PART 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS

Subpart Z—Toxic and Hazardous Substances

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AUTHORITY: Sections 4, 6, and 8 of the Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, and 657); Secretary of Labor's Order No. 12–71 (36 FR 8754), 8–76 (41 FR 25059), 9–83 (48 FR 35736), 1–90 (55 FR 9033), 6– 96 (62 FR 111), and 3–2000 (65 FR 50017), as applicable, and 29 CFR part 1911.

All of subpart Z issued under section 6(b) of the Occupational Safety and Health Act of 1970 (29 U.S.C 653), except those substances that have exposure limits in Tables Z–1, Z–2, and Z–3 of 29 CFR 1910.1000. Section 1910.1000 also issued under section (6)(a) of the Act (29 U.S.C. 655(a)). Section 1910.1000, Tables Z–1, Z–2, and Z–3 also issued under 5 U.S.C. 553, but not under 29 CFR part 1911, except for the inorganic arsenic, benzene, and cotton dust listings.

Section 1910.1001 also issued under section 107 of the Contract Work Hours and Safety Standards Act (40 U.S.C. 333) and 5 U.S.C. 553.

Section 1910.1002 also issued under 5 U.S.C. 553, but not under 29 U.S.C. 655 or 29 CFR part 1911.

Sections 1910.1018, 1910.1029, and 1910.1200 also issued under 29 U.S.C. 653.

SOURCE: 39 FR 23502, June 27, 1974, unless otherwise noted. Redesignated at 40 FR 23072, May 28, 1975.

§ 1910.1000 Air contaminants.

An employee's exposure to any substance listed in Tables Z–1, Z–2, or Z–3 of this section shall be limited in accordance with the requirements of the following paragraphs of this section.

(a) *Table Z–1*—(1) *Substances with limits preceded by ''C''—Ceiling Values.* An employee's exposure to any substance in Table Z–1, the exposure limit of which is preceded by a ''C'', shall at no time exceed the exposure limit given for that substance. If instantaneous monitoring is not feasible, then the ceiling shall be assessed as a 15-minute time weighted average exposure which shall not be exceeded at any time during the working day.

(2) *Other substances—8-hour Time Weighted Averages.* An employee's exposure to any substance in Table Z–1, the exposure limit of which is not preceded by a ''C'', shall not exceed the 8-hour Time Weighted Average given for that substance in any 8-hour work shift of a 40-hour work week.

(b) *Table Z–2.* An employee's exposure to any substance listed in Table Z–2 shall not exceed the exposure limits specified as follows:

(1) *8-hour time weighted averages.* An employee's exposure to any substance listed in Table Z–2, in any 8-hour work shift of a 40-hour work week, shall not exceed the 8-hour time weighted average limit given for that substance in Table Z–2.

(2) *Acceptable ceiling concentrations.* An employee's exposure to a substance listed in Table Z–2 shall not exceed at any time during an 8-hour shift the acceptable ceiling concentration limit given for the substance in the table, except for a time period, and up to a concentration not exceeding the maximum duration and concentration allowed in the column under ''acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift.''

(3) *Example.* During an 8-hour work shift, an employee may be exposed to a concentration of Substance A (with a 10 ppm TWA, 25 ppm ceiling and 50 ppm peak) above 25 ppm (but never above 50 ppm) only for a maximum period of 10 minutes. Such exposure must be compensated by exposures to concentrations less than 10 ppm so that the cumulative exposure for the entire 8-hour work shift does not exceed a weighted average of 10 ppm.

(c) *Table Z–3.* An employee's exposure to any substance listed in Table Z–3, in any 8-hour work shift of a 40-hour work week, shall not exceed the 8-hour time weighted average limit given for that substance in the table.

(d) *Computation formulae.* The computation formula which shall apply to employee exposure to more than one substance for which 8-hour time weighted averages are listed in subpart Z of 29 CFR part 1910 in order to determine whether an employee is exposed over the regulatory limit is as follows:

(1)(i) The cumulative exposure for an 8-hour work shift shall be computed as follows:

E = (Ca Ta+Cb Tb+. . .Cn Tn)÷8

Where:
E is the equivalent exposure for the working shift.
C is the concentration during any period of time T where the concentration remains constant.
T is the duration in hours of the exposure at the concentration C.

The value of E shall not exceed the 8-hour time weighted average specified in subpart Z of 29 CFR part 1910 for the substance involved.

(ii) To illustrate the formula prescribed in paragraph (d)(1)(i) of this section, assume that Substance A has an 8-hour time weighted average limit of 100 ppm noted in Table Z–1. Assume that an employee is subject to the following exposure:

Two hours exposure at 150 ppm
Two hours exposure at 75 ppm
Four hours exposure at 50 ppm

Substituting this information in the formula, we have
(2×150+2×75+4×50)÷8=81.25 ppm

Since 81.25 ppm is less than 100 ppm, the 8- hour time weighted average limit, the exposure is acceptable.

(2)(i) In case of a mixture of air contaminants an employer shall compute the equivalent exposure as follows:

E_m=(C1÷L1+C2÷L2)+. . .(Cn÷Ln)

Where:
E_m is the equivalent exposure for the mixture.
C is the concentration of a particular contaminant.
L is the exposure limit for that substance specified in subpart Z of 29 CFR part 1910.

The value of E_m shall not exceed unity (1).

(ii) To illustrate the formula prescribed in paragraph (d)(2)(i) of this section, consider the following exposures:

Substance	Actual concentration of 8-hour exposure (ppm)	8-hour TWA PEL (ppm)
B	500	1,000
C	45	200
D	40	200

Substituting in the formula, we have:
E_m =500÷1,000+45÷200+40÷200
E_m =0.500+0.225+0.200
E_m =0.925

Since E_m is less than unity (1), the exposure combination is within acceptable limits.

(e) To achieve compliance with paragraphs (a) through (d) of this section, administrative or engineering controls must first be determined and implemented whenever feasible. When such controls are not feasible to achieve full compliance, protective equipment or any other protective measures shall be used to keep the exposure of employees to air contaminants within the limits prescribed in this section. Any equipment and/or technical measures used for this purpose must be approved for each particular use by a competent industrial hygienist or other technically qualified person. Whenever respirators are used, their use shall comply with 1910.134.

(f) *Effective dates.* The exposure limits specified have been in effect with the method of compliance specified in paragraph (e) of this section since May 29, 1971.

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS

Substance	CAS No. (c)	ppm (a)[1]	mg/m^3 (b)[1]	Skin Designation
Acetaldehyde	75-07-0	200	360	
Acetic acid	64-19-7	10	25	
Acetic anhydride	108–24–7	5	20	
Acetone	67–64–1	1000	2400	
Acetonitrile	75–05–8	40	70	
2-Acetylaminofluorine; see 1910.1014	53–96–3			
Acetylene dichloride; see 1,2-Dichloroethylene.				
Acetylene tetrabromide	79–27–6	1	14	
Acrolein	107–02–8	0.1	0.25	
Acrylamide	79–06–1	.....	0.3	X
Acrylonitrile; see 1910.1045	107–13–1			
Aldrin	309–00–2	.....	0.25	X
Allyl alcohol	107–18–6	2	5	X
Allyl chloride	107–05–1	1	3	
Allyl glycidyl ether (AGE)	106–92–3	(C)10	(C)45	
Allyl propyl disulfide	2179–59–1	2	12	
alpha-Alumina	1344–28–1			
Total dust		.....	15	
Respirable fraction		.....	5	
Aluminum, metal (as Al)	7429–90–5			
Total dust		.....	15	
Respirable fraction		.....	5	
4-Aminodiphenyl; see 1910.1011	92–67–1			
2-Aminoethanol; see Ethanolamine.				
2-Aminopyridine	504–29–0	0.5	2	
Ammonia	7664–41–7	50	35	
Ammonium sulfamate	7773–06–0			
Total dust		.....	15	
Respirable fraction		.....	5	
n-Amyl acetate	628–63–7	100	525	

