikel, Dr. Tom Davison, Cliff Sheckler, Roy Winkworth (employee relations) Frank Angelos, (Environmental Control) J. Robbin (P&FM District Sales Office, Chicago) and Bill Raines. Dr. Eugene Stefl of Raybestos and Attorney Carol Halfpenny, representing Raybestos, also were present.

The first witness was Mr. Gaddam Reddy, Environmental Control Engineer, Illinois Environmental Protection Agency. Mr. Reddy, a native of India, spoke with such a decided accent that it was difficult to understand what he was saying. The gist of it appeared to be that the EPA (enforcement arm of the Illinois Pollution Control Setup) did not have the personnel nor the

equipment to do the kind of sampling of ambient air that the regulations called for.

The second witness was Cliff Sheckler, speaking for the National Insulation Manufacturers Association. He gave a statement on the health aspects of Fiber Glass. This was intended to counter the allegations made by Mr. Golinken at Chicago, although no reference to those allegations was made by Sheckler. There were no questions from the Board.

The third witness was Fred Engelking of Caterpillar Tractor. He is a Chemist who is in charge of Research and Development on Friction Materials in the Research Department of Caterpillar. He gave an excellent slide presentation covering the types of equipment that Caterpillar makes that use brakes, the five different types of braking systems and some of the research Caterpillar has done. He states that no safe substitute has ever been developed for asbestos in brake linings. He showed very impressive graphs demonstrating the difference in "slip time" of asbestos containing brake linings versus sintered metal. The latter are very noisy and, worse, tend to lock, throwing the driver into the windshield.

Caterpillar has done research somewhat to that of Lynch. They see no fibers ^{larger} ~~smaller~~ than 5 microns; their results generally parallel those of Lynch.

Caterpillar wants the brake lining ban modified so that:

1. Asbestos brake linings would be permitted if in totally enclosed brake compartments.
2. Asbestos containing brake linings would be permitted in any event until conclusive medical evidence has been shown to prove the need for a ban on them. Even then, a threshold limit value should be assigned rather than a complete ban. (An interesting contrast to Nicholson's "Make Industry Prove It's Safe" Testimony in Chicago.)

The fourth witness was Dr. Howard Ayer of the National Institute of Occupational Safety and Health, H.E.W. He talked about sampling and calculating methods and the great variations in sampling. He talked about reliability, reproducibility and cost of sampling techniques, particularly those that would have to be used for the ambient air. It appeared that his testimony was aimed at supporting a "visible emission" versus "numerical" standard, although Ayer expressed some doubts about the idea of a visible emission standard. It was never entirely clear who invited him to testify, although he stated that he had been "invited" the previous day.

The final witness was Mr. Middleton of Chemical Workers. He said he wanted to talk about in-plant conditions and gave a bit of background as to his interest in the subject, including the fact that he had attended Dr. Selikoff's seminar in March. He implied strongly that the Union had "discovered" the asbestos health problem and had "brought it to the attention of the company and got the company to do something about it" but when one ignores those jabs, his testimony was helpful in that he said that the company and the Union had setup a joint Environmental Control Committee and that conditions were "improved". He said that J-M was making "progress" on dust control although the Union would take a "wait-and-see" attitude. He pushed for some provision for change of clothing so that workers do not take asbestos-laden clothes home from work. He also said that he wants TLV under the Occupational Safety and Health Act lowered, although he did not cite a figure. He did say that the Union and the company are now cooperating. When he completed his testimony, Cliff Sheckler rose and, speaking for Johns-Manville, thanked him for his comments.

Before adjoining the hearings, Lawton mentioned that there would be additional hearings only if the full Board chooses to make "substantial" changes in the proposed regulations. He implied that he did not think this would happen!

W. P. Raines

mab-12

Illinois urged to put curbs on asbestos use

By Bruce Ingersoll

If smoking two packs a day doesn't give you lung cancer, there is a good chance that working with asbestos will, a New York environmental scientist has warned.

Lung cancer has been solidly linked with smoking and with inhaling asbestos fibers, William J. Nicholson testified, but new medical evidence reveals that cigarettes and asbestos make for a far deadlier mix.

"Asbestos workers who smoke run more than 50 times the risk of dying of lung cancer than men who neither smoke cigarettes nor work with asbestos," he asserted.

Nicholson, assistant professor of community medicine at Mount Sinai School of Medicine in New York City, appeared Friday at a hearing on proposed state regulations on the use and manufacture of asbestos products.

He and Harold Romer, New York City's assistant commissioner of air resources, urged the Illinois Pollution Control Board to adopt a proposed ban on spraying asbestos insulating and fireproofing materials.

Romer pointed out at the hearing at the Field Museum of Natural History that his city, Boston, Philadelphia and Chicago already have outlawed asbestos spraying.

Nicholson told of research tying the rise in asbestos use to greater incidence of asbestosis, a disease characterized by asbestos-fiber scars on the lungs.

Asbestos is used in more

than 3,200 products, ranging from clutch linings to women's coats to vehicle snow sprayed on Christmas trees.

Nicholson said Dutch and Scottish studies show a "strong" link between occupational exposure to asbestos in shipyards and mesothelioma, a rare form of cancer.

Fred L. Pundsack, vice president of research and development for Johns-Manville Corp., which has a large asbestos-manufacturing complex in Waukegan, said asbestos levels in urban air are low and pose no health threat.

He cited a recent report to the National Academy of Sciences stating, "There is no evidence that the small numbers of (asbestos) fibers in most members of the general population affect health or longevity."

In addition to the spraying ban, the proposed Illinois regu-

lations would require safeguards to keep asbestos from escaping construction and building-demolition sites, set stringent limits on emissions from asbestos plants, and outlaw asbestos in brake linings by 1975.

"Virtually every vehicle on the road carries several pounds of asbestos in its brakes," said Colin F. Harwood, an IIT Research Institute chemist who explored the asbestos problem for the state.

Guard unit cites Sun-Times

Ken Towers, assistant managing editor of The Sun-Times, accepts award for this newspaper from the 178th Infantry, Illinois National Guard, a community action plaque. Presenting the award are Mrs. LaJune Horton, co-chairman of the unit's community relations committee, and Lt. Col. Frank A. Marchant Jr., 178th commander. (Sun-Times Photo by Bob Black)

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Dr. Davison:

This confirms my belief that there is a synergism between cigarettes and asbestos as expressed in my letter to the News-Sun 7/21. It seems to me that any survey of asbestos induced lung cancer, without giving consideration to cigarette smoke, would be misleading and useless.

April Shuster

October 20, 1971

DESK MEMORANDUM

RE: ILLINOIS POLLUTION CONTROL BOARD HEARING ON ASBESTOS

CHICAGO ----- OCTOBER 15, 1971

On October 15, 1971, Dr. F. L. Pundsack, Vice President, Research and Development, Johns-Manville Corporation, presented testimony on behalf of the AIA/NA at the second of three hearings being held by the Illinois Pollution Control Board on proposed regulations affecting asbestos. The hearing was held in Chicago's Field Museum, and was attended by approximately 70 people. Appearing with Dr. Pundsack to help answer questions posed by the Board were Dr. Joseph L. Goodman, Medical Director, Raybestos-Manhattan; George L. Swallow, Manager, Occupational Environmental Control, Johns-Manville; and I. H. Weaver, Corporate Director, Environmental Control, Raybestos-Manhattan. The hearing was chaired by Samuel Lawton, a member of the Board. Also present were Board member Jacob Dumelle and Lawton's Administrative Assistant, Timothy Harker. All three asked questions during the hearing.

The first person to testify was Dr. Colin Harwood of the Illinois Institute of Technology Research Institute (IITRI). Dr. Harwood served as advisor to the Board on the proposed regulations, and was present at the meeting held on September 17 between a team from the industry and representatives of the Board (a report on this meeting by W. P. Raines was distributed on September 22).

Basically, Dr. Harwood supported the regulations as written. He said that while there is no cause for panic about the amount of asbestos in the ambient air, controls should be instituted. He said that the requirements of the proposed regulations are within the capabilities of existing technology, and that an efficiency standard or a "no visible emissions" standard would not be sufficient to control emissions. He also stated that brake lining wear contributes to the background level in the ambient air, and that he has faith in the industry's ability to develop a non-asbestos containing lining by 1975. Dr. Harwood promised to send me a copy of his final report to the Board in the near future.

The second person to testify was Bill Nicholson of Mount Sinai Hospital (a copy of his prepared remarks is attached). Nicholson, after giving the standard Mount Sinai pitch on the insulation workers studied by Dr. Selikoff, congratulated the

-more-

FMSI 03032

Board on its proposed ban of sprayed fireproofing. He said that permitting the spraying of buildings with asbestos-containing compounds would be "playing Russian roulette" with the lives of the general public. He also said that the regulations with regard to demolition should be made stronger. He opposed the use of a numerical standard for emissions from manufacturing facilities because of the difficulty of accurate measuring of very low ambient air concentrations. Instead, Nicholson recommended that the Board adopt an equipment efficiency standard and a "no visible emissions" standard, based on the Federal EPA model. While this position was in general agreement with the AIA/NA position, under questioning Nicholson said that he would not be opposed to ambient air testing as a sort of check-up on the efficiency standard. With regard to brake linings, Nicholson quoted some figures showing that ambient air levels at toll booths on the Long Island Thruway were 3-4 times higher than samples taken a few blocks away (all levels were in the nanogram per cubic meter range). Nevertheless, he did not indicate full support for the ban, but suggested that the regulation be rewritten to include a clause saying that if the industry could demonstrate no hazard from brake linings, the ban would not go into effect (once again we see the position being taken that asbestos should be considered guilty until proven safe).

The next speaker was a man named Golinken (?), who identified himself as an insulation contractor in the Chicago area. Golinken started off by saying that he had no comments to make with regard to the "asbestos" regulations, but that he was really concerned about the hazards of fiber glass inside ducts. He then proceeded to give the standard asbestos workers union pitch against fiber glass. The Board appeared to be somewhat confused as to the *raison d'etre* for Golinken's presentation and had no questions.

