FILE NAME: Pennsylvania (PA)

DATE: 1968

DOC#: PA034

DOCUMENT DESCRIPTION: 1968 Updated of 1961 Govt Regulations for Threshold Limits in Places of Employment

RULES AND REGULATIONS
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HEALTH

CHAPTER 4

Article 432

Regulations Establishing Threshold Limits in Places of Employment*

(Adopted October 27, 1961)

Section 1. Purpose

The purpose of these regulations and standards is to prescribe minimum requirements and standards for the maintenance of occupational health in places of employment in Pennsylvania.

Section 2. Application

These regulations and standards shall apply to every place of employment.

Section 3. Definitions

A. "Atmospheric contaminant" shall mean a harmful substance or material in air usually occurring in the form of a dust, fume, gas, vapor, or mist.

B. "Department" shall mean the Department of Health, Commonwealth of Pennsylvania.

C. "Dust" shall mean finely divided solid particles dispersed in air and having been formed by mechanical means such as grinding, crushing, blasting, and drilling.

D. "Fume" shall mean solid particles dispersed in air resulting from some chemical or physical process that involved a change of state, such as combustion, sublimation, or evaporation and condensation.

E. "Gas" shall mean a formless fluid occupying the space of enclosure.

F. "General or dilution ventilation" shall mean ventilation provided to dilute the concentration of dusts, fumes, gases, vapors, or mists in the atmosphere of all or part of the place of employment.

G. "Local exhaust ventilation" shall mean that type of ventilation in which suction is applied at the point of generation of dusts, fumes, gases, vapors, and mists.

H. "Mist" shall mean liquid droplets suspended in air.

I. "Place of employment" shall mean a location or site where an individual possesses employment in a trade, occupation, or profession for the sake of monetary gain.

J. (amended August 18, 1964) "Threshold Limit Value" shall mean the maximum average atmospheric concentration of contaminant to which workers may be exposed for an eight hour working day. (These values are set forth in Table 1 hereof, which table is a part of these regulations.)

K. "Vapor" shall mean any liquid, except water, which when held in suspension in air will revert to its original liquid state after release from heat, chemical action, or pressure conditions.

L. (added August 18, 1964) "Short-Term Limit" shall mean the maximum atmospheric concentration of a contaminant to which a workman may be exposed for a specified short-time period. The concentration represents an upper limit of exposure for the specified time and assumes that there are sufficient recovery periods between episodes for recuperation. The daily average exposure to the contaminant, including these episodes, shall be such that the threshold limit value set forth in Table 1 shall not be exceeded. (These values are set forth in Table 2 hereof, which table is a part of these regulations.)

M. (added January 25, 1968) "Confined space" shall mean any tank, vessel or area so enclosed that adequate dilution ventilation will not be obtained by natural air movement.

* *Adopted pursuant to the provisions of the Administrative Code of 1929: Act of April 9, 1929, P.L. 177, as amended.*

Section 4. Employer's Duties

A. Every employer shall install and provide such control measures and protective equipment as is required for the protection of health.

B. Every employer shall inform and periodically instruct his employees regarding known hazards and proper methods for utilizing industrial hygiene control measures which are provided.

C. When it is necessary for an employer to provide protective equipment, such employer shall provide an approved means for cleaning and sterilizing such protective equipment, and the employer shall cause such equipment to be maintained in a clean and sanitary condition. Respiratory equipment shall not be passed from one man to another until such equipment is clean and sterilized. When filter or cartridge type respirators are used, such employee shall have such respirator for his own exclusive use. Respiratory equipment and replacement units shall be stored, when not in use, in approved containers.

D. (amended August 20, 1963) When employees are exposed to compounds capable of causing occupational disease by inhalation and/or skin or mucous membrane absorption, the department may require their employer to provide physical examinations and other tests for them at periodic intervals.

Section 5. Threshold Limit Values and Short-Term Limits

A. (amended August 18, 1964) No employee shall be exposed to atmospheric concentrations of contaminants which concentrations may give rise to occupational disease. Tables 1 and 2 shall be used for the determination of permissible levels.

B. Exposures to atmospheric contaminants or adverse environmental conditions not referred to in Section 5A shall be controlled when necessary to protect health.

Section 6. Air Recirculation and Discharge

A. No air from any local exhaust ventilation system may be recirculated without express approval by the Department.

B. The discharge of air from any exhaust system shall be such that no air contamination will enter any window, door, or other opening of any work area in quantities sufficient to create a health hazard to or in such area.

Section 7. Confined Space

(amended January 25, 1968)

No individual shall be permitted to enter any confined space unless another workman supplied with emergency protective equipment is stationed outside the confined space to summon help and to assist the workman and until one of the three following conditions have been met:

A. It has been ascertained by air sampling that the atmosphere in the confined space contains an adequate quantity of oxygen and that harmful atmospheric contaminants have been diluted to safe concentrations prior to and during occupancy; or

B. The workman is equipped with a supplied-air respirator or self-contained breathing apparatus, a safety harness, a safety line and protective clothing, where necessary; or

C. It is ascertained that no harmful contaminants are present and mechanically induced dilution ventilation is used before entry and during occupancy to insure an adequate quantity of oxygen in the confined space.

Section 8. Housekeeping

A. The interiors, exteriors, and environs of buildings where hazardous materials are used, stored, or handled, shall be cleaned and maintained in such a manner as to prevent harmful exposure to hazardous materials.