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS—Continued

Substance	CAS No. (c)	ppm (a)[1]	mg/m^3 (b)[1]	Skin Designation
sec-Amyl acetate	626–38–0	125	650	
Aniline and homologs	62–53–3	5	19	X
Anisidine (o-, p-isomers)	29191–52–4	.....	0.5	X
Antimony and compounds (as Sb)	7440–36–0	.....	0.5	
ANTU (alpha Naphthylthiourea)	86–88–4	.....	0.3	
Arsenic, inorganic compounds (as As); see 1910.1018	7440–38–2			
Arsenic, organic compounds (as As)	7440–38–2	.....	0.5	
Arsine	7784–42–1	0.05	0.2	
Asbestos; see 1910.1001	([4])			
Azinphos-methyl	86–50–0	.....	0.2	X
Barium, soluble compounds (as Ba)	7440–39–3	.....	0.5	
Barium sulfate	7727–43–7			
Total dust		.....	15	
Respirable fraction		.....	5	
Benomyl	17804–35–2			
Total dust		.....	15	
Respirable fraction		.....	5	
Benzene; see 1910.1028	71–43–2			
See Table Z–2 for the limits applicable in the operations or sectors excluded in 1910.1028 d				
Benzidine; see 1910.1010	92–87–5			
p-Benzoquinone; see Quinone.				
Benzo(a)pyrene; see Coal tar pitch volatiles..				
Benzoyl peroxide	94–36–0	.....	5	
Benzyl chloride	100–44–7	1	5	
Beryllium and beryllium compounds (as Be)	7440–41–7		([2])	
Biphenyl; see Diphenyl.				
Bismuth telluride, Undoped	1304–82–1			
Total dust		.....	15	
Respirable fraction		.....	5	
Boron oxide	1303–86–2			
Total dust		.....	15	
Boron trifluoride	7637–07–2	(C)1	(C)3	
Bromine	7726–95–6	0.1	0.7	
Bromoform	75–25–2	0.5	5	X
Butadiene (1,3-Butadiene); See 29 CFR 1910.1051; 29 CFR 1910.19(l).	106–99–0	1 ppm/5 ppm STEL	.....	
Butanethiol; see Butyl mercaptan.				
2-Butanone (Methyl ethyl ketone)	78–93–3	200	590	
2-Butoxyethanol	111–76–2	50	240	X
n-Butyl-acetate	123–86–4	150	710	
sec-Butyl acetate	105–46–4	200	950	
tert-Butyl acetate	540–88–5	200	950	
n-Butyl alcohol	71–36–3	100	300	
sec-Butyl alcohol	78–92–2	150	450	
tert-Butyl alcohol	75–65–0	100	300	
Butylamine	109–73–9	(C)5	(C)15	X
tert-Butyl chromate (as CrO3)	1189–85–1	.....	(C)0.1	X
n-Butyl glycidyl ether (BGE)	2426–08–6	50	270	
Butyl mercaptan	109–79–5	10	35	
p-tert-Butyltoluene	98–51–1	10	60	
Cadmium (as Cd); see 1910.1027	7440–43–9			
Calcium carbonate	1317–65–3			
Total dust		.....	15	
Respirable fraction		.....	5	
Calcium hydroxide	1305–62–0			
Total dust		.....	15	
Respirable fraction		.....	5	
Calcium oxide	1305–78–8	.....	5	
Calcium silicate	1344–95–2			
Total dust		.....	15	
Respirable fraction		.....	5	
Calcium sulfate	7778–18–9			
Total dust		.....	15	
Respirable fraction		.....	5	
Camphor, synthetic	76–22–2	.....	2	
Carbaryl (Sevin)	63–25–2	.....	5	
Carbon black	1333–86–4	.....	3.5	
Carbon dioxide	124–38–9	5000	9000	
Carbon disulfide	75–15–0		([2])	
Carbon monoxide	630–08–0	50	55	

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS—Continued

Substance	CAS No. (c)	ppm (a)[1]	mg/m^3 (b)[1]	Skin Designation
Carbon tetrachloride	56–23–5		([2])	
Cellulose	9004–34–6			
Total dust			15	
Respirable fraction			5	
Chlordane	57–74–9		0.5	
Chlorinated camphene	8001–35–2		0.5	
Chlorinated diphenyl oxide	55720–99–5		0.5	
Chlorine	7782–50–5	(C)1	(C)3	
Chlorine dioxide	10049–04–4	0.1	0.3	
Chlorine trifluoride	7790–91–2	(C)0.1	(C)0.4	
Chloroacetaldehyde	107–20–0	(C)1	(C)3	
a-Chloroacetophenone (Phenacyl chloride)	532–27–4	0.05	0.3	
Chlorobenzene	108–90–7	75	350	
o-Chlorobenzylidene malononitrile	2698–41–1	0.05	0.4	
Chlorobromomethane	74–97–5	200	1050	
2-Chloro-1,3-butadiene; see beta-Chloroprene.				
Chlorodiphenyl (42% Chlorine) (PCB)	53469–21–9		1	X
Chlorodiphenyl (54% Chlorine) (PCB)	11097–69–1		0.5	X
1-Chloro-2,3-epoxypropane; see Epichlorohydrin.				
2-Chloroethanol; see Ethylene chlorohydrin.				
Chloroethylene; see Vinyl chloride.				
Chloroform (Trichloromethane)	67–66–3	(C)50	(C)240	
bis(Chloromethyl) ether; see 1910.1008	542–88–1			
Chloromethyl methyl ether; see 1910.1006	107–30–2			
1-Chloro-1-nitropropane	600–25–9	20	100	
Chloropicrin	76–06–2	0.1	0.7	
beta-Chloroprene	126–99–8	25	90	X
2-Chloro-6-(trichloromethyl) pyridine	1929–82–4			
Total dust			15	
Respirable fraction			5	
Chromic acid and chromates (as CrO3)	([4])		([2])	
Chromium (II) compounds.				
(as Cr)	7440–47–3		0.5	
Chromium (III) compounds.				
(as Cr)	7440–47–3		0.5	
Chromium metal and insol. salts (as Cr)	7440–47–3		1	
Chrysene; see Coal tar pitch volatiles.				
Clopidol	2971–90–6			
Total dust			15	
Respirable fraction			5	
Coal dust (less than 5% SiO2), respirable fraction			([3])	
Coal dust (greater than or equal to 5% SiO2), respirable fraction.			([3])	
Coal tar pitch volatiles (benzene soluble fraction), anthracene, BaP, phenanthrene, acridine, chrysene, pyrene.	65966–93–2		0.2	
Cobalt metal, dust, and fume (as Co)	7440–48–4		0.1	
Coke oven emissions; see 1910.1029.				
Copper	7440–50–8			
Fume (as Cu)			0.1	
Dusts and mists (as Cu)			1	
Cotton dust e; see 1910.1043			1	
Crag herbicide (Sesone)	136–78–7			
Total dust			15	
Respirable fraction			5	
Cresol, all isomers	1319–77–3	5	22	X
Crotonaldehyde	123–73–9; 4170–30–3	2	6	
Cumene	98–82–8	50	245	X
Cyanides (as CN)	([4])		5	X
Cyclohexane	110–82–7	300	1050	
Cyclohexanol	108–93–0	50	200	
Cyclohexanone	108–94–1	50	200	
Cyclohexene	110–83–8	300	1015	
Cyclopentadiene	542–92–7	75	200	
2,4-D (Dichlorophenoxyacetic acid)	94–75–7		10	
Decaborane	17702–41–9	0.05	0.3	X
Demeton (Systox)	8065–48–3		0.1	X
Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone)	123–42–2	50	240	
1,2-Diaminoethane; see Ethylenediamine.				
Diazomethane	334–88–3	0.2	0.4	
Diborane	19287–45–7	0.1	0.1	

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS—Continued

Substance	CAS No. (c)	ppm (a)[1]	mg/m^3 (b)[1]	Skin Designation
1,2-Dibromo-3-chloropropane (DBCP); see 1910.1044	96–12–8			
1,2-Dibromoethane; see Ethylene dibromide.				
Dibutyl phosphate	107–66–4	1	5	
Dibutyl phthalate	84–74–2		5	
o-Dichlorobenzene	95–50–1	(C)50	(C)300	
p-Dichlorobenzene	106–46–7	75	450	
3,'-Dichlorobenzidine; see 1910.1007	91–94–1			
Dichlorodifluoromethane	75–71–8	1000	4950	
1,3-Dichloro-5,5-dimethyl hydantoin	118–52–5		0.2	
Dichlorodiphenyltrichloroethane (DDT)	50–29–3		1	X
1,1-Dichloroethane	75–34–3	100	400	
1,2-Dichloroethane; see Ethylene dichloride.				
1,2-Dichloroethylene	540–59–0	200	790	
Dichloroethyl ether	111–44–4	(C)15	(C)90	X
Dichloromethane; see Methylene chloride.				
Dichloromonofluoromethane	75–43–4	1000	4200	
1,1-Dichloro-1-nitroethane	594–72–9	(C)10	(C)60	
1,2-Dichloropropane; see Propylene dichloride.				
Dichlorotetrafluoroethane	76–14–2	1000	7000	
Dichlorvos (DDVP)	62–73–7		1	X
Dicyclopentadienyl iron	102–54–5			
Total dust			15	
Respirable fraction			5	
Dieldrin	60–57–1		0.25	X
Diethylamine	109–89–7	25	75	
2-Diethylaminoethanol	100–37–8	10	50	X
Diethyl ether; see Ethyl ether.				
Difluorodibromomethane	75–61–6	100	860	
Diglycidyl ether (DGE)	2238–07–5	(C)0.5	(C)2.8	
Dihydroxybenzene; see Hydroquinone.				
Diisobutyl ketone	108–83–8	50	290	
Diisopropylamine	108–18–9	5	20	X
4-Dimethylaminoazobenzene; see 1910.1015	60–11–7			
Dimethoxymethane; see Methylal.				
Dimethyl acetamide	127–19–5	10	35	X
Dimethylamine	124–40–3	10	18	
Dimethylaminobenzene; see Xylidine.				
Dimethylaniline (N,N-Dimethylaniline)	121–69–7	5	25	X
Dimethylbenzene; see Xylene.				
Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate	300–76–5		3	
Dimethylformamide	68–12–2	10	30	X
2,6-Dimethyl-4-heptanone; see Diisobutyl ketone.				
1,1-Dimethylhydrazine	57–14–7	0.5	1	X
Dimethylphthalate	131–11–3		5	
Dimethyl sulfate	77–78–1	1	5	X
Dinitrobenzene (all isomers)			1	X
(ortho)	528–29–0			
(meta)	99–65–0			
(para)	100–25–4			
Dinitro-o-cresol	534–52–1		0.2	X
Dinitrotoluene	25321–14–6		1.5	X
Dioxane (Diethylene dioxide)	123–91–1	100	360	X
Diphenyl (Biphenyl)	92–52–4	0.2	1	
Diphenylmethane diisocyanate; see Methylene bisphenyl isocyanate.				
Dipropylene glycol methyl ether	34590–94–8	100	600	X
Di-sec octyl phthalate (Di-(2-ethylhexyl) phthalate)	117–81–7		5	
Emery	12415–34–8			
Total dust			15	
Respirable fraction			5	
Endrin	72–20–8		0.1	X
Epichlorohydrin	106–89–8	5	19	X
EPN	2104–64–5		0.5	X
1,2-Epoxypropane; see Propylene oxide.				
2,3-Epoxy-1-propanol; see Glycidol.				
Ethanethiol; see Ethyl mercaptan.				
Ethanolamine	141–43–5	3	6	
2-Ethoxyethanol (Cellosolve)	110–80–5	200	740	X
2-Ethoxyethyl acetate (Cellosolve acetate)	111–15–9	100	540	X
Ethyl acetate	141–78–6	400	1400	
Ethyl acrylate	140–88–5	25	100	X