Following a 45 minute break for lunch, Harold Romer of the New York City Environmental Protection Administration launched into the most vitriolic attack on asbestos of the entire day. By comparison, Nicholson was a tower of objectivity. Quite naturally, Romer spent considerable time on the New York City experience with spraying. He called the asbestos that is being found in the lungs of city dwellers a "time bomb" for the future, and expressed great concern over the demolition of buildings containing asbestos products of any type. He also took broad swipes at numerous other uses of asbestos, including in talcum powder, in women's coats, as Christmas tree "snow" and others. He supported the ban on brake linings and called for close controls on every conceivable use of asbestos. Romer made numerous factual errors in his presentation. For example, he stated quite unequivocally that

EM size asbestos fibers were extremely hazardous to human health. Dr. Pundsack took Romer to task on this particular error, but there were so many others that refuting them all would have taken up half the afternoon.

Dr. Pundsack was next to testify. A copy of his presentation is attached. Dr. Pundsack replied to Nicholson's comments about asbestos levels on the Long Island Thruway by saying that if asbestos concentrations from brake lining wear were going to be high anywhere, they would be high at the spot sampled, yet the levels found were insignificant when compared with safe occupational levels. He also commented that at the low levels found, the margin of error was so high as to make the findings useless. Following his prepared comments, Dr. Pundsack introduced Dr. Goodman, who reported on a study by Dr. Paul Gross in which he injected brake lining dust into the lungs of test animals and produced no disease. Dr. Goodman also commented on another study by Dr. Gross in which human lungs were digested and the amount of fiber calculated. These tests showed no relationship between disease and the inhalation by people in the general public of even large amounts of EM sized asbestos fibers.

Numerous questions were asked of Dr. Pundsack following his prepared testimony. They dealt with such subjects as: loosely-bound vs locked-in products, how a visible emissions standard would work (the AIA/NA was asked to submit in writing its specific recommendations in this area), the possibility of asbestos fiber accumulating in the community air, asbestos in water, whether chrysotile is less hazardous than crocidolite, the Selikoff study of insulation workers, talc and GI cancer, etc. All questions were handled skillfully by Dr. Pundsack. The total AIA/NA presentation, including the question and answer period, lasted approximately one hour. The AIA/NA was asked to submit numerous documents, medical papers, specific recommendations and other supporting data to the Board.

Following the AIA/NA presentation, Ivan Sabourin gave a short presentation on the Canadian-American asbestos industry.

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10/15/71
Dr. F. L. Pundsack

Presentation to Illinois Pollution Control Board

October 15, 1971

My name is Dr. Fred L. Pundsack, and I am Vice President of Research and Development for the Johns-Manville Corporation. I am an inorganic chemist with a Ph.D. degree from the University of Illinois, and I have been involved in asbestos research since 1952. I am here today representing the Asbestos Information Association, an organization sponsored by nine leading manufacturers of asbestos products to provide information on asbestos and its health implications. The members of this Association are listed in a fact sheet which I have provided.

In the event that my presentation prompts questions relating to environmental control technology or the medical aspects of the asbestos situation, I have asked three experts in these fields to accompany me here today to assist in answering questions of a highly technical or medical nature. They are Dr. Joseph L. Goodman, Associate Professor, Department of Preventive Medicine, Medical University of South Carolina, and Medical Director, Raybestos-Manhattan Corporation; Mr. Isaac H. Weaver, Corporate director for Environmental Control for the Raybestos-Manhattan Corporation; and Mr. George L. Swallow, Manager of Occupational Environmental Control, Johns-Manville Corporation.

Before proceeding, I would like to express the appreciation of the Asbestos Information Association for the opportunity to testify on the proposed asbestos regulations.

Asbestos has numerous important applications in our modern industrial society. Among these, it provides built-in protection against fire and deterioration in scores of common products in daily use. Through the years it has saved countless lives and billions of dollars in property damage by preventing or checking the spread of fires. Asbestos-containing acoustical products make a valuable contribution to noise abatement.

Products containing asbestos are used, among other applications, in the construction of schools, houses, theaters, factories, office and other public buildings, and in the insulation of furnaces, boilers and electrical equipment.

The asbestos industry within the state of Illinois plays an important role in the economic life of the state and its people. The member companies of the Asbestos Information Association own and operate a total of eight plants within the boundaries of the state. Some of the product lines produced at these eight plants include: asbestos-cement pipe, packings, gaskets, friction materials--including both conventional and disc brake linings--asbestos-cement sheet products, asbestos roofing and siding shingles, insulations, and many others. A total of 3,118

Illinois residents are employed at these manufacturing facilities. Last year, these employees received a total of \$ 24.4 million in wages, salaries and fringe benefits. Services and goods purchased within the state, such as water, electricity, telephone service, raw materials and freight amounted to more than \$ 17 million in 1970. In addition, state, county and local taxes, amounting to nearly a million dollars last year, helped to pay for new schools, roads and other benefits to the state and its citizens. The value of goods produced at these manufacturing locations last year totalled \$ 70.1 million, with approximately \$14.5 million worth of these asbestos-containing products being sold within the state.

As you can see, the economic contribution of the asbestos industry in the State of Illinois is by no means small. And the figures I have just given you represent only those companies that are members of the Asbestos Information Association. There are also within the state many other concerns -- both large and small--whose livelihood depends in some measure on the use of asbestos or asbestos-containing products. Such concerns would include many segments of the construction industry, companies engaged in the manufacture of asbestos-containing products, companies which use finished asbestos-containing products in the manufacture of other products, and many others. The economic value to the State derived by the use of asbestos by these other

concerns is difficult to gauge, however it would certainly double or triple the figures I gave you earlier with regard to the contribution of the member companies of the Asbestos Information Association.

The asbestos industry has recognized for many years that there are occupational health hazards associated with the excessive inhalation of asbestos dust over long periods of time. As a result, the industry, beginning in the late 1920s, has sponsored and cooperated in a wide variety of scientific research projects designed to identify these hazards and to eliminate them wherever they may exist, not only in asbestos mines, mills and manufacturing plants, but also among fabricators and applicators of finished asbestos products. Today, the asbestos industry, either as individual companies or through the Quebec Asbestos Mining Association's sponsorship of the Institute of Occupational and Environmental Health in Montreal, is supporting medical research at such highly regarded institutions as McGill University in Montreal, Tulane University in Louisiana, St. Luke's Hospital in Cleveland, the Environmental Sciences Laboratory at Mount Sinai Hospital in New York, the Industrial Health Foundation in Pittsburgh, the University of California at Berkeley, Fairleigh-Dickinson University in New Jersey, the University of Pittsburgh, the Medical College of South Carolina, and a number of others, both here and overseas. In addition, the industry has cooperated extensively

in various investigations into asbestos-health conducted by agencies of the Federal Government, including the U.S. Public Health Service, the Federal Environmental Protection Agency, the National Institute of Occupational Safety and Health, and others. In the industry's own research laboratories, scientists and engineers are also engaging in work related to health, developing safer packaging and handling techniques for loosely bound asbestos products and also developing and improving techniques for the measurement and control of asbestos emissions both in the work-place and in the ambient air.

As a result of these activities, over the years the industry has amassed a substantial amount of medical knowledge and technological know-how in the asbestos-health area.

Basically, the known facts about asbestos-related disease can be summed up as follows:

First, asbestos-related health risks are basically confined to the occupational and para-occupational setting.

Second, the effects of excessive inhalation of asbestos are both time and dose related. This means that asbestos-related diseases may develop, generally, only after the inhalation of substantial amounts of asbestos dust over a substantial period of time.

And third, there is presently no evidence of hazard to the general public from exposure to the minute amounts of asbestos that may be present in community air.

Because the general purpose of the regulations under discussion here today is to prevent the emission of hazardous quantities of asbestos fibers into the air that the general public breathes, I will restrict my further comments on health to this area. It is very important to realize in any discussion of a possible public health hazard from asbestos exposure that the only scientific studies we have to go on are those of groups of people in occupational and para-occupational environments. There is no basis for assuming that data on occupational health risks associated with heavy, long term asbestos exposure can be applied to the general public without taking into consideration the vast differences in exposure between the two.

Despite the fact that the only studies in existence are of occupational and para-occupational populations, a careful analysis of the data available can give us some general information about the question of a possible public hazard from asbestos. The substance of this information is that diseases associated with occupational exposure to asbestos are dose related and that the doses below which no measurable increase in disease occurs are far higher than any dose to which the general public is exposed.

This evidence is based on a number of epidemiological studies--- three of the most prominent being one by Dr. J. Corbett McDonald of 10,421 past and present asbestos mining and milling workers in Quebec, a second by Dr. M. L. Newhouse of 4,500 men who were employed in a British asbestos factory between 1933 and 1964 and the Third a study by Drs. Knox, Doll and associates of 878 workers in an asbestos textile factory, also in Great Britain.

Dr. McDonald, in his study, divided his subjects into eight categories, based on length of employment and severity of dust exposure. He noted that only in the highest time-exposure category, comprising five per cent of the total, was there any increase in deaths from respiratory and cardiac diseases, including lung cancer. Taken as a group, the Quebec asbestos workers had a mortality rate from all causes lower than the level expected in the general population.

Dr. Newhouse in her study in Great Britain found that workers who had low and moderate occupational exposure to asbestos dust showed a rate of deaths from diseases of the lung, including cancer of the lung and pleura, that were comparable with that of the general public. On the other hand, another study by Dr. Newhouse of mesothelioma (a relatively rare cancer of the lining around the lungs) in the London area showed a small number of cases among people who lived in close proximity to an asbestos textile plant and also among people living in the household of an asbestos worker, who presumably brought home quantities of the material on his clothes from work. The intensity of exposure experienced by these

so-called para-occupational populations in London is difficult to gauge, but there is every reason to believe that they were in fact higher than the low and moderate occupational levels in factories that have been shown to produce no excess of mesothelioma. These studies do, however, point up the need for proper control of emissions of asbestos from factories so that neighboring areas will not suffer para-occupational exposures to asbestos.

The Knox-Doll study, like the Newhouse and McDonald studies, confirmed the fact that low to moderate levels of asbestos exposure will not produce an excess of disease. It should always be remembered that these low to moderate levels in occupational settings inside factories were certainly higher than any to which the general public in this country is exposed.