B. Employees engaged in such cleaning operations and all others who may be exposed shall wear protective equipment as is required. The cleaning operations should be done by suction apparatus.

C. Where wet processes are used, reasonable drainage should be maintained. False floors, platforms, mats, or other means of safe footing should be provided.

Section 9. Labeling

Adequate identification, warning, and caution labels shall be applied to all containers of hazardous chemicals.

Table 1. Threshold Limit Values

Substance	8-hour maximum average exposure P.P.M.[a]	Mg. per[b] Cu. M.
Acetaldehyde	200	–
Acetic acid	10	–
Acetic anhydride	5	–
Acetone	1,000	–
Acetonitrile	40	–
Acetylene tetrabromide	1	–
Acrolein	0.1	–
Acrylamide–Skin	–	0.3
Acrylonitrile–Skin	20	–
Aldrin (1, 2, 3, 4, 10, 10-hexachloro-1, 4, 4a, 5, 8, 8a-hexahydro-1, 4, 5, 8-dimethanonaphthalene)–Skin	–	0.25
Allyl alcohol–Skin	2	–
Allyl chloride	1	–
Allyl glycidyl ether (AGE)	10	–
Allyl propyl disulfide	2	–
2–Aminopyridine	0.5	–
Ammonia	50	–
Ammonium sulfamate (Ammate)	–	15
Amyl acetate	100	–
sec-Amyl acetate	125	–
Amyl alcohol (isoamyl alcohol)	100	–
Aniline–Skin	5	–
Anisidine (o-, p-isomers)–Skin	–	0.5
Antimony	–	0.5
ANTU (alpha naphthyl thiourea)	–	0.3
Arsenic	–	0.5
Arsine	0.05	–
Azinphos-methyl–Skin	–	0.2
Barium (soluble compounds)	–	0.5
Benzene (benzol)–Skin	25	–
Benzoyl peroxide	–	5
Benzyl chloride	1	–
Beryllium	–	0.002
Boron oxide	–	15
Boron trifluoride	1	–
Bromine	0.1	–
Bromoform–Skin	0.5	–
Butadiene (1,3-butadiene)	1,000	–
2-Butanone (methyl ethyl ketone)	200	–
2-Butoxy ethanol (Butyl Cellosolve)–Skin	50	–
n-Butyl acetate	200	–
sec-Butyl acetate	200	–
tert. Butyl acetate	200	–
Butyl alcohol	100	–
tert. Butyl alcohol	100	–
Butylamine–Skin	5	–
tert. Butyl chromate (as CrO_3)–Skin	–	0.1
n-Butyl glycidyl ether (BGE)	50	–
Butyl mercaptan	10	–
p-tert. Butyltoluene	10	–
Cadmium (Metal dust and soluble salts)	–	0.2
Cadmium oxide fume	–	0.1
Calcium arsenate	–	1
Calcium oxide	–	5
Camphor	–	2
Carbaryl (Sevin)	–	5
Carbon black	–	3.5
Carbon dioxide	5,000	–
Carbon disulfide–Skin	20	–
Carbon monoxide	50	–
Carbon tetrachloride–Skin	10	–
Chlordane (1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene)–Skin	–	0.5
Chlorinated camphene, 60% –Skin	–	0.5
Chlorinated diphenyl oxide	–	0.5
Chlorine	1	–
Chlorine dioxide	0.1	–
Chlorine trifluoride	0.1	–
Chloroacetaldehyde	1	–
Chlorobenzene (monochlorobenzene)	75	–
O-Chlorobenzylidene malononitrile (OCBM)	0.05	–
Chlorobromomethane	200	–
Chlorodiphenyl (42% Chlorine) –Skin	–	1
Chlorodiphenyl (54% Chlorine) –Skin	–	0.5
Chloroform (trichloromethane)	50	–
1-Chloro-1-nitropropane	20	–
Chloropicrin	0.1	–
Chloroprene (2-chloro-1,3-butadiene)–Skin	25	–
Chromic acid and chromates (as CrO_3)	–	0.1
Coal tar pitch volatiles (benzene soluble fraction)	–	0.2
Cobalt	–	0.5
Copper fume	–	0.1
Copper dusts and mists	–	1
Cotton dust (raw)	–	1