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS—Continued

Substance	CAS No. (c)	ppm (a)[1]	mg/m[3] (b)[1]	Skin Designation
Ethyl alcohol (Ethanol)	64–17–5	1000	1900	
Ethylamine	75–04–7	10	18	
Ethyl amyl ketone (5-Methyl-3-heptanone)	541–85–5	25	130	
Ethyl benzene	100–41–4	100	435	
Ethyl bromide	74–96–4	200	890	
Ethyl butyl ketone (3-Heptanone)	106–35–4	50	230	
Ethyl chloride	75–00–3	1000	2600	
Ethyl ether	60–29–7	400	1200	
Ethyl formate	109–94–4	100	300	
Ethyl mercaptan	75–08–1	(C)10	(C)25	
Ethyl silicate	78–10–4	100	850	
Ethylene chlorohydrin	107–07–3	5	16	X
Ethylenediamine	107–15–3	10	25	
Ethylene dibromide	106–93–4		([2])	
Ethylene dichloride (1,2-Dichloroethane)	107–06–2		([2])	
Ethylene glycol dinitrate	628–96–6	(C)0.2	(C)1	X
Ethylene glycol methyl acetate; see Methyl cellosolve acetate..				
Ethyleneimine; see 1910.1012	151–56–4			
Ethylene oxide; see 1910.1047	75–21–8			
Ethylidene chloride; see 1,1-Dichloroethane.				
N-Ethylmorpholine	100–74–3	20	94	X
Ferbam	14484–64–1			
Total dust		.....	15	
Ferrovanadium dust	12604–58–9	.....	1	
Fluorides (as F)	([4])	.....	2.5	
Fluorine	7782–41–4	0.1	0.2	
Fluorotrichloromethane (Trichlorofluoromethane)	75–69–4	1000	5600	
Formaldehyde; see 1910.1048	50–00–0			
Formic acid	64–18–6	5	9	
Furfural	98–01–1	5	20	X
Furfuryl alcohol	98–00–0	50	200	
Grain dust (oat, wheat, barley)	.....	.....	10	
Glycerin (mist)	56–81–5			
Total dust		.....	15	
Respirable fraction		.....	5	
Glycidol	556–52–5	50	150	
Glycol monoethyl ether; see 2-Ethoxyethanol.				
Graphite, natural, respirable dust	7782–42–5		([3])	
Graphite, synthetic				
Total dust		.....	15	
Respirable fraction		.....	5	
Guthion; see Azinphos methyl.				
Gypsum	13397–24–5			
Total dust		.....	15	
Respirable fraction		.....	5	
Hafnium	7440–58–6	.....	0.5	
Heptachlor	76–44–8	.....	0.5	X
Heptane (n-Heptane)	142–82–5	500	2000	
Hexachloroethane	67–72–1	1	10	X
Hexachloronaphthalene	1335–87–1	.....	0.2	X
n-Hexane	110–54–3	500	1800	
2-Hexanone (Methyl n-butyl ketone)	591–78–6	100	410	
Hexone (Methyl isobutyl ketone)	108–10–1	100	410	
sec-Hexyl acetate	108–84–9	50	300	
Hydrazine	302–01–2	1	1.3	X
Hydrogen bromide	10035–10–6	3	10	
Hydrogen chloride	7647–01–0	(C)5	(C)7	
Hydrogen cyanide	74–90–8	10	11	X
Hydrogen fluoride (as F)	7664–39–3		([2])	
Hydrogen peroxide	7722–84–1	1	1.4	
Hydrogen selenide (as Se)	7783–07–5	0.05	0.2	
Hydrogen sulfide	7783–06–4		([2])	
Hydroquinone	123–31–9	.....	2	
Iodine	7553–56–2	(C)0.1	(C)1	
Iron oxide fume	1309–37–1	.....	10	
Isoamyl acetate	123–92–2	100	525	
Isoamyl alcohol (primary and secondary)	123–51–3	100	360	
Isobutyl acetate	110–19–0	150	700	
Isobutyl alcohol	78–83–1	100	300	
Isophorone	78–59–1	25	140	
Isopropyl acetate	108–21–4	250	950	

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS—Continued

Substance	CAS No. (c)	ppm (a)[1]	mg/m^3 (b)[1]	Skin Designation
Isopropyl alcohol	67–63–0	400	980	
Isopropylamine	75–31–0	5	12	
Isopropyl ether	108–20–3	500	2100	
Isopropyl glycidyl ether (IGE)	4016–14–2	50	240	
Kaolin	1332–58–7			
Total dust		.....	15	
Respirable fraction		.....	5	
Ketene	463–51–4	0.5	0.9	
Lead, inorganic (as Pb); see 1910.1025	7439–92–1			
Limestone	1317–65–3			
Total dust		.....	15	
Respirable fraction		.....	5	
Lindane	58–89–9	.....	0.5	X
Lithium hydride	7580–67–8	.....	0.025	
L.P.G. (Liquefied petroleum gas)	68476–85–7	1000	1800	
Magnesite	546–93–0			
Total dust		.....	15	
Respirable fraction		.....	5	
Magnesium oxide fume	1309–48–4			
Total particulate		.....	15	
Malathion	121–75–5			
Total dust		.....	15	X
Maleic anhydride	108–31–6	0.25	1	
Manganese compounds (as Mn)	7439–96–5	.....	(C)5	
Manganese fume (as Mn)	7439–96–5	.....	(C)5	
Marble	1317–65–3			
Total dust		.....	15	
Respirable fraction		.....	5	
Mercury (aryl and inorganic) (as Hg)	7439–97–6		([2])	
Mercury (organo) alkyl compounds (as Hg)	7439–97–6		([2])	
Mercury (vapor) (as Hg)	7439–97–6		([2])	
Mesityl oxide	141–79–7	25	100	
Methanethiol; see Methyl mercaptan.				
Methoxychlor	72–43–5			
Total dust		.....	15	
2-Methoxyethanol (Methyl cellosolve)	109–86–4	25	80	X
2-Methoxyethyl acetate (Methyl cellosolve acetate)	110–49–6	25	120	X
Methyl acetate	79–20–9	200	610	
Methyl acetylene (Propyne)	74–99–7	1000	1650	
Methyl acetylene-propadiene mixture (MAPP)		1000	1800	
Methyl acrylate	96–33–3	10	35	X
Methylal (Dimethoxy-methane)	109–87–5	1000	3100	
Methyl alcohol	67–56–1	200	260	
Methylamine	74–89–5	10	12	
Methyl amyl alcohol; see Methyl isobutyl carbinol.				
Methyl n-amyl ketone	110–43–0	100	465	
Methyl bromide	74–83–9	(C)20	(C)80	X
Methyl butyl ketone; see 2-Hexanone.				
Methyl cellosolve; see 2-Methoxyethanol.				
Methyl cellosolve acetate; see 2-Methoxyethyl acetate.				
Methyl chloride	74–87–3		([2])	
Methyl chloroform (1,1,1-Trichloroethane)	71–55–6	350	1900	
Methylcyclohexane	108–87–2	500	2000	
Methylcyclohexanol	25639–42–3	100	470	
o-Methylcyclohexanone	583–60–8	100	460	X
Methylene chloride	75–09–2		([2])	
Methyl ethyl ketone (MEK); see 2-Butanone.				
Methyl formate	107–31–3	100	250	
Methyl hydrazine (Monomethyl hydrazine)	60–34–4	(C)0.2	(C)0.35	X
Methyl iodide	74–88–4	5	28	X
Methyl isoamyl ketone	110–12–3	100	475	
Methyl isobutyl carbinol	108–11–2	25	100	X
Methyl isobutyl ketone; see Hexone.				
Methyl isocyanate	624–83–9	0.02	0.05	X
Methyl mercaptan	74–93–1	(C)10	(C)20	
Methyl methacrylate	80–62–6	100	410	
Methyl propyl ketone; see 2-Pentanone.				
alpha-Methyl styrene	98–83–9	(C)100	(C)480	
Methylene bisphenyl isocyanate (MDI)	101–68–8	(C)0.02	(C)0.2	
Mica; see Silicates.				