In addition to these studies, there are several studies of the effect of various doses of asbestos on laboratory animals which also indicate that there are dose levels below which no measurable disease effect is observed. Dr. William Smith of Fairleigh-Dickinson University studied mesothelioma cancers in hamsters, and his data show that below certain specific doses of asbestos, no cancers were observed to develop over the entire natural life span of the animals. Dr. Merl Stanton of the National Institute of Health, Bethesda, Maryland, conducted a somewhat similar study with rats and observed the same type of dose-related response.

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The most well-known of the American epidemiological studies related to asbestos exposure is that made by Dr. I. J. Selikoff of 632 members of the Heat Frost and Asbestos Insulation Workers Union in the New York/New Jersey area. These men, for the most part, are journeymen-craftsmen who work on construction sites and apply insulation to boilers, steam and hot water pipes, heating ducts, etc., during the construction of a building or a power plant. They may also be involved in tearing off old insulation. When one construction job is completed, they move to another construction job.

The occupational environment to which they may be exposed involves not only asbestos but also silica and particulate materials. In addition they are exposed to a variety of fumes from organic solvents and adhesives with which they work. In short, they have a widely varied and, in the past at least, a relatively uncontrolled occupational dust and fume exposure.

Dr. Selikoff found that the death rate from lung cancer was extremely high in this group of 632 workers, but that this very high mortality rate occurred almost exclusively among those workers who were cigarette smokers.

On the other hand, those workers who had no history of cigarette smoking had essentially no greater incidence of lung cancer than the general population of non-smokers.

In general, the mortality rate of insulation workers reported by Selikoff is much higher than the rates found in studies of larger groups of people who work in factories producing asbestos-containing products, and in mines and mills processing asbestos. Why the incidence of certain diseases among insulation workers is so much higher than the other groups studied is a question as yet unanswered.

Unfortunately, as is so often the case with diseases that take from 10 to 40 years to develop, reliable data as to the past occupational exposure of these men to asbestos and other potentially hazardous dust and fumes in their work are not available.

As a result, at the present time we have little information as to what other factors may have influenced their high rate of disease except that those insulation workers who smoked cigarettes developed lung cancer at a rate far higher than the general population who smoked.

In 1970, with a grant from the National Air Pollution Control Administration, The National Academy of Sciences called together a blue-ribbon panel of asbestos-health experts to draft a document on the problem that would serve as the

medical basis for the Federal asbestos emission standards.

Among those asked to serve on the panel were Dr. Clark Cooper of the University of California, Dr. Lewis Cralley of the Public Health Service, Dr. George Wright, Dr. Irving Selikoff and others.

The result of their study was a fifty-three page document on asbestos/health. As a conclusion to this part of my presentation, I would like to read a few pertinent excerpts from the report, which constitutes the most up-to-date evaluation of the asbestos-health problem that is available.

On page 20, the report states (quote) We cannot extrapolate from the mortality experience of those who are directly and indirectly exposed in their employment to the general public who have had moderate or slight exposure from ambient air. There is evidence to suggest a gradient of effect from direct occupational, to indirect occupational, to family and neighborhood situations, in all of which dust concentrations are probably high by comparison with most community air. This suggests that there are levels of asbestos exposure that will not be associated with any

detectable risk! What those levels are is not known, but there is no evidence that persons in the general population--without occupational, household or neighborhood exposures--have any increased risk of neoplasm, even though there may be ferruginous bodies or fibers in their lungs (end quote).

- . In the conclusion and recommendation section of the report for the National Academy of Sciences, the following statements are made:

(quote) At present, there is no evidence that the small numbers of fibers found in most members of the general population affect health or longevity. Asbestos is too important in our technology and economy for its essential use to be stopped. But, because of the known serious effects of uncontrolled inhalation of asbestos minerals in industry. . . it would be highly imprudent to permit unrestricted additional contamination of the public environment with asbestos (end quote).

I believe that these statements from the report adequately express the position of the asbestos industry with regard to the health hazards of asbestos. We do not believe that at present the general public is in danger from the minute amounts of asbestos that exist in the ambient air. However we also believe that it is prudent and feasible to establish reasonable emission controls that will protect the public and ensure that hazardous levels of asbestos will not develop in the community air in the future.

With this position in mind, I would now like to discuss the asbestos regulations proposed for the State of Illinois. To begin with, I would like to commend the Illinois Pollution Control Board for its efforts to ensure a safe environment for the State and all its citizens. Your credentials as a progressive yet fair control board are well known and respected in environmental circles throughout the nation.

While the asbestos industry as represented by the Asbestos Information Association is of the position that there is presently no hazard to the general public from the minute amounts of asbestos existing in the community air, we nevertheless are in favor of regulations designed to accomplish one or more of the following three objectives:

One, to ensure the health and safety of those occupationally exposed to asbestos fiber.

Two, to prevent possibly hazardous amounts of asbestos fiber from escaping into the ambient air, and

Three, to eliminate, where possible, the nuisance of even small amounts of asbestos fiber from escaping into the ambient air.

While this third point is not directly related to health because of the small amounts of fiber involved, we wholeheartedly support the position that the environment should be as clean as possible.

For these reasons, we support most of the items in the proposed regulations. However, we do have several specific comments and

suggestions to make regarding the regulations that we hope will be of help to the Board in arriving at a final document that will not only be effective but also practical and reasonable. I will discuss the sections upon which we wish to comment in the order in which they appear in the regulations.

Our first suggestion is with regard to Part II: General Requirements, Section 201. This section calls for the obtaining of a permit to engage in any activity which could discharge asbestos fiber into the environment. We feel that this section is not specific enough with regard to which activities would be covered. As you are probably aware, in the vast majority of asbestos-containing products used in the country, the asbestos is locked in place with cement, plastics or other binding materials, and does not constitute a source of emissions to the atmosphere. Asbestos-cement pipe and vinyl-asbestos floor tile are examples of such products. Other products and activities do constitute possible emission sources, and under the regulation would require a permit. If it would be of help to the Board, the Association I represent would be most willing to prepare a list of those products in common use where the asbestos is in a non-locked-in or loosely-bound state and thus constitute a possible emission source which would require a permit.

As to Section 201, Sub-section B, requiring a satisfactory course of health instruction for employees in those industries involving the handling of loose or loosely-bound asbestos products, I would like to point out that

the various trade associations in the asbestos industry have over the years produced a number of safety practices manuals and booklets dealing with various sections of the industry. The Asbestos Information Association would therefore recommend for your consideration as instructional material for use under Section 201, Sub-section B, the safety practices booklets which I have submitted to the Board with my presentation. The four booklets are:

1. Recommended Safety Practices for Handling Asbestos Fiber
2. Recommended Health Safety Practices for Handling and Fabricating Asbestos Textile Products.
3. Recommended Practices for Fabricating, Handling and Applying Asbestos-Cement Products in the Building and Construction Industries...and
4. Recommended Health Safety Practices for Handling and Applying Thermal Insulation Products Containing Asbestos.

Under Part V, Section 501, it is our opinion that Subsection B, which requires the enclosure of walls before toppling during demolition, is both impractical and unnecessary. We know of no suitable method for enclosing the walls of a structure during demolition. Even more important is the fact that there is, in reality, very little asbestos used in the construction of a modern medium-sized or high-rise structure. In addition, dust counts taken during the demolition of a building in

Easton, Pennsylvania, which did contain significant quantities of asbestos products, showed very little dispersion of fiber into the surrounding air, both upwind and downwind of the demolition site. This is due to the fact that most asbestos-containing products in which the fiber is locked-in with cement, plastic or other binding materials do not readily release fiber in the atmosphere, even during demolition. Subsection A of Section 501 requires the prior removal before toppling of boiler and pipe insulations....two asbestos-containing products that might release dust from improper demolition. Since this will remove any loosely-bound asbestos products from the structure, we believe enclosure of the walls to be unnecessary, and recommend that simple wetting of the walls to be toppled would be sufficient to control the dispersion of dust from whatever small amount of asbestos-containing products the walls might contain.

With regard to Part VI, Section 601 of the regulations, we would like to recommend for your consideration a completely new approach to the control of asbestos emissions from manufacturing

operations. . As presently written, the regulations call for the establishment of a numerical emission standard of .5 fibers per cubic centimeter of air from any manufacturing operation, and .05 fibers per cc of air at the boundary line of the plant or factory.

We would recommend that Section 601 of the regulations be re-written so as to substitute a control practice standard for the present numerical emission standard. The reasons for this recommended approach are varied, but are primarily based on the lack of specific data with regard to safe non-occupational levels and the difficulty of accurate and meaningful emission sampling techniques at very low fiber concentrations.

The Federal Environmental Protection Agency studied this problem very carefully in preparing its national emission standards on asbestos, and arrived at the conclusion that a numerical standard was impractical at this time. In this regard, I would like to read a few excerpts from a document prepared by the EPA as justification for this viewpoint.

The document states that ideally, national emission standards for asbestos would be established on a concentration basis related to health effects and would provide an ample margin of protection to the public health regardless of the number of sources in a given geographical area. There are many practical considerations, the report goes on, which prohibit the establishment of a numerical standard at this time.

Foremost of these problems is the lack of a data base. This base is lacking from both the health-effects standpoint for non-occupational exposure and the emissions standpoint. The majority of data available on asbestos health effects is related to occupational exposure and cannot be readily extrapolated to non-occupational levels.

A little later on, the report states that (quote) a control practice approach to reducing asbestos exposure levels offers a practical alternative to numerical emission limits. A major advantage of a control practice standard would be realized in enforcement. Inspectors could be easily trained to certify compliance with control practice regulations (end quote).

The report goes on to describe some of the many difficulties involved in asbestos sampling and analysis, especially with regard to emissions into the ambient air, and concludes that present techniques are not only time consuming and expensive, but that they

also tend to distort the concentration of asbestos in the sample being analyzed and are hence not meaningful in establishing the actual amount of asbestos being emitted into the atmosphere.