Table 1. *(Continued)*

Substance	8-hour maximum average exposure P.P.M.[a]	Mg. per[b] Cu. M.
Crag (R) herbicide (sodium 2-[2,4-dichlorophenoxyl] ethanol hydrogen sulfate)	–	15
Cresol (all isomers)–Skin	5	–
Crotonaldehyde	2	–
Cumene–Skin	50	–
Cyanide (as CN)–Skin	–	5
Cyclohexane	300	–
Cyclohexanol	50	–
Cyclohexanone	50	–
Cyclohexene	300	–
Cyclopentadiene	75	–
2,4-D (2,4-dichlorophenoxy-acetic acid)	–	10
DDT (2,2,-bis (p-chlorophenyl)-1,1,1-trichloroethane)–Skin	–	1
Decaborane–Skin	0.05	–
Demeton (systox)–Skin	–	0.1
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	–
Diazomethane	0.2	–
Diborane	0.1	–
1,2-Dibromoethane (Ethylene dibromide)–Skin	25	–
o-Dichlorobenzene	50	–
p-Dichlorobenzene	75	–
Dichlorodifluoromethane	1,000	–
1,3-Dichloro-5,5-dimethyl hydantoin	–	0.2
1,1-Dichloroethane	100	–
1,2-Dichloroethane (Ethylene dichloride)	50	–
1,2-Dichloroethylene	200	–
Dichloroethyl ether–Skin	15	–
Dichloromonofluoromethane	1,000	–
1,1-Dichloro-1-nitroethane	10	–
Dichlorotetrafluoroethane	1,000	–
DDVP (o,o-Dimethyl-2,2-dichlorovinyl phosphate)–Skin	–	1
Dieldrin (1,2,3,4,10,10-hexa-chloro-6,7-epoxy-1,4,4a,5,6,7, 8,8a-octahydro-1,4,5,8-dimethanonaphthalene)–Skin	–	0.25
Diethylamine	25	–
Diethylaminoethanol–Skin	10	–
Difluorodibromomethane	100	–
Diglycidyl ether (DGE)	0.5	–
Diisobutyl ketone	50	–
Dimethyl acetamide–Skin	10	–
Dimethylamine	10	–
Dimethylaniline (n-dimethyl-aniline)–Skin	5	–
Dimethyl 1,2-dibromo-2,2-dichloroethyl phosphate	–	3
Dimethylformamide–Skin	10	–
1,1-Dimethylhydrazine–Skin	0.5	–
Dimethylsulfate–Skin	1	–
Dinitrobenzene (all isomers)–Skin	–	1
Dinitro-o-cresol–Skin	–	0.2
Dinitrotoluene–Skin	–	1.5
Dioxane (diethylene dioxide)–Skin	100	–
Dipropylene glycol methyl ether–Skin	100	–
Di sec. octyl phthalate (Di-2-ethylhexyl-phthalate)	–	5
Endrin (1,2,3,4,10,10-hexa-chloro-6,7-epoxy-1,4,4a,5, 6,7,8,8a-octa hydro-1,4,-endo-5,8,-dimethanonaphthalene)–Skin	–	0.1
Epichlorhydrin–Skin	5	–
EPN (o-ethyl o-p-nitrophenyl thionobenzenephosphonate)–Skin	–	0.5
Ethanolamine	3	–
2-Ethoxyethanol (cellosolve)–Skin	200	–
2-Ethoxyethylacetate (cellosolve acetate)–Skin	100	–
Ethyl acetate	400	–
Ethyl acrylate–Skin	25	–
Ethyl alcohol (ethanol)	1,000	–
Ethylamine	10	–
Ethyl sec-amyl ketone	25	–
Ethylbenzene	100	–
Ethyl bromide	200	–
Ethyl butyl ketone (3-Heptanone)	50	–
Ethyl chloride	1,000	–
Ethyl ether	400	–
Ethyl formate	100	–
Ethyl mercaptan	10	–

Table 1. *(Continued)*

Substance	8-hour maximum average exposure P.P.M.[a]	Mg. per[b] Cu. M.
n-Ethylmorpholine–Skin	20	–
Ethyl silicate	100	–
Ethylene chlorohydrin–Skin	5	–
Ethylenediamine	10	–
Ethylene glycol dinitrate (Combined EGDN + NG)–Skin	0.2	–
Ethylene glycol monomethyl ether acetate (methyl cellosolve acetate)	25	–
Ethylene imine–Skin	0.5	–
Ethylene oxide	50	–
Ferbam (ferric dimethyl dithiocarbamate)	–	15
Ferrovanadium dust	–	1
Fluoride (as F)	–	2.5
Fluorine	0.1	–
Fluorotrichloromethane	1,000	–
Formaldehyde	5	–
Formic acid	5	–
Furfural–Skin	5	–
Furfuryl alcohol	50	–
Glycidol (2,3-Epoxy-1-propanol)	50	–
Hafnium	–	0.5
Heptachlor (1,4,5,6,7,8,8a-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindane)–Skin	–	0.5
Heptane (n-heptane)	500	–
Hexachloroethane–Skin	1	–
Hexane (n-hexane)	500	–
Hexanone (methyl butyl ketone)	100	–
Hexone (methyl isobutyl ketone)	100	–
sec-Hexyl acetate	50	–
Hydrazine–Skin	1	–
Hydrogen bromide	3	–
Hydrogen chloride	5	–
Hydrogen cyanide–Skin	10	–
Hydrogen fluoride	3	–
Hydrogen peroxide, 90%	1	–
Hydrogen selenide	0.05	–
Hydrogen sulfide	10	–
Hydroquinone	–	2
Inert or nuisance particulates	–	15
Iodine	0.1	–
Iron oxide fume	–	10
Isoamyl acetate	100	–
Isobutyl acetate	150	–
Isophorone	25	–
Isopropyl acetate	250	–
Isopropylamine	5	–
Isopropyl glycidyl ether (IGE)	50	–
Ketene	0.5	–
Lead	–	0.2
Lead arsenate	–	0.15
Lindane (hexachlorocyclohexane, gamma isomer)–Skin	–	0.5
Lithium hydride	–	0.025
L.P.G. (liquified petroleum gas)	1,000	–
Magnesium oxide fume	–	15
Malathion (o,o-dimethyl dithiophosphate of diethyl mercaptosuccinate)–Skin	–	15
Manganese	–	5
Mercury–Skin	–	0.1
Mercury (organic compounds)–Skin	–	0.01
Mesityl oxide	25	–
Methoxychlor (2,2-di-p-methoxy-phenyl-1,1,1-trichloroethane)	–	15
2-Methoxy-ethanol (methyl cellosolve)	25	–
Methyl acetate	200	–
Methyl acetylene (propine)	1,000	–
Methyl acetylene-propadiene mixture (MAPP)	1,000	–
Methyl acrylate–Skin	10	–
Methylal (dimethoxymethane)	1,000	–
Methyl alcohol	200	–
Methylamine	10	–
Methyl (n-amyl) ketone (2-Heptanone)	100	–
Methyl bromide–Skin	20	–
Methyl chloride	100	–
Methyl chloroform (1,1,1-trichloroethane)	350	–
Methylcyclohexane	500	–
Methylcyclohexanol	100	–
Methylcyclohexanone	100	–
Methylene bis phenyl isocyanate (MDI)	–	0.2
Methylene chloride (dichloromethane)	500	–
Methyl formate	100	–