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS—Continued

Substance	CAS No. (c)	ppm (a)[1]	mg/m^3 (b)[1]	Skin Designation
Molybdenum (as Mo)	7439–98–7			
Soluble compounds			5	
Insoluble compounds.				
Total dust			15	
Monomethyl aniline	100–61–8	2	9	X
Monomethyl hydrazine; see Methyl hydrazine.				
Morpholine	110–91–8	20	70	X
Naphtha (Coal tar)	8030–30–6	100	400	
Naphthalene	91–20–3	10	50	
alpha-Naphthylamine; see 1910.1004	134–32–7			
beta-Naphthylamine; see 1910.1009	91–59–8			
Nickel carbonyl (as Ni)	13463–39–3	0.001	0.007	
Nickel, metal and insoluble compounds (as Ni)	7440–02–0		1	
Nickel, soluble compounds (as Ni)	7440–02–0		1	
Nicotine	54–11–5		0.5	X
Nitric acid	7697–37–2	2	5	
Nitric oxide	10102–43–9	25	30	
p-Nitroaniline	100–01–6	1	6	X
Nitrobenzene	98–95–3	1	5	X
p-Nitrochlorobenzene	100–00–5		1	X
4-Nitrodiphenyl; see 1910.1003	92–93–3			
Nitroethane	79–24–3	100	310	
Nitrogen dioxide	10102–44–0	(C)5	(C)9	
Nitrogen trifluoride	7783–54–2	10	29	
Nitroglycerin	55–63–0	(C)0.2	(C)2	X
Nitromethane	75–52–5	100	250	
1-Nitropropane	108–03–2	25	90	
2-Nitropropane	79–46–9	25	90	
N-Nitrosodimethylamine; see 1910.1016.				
Nitrotoluene (all isomers)		5	30	X
o-isomer	88–72–2			
m-isomer	99–08–1			
p-isomer	99–99–0			
Nitrotrichloromethane; see Chloropicrin.				
Octachloronaphthalene	2234–13–1		0.1	X
Octane	111–65–9	500	2350	
Oil mist, mineral	8012–95–1		5	
Osmium tetroxide (as Os)	20816–12–0		0.002	
Oxalic acid	144–62–7		1	
Oxygen difluoride	7783–41–7	0.05	0.1	
Ozone	10028–15–6	0.1	0.2	
Paraquat, respirable dust	4685–14–7; 1910–42–5; 2074–50–2		0.5	X
Parathion	56–38–2		0.1	X
Particulates not otherwise regulated (PNOR) f.				
Total dust			15	
Respirable fraction			5	
PCB; see Chlorodiphenyl (42% and 54% chlorine).				
Pentaborane	19624–22–7	0.005	0.01	
Pentachloronaphthalene	1321–64–8		0.5	X
Pentachlorophenol	87–86–5		0.5	X
Pentaerythritol	115–77–5			
Total dust			15	
Respirable fraction			5	
Pentane	109–66–0	1000	2950	
2-Pentanone (Methyl propyl ketone)	107–87–9	200	700	
Perchloroethylene (Tetrachloroethylene)	127–18–4		([2])	
Perchloromethyl mercaptan	594–42–3	0.1	0.8	
Perchloryl fluoride	7616–94–6	3	13.5	
Petroleum distillates (Naphtha) (Rubber Solvent)		500	2000	
Phenol	108–95–2	5	19	X
p-Phenylene diamine	106–50–3		0.1	X
Phenyl ether, vapor	101–84–8	1	7	
Phenyl ether-biphenyl mixture, vapor		1	7	
Phenylethylene; see Styrene.				
Phenyl glycidyl ether (PGE)	122–60–1	10	60	
Phenylhydrazine	100–63–0	5	22	X
Phosdrin (Mevinphos)	7786–34–7		0.1	X
Phosgene (Carbonyl chloride)	75–44–5	0.1	0.4	
Phosphine	7803–51–2	0.3	0.4	

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS—Continued

Substance	CAS No. (c)	Ppm (a)[1]	mg/m^3 (b)[1]	Skin Designation
Phosphoric acid	7664–38–2	.....	1	
Phosphorus (yellow)	7723–14–0	.....	0.1	
Phosphorus pentachloride	10026–13–8	.....	1	
Phosphorus pentasulfide	1314–80–3	.....	1	
Phosphorus trichloride	7719–12–2	0.5	3	
Phthalic anhydride	85–44–9	2	12	
Picloram	1918–02–1			
Total dust		.....	15	
Respirable fraction		.....	5	
Picric acid	88–89–1	.....	0.1	X
Pindone (2-Pivalyl-1,3-indandione)	83–26–1	.....	0.1	
Plaster of Paris	26499–65–0			
Total dust		.....	15	
Respirable fraction		.....	5	
Platinum (as Pt)	7440–06–4			
Metal		.....	.....	
Soluble salts		.....	0.002	
Portland cement	65997–15–1			
Total dust			15	
Respirable fraction		.....	5	
Propane	74–98–6	1000	1800	
beta-Propriolactone; see 1910.1013	57–57–8			
n-Propyl acetate	109–60–4	200	840	
n-Propyl alcohol	71–23–8	200	500	
n-Propyl nitrate	627–13–4	25	110	
Propylene dichloride	78–87–5	75	350	
Propylene imine	75–55–8	2	5	X
Propylene oxide	75–56–9	100	240	
Propyne; see Methyl acetylene.				
Pyrethrum	8003–34–7	.....	5	
Pyridine	110–86–1	5	15	
Quinone	106–51–4	0.1	0.4	
RDX; see Cyclonite.				
Rhodium (as Rh), metal fume and insoluble compounds	7440–16–6	.....	0.1	
Rhodium (as Rh), soluble compounds	7440–16–6	.....	0.001	
Ronnel	299–84–3	.....	15	
Rotenone	83–79–4	.....	5	
Rouge				
Total dust		.....	15	
Respirable fraction		.....	5	
Selenium compounds (as Se)	7782–49–2	.....	0.2	
Selenium hexafluoride (as Se)	7783–79–1	0.05	0.4	
Silica, amorphous, precipitated and gel	112926–00–8		([3])	
Silica, amorphous, diatomaceous earth, containing less than 1% crystalline silica.	61790–53–2		([3])	
Silica, crystalline cristobalite, respirable dust	14464–46–1		([3])	
Silica, crystalline quartz, respirable dust	14808–60–7		([3])	
Silica, crystalline tripoli (as quartz), respirable dust	1317–95–9		([3])	
Silica, crystalline tridymite, respirable dust	15468–32–3		([3])	
Silica, fused, respirable dust	60676–86–0		([3])	
Silicates (less than 1% crystalline silica)				
Mica (respirable dust)	12001–26–2		([3])	
Soapstone, total dust	.....		([3])	
Soapstone, respirable dust	.....		([3])	
Talc (containing asbestos); use asbestos limit; see 29 CFR 1910.1001.	.....		([3])	
Talc (containing no asbestos), respirable dust	14807–96–6		([3])	
Tremolite, asbestiform; see 1910.1001.				
Silicon	7440–21–3			
Total dust		.....	15	
Respirable fraction		.....	5	
Silicon carbide	409–21–2			
Total dust		.....	15	
Respirable fraction		.....	5	
Silver, metal and soluble compounds (as Ag)	7440–22–4	.....	0.01	
Soapstone; see Silicates.			0	
Sodium fluoroacetate	62–74–8	.....	.05	X
Sodium hydroxide	1310–73–2	.....	2	
Starch	9005–25–8			
Total dust		.....	15	
Respirable fraction		.....	5	