The National Academy of Sciences Committee report on asbestos health, which I quoted from earlier, agrees with the EPA position on numerical standards. It states (quote) because of methodologic and other uncertainties, it is not yet feasible to base control on numerical ambient air quality standards (end quote).

I will not go into detail on the specifics of a control practice standard since they would be primarily of an engineering nature, however, I will submit for your consideration, as soon as they are published, the asbestos emission standards proposed by the Environmental Protection Agency. These standards will contain sufficient information to set up a similar program for the State of Ill

Section 602 of Part IV of the regulations deals with the discharge of asbestos-containing waste into the sewage systems or waters of the state. We believe that this section is unnecessary. In the first place, the water pollution control systems in use in most asbestos manufacturing plants across the state effectively remove the majority of asbestos wastes from the effluent before discharge into state waters.

Secondly, sewage plants also remove asbestos fibers from waste water during purification. In reality, the high dillution of small quantities of asbestos fibers in water is as effective and safe a method for the disposal of asbestos wastes as could be devised. There is no evidence that the swallowing of small amounts of asbestos constitutes any health hazard whatever.

In addition, studies conducted by Johns-Manville have found small amounts of asbestos fiber in samples of water tested from sources all over the United States, including well and spring water. The reason for this is quite simple. Asbestos-bearing serpentine rock is to be found in a majority of the states of the union, including Illinois, and the simple process of water flowing over and through these rocks errodes a certain amount of asbestos fiber.

Thus, we have all been drinking tiny amounts of asbestos in our water since birth, without any discernable adverse effects.

In Part VII, Section 701 of the regulations, we would recommend the addition of the word "visible" in the next to the last line, so that the amended section would read: "No product which may emit

asbestos-fiber during its transportation shall be transported unless such product is enclosed in such a manner as to preclude the "visible" emission of asbestos fiber into the ambient air." The problem here is once again with analysis techniques and enforcement. The EPA has gone to a (quote) no visible emissions (end quote) standard in circumstances similar to this one, and we would recommend to the Board that this also be applied in Illinois. This would also be useful in other sections of the proposed regulations where measurement and enforcement would tend to be extremely difficult if not impossible.

Our final comment is with regard to Part VII, Section 702, which would prohibit the use of asbestos in the brake lining of vehicles manufactured after January 1, 1975, and sold for use within the State of Illinois. We believe that on the basis of the existing scientific evidence such a prohibition is completely unnecessary. In 1968, this question was investigated thoroughly by the United States Public Health Service, and a report on these investigations by Jeremiah R. Lynch, entitled "Brake Lining Decomposition Products" was published in the Journal of the Air Pollution Control Association. The report stated that (quote) except in all but the most extreme driving conditions, only a very small fraction of the 30 to 50 per cent asbestos present in a brake lining escapes into the atmosphere as free fiber (end quote). Lynch found that the average amount of free fiber released was less than one per cent of the fiber present in the brake lining composition. The percentage was higher only under conditions that would have resulted in brake failure. Lynch further

reported that the majority of the fiber in linings was converted into an inert non-fibrous material by the heat of friction, and concluded that the use of asbestos-containing brake linings was "an inconsequential health factor in urban air pollution." His conclusion is reasonable in light of the fact that hundreds of millions of cars using asbestos-containing brake linings have been stopping and starting in this country for more than half a century, and yet there has been no epidemic of asbestos-related disease among the general public nor have significant quantities of asbestos been demonstrated to exist in the community air. While we consider this evidence to be conclusive, if the Board is still concerned about asbestos emissions from brake linings, you will be interested to know that the Federal Environmental Protection Agency has contracted with the Bendix Corporation to do additional tests in this area. This study is due for completion in June of 1972, and we would recommend that the Board, at the very least, await the outcome of the EPA study before making a final decision on asbestos-containing brake linings. It is our belief that the Bendix study will confirm the conclusion reached by Lynch as to the safety of asbestos-containing brake linings.

This concludes my presentation on the proposed regulations. I have submitted for your consideration copies of all the medical papers, reports, booklets and documents that I referred to in my presentation. I would once again like to express the appreciation of the Asbestos Information Association for the opportunity to appear here this morning. Thank you.

PROPOSED
NATIONAL EMISSION STANDARDS FOR ASBESTOS

COMMENTS AND SUGGESTIONS
FROM
ASBESTOS INFORMATION ASSOCIATION/NORTH AMERICA

AUGUST 11, 1971

FMSI 03057

ASBESTOS MINING AND MILLING

1.1 Asbestos Mining

1.1.2 Blasting

This standard is considered unnecessary and unworkable for the following reasons:

- (1) The ore bodies in their natural state are wet. The California ores of the Coalinga type contain approximately 20% moisture. The U.S. chrysotile ores of the Jeffrey type contain about 8% moisture. In addition, the subsurface open pit mines are naturally surface wetted by water seepage from the pit walls, and by rain and snow.
- (2) It could be impossible to schedule blasting operations to conform to the low wind velocity and rain requirement.

1.1.4 Ore Hauling

1.1.4.1 Dust Covers

Vehicles used to haul dry asbestos on all mine owned property shall be equipped with suitable covers.

1.1.4.2 Wetting

Where sufficient water is available dry ore shall be wetted thoroughly during transportation.

1.1.4.3 Public Roads

Vehicles used to haul asbestos ores on public roads shall be equipped with suitable covers.

1.2 Asbestos Milling

1.2.1 Ore Dumping

Asbestos emissions resulting from dumping of asbestos ore shall be minimized by wetting prior to or during dumping and/or by enclosure of the dumping area.

1.2.2 Ore Dumps

Ore dumps open to the atmosphere must be maintained in a wet state.

1.2.3 Conveyors

All external conveyors used to transport ore must be so constructed as to prevent spillage of the ore to the ground. All external conveyors used to transport tailings or loose asbestos containing materials must be of the totally enclosed type.

1.2.7 Product Packaging

1.2.7.1 Individual Packaging

We wish to reserve comment on the packaging portion of this standard until a program investigating packaging and shipping methods that is presently underway is completed.

We suggest that the bags be printed with the label presently being used by the member companies of the Quebec Asbestos Mining Association.

1.2.8 Tailings Dumps

Asbestos mill tailings dumps shall be stabilized, wetted or otherwise treated in order to control dust emissions.

ASBESTOS PROCESSING AND PRODUCT USE

We suggest, in order to simplify the wording of the standards, that asbestos using products be divided into three categories and these categories be referred to in the standards.

These categories are:

(1) locked in

Asbestos containing products where the asbestos is firmly bound in a matrix of polymeric, cementitious or other binding materials.

Examples of such products would be:

- vinyl asbestos floor tile
- asbestos reinforced plastics
- asbestos reinforced gaskets and packings
- asbestos cement pipe
- asbestos cement sheets and shingles
- asbestos reinforced brake linings and clutch facings
- asbestos reinforced paper and roofing felts.

(2) unlocked

Products where the asbestos fiber is loosely bound and could pose an emission problem.

Examples of such products would be:

- calcium silicate insulation
- asbestos containing insulating cements

(3) asbestos textiles

Our suggested modifications to this section of the standards utilizes these categories and are as follows:

1.3 Asbestos Processing

1.3.3 Product Shipment

1.3.3.1 Labeling

All Category 2 (unlocked) asbestos fiber containing products must be labeled as to asbestos content.

1.3.3.2 Packaging

All Category 2 (unlocked) asbestos containing products must be packaged in dust-tight containers.

1.3.3.3' Special Products

Special products in the group 2 category (unlocked) such as dry, powdery, asbestos cement mixes containing loose asbestos must be packaged according to Section 1.2.7.

1.4 Product Use

1.4.1 Block Insulation

1.4.1.1 Premolded or Prefabricated Insulation

To the maximum extent possible, contractors installing asbestos containing block insulation in areas open to the atmosphere shall utilize premolded or prefabricated shapes which require a minimum of cutting or grinding.

1.4.1.2 Field Fabrication

Where field fabrication is unavoidable, properly designed hoods exhausting to fabric filters or devices of equivalent efficiency as described in Section 2.1 shall be installed on power tools used for cutting and grinding.

1.4.2 Asbestos Containing Powders

Asbestos containing powders shall be wetted immediately upon opening shipping container prior to removal of contents.

1.5 Waste Disposal and Demolition

1.5.2 Waste Disposal

Asbestos bearing waste materials shall be disposed of by methods which prevent release of asbestos into the atmosphere during all phases of the disposal.

1.6 Specific Prohibitions

1.6.1 Sprayed Asbestos Fireproofing

The application of asbestos containing fireproofing on buildings by means of spraying is prohibited.

EQUIPMENT SPECIFICATIONS AND MAINTENANCE

FMSI 03064

2.1 Equipment Specifications

2.1.1 Fabric Filters

2.1.1.2 Bypasses

No control system shall employ bypasses unless such devices are clearly required for start-up purposes or are required to prevent damage to the filters in high temperature applications.

2.1.2.1 Scrubbers

We suggest that the following sentence be added to this paragraph:

"Low energy scrubbers may be used when it can be demonstrated that their efficiency is equal to that of the high energy Venturi type specified in the previous sentence."

2.2 Equipment Maintenance

We suggest that the wording of the unannounced maintenance inspections included in the first paragraph of this heading be modified to be identical to that in the Occupational Safety and Health Act Record Form.

2.2.2 Scrubbers

We suggest that the following phrase be added to this paragraph:

"Unless it can be demonstrated that the required efficiency of the unit can be maintained with a lower pressure drop."

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NATIONAL EMISSION STANDARD FOR ASBESTOS

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I. Introduction

As empowered by Section 112 of the Clean Air Act as Amended 1970, the Administrator of the Environmental Protection Agency issues the following proposed standard for asbestos emission sources. This action is taken subsequent to naming asbestos as a hazardous air pollutant on March 31, 1971. It is the intent of this standard to reduce the level of asbestos emissions through the application of required control practices. This standard establishes minimum requirements for emission control and should not be construed as limiting more stringent measures.

The scope of uses of asbestos and asbestos containing products is extremely large in the United States. New uses are being developed continually; many without regard to atmospheric emissions. Some uses have been determined by air pollution control officials to generate a degree of atmospheric emissions unwarranted by the value of those uses, and prohibition of such uses is proposed.