Table 1. *(Continued)*

Substance	8-hour maximum average exposure P.P.M.[a]	Mg. per[b] Cu. M.
Methyl iodide–Skin	5	–
Methyl isobutyl carbinol (methyl amyl alcohol)–Skin	25	–
Methyl isocyanate–Skin	0.02	–
Methyl mercaptan	10	–
Methyl methacrylate	100	–
αMethyl styrene	100	–
Monomethyl aniline–Skin	2	–
Monomethyl hydrazine–Skin	0.2	–
Molybdenum (soluble compounds)	–	5
(insoluble compounds)	–	15
Morpholine–Skin	20	–
Naphtha (coal tar)	200	–
Naphtha (petroleum)	500	–
Naphthalene	10	–
Nickel, metal and soluble compounds	–	1
Nickel carbonyl	0.001	–
Nicotine–Skin	–	0.5
Nitric acid	2	–
p-Nitroaniline–Skin	1	–
Nitrobenzene–Skin	1	–
p-Nitrochlorobenzene–Skin	–	1
Nitroethane	100	–
Nitrogen dioxide	5	–
Nitrogen trifluoride	10	–
Nitroglycerin (combined EGDN + NG)–Skin	0.2	–
Nitromethane	100	–
1-Nitropropane	25	–
2-Nitropropane	25	–
Nitrotoluene–Skin	5	–
Octane	500	–
Oil mist (mineral)	–	5
Osmium tetroxide	–	0.002
Oxalic acid	–	1
Oxygen difluoride	0.05	–
Ozone	0.1	–
Parathion (o,o,diethyl-o-p-nitrophenyl thiophosphate)–Skin	–	0.1
Pentaborane	0.005	–
Pentachloronaphthalene–Skin	–	0.5
Pentachlorophenol–Skin	–	0.5
Pentane	1,000	–
Pentanone (methyl propyl ketone)	200	–
Perchloroethylene (tetrachloroethylene)	100	–
Perchloromethyl mercaptan	0.1	–
Perchloryl fluoride	3	–
Phenol–Skin	5	–
p-Phenylene diamine–Skin	–	0.1
Phenyl ether (vapor)	1	–
Phenyl glycidyl ether (PGE)	50	–
Phenylhydrazine–Skin	5	–
Phosdrin (2-carbomethoxy-1-methyl vinyl dimethyl phosphate)–Skin	–	0.1
Phosgene	0.1	–
Phosphine	0.3	–
Phosphoric acid	–	1
Phosphorus (yellow)	–	0.1
Phosphorus pentachloride	–	1
Phosphorus pentasulfide	–	1
Phosphorus trichloride	0.5	–
Phthalic anhydride	2	–
Picric acid–Skin	–	0.1
Pival	–	0.1
Platinum (soluble salts)	–	0.002
Propane	1,000	–
Propyl acetate	200	–
Propyl alcohol (isopropyl alcohol)	400	–
Propyl ether (isopropyl ether)	500	–
n-Propyl nitrate	25	–
Propylene dichloride (1,2-dichloropropane)	75	–
Propylene imine–Skin	2	–
Propylene oxide	100	–
Pyrethrum	–	5
Pyridine	5	–
Quinone	0.1	–
Rhodium – Metal fume and dusts	–	0.1
Soluble salts	–	0.001
Rotenone (commercial)	–	5
Selenium compounds (as Se)	–	0.2
Selenium hexafluoride	0.05	–
Silver, metal and soluble compounds	–	0.01
Sodium fluoroacetate (1080)–Skin	–	0.05