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS—Continued

Substance	CAS No. (c)	ppm (a)[1]	mg/m^3 (b)[1]	Skin Designation
Stibine	7803–52–3	0.1	0.5	
Stoddard solvent	8052–41–3	500	2900	
Strychnine	57–24–9	.....	0.15	
Styrene	100–42–5		([2])	
Sucrose	57–50–1			
Total dust		.....	15	
Respirable fraction		.....	5	
Sulfur dioxide	7446–09–5	5	13	
Sulfur hexafluoride	2551–62–4	1000	6000	
Sulfuric acid	7664–93–9	.....	1	
Sulfur monochloride	10025–67–9	1	6	
Sulfur pentafluoride	5714–22–7	0.025	0.25	
Sulfuryl fluoride	2699–79–8	5	20	
Systox; see Demeton.				
2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	93–76–5	.....	10	
Talc; see Silicates.				
Tantalum, metal and oxide dust	7440–25–7	.....	5	
TEDP (Sulfotep)	3689–24–5	.....	0.2	X
Tellurium and compounds (as Te)	13494–80–9	.....	0.1	
Tellurium hexafluoride (as Te)	7783–80–4	0.02	0.2	
Temephos	3383–96–8			
Total dust		.....	15	
Respirable fraction		.....	5	
TEPP (Tetraethyl pyrophosphate)	107–49–3	.....	0.05	X
Terphenyls	26140–60–3	(C)1	(C)9	
1,1,1,2-Tetrachloro-2,2-difluoroethane	76–11–9	500	4170	
1,1,2,2-Tetrachloro-1,2-difluoroethane	76–12–0	500	4170	
1,1,2,2-Tetrachloroethane	79–34–5	5	35	X
Tetrachloroethylene; see Perchloroethylene.				
Tetrachloromethane; see Carbon tetrachloride.				
Tetrachloronaphthalene	1335–88–2	.....	2	X
Tetraethyl lead (as Pb)	78–00–2	.....	0.075	X
Tetrahydrofuran	109–99–9	200	590	
Tetramethyl lead (as Pb)	75–74–1	.....	0.075	X
Tetramethyl succinonitrile	3333–52–6	0.5	3	X
Tetranitromethane	509–14–8	1	8	
Tetryl (2,4,6-Trinitrophenylmethylnitramine)	479–45–8	.....	1.5	X
Thallium, soluble compounds (as Tl)	7440–28–0	.....	0.1	X
4,4′-Thiobis (6-tert, Butyl-m-cresol)	96–69–5			
Total dust		.....	15	
Respirable fraction		.....	5	
Thiram	137–26–8	.....	5	
Tin, inorganic compounds (except oxides) (as Sn)	7440–31–5	.....	2	
Tin, organic compounds (as Sn)	7440–31–5	.....	0.1	
Titanium dioxide	13463–67–7			
Total dust		.....	15	
Toluene	108–88–3		([2])	
Toluene-2,4-diisocyanate (TDI)	584–84–9	(C)0.02	(C)0.14	
o-Toluidine	95–53–4	5	22	X
Toxaphene; see Chlorinated camphene.				
Tremolite; see Silicates.				
Tributyl phosphate	126–73–8	.....	5	
1,1,1-Trichloroethane; see Methyl chloroform.				
1,1,2-Trichloroethane	79–00–5	10	45	X
Trichloroethylene	79–01–6		([2])	
Trichloromethane; see Chloroform.				
Trichloronaphthalene	1321–65–9	.....	5	X
1,2,3-Trichloropropane	96–18–4	50	300	
1,1,2-Trichloro-1,2,2-trifluoroethane	76–13–1	1000	7600	
Triethylamine	121–44–8	25	100	
Trifluorobromomethane	75–63–8	1000	6100	
2,4,6-Trinitrophenol; see Picric acid.				
2,4,6-Trinitrophenylmethylnitramine; see Tetryl.				
2,4,6-Trinitrotoluene (TNT)	118–96–7	.....	1.5	X
Triorthocresyl phosphate	78–30–8	.....	0.1	
Triphenyl phosphate	115–86–6	.....	3	
Turpentine	8006–64–2	100	560	
Uranium (as U)	7440–61–1			
Soluble compounds		.....	0.05	
Insoluble compounds		.....	0.25	

TABLE Z–1—LIMITS FOR AIR CONTAMINANTS—Continued

Substance	CAS No. (c)	ppm (a)[1]	mg/m^3 (b)[1]	Skin Designation
Vanadium	1314–62–1			
Respirable dust (as V2 O5)			(C)0.5	
Fume (as V2 O5)			(C)0.1	
Vegetable oil mist				
Total dust			15	
Respirable fraction			5	
Vinyl benzene; see Styrene.				
Vinyl chloride; see 1910.1017	75–01–4			
Vinyl cyanide; see Acrylonitrile.				
Vinyl toluene	25013–15–4	100	480	
Warfarin	81–81–2		0.1	
Xylenes (o-, m-, p-isomers)	1330–20–7	100	435	
Xylidine	1300–73–8	5	25	X
Yttrium	7440–65–5		1	
Zinc chloride fume	7646–85–7		1	
Zinc oxide fume	1314–13–2		5	
Zinc oxide	1314–13–2			
Total dust			15	
Respirable fraction			5	
Zinc stearate	557–05–1			
Total dust			15	
Respirable fraction			5	
Zirconium compounds (as Zr)	7440–67–7		5	

[1] The PELs are 8-hour TWAs unless otherwise noted; a (C) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples.

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

(b) Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.

(c) The CAS number is for information only. Enforcement is based on the substance name. For an entry covering more than one metal compound, measured as the metal, the CAS number for the metal is given—not CAS numbers for the individual compounds.

(d) The final benzene standard in 1910.1028 applies to all occupational exposures to benzene except in some circumstances the distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures; for the excepted subsegments, the benzene limits in Table Z–2 apply. See 1910.1028 for specific circumstances.

(e) This 8-hour TWA applies to respirable dust as measured by a vertical elutriator cotton dust sampler or equivalent instrument. The time-weighted average applies to the cotton waste processing operations of waste recycling (sorting, blending, cleaning and willowing) and garnetting. See also 1910.1043 for cotton dust limits applicable to other sectors.

(f) All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by the Particulates Not Otherwise Regulated (PNOR) limit which is the same as the inert or nuisance dust limit of Table Z–3.

[2] See Table Z–2.

[3] See Table Z–3.

[4] Varies with compound.

TABLE Z–2

Substance	8-hour time weighted average	Acceptable ceiling concentration	Acceptable maximum peak above acceptable ceiling concentration for an 8-hr shift	
			Concentration	Maximum duration
Benzene [a] (Z37.40–1969)	10 ppm	25 ppm	50 ppm	10 minutes.
Beryllium and beryllium compounds (Z37.29–1970)	2 µg/m^3	5 µg/m^3	25 µg/m^3	30 minutes.
Cadmium fume [b] (Z37.5–1970)	0.1 mg/m^3	0.3 mg/m^3		
Cadmium dust [b] (Z37.5–1970)	0.2 mg/m^3	0.6 mg/m^3.		
Carbon disulfide (Z37.3–1968)	20 ppm	30 ppm	100 ppm	30 minutes.
Carbon tetrachloride (Z37.17–1967)	10 ppm	25 ppm	200 ppm	5 min. in any 4 hrs.
Chromic acid and chromates (Z37.7–1971)		1 mg/10m^3.		
Ethylene dibromide (Z37.31–1970)	20 ppm	30 ppm	50 ppm	5 minutes.
Ethylene dichloride (Z37.21–1969)	50 ppm	100 ppm	200 ppm	5 min. in any 3 hrs.
Fluoride as dust (Z37.28–1969)	2.5 mg/m^3			
Formaldehyde; see 1910.1048				
Hydrogen fluoride (Z37.28–1969)	3 ppm			
Hydrogen sulfide (Z37.2–1966)		20 ppm	50 ppm	10 mins. once, only if no other meas. exp. occurs.
Mercury (Z37.8–1971)		1 mg/10m^3		
Methyl chloride (Z37.18–1969)	100 ppm	200 ppm	300 ppm	5 mins. in any 3 hrs.
Methylene Chloride: See § 1919.52..				
Organo (alkyl) mercury (Z37.30–1969)	0.01 mg/m^3	0.04 mg/m^3		
Styrene (Z37.15–1969)	100 ppm	200 ppm	600 ppm	5 mins. in any 3 hrs.
Tetrachloroethylene (Z37.22–1967)	100 ppm	200 ppm	300 ppm	5 mins. in any 3 hrs.
Toluene (Z37.12–1967)	200 ppm	300 ppm	500 ppm	10 minutes.
Trichloroethylene (Z37.19–1967)	100 ppm	200 ppm	300 ppm	5 mins. in any 2 hrs.

[a] This standard applies to the industry segments exempt from the 1 ppm 8-hour TWA and 5 ppm STEL of the benzene standard at 1910.1028.
[b] This standard applies to any operations or sectors for which the Cadmium standard, 1910.1027, is stayed or otherwise not in effect.

TABLE Z–3—MINERAL DUSTS

Substance	mppcf [a]	mg/m^3
Silica:		
Crystalline		
Quartz (Respirable)	250 [b] / %SiO_2+5	10 mg/m^3 [e] / % SiO_2 + 2
Quartz (Total Dust)		30 mg/m^3 / % SiO_2 + 2
Cristobalite: Use 1.2 the value calculated from the count or mass formulae for quartz		
Tridymite: Use 1.2 the value calculated from the formulae for quartz		
Amorphous, including natural diatomaceous earth	20	80 mg/m^3 / %SiO_2
Silicates (less than 1% crystalline silica):		
Mica	20	
Soapstone	20	
Talc (not containing asbestos)	20 [c]	
Talc (containing asbestos) Use asbestos limit.		
Tremolite, asbestiform (see 29 CFR 1910.1001).		
Portland cement	50	

TABLE Z–3—MINERAL DUSTS—Continued

Substance	mppcf [a]	mg/m^3
Graphite (Natural)	15	
Coal Dust:		
Respirable fraction less than 5% SiO_2		$\frac{2.4\ mg/m^3\ [e]}{\%\ SiO_2 + 2}$
Respirable fraction greater than 5% SiO_2		$\frac{10\ mg/m^3\ [e]}{\%\ SiO_2 + 2}$
Inert or Nuisance Dust: [d]		
Respirable fraction	15	5 mg/m^3
Total dust	50	15 mg/m^3

Note—Conversion factors - mppcf × 35.3 = million particles per cubic meter = particles per c.c.

a Millions of particles per cubic foot of air, based on impinger samples counted by light-field techniques.

b 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.

c Containing less than 1% quartz; if 1% quartz or more, use quartz limit.

d All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by this limit, which is the same as the Particulates Not Otherwise Regulated (PNOR) limit in Table Z–1.

e Both concentration and percent quartz for the application of this limit are to be determined from the fraction passing a sizeselector with the following characteristics:

Aerodynamic diameter (unit density sphere)	Percent passing selector
2	90
2.5	75
3.5	50
5.0	25
10	0

The measurements under this note refer to the use of an AEC (now NRC) instrument. The respirable fraction of coal dust is determined with an MRE; the figure corresponding to that of 2.4 mg/m^3 in the table for coal dust is 4.5 mg/m^{3K}.