II. Emission Standards

1.1 Asbestos Mining

1.1.1 Drilling

1.1.1.1 Dry Drilling - All air swept or dry drills shall be equipped with fabric filter devices for collection of drilling debris.

1.1.1.2 Wet Drilling - Wet drills shall be equipped with cyclone collectors for collecting entrained mists.

1.1.2 Blasting - Surface blasting of ore deposits shall always be preceded by surface wetting and be limited to the following atmospheric conditions.

- or
1. low surface wind velocity (0-3 mph)
 2. rain

1.1.3 Road Treatment - Mine roads surfaced with asbestos tailings shall be treated with water or chemical agents to control dust from vehicle traffic.

1.1.4 Ore Hauling

1.1.4.1 Dust Covers - Vehicles used to haul asbestos ore on mine owned property shall be equipped with dust covers.

1.1.4.2 Wetting - Where sufficient water is available the ore shall be wetted thoroughly during transportation.

1.1.4.3 Public Roads - Vehicles used to haul asbestos ores on public roads must be of dust tight construction.

1.2 Asbestos Milling

1.2.1 Ore Dumping - Asbestos emissions resulting from dumping of asbestos ore shall be minimized by wetting prior to dumping or enclosure of the dumping area.

1.2.2 Ore Dumps - Ore dumps open to the atmosphere must be maintained in a wet state through the use of permanent sprinkler systems.

1.2.3 Conveyors - All external conveyors used to transport ore, tailings or loose asbestos containing materials must be of the totally enclosed type.

1.2.4 Ore Dryers - Asbestos ore dryer exhaust must be treated in fabric filter installations or by devices of equivalent efficiency as described in Section 2.1.

1.2.5 Ore Crushers - All dust emissions from ore crushers shall be ventilated to fabric filters or devices of equivalent efficiency as described in Section 2.1 prior to discharge into the atmosphere.

1.2.6 Mill Air - All forced exhaust gases from asbestos mills must be treated in fabric filters or devices of equivalent efficiency as described in Section 2.1.

1.2.7 Product Packaging -

1.2.7.1 Individual Packaging - All forms of asbestos fiber must be packaged in dust tight containers, capable of withstanding 4 drops, one each on front, back and ends from a height of four feet without leakage, and labelled as to their asbestos content.

1.2.7.2 Bulk Shipment - Bulk shipment shall be in dust tight vehicles labelled as to their asbestos content. Loading and unloading must be accomplished in a manner which does not exhaust asbestos to the atmosphere without the control equivalent of fabric filters as described in Section 2.1.

1.2.8 Tailings Dumps - Asbestos mill tailings dumps shall be stabilized, wetted, or otherwise treated to prevent dust emissions.

1.3 Asbestos Processing

1.3.1 Manufacturing - Manufacturers of products containing asbestos must control all atmospheric discharges of gas streams used for manufacture or dust removal by fabric filtration devices or devices of equivalent efficiency, as described in Section 2.1, except where explosion hazards or materials problems exist, in which case wet collectors, as described in Section 2.1.2 may be used.

1.3.2 Ventilation Air - In operations where in-plant conditions result in the emission of significant amounts of asbestos from general ventilation air, evidenced by presence of visible accumulations of asbestos on surfaces adjacent to the place of ventilation, the ventilation air must be treated by fabric filtration or devices of equivalent efficiency as described in Section 2.1.

1.3.3 Product Shipment

1.3.3.1 Labelling - All products containing asbestos must be labelled as to content.

1.3.3.2 Packaging - Asbestos products must be packaged in dust tight containers except those products such as filled plastics which do not readily dust.

1.3.3.3 Special Products - Those products such as asbestos cement mixes containing loosely bound asbestos must be packaged according to Section 1:2.7.

1.4 Product Use

1.4.1 Block Insulation

1.4.1.1 Pre-molded Insulation - To the maximum extent possible contractors installing asbestos containing block insulation in areas open to the atmosphere shall utilize pre-molded shapes which do not require cutting or grinding.

1.4.1.2 Field Fabrication - Where field fabrication is unavoidable, high velocity hoods exhausting to fabric filters or devices of equivalent efficiency as described in Section 2.1 shall be installed on tools used for cutting and grinding.

1.4.2 Asbestos Containing Powders - Asbestos containing powders shall be wetted prior to exposure to the atmosphere when used in areas without air pollution controls as described in Section 2.1.

1.5 Waste Disposal and Demolition

1.5.1 Removal of Asbestos Containing Insulation - When removing asbestos insulation from structures containing in excess of 50 lbs. of insulation or fireproofing, or when such structures are demolished contractors shall utilize the best available means to limit dust emissions from the operation. Such means may include but not be limited to:

- A. Enclosure
- B. Wetting

1.5.2 Waste Disposal - Asbestos bearing waste materials shall be segregated from other solid waste and disposed of by a method which prevents release of asbestos into the atmosphere during all phases of the disposal.

1.6 Specific Prohibitions

1.6.1 Sprayed Asbestos Insulation and Fireproofing - The application of asbestos containing insulation and fireproofing by means of spraying is prohibited.

1.6.2 Dispersive Uses - Any use of asbestos or asbestos containing materials in powder form which involves dispersing the material in the environment is prohibited.

2.1 Equipment Specifications

2.1.1 Fabric Filters - Fabric filters specified by this regulation shall consist of the following.

2.1.1.1 Construction - The inlet side of fabric filters shall be of leakproof construction or maintained under negative pressure.

2.1.1.2 Bypasses - No control system shall employ bypasses unless such devices are clearly required for start-up purposes.

2.1.1.3 Hoppers - Provisions shall be included for emptying dust hoppers without release of asbestos to the atmosphere.

2.1.1.4 Fabrics

2.1.1.4.1 Natural Fabrics - Natural fiber filter fabrics shall have a maximum flow permeability of 20 cfm/ft² at 1/2 in. H₂O.

2.1.1.4.2 Synthetic Fabrics - Synthetic fabrics in high temperature applications shall have a maximum permeability of 30 cfm/ft² in. H₂O.

2.1.2 Alternative Devices

2.1.2.1 Scrubbers - Scrubbers used where fabric filters cannot be installed shall be of the high energy venturi type operated with above 40 in. w.g. pressure drop.

2.1.2.2 Other Devices - Alternative devices used where fabric filters can be installed must be demonstrated by the user to have control performance equivalent or superior to fabric filters.

2.2 Equipment Maintenance

Control equipment required by this regulation shall be regularly maintained to insure high efficiency. Unannounced maintenance inspections will be performed by authorized personnel and the finding of any of the following conditions will be considered a violation of this regulation.

2.2.1 Fabric Filters

2.2.1.1 External Leaks - The presence of external leaking of untreated asbestos containing gases from duct work, hoppers, discharge valves, seal faces, etc. will be a violation.

2.2.1.2 Ruptured Bags - The presence of torn or ruptured bags in an operating system will be a violation.

2.2.1.3 Improperly Positioned Bags - The presence of any bag not properly positioned to prevent leakage will be a violation.

2.2.1.4 Holes - The presence of any bag containing a hole larger than $\frac{1}{4}$ " diameter will be a violation.

2.2.1.5 Worn Bags - The presence of any bag with more than one pinhole or being badly worn or theadbare will be a violation.

2.2.1.6 Housekeeping - The presence of accumulations of asbestos particles in the clean air side of baghouses after repair or replacement will constitute a violation.

2.2.2 Scrubbers

2.2.2.1 Pressure drop - Any scrubber operating with less than 40" H₂O pressure drop will be a violation.

2.2.2.2 Leaks - Any external leaks of untreated asbestos containing gas from ductwork, flanges, etc. will be a violation.

2.2.2.3 Scrubbing Medium - Any scrubber operating with less scrubbing fluid flow rate than its design requirement will be a violation.

2.2.3 Alternative Devices - Inspection criteria for alternative devices will be established at the time of their certification.

BULLETIN

NO. 411

September 9, 1971

ASBESTOS STUDY COMMITTEE FORMATION

Mr. J. W. Greenen, wishes to announce the formation of a new Committee, the Asbestos Study Committee within the Friction Materials Standards Institute, Inc.

The members of this Committee are as follows:

Asbestos Study Committee

Dr. E. P. Stefl, Chairman	Raybestos-Manhattan, Inc.
M. J. C. Henning	World Bestos Company
Dr. W. Spurgeon	Bendix Corporation
Mr. W. B. Reitze	Johns-Manville Corporation
Mr. J. B. Graham	Carlisle Corporation
E. H. Jeierabend	Abey Corporation

E. W. DRISLANE
Executive Secretary

Distribution: General Active Members
" Regional Members

R 71-16
Asbestos and Spray Insulation

EXPLANATION OF PROPOSED REGULATIONS

Science is pointing its medical finger at asbestos and describing the "miracle fiber" as a mineral whose commercial blessings can exact a rather costly toll. Asbestos insulation and factory workers exposed to heavy concentrations of asbestos fiber over prolonged periods have suffered devastating consequences. They are visited with an alarmingly high incidence of asbestosis, which produces a diffuse fibrosis of the lower lung, of lung cancer and of an extremely rare cancer of the lining of the lung and abdomen, mesothelioma. The rates of lung cancer are extraordinarily high especially among asbestos workers who are smokers, indicating the synergistic potential of the mineral fiber.

The medical evidence is indefinite as to why asbestos is carcinogenic, with three theories in vogue: (1) The fibers once ingested or inhaled act as a continuous physical irritant, inducing a tumor after 20 to 30 years; (2) The fibers contain carcinogens such as benzo(a)pyrene; (3) Fibers accumulate in the lung and remain immobilized as "asbestos bodies" which cause cancer upon disintegration.

Similarly, while the adverse effect of prolonged exposure to heavy concentrations of asbestos is clearly documented, the medical data is disturbingly vague as to the results of long-term exposure to low and moderate concentrations. Nor is there a clear dose-time relationship for exposure to heavy concentrations. In short, as with many other environmental contaminants, the public has discovered too late that asbestos is potentially dangerous and too little of the extent of that threat.

