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TOXICITY

MAXIMUM ACCEPTABLE CONCENTRATIONS
OF AIR CONTAMINANTS

SAFETY AND WELFARE
ENGINEERING STANDARD

ISSUED
APRIL 1961
REVISED
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1. GENERAL

1.1 This standard provides a list of maximum acceptable concentrations (MAC's) of air contaminants to provide criteria for safe Company work environments. (MAC refers to the maximum acceptable concentration of air contaminants in the atmosphere of working places from the viewpoint of occupational disease prevention.)

2. INTERPRETATION OF MAC'S

2.1 The listed MAC's are recommended threshold limit values of the American Conference of Governmental Industrial Hygienists and are reprinted with their permission. These values are reviewed and are published annually by ACGIH, with modifications and additions, if any, to the previous list.

2.2 The MAC's should be used as guides in the control of potential health hazards and should not be regarded as fine lines between safe and dangerous concentrations. It is important that the tabulated MAC's be used with discretion, and also as bench marks towards the establishment of safe working environments. Many situations may require detailed review by specialized engineers, toxicologists, or both, to avoid over or under design of control measures.

2.3 The ACGIH values represent conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect. The values listed refer to time-weighted average concentrations for a normal eight-hour workday. According to ACGIH, the amount by which the listed MAC's 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. Therefore, it is recommended in this standard that the amount by which the tabulated MAC's may safely be exceeded for short durations be given additional evaluation for individual cases. For additional information on the toxicity of chemicals, reference can be made to the Haskell Laboratory for Toxicology and Industrial Medicine.

2.4 Threshold limits are based on the best available information from industrial experience, from

experimental studies, and, when possible, from a combination of the two. These values are based on various criteria of toxic effects or on pronounced discomfort; thus, they should not be used to rank the toxicity or the potential health hazard of chemicals, nor should they be considered as the sole criterion in proving or disproving diagnosis of suspected occupational disease. Nor are the tabulated values intended for use, or for modification for use, in the evaluation or control of community air pollution, since other factors become important in these problems, such as prolonged exposure and the age and health of an individual. In addition, with the control of concentrations in a community to the MAC values only, air-pollution nuisances may result. (For many chemicals the odor thresholds are considerably below the MAC's.)

3. LIMITATIONS

3.1 The listed MAC's apply to normal, healthy workers only.

3.2 Where state codes or local plant rules specify MAC's different from those in Tables 1 through 3 the lower of the two values should be used for the design of control facilities.

3.3 Special consideration should be given to the application of the recommended MAC values in the evaluation of health hazards where there is exposure to combinations of two or more substances, because effects may be disproportionate to concentration of individual chemicals.

4. DESCRIPTION OF TABLES

4.1 The recommended MAC values are arranged in three sections as follows:

Table 1 - Gases and Vapors
Table 2 - Toxic Dusts, Fumes, and Mists
Table 3 - Mineral Dusts

4.2 The definitions of abbreviations in the tables and following sample calculations are given below:

PPM = Parts of vapor or gas per million parts of air by volume
Approx Mg per Cu M = Approximate milligrams per cu meter of air
Mg per Cu M = Milligrams per cu meter of air
MPPCF = Millions of particles per cu ft of air, based on impinger samples counted by light-field techniques
Mol Wt = Molecular weight
T = Temperature of air-gas mixture.
 $^{\circ}R = ^{\circ}F + 460$

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4.3 Sample Calculation 4.3.1 What concentration of sulfur dioxide (SO₂) in ppm by volume results from mixing 0.01 lb per min SO₂ with 1000 cfm of air at 70 degrees F and 29.92-in. mercury pressure? PPM by volume (SO₂) = $\frac{\text{cfm SO}_2}{\text{cfm Air}} \times 10^6$ 1 lb mol of gas = 359 cu ft at 32°F and 29.92-in. mercury pressure Mol Wt of SO₂ = 64.1 Lb mol SO₂ per min = $\frac{0.01}{64.1}$		
CFM SO₂ = $\frac{0.01}{64.1} \times 359 \times \frac{460 + 70}{460 + 32}$ = 0.0605 PPM by volume (SO₂) = $\frac{0.0605}{1000} \times 10^6 = 60.5$ 4.3.2 A general formula for conversion of PPM to Mg per Cu M follows: Mg per Cu M = $\frac{21.9 \times \text{Mol Wt} \times \text{PPM}}{T}$ At normal room temperature of 70°F (530°R) Mg per Cu M = 0.0413 x Mol Wt x PPM		