[58 FR 35340, June 30. 1993; 58 FR 40191, July 27, 1993, as amended at 61 FR 56831, Nov. 4, 1996; 62 FR 1600, Jan. 10, 1997; 62 FR 42018, Aug. 4, 1997]

§ 1910.1450 Occupational exposure to hazardous chemicals in laboratories.

(a) *Scope and application.* (1) This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

(2) Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:

(i) For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

(ii) Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

(iii) Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements, paragraphs (d) and (g)(1)(ii) of this section shall apply.

(3) This section shall not apply to:

(i) Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such use occurs in a laboratory.

(ii) Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

(A) Procedures using chemically-impregnated test media such as Dip-and- Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and

(B) Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

(b) *Definitions—*

Action level means a concentration designated in 29 CFR part 1910 for a specific substance, calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

Assistant Secretary means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

Carcinogen (see *select carcinogen*).

Chemical Hygiene Officer means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

Chemical Hygiene Plan means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

Combustible liquid means any liquid having a flashpoint at or above 100 °F (37.8 °C), but below 200 °F (93.3 °C), except any mixture having components with flashpoints of 200 °F (93.3 °C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

Compressed gas means:

(i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 °F (21.1 °C); or

(ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 °F (54.4 °C) regardless of the pressure at 70 °F (21.1 °C); or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100 °F (37.8 °C) as determined by ASTM D–323–72.

Designated area means an area which may be used for work with ''select carcinogens,'' reproductive toxins or substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of a laboratory or a device such as a laboratory hood.

Emergency means any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the workplace.

Employee means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

Explosive means a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

Flammable means a chemical that falls into one of the following categories:

(i) *Aerosol, flammable* means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;

(ii) *Gas, flammable* means:

(A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or

(B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.

(iii) *Liquid, flammable* means any liquid having a flashpoint below 100 °F (37.8 °C), except any mixture having components with flashpoints of 100 °F (37.8 °C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

(iv) *Solid, flammable* means a solid, other than a blasting agent or explosive as defined in § 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Flashpoint means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24–1979 (ASTM D 56–79))-for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 °F (37.8 °C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester (see American National Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, Z11.7– 1979 (ASTM D 93–79))-for liquids with a viscosity equal to or greater than 45 SUS at 100 °F (37.8 °C), or that contain suspended solids, or that have a tendency to form a surface film under test; or

(iii) Setaflash Closed Tester (see American National Standard Method of Test for Flash Point by Setaflash Closed Tester (ASTM D 3278–78)).

Organic peroxides, which undergo autoaccelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

Hazardous chemical means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term *health hazard* includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

Laboratory means a facility where the ''laboratory use of hazardous chemicals'' occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis.

Laboratory scale means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. ''Laboratory scale'' excludes those workplaces whose function is to produce commercial quantities of materials.

Laboratory-type hood means a device located in a laboratory, enclosure on five sides with a moveable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

Laboratory use of hazardous chemicals means handling or use of such chemicals in which all of the following conditions are met:

(i) Chemical manipulations are carried out on a ''laboratory scale;''

(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and

(iv) ''Protective laboratory practices and equipment'' are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

Medical consultation means a consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

Organic peroxide means an organic compound that contains the bivalent −O−O− structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

Oxidizer means a chemical other than a blasting agent or explosive as defined in § 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

Physical hazard means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.

Protective laboratory practices and equipment means those laboratory procedures, practices and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

Reproductive toxins means chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis)

Select carcinogen means any substance which meets one of the following criteria:

(i) It is regulated by OSHA as a carcinogen; or

(ii) It is listed under the category, ''known to be carcinogens,'' in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or

(iii) It is listed under Group 1 (''carcinogenic to humans'') by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category, ''reasonably anticipated to be carcinogens'' by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(A) After inhalation exposure of 6–7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3;

(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or

(C) After oral dosages of less than 50 mg/kg of body weight per day.

Unstable (reactive) means a chemical which is the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

Water-reactive means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

(c) *Permissible exposure limits.* For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910, subpart Z.

(d) *Employee exposure determination*— (1) *Initial monitoring.* The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).

(2) *Periodic monitoring.* If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

(3) *Termination of monitoring.* Monitoring may be terminated in accordance with the relevant standard.

(4) *Employee notification of monitoring results.* The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

(e) *Chemical hygiene plan—General.* (Appendix A of this section is non-mandatory but provides guidance to assist

employers in the development of the Chemical Hygiene Plan.)

(1) Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

(i) Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and

(ii) Capable of keeping exposures below the limits specified in paragraph (c) of this section.

(2) The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.

(3) The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection:

(i) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

(ii) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;

(iii) A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

(iv) Provisions for employee information and training as prescribed in paragraph (f) of this section;

(v) The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;

(vi) Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;

(vii) Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer and, if appropriate, establishment of a Chemical Hygiene Committee; and

(viii) Provisions for additional employee protection for work with particularly hazardous substances. These include ''select carcinogens,'' reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

(A) Establishment of a designated area;

(B) Use of containment devices such as fume hoods or glove boxes;

(C) Procedures for safe removal of contaminated waste; and

(D) Decontamination procedures.

(4) The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

(f) *Employee information and training.* (1) The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

(2) Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.

(3) *Information.* Employees shall be informed of:

(i) The contents of this standard and its appendices which shall be made available to employees;

(ii) The location and availability of the employer's Chemical Hygiene Plan;

(iii) The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;

(iv) Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and

(v) The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.

(4) *Training.* (i) Employee training shall include:

(A) Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);

(B) The physical and health hazards of chemicals in the work area; and

(C) The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

(ii) The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

(g) *Medical consultation and medical examinations.* (1) The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

(i) Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.

(ii) Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

(iii) Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

(2) All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.

(3) *Information provided to the physician.* The employer shall provide the following information to the physician:

(i) The identity of the hazardous chemical(s) to which the employee may have been exposed;

(ii) A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and

(iii) A description of the signs and symptoms of exposure that the employee is experiencing, if any.

(4) *Physician's written opinion.* (i) For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:

(A) Any recommendation for further medical follow-up;

(B) The results of the medical examination and any associated tests;

(C) Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace; and

(D) A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

(ii) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

(h) *Hazard identification.* (1) With respect to labels and material safety data sheets:

(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.

(ii) Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.

(2) The following provisions shall apply to chemical substances developed in the laboratory:

(i) If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.

(ii) If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.

(iii) If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of material safety data sheets and labeling.

(i) *Use of respirators.* Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

(j) *Recordkeeping.* (1) The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.

(2) The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

(k) *Dates*—(1) *Effective date.* This section shall become effective May 1, 1990.

(2) *Start-up dates.* (i) Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.

(ii) Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

(l) *Appendices.* The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

APPENDIX A TO § 1910.1450—NATIONAL RESEARCH COUNCIL RECOMMENDATIONS CONCERNING CHEMICAL HYGIENE IN LABORATORIES (NON-MANDATORY)

TABLE OF CONTENTS

As guidance for each employer's development of an appropriate laboratory Chemical Hygiene Plan, the following non-mandatory recommendations are provided. They were extracted from ''Prudent Practices for Handling Hazardous Chemicals in Laboratories'' (referred to below as ''Prudent Practices''), which was published in 1981 by the National Research Council and is available from the National Academy Press, 2101 Constitution Ave., NW., Washington DC 20418.

''Prudent Practices'' is cited because of its wide distribution and acceptance and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council. However, none of the recommendations given here will modify any requirements of the laboratory standard. This Appendix merely presents pertinent recommendations from ''Prudent Practices'', organized into a form convenient for quick reference during operation of a laboratory facility and during development and application of a Chemical Hygiene Plan. Users of this appendix should consult ''Prudent Practices'' for a more extended presentation and justification for each recommendation.

''Prudent Practices'' deals with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards. Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term ''chemical hygiene'' being substituted for the word ''safety''. However, since conditions producing or threatening physical injury often pose toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F.

The recommendations from ''Prudent Practices'' have been paraphrased, combined, or otherwise reorganized, and headings have been added. However, their sense has not been changed.