But two depressing facts are agreed upon: That millions of Americans are likely to contain "asbestos bodies" in their lungs and that asbestos fiber once released is relatively indestructible. That is, the qualities of durability and of resistance to normal chemical and physical stress, which make asbestos such a commercial success, render it potentially dangerous to present and future generations because of the tendency of the fibers to accumulate in the atmosphere and in the lungs.

In light of these facts, the PCB has proposed the nation's most comprehensive set of asbestos controls. To ban all uses of asbestos would be "alarmism" at its most clamorous. But ignoring

the need to explore and, perhaps, to adopt controls for the significant contributors to a swelling volume of asbestos fiber in our air would constitute a foolish complacency.

To this end, the suggested regulations would identify these "significant contributors" as the commercial use of asbestos in construction work; the demolition of asbestos-containing structures; the manufacturing and processing of asbestos-containing products; the transportation of certain asbestos-containing products; the disposal of asbestos-containing waste; and the use of asbestos in the brakes of millions of vehicles.

Part II would impose several general requirements upon all commercial construction, repair, alteration, demolition, manufacturing or processing activity from which asbestos fiber is discharged into the environment. The persons responsible for such activity must obtain a permit from the EPA. The permit system will serve to produce the advanced assurance of compliance with the applicable control regulations and will thus reduce the cost and burden of in-the-field enforcement.

In addition these commercial activities would have to provide facilities to prevent the removal of asbestos fibers from the site of such activity on the clothing of employees. Indeed, this poses a rather new concept of air pollution control. Those who have died from lung ailments induced by long, close association to an asbestos worker may be powerful proof of the need for novelty.

Finally, Part II would provide for careful waste disposal procedures, as wind-blown refuse heaps and scrap piles contribute to the volume of asbestos fiber in our air. The simple steps for control eliminate any excuse for such dangerously sloppy housework.

Part III would prohibit the spraying of asbestos-containing insulation and fireproofing. Experience has indicated that procedural safeguards are inadequate and their enforcement is an overtaxing burden. Chicago has banned spray asbestos, and New York city and Philadelphia are considering doing so.

Procedural safeguards designed to reduce fiber emissions would be required to spray non-asbestos insulation. The biological effects of these fibers is unknown. Prudence would seem to dictate reasonable efforts to soften the potential future blow from spray fiber aspiring to asbestos' status.

Part IV suggests that various asbestos-related activities at construction sites be done within an enclosure. It would also require that asbestos construction products be so installed as to preclude the emission of fiber into the circulating air.

Part V expresses, ironically, what may be a key reason for banning spray asbestos. It would require that procedural safeguards be pursued in order to demolish a structure whose destruction would otherwise expose members of the public to asbestos fiber. Clouds of dust are often raised by demolition work. The facts that great numbers of persons may be exposed to this dust in urban areas and that the post-war generation of high-rises were the first buildings to use asbestos insulation extensively speak in favor of some such regulation.

Part VI suggests an emission standard for manufacturers of asbestos products. The standard is believed to be within the capture efficiency of baghouse filtration. The proposed boundary standard is thought to be a method for preventing dilution of exhaust gases.

The standard would measure only fibers longer than five microns. The justification for this seems to be the administrative convenience of avoiding difficulties in measuring fibers from .5 to five microns in length. Medical evidence has indicated that the very small fibers may be the most dangerous. And the Board will seek extensive evidence on this point.

Part VII would prohibit the use of brake lining in vehicles manufactured after January 1, 1975 and sold for use in Illinois.

If brake lining decomposition emits asbestos fiber, then the tremendous number of vehicles using asbestos, and the impracticality of controlling these numerous small emission sources would appear to speak to the need for a product ban. The prohibition is carefully worded to avoid the necessity of fitting vehicles produced prior to 1975 with non-asbestos brakes. It is contemplated that the ban will necessitate design changes, probably to disc brakes, and it is thought that requiring the individual vehicle owner to undergo this expense is unreasonable. The time lag of over three years is thought to be sufficient for vehicle manufacturers to accomplish any necessary design changes.

Proposed Regulation Only
June 9, 1971
CHAPTER V: TOXIC SUBSTANCES
ASBESTOS: SPRAY INSULATION

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PART I: INTRODUCTION

101. Authority

Pursuant to the authority in Sections 9, 10 and 13 of the Environmental Protection Act which empower the Board to adopt regulations forbidding the "sale, offer, or use for reasons of air pollution control" of any article, and to set "standards specifying the maximum amounts or concentrations of various contaminants that may be discharged into the atmosphere"; and to set standards for the issuance of permits for the operation of any equipment or facility capable of causing or contributing to air pollution; and to promulgate "conditions regarding the... use of any...article determined by the Board to constitute an air pollution hazard"; and to adopt effluent standards limiting the amounts of contaminants that may be discharged into the water of Illinois, the Board adopts the following rules and regulations:

102. Policy

It is the purpose of the General Assembly in adopting the Environmental Protection Act to maintain and enhance the purity of the air and water of Illinois in order to protect health, welfare and the quality of life. Accordingly, it is hereby determined that the uncontrolled discharge of asbestos fiber into the environment tends to severely endanger the public health and welfare and that the uncontrolled spraying of fiber-containing materials unreasonably interferes with the enjoyment of life and property.

It is the purpose of these regulations to control the amount of asbestos fiber released into the environment from the major sources of emission. Such control is necessary not only to protect those members of the public who are in proximity to heavy concentrations of asbestos fiber but also to safeguard the health of future generations endangered by the continuous discharge of asbestos fiber which can be toxic and which tends to be cumulative both in the atmosphere and in the human body.

Where health can be protected by the adoption of an emission standard or of procedural safeguards, such a course has been pursued. In those instances where restriction is unfeasible because of the tremendous number of small, uncontrollable emission sources (automotive) or because of the unusual nature of the emission source (spray asbestos at construction sites) a product ban has been resorted to. These prohibitions have been made with full consideration given to the available alternative materials.

It is also the purpose of these regulations to reduce the emission of non-asbestos particulate from spray-fireproofing and

insulation. To protect against these emissions, the biological effects of which are unknown, procedural safeguards have been enacted.

103. Definitions

- Agency - The Illinois Environmental Protection Agency
- Asbestos - Any fiber or any mixture containing fiber of hydrated silicate mineral, which, on the basis of its crystalline structure, falls into one of two categories:
- (1) pyroxenes - chrysotile fiber;
 - (2) amphiboles - crocidolite, amosite, tremolite, actinolite or anthophyllite fiber.
- Board - The Pollution Control Board of Illinois.
- Commercial Activity - Any activity done for hire or having financial profit as a primary aim.
- Debris - Asbestos-containing waste produced by the demolition of a structure.
- Spraying - The pneumatic application of material used for fireproofing or insulation.
- Waste - Any asbestos-containing matter which has been or is intended to be discarded.

PART II: General Requirements

No commercial activity, not otherwise hereinafter prohibited, involving the discharge of asbestos fiber into the environment from the construction, alteration, repair or demolition of a structure or from the processing or manufacturing of asbestos-containing products, shall be conducted unless the person or entity in charge of such activity complies with the following regulations:

201. A permit shall be obtained from the Agency to engage in such activity. Before obtaining such permit, the applicant shall demonstrate compliance with the following safeguards:

(a) The designation of personnel to exercise full-time supervisory authority over all aspects of the activity from which the release of asbestos fiber into the environment could result, in such a manner as to insure compliance

with the pertinent asbestos control regulations.

(b) That each employee engaged in such activity has completed or will complete a satisfactory course of instruction on the potential hazards of exposure to asbestos fiber including the precautions that must be observed to prevent or restrict the dispersion of asbestos fiber into the environment.

(c) That such additional safeguards as are hereinafter specifically required and such precautions consistent with the purpose of these regulations as the Agency deems necessary under the circumstances shall be complied with.

202. Facilities shall be provided and procedures instituted and supervised that prevent the removal of asbestos-containing material from the site on the clothing of employees.
203. Asbestos-containing wastes shall be immediately vacuumed or otherwise collected where vacuuming is impossible, and shall be placed in a container resistant to tearing or breaking under normal handling conditions, which shall be tightly sealed and clearly marked as containing asbestos waste. Such containers shall be placed directly upon a vehicle for disposal by burial at an approved site.

Section 203 shall not apply to the demolition of a structure, except as provided in Section 501(a), (d) and (e) or to the disposal of sludge waste except as provided in Section 603.

PART III: SPRAY FIREPROOFING AND INSULATION

301. The spraying of asbestos-containing material is prohibited.
302. Non-asbestos particulate matter used for insulation or fireproofing shall not be sprayed unless the following procedures are taken:
- (a) Before the start of spraying operations, all floor areas shall be swept clean and cleared of all objects, material and equipment other than that employed in the application of the fiber-containing material, or, in the alternative, all such objects, material and equipment shall be covered with plastic or plastic-coated tarpaulins.
- (b) The entire floor or area to be sprayed shall be enclosed with plastic or plastic-coated tarpaulins in a manner which shall preclude the escape of fiber-containing material from the enclosure. All interior open areas such as elevator shafts and stairwells shall be enclosed in a manner which shall prevent the escape of fiber-containing

.. material from the working area. "Stack effect" of the shafts, stairwells and comparable spaces shall be considered in providing proper enclosures.

(c) Regardless of adherence to the stated control practices, any visible emission of fiber-containing materials beyond the building perimeter will be considered a violation.

(d) In case of visible emission of fibrous material from the construction site, immediate steps shall be taken to cause the cessation of such emissions by either effective control measures or work stoppage at the source of the emissions. There shall then be immediate and complete cleanup of all material that has escaped the construction site, and measures shall be taken that will insure that no further dispersal of any fibrous material into the atmosphere can occur.

(e) The entire sprayed area, all ledges and surfaces including tarpaulins within the enclosure shall be thoroughly vacuumed upon completion of the spraying operation and immediately before the enclosure is dismantled. The vacuum cleaner shall contain a strong, single-service, disposable inner bag of durable material which shall be removed from the vacuum cleaner and tightly sealed. The bag shall then be placed in a container and disposed of at an approved site in accordance with Section 203.