TABLE 1 - GASES AND VAPORS

Substance	PPM	Approx Mg per Cu M	Substance	PPM	Approx Mg per Cu M
Acetaldehyde	200	360	Carbon dioxide	5000	9000
Acetic acid	10	25	Carbon disulfide*	20	60
Acetic anhydride	5	20	Carbon monoxide	100	110
Acetone	1000	2400	Carbon tetrachloride*	10	65
Acetonitrile	40	70	Cellulose		
Acrylonitrile	1	14	(2-ethoxyethanol)	200	740
Acrolein	0.5	1.2	Cellulose acetate		
Acrylonitrile*	20	45	(2-ethoxyethyl acetate)	100	540
Allyl alcohol*	2	5	Chlorine	1	3
Allyl chloride	5	15	Chlorine dioxide	0.1	0.3
Allyl glycidyl ether	10	45	Chlorine trifluoride	0.1	0.4
Allyl propyl disulfide	2	12	Chloroacetaldehyde	1	3
Ammonia	100	70	Chlorobenzene		
Amyl acetate	200	1050	(monochlorobenzene)	75	350
Amyl alcohol			Chloroform		
(isomyl alcohol)	100	360	(trichloromethane)	50	240
Aniline*	5	19	1-Chloro-1-nitropropane	20	100
Arsine	0.05	0.2	Chloroplatin	0.1	0.7
			Chloroprene (2-chloro-1,3-butadiene)	25	90
Benzene (benzol)	25	80	Cresol (all isomers)*	5	22
Benzyl chloride	1	5	Cyclohexane	400	1400
Boron trifluoride	1	3	Cyclohexanol	50	200
Bromine	0.1	0.7	Cyclohexanone	50	200
Butadiene (1, 3-butadiene)	1000	2200	Cyclohexene	400	1350
2-Butanone			Decabenzene*	0.05	0.3
(methyl ethyl ketone)	200	590	Diacetone alcohol		
Butyl acetate			(4-hydroxy-1-methyl-2-pentanone)	50	240
(n-butyl acetate)	200	950	Dibenzene	0.1	0.1
Butyl alcohol			1, 2-Dibromomethane		
(n-butanol)	100	300	(ethylene dibromide)*	25	190
tert Butyl alcohol	100	300	a-Dichlorobenzene	50	300
Butylamine	5	15	p-Dichlorobenzene	75	450
Butyl cellosolve			Dichlorodifluoromethane	1000	4950
(2-butoxyethanol)	50	240	1, 1-Dichloroethane	100	400
n-Butyl glycidyl ether	50	270			
Butyl mercaptan	10	35			
p-tert Butyltoluene	10	60			

* Indicates that the liquid compound can penetrate the skin to cause systemic effects



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TABLE 1 - GASES AND VAPORS (CONT'D)