Corresponding Sections of the Standard and thisAppendix

The following table is given for the convenience of those who are developing a Chemical Hygiene Plan which will satisfy the requirements of paragraph (e) of the standard. It indicates those sections of this appendix which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

Paragraph and topic in laboratory standard	Relevant appendix section
(e)(3)(i) Standard operating procedures for handling toxic chemicals.	C, D, E
(e)(3)(ii) Criteria to be used for implementation of measures to reduce exposures.	D
(e)(3)(iii) Fume hoof performance	C4b
(e)(3)(iv) Employee information and training (including emergency procedures).	D10, D9
(e)(3)(v) Requirements for prior approval of laboratory activities	E2b, E4b
(e)(3)(vi) Medical consultations and medical examinations.	D5, E4f
(e)(3)(vii) Chemical hygiene responsibilities	B
(e)(3)(viii) Special precautions for work with particularly hazardous substances.	E2, E3, E4

In this appendix, those recommendations directed primarily at administrators and supervisors are given in sections A–D. Those recommendations of primary concern to employees who are actually handling laboratory chemicals are given in section E. (Reference to page numbers in ''Prudent Practices'' are given in parentheses.)

A. General Principles for Work with Laboratory Chemicals

In addition to the more detailed recommendations listed below in sections B–E, ''Prudent Practices'' expresses certain general principles, including the following:

1. *It is prudent to minimize all chemical exposures*. Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2, 10). Skin contact with chemicals should be avoided as a cardinal rule (198).

2. *Avoid underestimation of risk*. Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken (10, 37, 38). One should assume that any mixture will be more toxic than its most toxic component (30, 103) and that all substances of unknown toxicity are toxic (3, 34).

3. *Provide adequate ventilation*. The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198).

4. *Institute a chemical hygiene program*. A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular, continuing effort, not merely a standby or short-term activity (6, 11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).

5. *Observe the PELs, TLVs*. The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded (13).

B. Chemical Hygiene Responsibilities

Responsibility for chemical hygiene rests at all levels (6, 11, 21) including the:

1. *Chief executive officer*, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7, 11).

2. *Supervisor of the department or other administrative unit*, who is responsible for chemical hygiene in that unit (7).

3. *Chemical hygiene officer(s)*, whose appointment is essential (7) and who must:

(a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7);

(b) Monitor procurement, use, and disposal of chemicals used in the lab (8);

(c) See that appropriate audits are maintained (8);

(d) Help project directors develop precautions and adequate facilities (10);

(e) Know the current legal requirements concerning regulated substances (50); and

(f) Seek ways to improve the chemical hygiene program (8, 11).

4. *Laboratory supervisor*, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:

(a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);

(b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);

(c) Know the current legal requirements concerning regulated substances (50, 231);

(d) Determine the required levels of protective apparel and equipment (156, 160, 162); and

(e) Ensure that facilities and training for use of any material being ordered are adequate (215).

5. *Project director or director of other specific operation*, who has primary responsibility for chemical hygiene procedures for that operation (7).

6. *Laboratory worker*, who is responsible for:

(a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7, 21, 22, 230); and

(b) Developing good personal chemical hygiene habits (22).

C. The Laboratory Facility

1. Design. The laboratory facility should have:

(a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);

(b) Adequate, well-ventilated stockrooms/ storerooms (218, 219);

(c) Laboratory hoods and sinks (12, 162);

(d) Other safety equipment including eyewash fountains and drench showers (162, 169); and

(e) Arrangements for waste disposal (12, 240).

2. *Maintenance.* Chemical-hygiene-related equipment (hoods, incinerator, etc.) should undergo continuing appraisal and be modified if inadequate (11, 12).

3. *Usage.* The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).

4. *Ventilation*—(a) *General laboratory ventilation.* This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).

(b) *Hoods.* A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201–206 for a discussion of hood design, construction, and evaluation.

(c) *Other local ventilation devices.* Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).

(d) *Special ventilation areas.* Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).

(e) *Modifications.* Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).

(f) *Performance.* Rate: 4–12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (194).

(g) *Quality.* General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60–100 lfm) (200, 204).

(h) *Evaluation.* Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation devices is made (12, 195, 207). See pp. 195–198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures (Recommendations for these are given in section E, below)

2. Chemical Procurement, Distribution, and Storage

(a) *Procurement.* Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).

(b) *Stockrooms/storerooms.* Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218–19).

Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).

(c) *Distribution.* When chemicals are hand carried, the container should be placed in an outside container or bucket. Freight-only elevators should be used if possible (223).

(d) *Laboratory storage.* Amounts permitted should be as small as practical. Storage on bench tops and in hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom (225– 6, 229).

3. Environmental Monitoring

Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when testing or redesigning hoods or other ventilation devices (12) or when a highly toxic substance is stored or used regularly (e.g., 3 times/week) (13).

4. Housekeeping, Maintenance, and Inspections

(a) Cleaning. Floors should be cleaned regularly (24).

(b) Inspections. Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6, 21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).

(c) *Maintenance.* Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Safety showers should be tested routinely (169). Other safety equipment should be inspected regularly. (*e.g.,* every 3–6 months) (6, 24, 171). Procedures to prevent restarting of out-of-service equipment should be established (25).

(d) *Passageways.* Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).

5. Medical Program

(a) *Compliance with regulations.* Regular medical surveillance should be established to the extent required by regulations (12).

(b) *Routine surveillance.* Anyone whose work involves regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11, 50).

(c) *First aid.* Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176–178 for description of some emergency first aid procedures.

6. Protective Apparel and Equipment

These should include for each laboratory:

(a) Protective apparel compatible with the required degree of protection for substances being handled (158–161);

(b) An easily accessible drench-type safety shower (162, 169);

(c) An eyewash fountain (162);

(d) A fire extinguisher (162–164);

(e) Respiratory protection (164–9), fire alarm and telephone for emergency use (162) should be available nearby; and

(f) Other items designated by the laboratory supervisor (156, 160).

7. Records

(a) Accident records should be written and retained (174).

(b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).

(c) Inventory and usage records for highrisk substances should be kept as specified in sections E3e below.

(d) Medical records should be retained by the institution in accordance with the requirements of state and federal regulations (12).

8. Signs and Labels

Prominent signs and labels of the following types should be posted:

(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers (28);

(b) Identity labels, showing contents of containers (including waste receptacles) and associated hazards (27, 48);

(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (27) and areas where food and beverage consumption and storage are permitted (24); and

(d) Warnings at areas or equipment where special or unusual hazards exist (27).

9. Spills and Accidents

(a) A written emergency plan should be established and communicated to all personnel; it should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drills (172).

(b) There should be an alarm system to alert people in all parts of the facility including isolation areas such as cold rooms (172).

(c) A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).

(d) All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8, 28).

10. Information and Training Program

(a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs (5, 15).

(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154, 169).

Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6).

Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.

(c) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).

(d) Frequency of Training: The training and education program should be a regular, continuing activity—not simply an annual presentation (15).

(e) Literature/Consultation: Literature and consulting advice concerning chemical hygiene should be readily available to laboratory personnel, who should be encouraged to use these information resources (14).

11. *Waste Disposal Program.*

(a) Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals (5).

(b) Content (14, 232, 233, 240): The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials can be incinerated. Transport from the institution must be in accordance with DOT regulations (244).

(c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened (24, 27).

Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage (226).

(d) Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals (14).

(e) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14, 238, 241).

Indiscriminate disposal by pouring waste chemicals down the drain (14, 231, 242) or adding them to mixed refuse for landfill burial is unacceptable (14).

Hoods should not be used as a means of disposal for volatile chemicals (40, 200).

Disposal by recycling (233, 243) or chemical decontamination (40, 230) should be used when possible.

E. Basic Rules and Procedures for Working with Chemicals

The Chemical Hygiene Plan should require that laboratory workers know and follow its rules and procedures. In addition to the procedures of the sub programs mentioned above, these should include the rules listed below.

1. General Rules

The following should be used for essentially all laboratory work with chemicals:

(a) *Accidents and spills*—Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention (33, 172).

Ingestion: Encourage the victim to drink large amounts of water (178).

Skin Contact: Promptly flush the affected area with water (33, 172, 178) and remove any contaminated clothing (172, 178). If symptoms persist after washing, seek medical attention (33).

Clean-up. Promptly clean up spills, using appropriate protective apparel and equipment and proper disposal (24 33). See pp. 233– 237 for specific clean-up recommendations.

(b) *Avoidance of ''routine'' exposure:* Develop and encourage safe habits (23); avoid unnecessary exposure to chemicals by any route (23);

Do not smell or taste chemicals (32). Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices (199).

Inspect gloves (157) and test glove boxes (208) before use.

Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).

(c) *Choice of chemicals:* Use only those chemicals for which the quality of the available ventilation system is appropriate (13).

(d) *Eating, smoking, etc.:* Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22, 24, 32, 40); wash hands before conducting these activities (23, 24).

Avoid storage, handling or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations (23, 24, 226).

(e) *Equipment and glassware:* Handle and store laboratory glassware with care to avoid damage; do not use damaged glassware (25). Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur (25). Use equipment only for its designed purpose (23, 26).

(f) *Exiting:* Wash areas of exposed skin well before leaving the laboratory (23).

(g) *Horseplay:* Avoid practical jokes or other behavior which might confuse, startle or distract another worker (23).