Table 1. *(Continued)*

Substance	8-hour maximum average exposure P.P.M.[a]	Mg. per[b] Cu. M.
Sodium hydroxide	–	2
Stibine	0.1	–
Stoddard solvent	500	–
Strychnine	–	0.15
Styrene monomer (phenylethylene)	100	–
Sulfur dioxide	5	–
Sulfur hexafluoride	1,000	–
Sulfuric acid	–	1
Sulfur monochloride	1	–
Sulfur pentafluoride	0.025	–
Sulfuryl fluoride	5	–
2, 4, 5T (2, 4, 5-Trichlorophenoxy-acetic acid)	–	10
Tantalum	–	5
TEDP (tetraethyl dithionopyrophosphate)–Skin	–	0.2
Tellurium	–	0.1
Tellurium hexafluoride	0.02	–
TEPP (tetraethyl pyrophosphate) –Skin	–	0.05
1, 1, 2, 2-Tetrachloroethane–Skin	5	–
1, 1, 2, 2-Tetrachloro-1, 2-difluoroethane	500	–
1, 1, 1, 2-Tetrachloro-2, 2-difluoroethane	500	–
Tetraethyl lead (as Pb)–Skin	–	0.075
Tetrahydrofuran	200	–
Tetramethyl lead (TML) (as Pb)–Skin	–	0.075
Tetramethyl succinonitrile–Skin	0.5	–
Tetranitromethane	1	–
Tetryl (2, 4, 6-trinitrophenyl–methylnitramine)–Skin	–	1.5
Thallium (soluble compounds) –Skin	–	0.1
Thiram (tetramethyl thiuram disulfide)	–	5
Tin (inorganic compounds)	–	2
(organic compounds)	–	0.1
Titanium dioxide	–	15
Toluene (toluol)	200	–
Toluene-2, 4-diisocyanate	0.02	–
o-Toluidine–Skin	5	–
1, 1, 2-Trichloroethane–Skin	10	–
Trichloroethylene	100	–
Trichloronaphthalene–Skin	–	5
1, 2, 3-Trichloropropane	50	–
1, 1, 2-Trichloro 1, 2, 2-trifluoroethane	1,000	–
Triethylamine	25	–
Trifluoromonobromomethane	1,000	–
Trinitrotoluene–Skin	–	1.5
Triorthocresyl phosphate	–	0.1
Triphenyl phosphate	–	3
Turpentine	100	–
Uranium (soluble compounds)	–	0.05
(insoluble compounds)	–	0.25
Vanadium (V_2O_5 dust)	–	0.5
(V_2O_5 fume)	–	0.1
Vinyl chloride (chloroethylene)	500	–
Vinyl toluene	100	–
Warfarin (3-[αacetonylbenzyl]-4-hydroxycoumarin)	–	0.1
Xylene (xylol)	100	–
Xylidine–Skin	5	–
Yttrium	–	1
Zinc oxide fume	–	5
Zirconium compounds (as Zr)	–	5

NOTE: The word "Skin" following a substance's name indicates that the substance can penetrate the skin to cause systemic effects.

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

[b] Milligrams of particulate per cubic meter of air.

Table 2. Short-Term Limits

Substance	Maximum average exposure for the time period specified: P.P.M.[a]	Mg. per[b] Cu. M.	Time in minutes
Acetic acid	40	–	5
Acetone	1,000	–	30
Acrolein	0.5	–	5
Acrylonitrile	40	–	30
Allyl alcohol	5	–	30
Allyl glycidyl ether (AGE)	10	–	5
Ammonia	100	–	30
Amyl acetate	200	–	30
Amyl alcohol	150	–	30
Aniline	50	–	30
Benzene	75	–	30
Benzoyl peroxide	–	10	15
Beryllium	–	0.025	5
Boron trifluoride	1	–	5
Bromine	0.4	–	30
2-Butanone (MEK)	300	–	5
2-Butoxy ethanol (butyl cellosolve)	200	–	5
Butyl acetate	300	–	30
Butyl alcohol	150	–	30
tert. Butyl alcohol	150	–	30
Butylamine	5	–	5
tert. Butyl chromate	–	0.1	30
Cadmium oxide fume	–	0.3	30
Calcium oxide	–	10	30
Carbaryl (Sevin)	–	30	30
Carbon disulfide	100	–	30
Carbon monoxide	400	–	15
Carbon tetrachloride	25	–	30
Chlordane	–	2	30
Chlorine	3	–	5
Chlorine trifluoride	0.1	–	5
Chloroacetaldehyde	1	–	5
Chloroform	400	–	30
Cobalt	–	0.5	30
Copper fume	–	0.1	30
Cyanide (as CN)	–	5	30
Cyclopentadiene	200	–	15
DDVP	–	3	30
Demeton (Systox)	–	0.5	30
Diacetone alcohol	150	–	30
o-Dichlorobenzene	50	–	15
1,3-Dichloro-5,5-Dimethylhydantoin	–	0.5	15
1,1-Dichloroethane	200	–	30
1,2-Dichloroethane (Ethylene dichloride)	200	–	30
Dichloroethyl ether	35	–	30
1,1-Dichloro-1-nitroethane	10	–	30
Dieldrin	–	1	30
Diethyl amine	100	–	30
Diglycidyl ether	0.5	–	5
Diisobutyl ketone	50	–	30
Dimethylamine	20	–	5
Endrin	–	0.5	30
EPN	–	2.5	30
Ethyl acetate	1,000	–	15
Ethyl acrylate	50	–	15
Ethyl alcohol	5,000	–	15
Ethylamine	25	–	30
Ethyl benzene	200	–	30
Ethylene diamine	20	–	5
Ethylene glycol dinitrate and Nitroglycerin	0.2	–	30
Ethylene glycol monomethyl ether acetate (Methyl Cellosolve acetate)	50	–	30
Ethyl ether	1,000	–	30
Ethylene imine	5	–	30
Ethylene oxide	200	–	30
N-Ethylmorpholine	20	–	15
Fluoride	–	10	30
Fluorine	0.5	–	5
Formaldehyde	5	–	5
Furfural	15	–	15
Furfural alcohol	50	–	15
Gasoline	500	–	30
Heptachlor	–	2	30
Heptane	500	–	30
Hexane	500	–	30
Hexanone (MBK)	200	–	30
Hexone (MIBK)	400	–	5
Hydrazine	1	–	30
Hydrogen chloride	5	–	5
Hydrogen cyanide	20	–	30
Hydrogen fluoride	3	–	15
Hydrogen sulfide	20	–	5
Iodine	0.1	–	5