(f) All areas used for opening bags containing fibrous material or the changing of hoppers shall be enclosed so as to prevent the escape of such material from the immediate area in which such activity occurs.

(g) Any plenum or other structure coated with or containing fibrous insulation and used in the circulation of air in a building shall be thoroughly cleaned of all debris and waste insulation. All applied fiber-containing insulation within a plenum or duct shall be coated with a sealant which precludes exposure of the fiber-containing material to the circulating air.

PART IV: CONSTRUCTION, ALTERATION AND REPAIR OF STRUCTURE

401. (a) The cutting, trimming, fitting or stripping of asbestos-containing material in the construction, alteration or repair of a structure which is done at the site of such structure shall be conducted within a special enclosure designed to preclude the escape of asbestos fiber from the immediate area of such enclosure.

(b) The mechanical exhaustion of dust from such enclosure to the ambient air is prohibited unless such exhaust system is equipped with a fabric filter for dust collection.

402. Asbestos-containing material applied in the construction, alteration or repair of a structure shall be coated with a sealant, provided with a cover or installed in some other manner so as to preclude exposure of the asbestos fiber to the circulating air.

PART V: DEMOLITION

501. Where the risk of public exposure to asbestos fiber from the dislodging of asbestos-containing materials is present, no demolition of a structure shall be initiated unless all safeguards necessary and practicable to reduce the emission of dust are taken.

Such procedures shall include, but are not necessarily limited to:

- (a) Boilers and pipes insulated with asbestos-containing material shall be wetted and stripped before toppling of walls is begun. This procedure shall be followed, where practicable, as to all other asbestos-lined surfaces. Such asbestos waste shall be immediately bagged and disposed of in accordance with Section 203.
- (b) Demolition by toppling of walls is prohibited except within an enclosure approved by the Agency as part of the permit granted for demolition of that structure.
- (c) Before the demolition of any section of the structure, adequate wetting to suppress the dust shall be employed.
- (d) Asbestos-containing debris shall not be dropped or thrown from any floor but shall be transported by dust-tight chutes or buckets. Asbestos-containing debris in chutes or buckets shall be sufficiently wetted to preclude dust dispersion at the point of discharge.
- (e) All asbestos-containing debris shall be thoroughly wetted before loading into trucks, other vehicles or containers. During transport such waste shall be enclosed or covered so as to prevent dust dispersion. Asbestos-containing debris shall be disposed by burial at an approved site.

502. In the event asbestos-containing matter becomes air-borne beyond the property boundaries or in the event freezing temperatures preclude the use of water for dust suppression, demolition work shall cease until adequate alternate measures can be taken.

PART VI: MANUFACTURING

601. (a) No factory, plant or enterprise which engages in the processing or manufacturing of any asbestos-containing product shall emit asbestos fiber into the ambient air in excess of .5 fiber per cubic centimeter of air. The ambient

air quality at the boundary of such factory, plant or enterprise shall not exceed .05 fiber per cubic centimeter of air.

(b) Only fibers of 5 microns or greater in length with a length to breadth ratio of 3 to 1 shall be counted.

(c) Sampling shall be determined by the membrane filter method with phase contrast microscopy at 430 X magnification.

602. No water used in processing or manufacturing which contains concentrations of asbestos fiber shall be discharged into sewage systems or to the waters of Illinois.

603. Waste sludge containing asbestos collected from settling ponds shall be enclosed during transport and shall be disposed by burial at an approved site.

PART VII: ASBESTOS-CONTAINING PRODUCTS

701. No product which may emit asbestos-fiber during its transportation shall be transported unless such product is enclosed in such a manner as to preclude the emission of asbestos fiber into the ambient air.

702. [The use of asbestos in the brake lining of vehicles manufactured after January 1, 1975; and sold for use in Illinois is prohibited.

III. Justification

This section was developed to explain the rationale for the standards presented in Section II of this report. It will not be presented in the official publication of the regulations. The justification is given for this type of standard and for each specific standard in the order they are presented in Section II.

Ideally, national emission standards for asbestos would be established on a concentration basis related to health effects and would provide an ample margin of protection to the public health regardless of the number of sources in a given geographic area. There are many practical considerations which prohibit the establishment of a numerical standard in the time frame established by the Clean Air Act of 1970. Foremost of these problems is the lack of data base. This base is lacking from both the health-effects standpoint for non-occupational exposure and the emissions standpoint.

The hazards of exposure to asbestos have been determined sufficient to warrant establishment of a national standard relating to control of exposure. Determination of the level of exposure to be considered safe has been complicated by many factors, not the least of which has been the time periods between exposure and onset of pathogenic effects. The majority of data available on asbestos health effects is related to occupational exposure and cannot be readily extrapolated to non-occupational levels.

Because of the large emphasis on occupational levels of exposure and a lack of simple analytical techniques, emission data is equally as uncertain for using engineering considerations to establish a numerical

standard. If difficulties in sampling and identifying asbestos particles could be overcome, source testing efforts would have to be placed in a position of establishing, rather than verifying a data base. This would be a formidable task even with contracted source tests and is unlikely to generate a sufficient base prior to promulgation of the standard.

A control practice approach to reducing asbestos exposure levels offers a practical alternative to numerical emission limits. The mainstay of an asbestos control practice standard is the fabric filter which on the basis of semi-quantitative data appears to provide acceptable control at reasonable cost.

While fabric filtration would be a key point in a national emission standard for asbestos, other devices or practices can be required in cases where fabric filters are not practical. Where no effective controls are available, the standard can be extended to ban the use of asbestos, provided a suitable substitute is available.

A major advantage of a control practice standard would be realized in enforcement. Inspectors could be easily trained to certify compliance with control practice regulations. Problems of certifying a numerical standard are enormous. The complexity can be illustrated by examining the state of the art in asbestos sampling and analytical techniques.

Sampling to date has been almost entirely occupational exposure tests without regard to air pollution in the general sense. The most common technique in U. S. testing has been a membrane type sampler with light microscopy used to analyze "fibrous particles". Samples are not taken isokinetically as recommended by OAP source testing methodology.

Johns-Manville has reported that attempts at isokinetic sampling of asbestos dust were unsuccessful. It is believed that a considerable amount of work would be necessary to develop an isokinetic procedure with proper nozzle dimensions to permit meaningful sampling of asbestos emission sources.

The fibrous particles reported by industrial hygienists are by no means specifically asbestos. It is assumed that they are asbestos from the nature of the source of the sample. Specific identification of asbestos requires the use of x-ray diffraction techniques coupled with visual representation by electron microscopy. Analysis of samples collected by membrane techniques and counted by electron microscopy is an involved and costly procedure. Each sample requires about 20 man hours at a cost of about \$30 per man-hour for analysis.

Even these sophisticated techniques tend to distort the actual asbestos content of the sample by increasing the number count of fibers during preparation. Thus the analysis is not meaningful in reporting total numbers of particles present in the original sample.

1.1 Asbestos Mining - Asbestos mining was determined by Davis (ref. 1) to be one of the largest sources of asbestos emissions in the U. S. Mining is predominantly surface type which is extremely difficult to control or quantitate emissions. Specific areas requiring control are drilling, blasting, and ore handling.

1.1.1 Drilling - Drilling occurs predominately in hard rock asbestos mining for the purpose of placing blasting charges. It has received considerable attention from persons interested in controlling occupational exposures. Air swept drills are the most common owing to a fast drilling rate, less bit wear, and lack of freezing problems encountered with wet sweeping methods. Emissions from air swept drills have been visibly reduced through the use of fabric filters (ref. 2). Where wet drilling is used a mist is generated which consists of fine asbestos particles and water. Cyclone collectors can collect this type of emission more readily than fabrics which plug when wet gas streams are filtered (ref. 3).

1.1.2 Blasting - The largest instantaneous emission source of asbestos known is ore blasting. Containment of dust emissions from blasting would be economically unfeasible. Present emission control is limited to minimizing dust generation during blasting. Experienced blasting crews know how to limit and place charges to minimize dust. Wetting of the surface prior to blast provides limited control (ref. 4). As blasting is not a daily occurrence at asbestos mines and most mines stockpile ore, limiting blasting to atmospheric conditions which would not be conducive to dispersion of the involved dust would not be restrictive to the total operation.

1.1.3 Road Treatment - Many mine roads are surfaced with asbestos mill tailings containing about 1% asbestos by weight. Vehicular traffic, some vehicles carrying up to 200 tons, grinds and abrades the tailings releasing considerable quantities of asbestos bearing dust. Many treatments have been tried, with water being one of the simplest (ref. 5). In some areas road treatment would produce hazardous driving conditions; however, it is the mining company's option not to surface roads with asbestos mill tailings.

1.1.4 Vehicles - Vehicles hauling asbestos ore are a controllable source of asbestos emissions. Hauling ore results in emissions through the jostling and air attrition of exposed ore. Where hauling is only over company property, dust covers for the ore would be sufficient in reducing hazards. Wetting is also very helpful in lowering emissions but water is not always available in arid regions. Where transportation of asbestos ore over public roads is involved, the hazard presented to the general population warrants more stringent control measures. Special dust tight vehicles are available (ref. 6).

1.2 Asbestos Milling - Asbestos mills were reported by Davis (ref. 7) as the most significant source of asbestos emissions. Mills have numerous points of asbestos emissions including: ore storage, ore drying, ore handling, ore processing, and tailing dumps. Wet milling offers advantages in many areas but is not applicable to all ores. There is one wet mill in the U. S.

1.2.1 Ore Dumping - Dumping of asbestos ores which are not wet results in emission of asbestos to atmosphere. Other industries have adopted special dumping enclosures (ref. 8). The option is open to utilize water sprays or enclosures for dumping.

1.2.2 Ore Dumps - Open ore dumps can be emission sources especially during extremely dry, windy weather. Other industries employ permanent sprinkler systems to control dust emissions (ref. 9). The option is available to provide enclosed storage.

1.2.3 Conveyors - Totally enclosed conveyors can readily prevent these systems from becoming emission sources during periods of high winds (ref. 10).