Substance	PPM	Approx Mg per Cu M	Substance	PPM	Approx Mg per Cu M
1, 2-Dichloroethane (ethylene dichloride)	50	200	Hydrazine*	1	1.3
1, 2-Dichloroethylene	200	790	Hydrogen bromide	3	10
Dichloroethyl ether	15	90	Hydrogen chloride	5	7
Dichloromono-fluoromethane	1000	4200	Hydrogen cyanide*	10	11
1, 1-Dichloro- 1-nitroethane	10	60	Hydrogen fluoride	3	2
Dichlorodifluoroethane	1000	7000	Hydrogen peroxide, 90%	1	1.4
Diethylamine	25	75	Hydrogen selenide	0.05	0.2
Difluorodibromomethane	100	860	Hydrogen sulfide	20	30
Diglycidyl ether	10	55	Iodine	0.1	1
Diisobutyl ketone	50	290	Isophorene	25	140
Dimethylaniline			Isopropylamine	5	12
(n-dimethylaniline)*	5	25	Mesityl oxide	25	100
Dimethylformamide	20	60	Methyl acetate	200	610
1, 1-Dimethylhydrazine*	0.5	1	Methyl acrylate	1000	1650
Dimethylsulfate*	1	5	Methyl acrylate*	10	35
Dipropylene glycol methyl ether	100	600	Methylal (dimethoxymethane)	1000	3100
Dioxane (diethylene dioxide)	100	360	Methyl alcohol (methanol)	200	260
Ethyl acetate	400	1400	Methyl bromide*	20	80
Ethyl acrylate*	25	100	Methyl cellosolve (2-methoxyethanol)	25	80
Ethyl alcohol (ethanol)	1000	1900	Methyl cellosolve acetate (ethylene glycol mono- methyl ether acetate)	25	120
Ethylamine	25	45	Methyl chloride	100	210
Ethylbenzene	200	870	Methyl chloroform (1, 1, 1-trichloroethane)	500	2700
Ethyl bromide	200	890	Methylcyclohexane	500	2000
Ethyl chloride	1000	2600	Methylcyclohexanol	100	470
Ethyl ether	400	1200	Methylcyclohexanone	100	460
Ethyl formate	100	300	Methyl ethyl ketone (see 2-Butanone)	100	250
Ethyl mercaptan	250	640	Methyl formate	25	100
Ethyl silicate	100	850	Methyl isobutyl carbinal (methyl amyl alcohol)	50	100
Ethylene chlorohydrin*	5	16	Methyl mercaptan	100	480
Ethylenediamine	10	30	o-Methyl styrene	500	1750
Ethylene dibromide (1, 2-dibromoethane)	25	190	Methylene chloride (dichloromethane)	2	9
Ethylene glycol dinitrate*	0.2	1.2	Monomethyl aniline*	200	800
Ethylene imine*	5	9	Naphtha (coal tar)	500	2000
Ethylene oxide	50	90	Nickel carbonyl	0.001	0.007
Fluorine	0.1	0.2	Nitric acid	10	25
Fluorotrichloromethane	1000	5600	p-Nitroaniline*	1	6
Formaldehyde	5	6	Nitrobenzene*	1	5
Furfural	5	20	Nitroethane	100	310
Furfuryl alcohol	50	200	Nitrogen dioxide	5	9
Gesoline	500	2000	Nitroglycerin*	0.2	2
Glycidal (2, 3-epoxy- 1-propanol)	50	150	Nitromethane	100	250
Heptane (n-heptane)	500	2000	2-Nitropropane	25	90
Hexane (n-hexane)	500	1800	Nitrotoluene*	5	30
Hexanone (methyl butyl ketone)	100	410			
Hexane (methyl isobutyl ketone)	100	410			

* Indicates that the liquid compound can penetrate
the skin to cause systemic effects

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TABLE 1 - GASES AND VAPORS (CONT'D)

Substance	PPM	Approx Mg per Cu M	Substance	PPM	Approx Mg per Cu M
Octane	500	2350	Stibine	0.1	0.5
Ozone	0.1	0.2	Stoddard solvent	500	2900
Pentane	1000	2950	Styrene monomer (phenylethylene)	100	420
Pentanene (methyl propyl ketene)	200	700	Sulfur dioxide	5	13
Perchloroethylene (tetrachloroethylene)	100	670	Sulfur hexafluoride	1000	6000
Perchloroethyl mercaptan	0.1	0.8	Sulfur monochloride	1	6
Phenol*	5	19	Sulfur pentafluoride	0.025	0.25
Phenyl glycidyl ether	50	310	1, 1, 2, 2-Tetrachloroethane*	5	35
Phenyldiazine*	5	22	Tetrahydrofuran	200	590
Phosgene (carbonyl chloride)	1	4	Tetrahydrofuran	1	8
Phosphine	0.05	0.07	Toluene (toluol)	200	750
Phosphorus trichloride	0.5	3	o-Toluidine*	5	22
Propyl acetate	200	840	Toluene-		
Propyl alcohol (isopropyl alcohol)	400	980	2, 4-diisocyanate	0.02**	0.14**
Propyl ether (isopropyl ether)	500	2100	Trichloroethylene	100	520
n-Propyl nitrate	25	110	1, 1, 2-Trichloro 1, 2, 2-trifluoroethane*	1000	7600
Propylene dichloride (1, 2-dichloropropane)	75	350	Triethylamine	25	100
Propylene mine*	25	60	Trifluoromethane-		
Propylene oxide	100	240	methane	1000	6100
Pyridine	5	15	Turpentine	100	560
Quinone	0.1	0.4	Vinyl chloride (chloroethylene)	500	1300
			Vinyl toluene	100	480
			Xylene (xylol)	200	870
			Xylidine*	5	25