Table 2. *(Continued)*

Substance	Maximum average exposure for the time period specified		
	P.P.M.[a]	Mg. per[b] Cu. M.	Time in minutes
Isopropyl glycidyl ether (IGE)	100	–	30
Lindane	–	1	30
Manganese	–	5	30
Melvinphos (Phosdrin)	–	0.5	30
Methyl acetate	400	–	5
Methyl acrylate	25	–	30
Methyl bromide	20	–	5
Methyl cellosolve	50	–	30
Methyl chloride	100	–	5
Methyl chloroform (1,1,1-trichloroethane)	1,500	–	5
Methylene bis phenyl-isocyanate (MDI)	–	0.25	5
Methylene chloride (Dichloromethane)	1,000	–	30
Methyl mercaptan	20	–	5
Methyl methacrylate	200	–	15
Methyl styrene	100	–	30
Morpholine	20	–	15
Naphtha (petroleum)	500	–	30
Naphthalene	15	–	5
Nickel carbonyl	0.04	–	5
Nitric acid	15	–	5
Nitrogen dioxide	25	–	5
Octane	500	–	30
Ozone	1	–	30
Parathion	–	0.5	30
Perchloroethylene	200	–	30
Phosgene	1	–	5
Phosphine	1	–	30
Phthalic anhydride	4	–	5
Propyl alcohol	400	–	30
Pyridine	10	–	30
Selenium compounds (as Se)	–	0.3	30
Styrene monomer	100	–	5
Sulfur dioxide	20	–	5
Sulfuric acid	–	3	5
TEDP	–	1	30
TEPP	–	0.25	30
1,1,2,2-Tetrachloro-ethane	10	–	30
Tetrahydrofuran	500	–	30
Tin (inorganic compounds)	–	5	30
Toluene	600	–	30
Toluene-2,4-diisocyanate (TDI)	0.02	–	5
Trichloroethylene	200	–	30
Triethyl amine	100	–	30
Trinitrotoluene	–	5	30
Vanadium (V_2O_5 dust and/or fume)	–	0.5	30
Vinyl chloride	500	–	5
Vinyl toluene	400	–	5
Xylene	300	–	30
Zinc oxide fume	–	10	30

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

[b]Milligrams of particulate per cubic meter of air.

Table 1. *(Continued)*

Mineral Dusts	
Substance	M.P.P.C.F.[c]
Silica	
Crystalline	
Quartz (threshold limit calculated from the formula)	250 $\%SiO_2+5$
Cristobalite (same)	
Amorphous, including natural diatomaceous earth	20
Graphite	15
Silicates (less than 1% crystalline silica)	
Asbestos	5
Mica	20
Soapstone	20
Talc	20
Tremolite	5
Portland cement	50
Miscellaneous (less than 1% crystalline silica)	50

[c]Millions of particles per cubic foot of air based on impinger samples counted by light-field techniques.

OCCUPATIONAL HEALTH

News & Views

Division of Occupational Health Pennsylvania Department of Health
Fall 1965 Vol. 3, No. 4

Malignancies in Asbestos Workers - A Preliminary Report -

Within recent years and months there has been a considerable amount of material in the literature which indicates that asbestosis is directly related to the incidence of malignant tumors and cancer.

As early as eight years ago a Pennsylvania pathologist reported that he had seen at autopsies many cancer cases in persons who also suffered from asbestosis. The pathologist is on the staff of a hospital which receives most of the patients from a nearby town where a large asbestos plant is located. This plant makes asbestos textiles and also brake linings and clutch facings. The findings of the pathologist have created concern in the asbestos industry and it was felt appropriate for our health department to review the problem.

To obtain as complete a story as possible the record rooms of six hospitals which draw their cases particularly from the area of the asbestos plant were searched for cases where asbestosis was considered during the period between 1956 and 1964. Seventy-five hospital records coded as asbestosis were located. These were people who either were diagnosed on admission, on x-rays, or at autopsy to have asbestosis or asbestosis was mentioned in the differential diagnosis.

After obtaining the 75 records, an attempt was made to locate these former patients. A large number were no longer alive and their survivors had to be contacted. For these 75 an occupational and smoking history was obtained from their survivors and/or from plant management. Seven either had not worked at this particular asbestos plant or the diagnosis had been rejected.

This left 68 asbestos workers who had worked in one particular plant. Further study of these records showed that 21 among them not only had evidence of asbestosis but also were suffering from cancer. Twelve of these had lung cancer and nine had various other growths such as bladder cancer, leukemia, etc. The smoking history of the 12 lung cancer cases revealed that five had never smoked which is more or less the same distribution of smokers versus non-smokers as in the general population. Of the nine cases with other malignancies, two never smoked and three were cigar smokers only.