1.2.4 Ore Dryers - Numerous types of asbestos ore dryers are found. Some types result in more dust emissions than others owing to the degree of agitation and air velocity encountered by the ore during drying. Johns-Manville has tried several devices in the Canadian operations and have found insulated baghouses to be the most efficient and not economically prohibitive (ref. 11).

1.2.5 Ore Crushers-- Ore crushers are a continuous source of dust emissions. In some operations primary crushing may be separate from the main operation and uncontrolled. The operation can be controlled by enclosure and hooding (ref. 12).

1.2.6 Mill Air - In both wet and dry milling air is used to control dust levels. Dry milling uses air as the separating medium for asbestos fibers from its host rock. Fabric filter installations are found on all well controlled mills, some handling as much as 4.5 million cfm (ref. 13).

1.2.7 Product Packaging - Many of the containers used to ship asbestos fiber are not dust tight or sufficiently durable to prevent spillage during shipment. As emissions occurring during shipping cannot readily be controlled by capture, a more positive approach to emission control is to prevent leaks from occurring. Some asbestos companies are using extremely strong bags at little cost penalty. Drop tests are commonly used to measure the durability of loaded packages.

Bulk shipments present different problems. Some loading and unloading systems employ air conveying of the material. After separation of the large fibers, the exhausting air must be controlled by fabric filtration to eliminate the invisible sub-micron particles. Dust tight vehicles are a must to prevent emissions during transit.

Labelling as to asbestos content is an important aspect of emission control. In the event of accident, clean-up crews can be advised to use dustless methods to remove spilled material. Shippers and handlers will be aware of the need to avoid rough handling and to minimize spills.

1.2.8 Tailings Dumps - Tailings dumps are most often extensive areas of exposed spent ore. Asbestos content still exceeds that of normal surface materials. Emissions occur during conveying, bulldozing or other disturbances and by natural forces. No clearly superior method has been developed for all tailing dumps. Each operator must decide which method will be best at his location. Wetting, chemical treatment, and reforestation have been used.

1.3 Asbestos Processing - The impact of asbestos processing on asbestos emissions to the atmosphere has not been thoroughly evaluated. Over 3000 uses for asbestos have been documented. An estimated 160 million are engaged in manufacturing asbestos products. Asbestos sources are varied and often diffuse, the regulations are limited to emission sources common to most processes.

1.3.1 Manufacturing - Sources of emissions include gas streams used to control dust levels inside plants or as part of the process itself, such as air conveying of material. Fabric filters have been utilized extensively where recirculation of air streams is desired (ref. 14). Low occupational exposures have been maintained by fabric filtration and air recirculation (ref. 15).

Some manufacturing operations generate explosive or fire hazard dusts. Others such as asbestos paper manufacturing ventilate extremely wet gas streams. Such operations are best controlled by high efficiency scrubbers.

1.3.2 Ventilation Air - In general most plants maintain occupationally safe levels within the working areas and where such levels are maintained exhaust of in-plant air to the atmosphere would not constitute a significant emission source. However, some operators prefer to equip personnel with respirators rather than control dust levels and ventilation air from these operations can be significant emission sources. Such sources are readily evident by the accumulation of fibrous particles around exhaust points. It would benefit operators to maintain safe implant levels rather than be faced with the prospect of filtering large amounts of ventilation air.

1.3.3 Product Shipment - The large variety of asbestos products require different degrees of packaging to limit emissions during shipping. Some products may not require any special packing, such as filled plastics or vinyl tiles. Others, such as asbestos cement, require dust tight packages equivalent to fiber shipping bags. More important is the requirement of labelling to instruct users to handle with care and to utilize proper disposal methods.

1.4 Product Use - Products containing asbestos are used extensively in the construction industry. Many users never generate dust from the product. This is especially true of products where the asbestos is firmly bound in a matrix of polymeric or cementitious material. Other users generate significant quantities of asbestos emissions from asbestos containing products where the asbestos is not firmly bound. Regulation and enforcement will be difficult and successful control will depend upon public awareness and concern. Emission controls have been developed for two useful types of products.

1.4.1 Block Insulation - Calcium silicate block insulation is used extensively in thermal insulation applications. This material contains 15% asbestos in a soft but rigid matrix.

Insulation unions have resisted efforts by manufacturers to introduce premolded block for bonds and joints which the unions claim will be detrimental to their trade. Premolded insulation would greatly reduce emissions from field shaping of these products. Where cutting is essential special saws have been developed which have fabric filtration of exhausted dust (ref. 15).

1.4.2 Asbestos Containing Portions - Powderous asbestos products are often used in the construction industry. Some such as portland cement contain 15 to 50 percent asbestos. They are usually mixed in open troughs or buckets, releasing large quantities of asbestos. Special packages have been developed which permit introduction of water and mixing prior to opening (ref. 16).

1.5 Waste Disposal and Demolition - Disposal of asbestos containing wastes is a very dispersed emission problem. Wastes containing asbestos include shipping containers, manufacturing rejects, used products, and collected dusts. There is little or no treatment given to waste materials containing asbestos with respect to minimizing emissions during disposal. Much material is discarded on open dumps and becomes a continual source of emissions.

1.5.1 Removal of Asbestos Containing Insulation - As almost every building contains some asbestos, the regulation is limited to structures containing over 50 lbs. The regulation also applied to industrial and ship building operations where large amounts of insulation are being used. British engineers have pioneered in the use of water and special injection nozzles to wet insulation prior to removal (ref. 17). Enclosure has also been used to limit atmospheric contamination. This standard has been left relatively unrestrictive to permit freedom in development of new and improved removal methods.

1.5.2 Waste Disposal - The method of ultimate disposal which minimizes asbestos emission to the atmosphere is subsurface disposal. A well operated disposal program will have to be established in which asbestos wastes are segregated and buried. These programs can be cooperatives between manufacturers, construction contractors, demolition contractors and disposal area managers. This program must include provisions to minimize emissions during all phases, including transportation to disposal sites (ref. 18).

1.6 Specific Prohibition - In establishing rigorous emission standards, consideration must be given to the recommendation of prohibition of those uses of hazardous materials where adequate controls have not been demonstrated or where the hazard presented exceeds the value achieved.

1.6.1 Sprayed Asbestos Insulation and Fireproofing - Spray application of asbestos fireproofing has been the most controversial source of asbestos emissions; largely generated by its use in densely populated areas. Officials in Chicago, New York, Philadelphia, and San Francisco are considering regulations to prohibit the use of asbestos containing spray fireproofing. Some have already instituted prohibition through permit control. Many unproven control systems for spraying have been proposed. Some have been proven inadequate (ref. 19).

Spray fireproofing manufacturers have responded rapidly to the cities objections by introducing non-asbestos containing substitutes which are economically competitive. Substitute materials being used such as expanded vermiculite, fiber glass and other minerals can be applied using the same equipment as used for asbestos containing compositions. No additional operator training is required.

Cities are also concerned with asbestos emissions which will be generated when asbestos fireproofed buildings are demolished. Asbestos fireproofing of structural steel was not introduced until the late 1940's and few building treated in this manner have been demolished. Officials estimate the year 2000 will be the beginning of demolition problems.

The presence of suitable substitutes at little or no increase in cost and difficulty of emissions control during both application and demolition indicate that prohibition is warranted.

1.6.2 Miscellaneous Uses - The finely divided nature of asbestos floats and shorts combined with the absorbitivity and chemical inactivity make these forms likely candidates for absorbing system and dispersing mediums. Other inert materials are available for such purposes, the use of asbestos is highly unwarranted in view of its hazardous nature. This prohibits such uses as insecticide dispersants and oil absorbants (ref. 20).

2.1 Equipment Specifications - Specifications on required control equipment are intended to insure equivalent asbestos removal efficiency. Most of the specifications are based upon best current installations.

2.1.1 Fabric Filters - Fabric filters are the primary control device required by this regulation. They have been reported to be better than 99.99 percent efficient on a mass basis collecting asbestos mill dust (ref. 21). Many reports of tests on return air from fabric filters show that the devices can control dust below occupational threshold values.

Baghouses have many years of demonstrated performance including over 30 years of use in the asbestos industry. The devices are reliable and economical. Market availability is excellent with over 50 manufacturers selling some 7500 units per year. Over 115,000 units are in use today (ref. 22).

2.1.1.1 Construction - Construction is specified to prevent emissions of untreated dust.

2.1.1.2 Bypasses - The prohibition of bypasses insures that plants will not operate in an uncontrolled manner.

2.1.1.3 Hoppers - Many filter users have no provisions for emptying hoppers without re-releasing the dust to the atmosphere. Fabric filter manufactures have developed many systems to handle collected dust.

2.1.1.4 Fabrics - Fabric efficiency is highly dependent upon air flow permeability. Low air permeability implies that the fabric will have high collection efficiency. The rating 20 cfm/ft² at 1/2 in. H₂O is equivalent to standard cotton bags which have attained 99.99 percent efficiency. The rating of 30 cfm/ft² at 1/2 in. H₂O is an equivalent rating for orlon fabrics used successfully by industry. Fabrics having higher permeabilities will not be permitted.

2.1.2 Alternative Devices - There are certain conditions where fabric filters are not applicable. These include very humid ambient temperature gas streams and explosive or flammable dust loads. Scrubbers are better suited for these cases but must be specified to guarantee equivalent efficiency. In addition, other devices installed at the option of the manufacturer must be certified for compliance.

2.1.2.1 Scrubbers - High energy venturi scrubbers are the most efficient type of scrubber for submicron particles. The pressure drops necessary for good efficiency are high and vary somewhat with scrubber design. Forty inches of pressure drop will obtain 95% efficiency for .25u particles in well designed units (ref. 23).

2.1.2.2 Other Devices - Alternative devices installed where fabric filters are applicable must be certified to be at least equivalent to fabric filters. This regulation is not intended to prevent development of improved devices but is designed to provide equivalent control of emissions.

It is not possible at this time to clearly define equivalency because of the long standing lack of performance data for fabric filters in the asbestos industry. Through the years the fabric filter has developed a

position of unchallenged superiority for control of asbestos emissions. Units are often purchased and installed with no written guarantee of performance and no performance testing. Therefore, the presentation of equivalency data will have to incorporate data from both fabric filters and the intended alternative device under similar operating conditions.

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