TABLE 2 - TOXIC DUSTS, FUMES AND MISTS

Substance	Mg per Cu M	Substance	Mg per Cu M
Aldrin (1, 2, 3, 4, 10, 10-hexachloro- 1, 4, 4a, 5, 8, 8a-hexahydro-1, 4, 5 8-dimethanonaphthalene)*	0.25	Chromic acid and chromates (as CrO ₃)	0.1
Amate (armonium sulfamate)	15	Crag herbicide (sodium 2- [2, 4-dichloro- phenoxy] ethanal hydrogen sulfate)	15
Antimony	0.5	Cyanide (as Cn)*	5
ANTU (alpha-naphthyl thiaurea)	0.3	2, 4-D (2, 4-dichlorophenoxyacetic acid)	10
Arsenic	0.5	DOT (2, 2-bis [p-chlorophenyl] -1, 1, 1-trichloroethane)	1
Berium (soluble compounds)	0.5	Dieldrin (1, 2, 3, 4, 10, 10-hexachloro- 6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a- octahydro-1, 4, 5, 8-dimethano- naphthalene)*	0.25
Beryllium	0.002	Dinitrobenzene*	1
Boron oxide	15	Dinitrotoluene*	1.5
Cadmium oxide fume	0.1	Cinitro-o-cresol*	0.2
Calcium arsenate	1	EPN (O-ethyl O-p-nitrophenyl thiobenzenephosphonate)*	0.5
Chlordane (1, 2, 4, 5, 6, 7, 8, 8-octachloro- 3a, 4, 7, 7a-tetrahydro-4, 7-methanoindane)	0.5		
Chlorinated camphene, 60%	0.5		
Chlorinated diphenyl oxide	0.5		
Chlorodiphenyl (42% chlorine)*	1		
Chlorodiphenyl (54% chlorine)*	0.5		

* Indicates that the liquid compound can penetrate the skin to cause systemic effects

** Probably sufficiently low to protect against primary sensitization, but may not protect persons specifically sensitized



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TABLE 2 - TOXIC DUSTS, FUMES AND MISTS (CONT'D)

Substance	Mg per Cu M	Substance	Mg per Cu M
Ferbam (ferric dimethyl dithiocarbamate)	15	Rotenone	5
Ferrovandium dust	1	Selenium compounds (as Se)	0.1
Fluoride	2.5	Sodium fluoroacetate (1080)*	0.05
Hydroquinone	2	Sodium hydroxide	2
Iron oxide fume	15	Strychnine	0.15
Lead	0.2	Sulfuric acid	1
Lead arsenate	0.15	TEDP (tetraethyl dithionopyrophosphate)*	0.2
Lindane (hexachlorocyclohexane, gamma isomer)	0.5	TEPP (tetraethyl pyrophosphate)*	0.05
Lithium hydride	0.025	Tellurium	0.1
Magnesium oxide fume	15	Tetryl (2, 4, 6-trinitrophenylmethyl- nitramine)*	1.5
Malathion (O, O-dimethyl dithiophosphate of diethyl mercaptosuccinate)*	15	Thallium (soluble compounds)	0.1
Manganese	5	Thiram (tetramethyl thiuram disulfide)	5
Mercury	0.1	Titanium dioxide	15
Mercury (organic compounds)*	0.01	Trichloronaphthalene*	5
Methoxychlor (2, 2-di-p-methoxyphenyl- 1, 1, 1-trichloroethane)	15	Trinitrotoluene*	1.5
Molybdenum (soluble compounds)	5	Triethocresyl phosphate	0.1
(insoluble compounds)	15	Triphenyl phosphate	3
Nicotine*	0.5	Uranium (soluble compounds)	0.05
Parathion (O, O-diethyl- O-p-nitro- phenyl thiophosphate)*	0.1	(insoluble compounds)	0.25
Pentachloronaphthalene*	0.5	Vanadium (V ₂ O ₅ dust)	0.5
Pentachlorophenol*	0.5	(V ₂ O ₅ fume)	0.1
Phosphoric acid	1	Warfarin (3- [α-ecatenylbenzyl] -4- hydroxycoumarin)	0.1
Phosphorus (yellow)	0.1	Yttrium	5
Phosphorus pentachloride	1	Zinc oxide fume	5
Phosphorus pentasulfide	1	Zirconium compounds (as Zr)	5
Pteric acid	0.1		
Pyrethrum	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.

TABLE 3 - MINERAL DUSTS

Substance	MPPCF**
Silica	
Crystalline	
Quartz and cristobalite, threshold limit calculated from the formula	$\frac{250}{\text{SiO}_2 \div 5}$
Amorphous, including natural diatomaceous earth	20
Silicates (less than 1% crystalline silica)	
Asbestos	5
Mica	20
Soapstone	20
Talc	20
Portland cement	50
Miscellaneous (less than 1% crystalline silica)	50

Notes: The percentage of crystalline silica in the above formula and tables is based on the amount found from an analysis of the airborne dust.

* Indicates that the liquid compound can penetrate the skin to cause systemic effects.



** Millions of particles per cu ft of air

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