Another interesting feature was that among the other cancers, not the lung cancers, there was one case of a malignant mesothelioma.

Another interesting finding was that of the 21 cases with cancer 13 worked in the textile department of the plant and four worked in brake line manufacture. The department where one man worked remains unknown and the rest worked at various other jobs.

Two of the 11 lung cancer cases and one of the lymphoblastoma cases had worked in the asbestos plant for a total of only six months which is a rather short exposure, and one wonders how much this short exposure may have contributed. Eighteen of these 21 cases had started work in the plant prior to 1940 and 12 had started work prior to 1920.

Of the 21 cases of cancer 11 were born before 1900 and only one was born after 1910.

Malignancies in Asbestos Workers

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WITHIN recent years and months a considerable amount of evidence has appeared in the literature which indicates that asbestosis is directly related to the incidence of malignant tumors and cancer.[1-3]

As early as ten years ago a Pennsylvania pathologist reported that he had seen at autopsies many cancer cases in persons who also suffered from asbestosis. The pathologist is on the staff of a hospital which receives most of the patients from a nearby town where a large asbestos producing plant is located. The findings of the pathologist have created concern in the asbestos industry and it was felt appropriate for the Pennsylvania Health Department to review the problem.

Exposures in the Plant

The following information was obtained from the files of the health department which has studied environmental exposures of workers in this plant on several occasions in the past 30 years. During this time there has been a tremendous improvement in dust conditions in all operations and dustiness has been held close to or below the present threshold limit.

The textile department used chrysotile, primarily, for many years. It was not uncommon for the milled fiber received by the textile plants to contain 30% or more of fines. The fiber of today is very much cleaner than that received prior to 1950. The use of light oil in the blending department began around 1955. This was helpful in improving conditions and minimizing dust. Prior to 1950 amosite was processed in small quantities for making thermal blankets. Although the processing of amosite never exceeded one card and the operations were at times intermittent, this operation was much dustier than from cards processing chrysotile. Crocidolite has never been handled in the textile department.

In the friction products operations extensive changes in the formulations have taken place over the past 30 years. Prior to 1945, coal tars and pitches were commonly used as impregnums in making brake linings, clutch facings, and packing materials. Since 1945, these have been essentially replaced by resins and other materials so that at present only a very small amount of tar and pitch is used in packing materials. A small amount of crocidolite is still used in making some packings.

The Study

Since asbestosis is a disease which, once established, progresses even after exposure to dust ceases, it was decided not to ask plant management for cases known to them. Instead, the record rooms of six hospitals which draw their patients from the area of the asbestos plant were checked for cases of asbestosis. Admissions only for the period between 1956 and 1964 were included. Seventy-five hospital records coded as asbestosis were located. Asbestosis was diagnosed in these people on admission, by x-ray, or at autopsy, or asbestosis was mentioned in the differential diagnosis.

After obtaining the 75 records, medical, occupational, and smoking histories were obtained for all these former patients. Many were deceased and their survivors had to be contacted. Other data were obtained from plant management. Seven either had not worked at the asbestos plant under study or the diagnosis had been changed. This left 68 asbestos workers who had worked at one time in the above-mentioned textile and friction materials plant. Further study of the records showed that 21 of these not only had evidence of asbestosis but also had suffered from malignancy. By the time of the

TABLE 1.—*Number of Cases and Duration of Occupational Asbestos Exposure by Departments*

Exposure Duration	Department			
	Textile	Friction	Textile and Friction	Unknown
Less than 10 years	1	0	1	1
10-20 years	3	3		
20-30 years	3	1	1	
30+ years	6		1	

Submitted for publication June 6, 1966; accepted July 1.

From Division of Occupational Health, Department of Health, Harrisburg, Pa.

Reprint requests to Division of Occupational Health, Department of Health, P.O. Box 90, Harrisburg, Pa 17120.

TABLE 2.—*Summary of Cases Studied*

Case	Birth	Death	Type of Tumor	Length of Employment in Asbestos	Type of Employment	Smoking	Remarks
1	1911	1962	Bronchogenic carcinoma, histologic type unspecified	1935-1957	Yarn twisting 1934-1962	12-15 cigarettes	
2	1906	1959	Squamous cell bronchogenic carcinoma	1929-1959	Weaver 1929-1959	1 pack/day	
3	1898	1958	Squamous cell bronchogenic carcinoma	1918-1928	Breakline weaver 1918-1928	No cigarettes	30 yr foundry work
4	1907	1961	Oat cell bronchogenic carcinoma	1927-1957	Weaving and later loom fixer	No cigarettes	
5	1895	1961	Squamous cell bronchogenic carcinoma	1947-1961	Laborer sweeper, picker house	1 pack+/day	Also cirrhosis of liver
6	1901	1956	Bronchogenic adenocarcinoma	Only 6 mo 1919	Weaver—later lath foundry worker	Cigars only	*Probably not due to asbestos*
7	1901	1957	Anaplastic bronchogenic carcinoma	3 mo only in 1923	Area unknown, later hotel operator 1923-1957 Linotype operator 1921-1923	No cigarettes	*Probably not asbestos*
8	1895	1956	Bronchogenic carcinoma, histologic type unspecified	1925-1937	Carding room, gardening for 19 yr thereafter	1 pack/day	
9	1897	1958	Squamous cell bronchogenic carcinoma	1922-1954	Weaver 1922-1954	Less than 10 cigarettes/day	
10	1906	1961	Alveolar cell carcinoma of the lung	1950-1960	Friction materials, laborer on lathe	Unknown	
11	1895	1960	Carcinoma of the lung, origin and type unknown	1926-1960	Inside driver in weaving room	No cigarettes	Diagnosis from hospital record no autopsy
12	1903	1956	Lung tumor, x-ray diagnosis	1919-1955	Loom fixer, machine shop foreman, toolmaker	2-3 cigarettes/day	
13	1907	1961	Anaplastic bronchogenic carcinoma	1928-1961	General foreman—spinning before last job	No	
14	1901	1961	Intra-abdominal adenocarcinoma, origin unknown	1934-1942	Most of the time in friction products, spinning 1922-1937, later upholsterer	1 pack/day	
15	1894	1956	Carcinoma of the colon	1922-1956	Weaver	5-10 cigarettes/day	
16	1884	1959	Lymphatic leukemia, chronicity unknown	6 mo only 1941	Sweeper and laborer June 12, 1941 Mechanics helper for 45 years for trucking company	No	Probably not due to asbestos
17	1901	1962	Malignant lymphoma	1926-1942	Carding room supervisor	No cigarettes, little pipe	
18	1888	1964	Chronic lymphatic leukemia	1938-1947	Laborer—handtrucker—supplied weavers with spools; farmer till 1937, sexton at church till death	Very few cigars only	3 coronaries
19	1877	1960	Acute leukemia, type unknown Carcinoma of throat, origin and type unknown	1922-1949	Shipping room only	5-10 cigarettes/day	? asbestosis
20	1895	1958	Multiple myeloma Carcinoma of prostate, metastatic	1935-1957	Weaver—loom fixer, textile foreman 1935-1947, packing mill 1947-1957	Pipe only	
21	1894	1957	Carcinoma of bladder	1917-1937	Supervisor friction mill 20 years 1917-1937, ice cream maker 20 years 1937-1957	1 pack+/day	

study all 21 had died. Ten of these cases have also been reported by O'Donnell in a paper which appeared in *Cancer* in August 1966.[4] Thirteen of these had lung cancer

and eight had various other growths which included two abdominal cancers, one bladder cancer, two lymphatic leukemias, one acute leukemia, one lymphoblastoma, and one multiple myeloma. No cases of mesothelioma were in this group. There were four cases as former plant employees but these employees had been admitted to hospitals either prior to 1956 or after 1964 and because of that are not included in this study.

The diagnosis of the condition of these 21 patients had been established in 13 by autopsy, in four by operation, in two by biopsy, and in two by x-ray only.

The death certificates of all 21 were obtained. The malignancy diagnosis was reported on 15 death certificates. Six were signed out as follows: two as cardiac failure, one as coronary disease, and three as asbestosis. If death certificates alone had been utilized in this study, these six cases of malignancy would have been missed.

The smoking history of the 13 lung cancer patients revealed that five had never smoked, seven smoked, and in one case no smoking history was obtainable. Of the eight patients with other malignancies, three were cigarette smokers, two never smoked, and three were cigar smokers only.

Of the 21 patients with cancer, 13 had worked in the textile department of the plant only, for a sum total of 301 years. Four worked in the friction materials department for a total of 48 years. The department where one man had worked remains unknown and three others worked at various jobs which included both textiles and friction materials (Table 1).

Two of the 13 lung cancer and one of the lymphoblastoma patients had worked in the asbestos plant for a period of less than six months each, which is a rather short exposure. One wonders if this short exposure could have contributed towards their disease. Eighteen of these 21 patients had started work in the plant prior to 1940 and 12 had started work prior to 1920. Of the 21 patients with cancer 9 were between 50 and 60 and 12 were over 60 years of age (Table 2).

Comments and Conclusions

The incidence of malignancy in this selected group of hospital admissions with asbestosis was very high—21 out of 68. This is eight times higher than in the general population 45 years of age and over, for the eight years of the study period.[5]

The incidence of 19% (or 16% if we do not consider exposures of less than one year) of lung cancer in this group of workers with asbestosis is comparable to that reported by Isselbacher [1] who summarized data of various authors and reported that of 603 persons with asbestosis, lung cancer was found in 83 (13.8%). It is also close to that reported in the literature review by Behrens [6] who collected 44 cases of lung cancer (14%) in 309 patients with asbestosis.

Only three patients with these malignancies had their first exposure after 1940, when dust conditions had been much improved. A repeat study in the future may clarify whether this reduction of cancer occurrence in more recent employees is due to a latent period, to the age factor, or to the dust control measures instituted by the plant.

The patients with lung cancer were generally younger than those with cancers of other organs. Eight of those in the lung cancer group were under 60 and all eight of those in the other group were over 60 (Table 2).

Summary

A study of 68 hospital admissions with asbestosis from an asbestos textile and friction materials plant included 21 malignancies —13 of these were carcinoma of the lung and eight carcinomas of other organs. Eighteen of the patients had exposures to asbestos in their occupational environment for a period of 10 to 36 years. Only three patients had their first exposure after 1940.

Extensive dust control measures have been instituted by the plant.

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