(h) *Mouth suction:* Do not use mouth suction for pipeting or starting a siphon (23, 32).

(i) *Personal apparel:* Confine long hair and loose clothing (23, 158). Wear shoes at all times in the laboratory but do not wear sandals, perforated shoes, or sneakers (158).

(j) *Personal housekeeping:* Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of an operation or at the end of each day (24).

(k) *Personal protection:* Assure that appropriate eye protection (154–156) is worn by all persons, including visitors, where chemicals are stored or handled (22, 23, 33, 154).

Wear appropriate gloves when the potential for contact with toxic materials exists (157); inspect the gloves before each use, wash them before removal, and replace them periodically (157). (A table of resistance to chemicals of common glove materials is given p. 159).

Use appropriate (164–168) respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls (164–5), inspecting the respirator before use (169).

Use any other protective and emergency apparel and equipment as appropriate (22, 157–162).

Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken (155).

Remove laboratory coats immediately on significant contamination (161).

(l) *Planning:* Seek information and advice about hazards (7), plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation (22, 23).

(m) *Unattended operations:* Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation (27, 128).

(n) *Use of hood:* Use the hood for operations which might result in release of toxic chemical vapors or dust (198–9).

As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm (13).

Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200).

Leave the hood ''on'' when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is ''off'' (200).

(o) *Vigilance:* Be alert to unsafe conditions and see that they are corrected when detected (22).

(p) *Waste disposal:* Assure that the plan for each laboratory operation includes plans and training for waste disposal (230).

Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan (22, 24).

Do not discharge to the sewer concentrated acids or bases (231); highly toxic, malodorous, or lachrymatory substances (231); or any substances which might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow (242).

(q) *Working alone:* Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous (28).

2. Working with Allergens and Embryotoxins

(a) *Allergens* (examples: diazomethane, isocyanates, bichromates): Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity (35).

(b) *Embryotoxins* (34–5) (examples: organomercurials, lead compounds, formamide): If you are a woman of childbearing age, handle these substances only in a hood whose satisfactory performance has been confirmed, using appropriate protective apparel (especially gloves) to prevent skin contact.

Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made.

Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.

Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.

3. Work with Chemicals of Moderate Chronic or High Acute Toxicity

EXAMPLES: diisopropylflurophosphate (41), hydro-fluoric acid (43), hydrogen cyanide (45).

Supplemental rules to be followed in addition to those mentioned above (Procedure B of ''Prudent Practices'', pp. 39–41):

(a) *Aim:* To minimize exposure to these toxic substances by any route using all reasonable precautions (39).

(b) *Applicability:* These precautions are appropriate for substances with moderate chronic or high acute toxicity used in significant quantities (39).

(c) *Location:* Use and store these substances only in areas of restricted access with special warning signs (40, 229).

Always use a hood (previously evaluated to confirm adequate performance with a face velocity of at least 60 linear feet per minute) (40) or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance (39); trap released vapors to prevent their discharge with the hood exhaust (40).

(d) *Personal protection:* Always avoid skin contact by use of gloves and long sleeves (and other protective apparel as appropriate) (39). Always wash hands and arms immediately after working with these materials (40).

(e) *Records:* Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved (40, 229).

(f) *Prevention of spills and accidents:* Be prepared for accidents and spills (41).

Assure that at least 2 people are present at all times if a compound in use is highly toxic or of unknown toxicity (39).

Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper (40).

If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

(g) *Waste:* Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible, chemically decontaminate by chemical conversion (40).

Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

4. Work with Chemicals of High Chronic Toxicity

(Examples: dimethylmercury and nickel carbonyl (48), benzo-a-pyrene (51), Nnitrosodiethylamine (54), other human carcinogens or substances with high carcinogenic potency in animals (38).)

Further supplemental rules to be followed, in addition to all these mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of ''Prudent Practices'' pp. 47–50).

(a) *Access:* Conduct all transfers and work with these substances in a ''controlled area'': a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and necessary precautions (48).

(b) *Approvals:* Prepare a plan for use and disposal of these materials and obtain the approval of the laboratory supervisor (48).

(c) *Non-contamination/Decontamination:* Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood (49). Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area (49, 50).

Decontaminate the controlled area before normal work is resumed there (50).

(d) *Exiting:* On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck (49).

(e) *Housekeeping:* Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder (50).

(f) *Medical surveillance:* If using toxicologically significant quantities of such a substance on a regular basis (*e.g.,* 3 times per week), consult a qualified physician concerning desirability of regular medical surveillance (50).

(g) *Records:* Keep accurate records of the amounts of these substances stored (229) and used, the dates of use, and names of users (48).

(h) *Signs and labels:* Assure that the controlled area is conspicuously marked with warning and restricted access signs (49) and that all containers of these substances are appropriately labeled with identity and warning labels (48).

(i) *Spills:* Assure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available (233–4).

(j) *Storage:* Store containers of these chemicals only in a ventilated, limited access (48, 227, 229) area in appropriately labeled, unbreakable, chemically resistant, secondary containers (48, 229).

(k) *Glove boxes:* For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and pressure at least 0.5 inches of water (48). For a positive pressure glove box, thoroughly check for leaks before each use (49). In either case, trap the exit gases or filter them through a HEPA filter and then release them into the hood (49).

(l) *Waste:* Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in a secondary container under the supervision of authorized personnel (49, 50, 233).

5. Animal Work with Chemicals of High Chronic Toxicity

(a) *Access:* For large scale studies, special facilities with restricted access are preferable (56).

(b) *Administration of the toxic substance:* When possible, administer the substance by injection or gavage instead of in the diet. If administration is in the diet, use a caging system under negative pressure or under laminar air flow directed toward HEPA filters (56).

(c) *Aerosol suppression:* Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood) (55, 56).

(d) *Personal protection:* When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator) (56).

(e) *Waste disposal:* Dispose of contaminated animal tissues and excreta by incineration if the available incinerator can convert the contaminant to non-toxic products (238); otherwise, package the waste appropriately for burial in an EPA-approved site (239).

F. Safety Recommendations

The above recommendations from ''Prudent Practices'' do not include those which are directed primarily toward prevention of physical injury rather than toxic exposure. However, failure of precautions against injury will often have the secondary effect of causing toxic exposures. Therefore, we list below page references for recommendations concerning some of the major categories of safety hazards which also have implications for chemical hygiene:

1. Corrosive agents: (35–6)
2. Electrically powered laboratory apparatus: (179–92)
3. Fires, explosions: (26, 57–74, 162–4, 174–5, 219–20, 226–7)
4. Low temperature procedures: (26, 88)
5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27, 75–101)

G. Material Safety Data Sheets

Material safety data sheets are presented in ''Prudent Practices'' for the chemicals listed below. (Asterisks denote that comprehensive material safety data sheets are provided).
*Acetyl peroxide (105)
*Acrolein (106)
*Acrylonilrile (107)
Ammonia (anhydrous) (91)
*Aniline (109)
*Benzene (110)
*Benzo[a]pyrene (112)
*Bis(chloromethyl) ether (113)
Boron trichloride (91)
Boron trifluoride (92)
Bromine (114)
*Tert-butyl hydroperoxide (148)
*Carbon disulfide (116)
Carbon monoxide (92)
*Carbon tetrachloride (118)
*Chlorine (119)
Chlorine trifluoride (94)
*Chloroform (121)
Chloromethane (93)
*Diethyl ether (122)
Diisopropyl fluorophosphate (41)
*Dimethylformamide (123)
*Dimethyl sulfate (125)
*Dioxane (126)
*Ethylene dibromide (128)
*Fluorine (95)
*Formaldehyde (130)
*Hydrazine and salts (132)
Hydrofluoric acid (43)
Hydrogen bromide (98)
Hydrogen chloride (98)
*Hydrogen cyanide (133)
*Hydrogen sulfide (135)
Mercury and compounds (52)
*Methanol (137)
*Morpholine (138)
*Nickel carbonyl (99)
*Nitrobenzene (139)
Nitrogen dioxide (100)
N-nitrosodiethylamine (54)
*Peracetic acid (141)
*Phenol (142)
*Phosgene (143)
*Pyridine (144)
*Sodium azide (145)
*Sodium cyanide (147)
Sulfur dioxide (101)
*Trichloroethylene (149)
*Vinyl chloride (150)

APPENDIX B TO § 1910.1450—REFERENCES (NON-MANDATORY)

The following references are provided to assist the employer in the development of a Chemical Hygiene Plan. The materials listed below are offered as non-mandatory guidance. References listed here do not imply specific endorsement of a book, opinion, technique, policy or a specific solution for a safety or health problem. Other references not listed here may better meet the needs of a specific laboratory. (a) Materials for the development of the Chemical Hygiene Plan:

1. American Chemical Society, Safety in Academic Chemistry Laboratories, 4th edition, 1985.

2. Fawcett, H.H. and W. S. Wood, Safety and Accident Prevention in Chemical Operations, 2nd edition, Wiley-Interscience, New York, 1982.

3. Flury, Patricia A., Environmental Health and Safety in the Hospital Laboratory, Charles C. Thomas Publisher, Springfield IL, 1978.

4. Green, Michael E. and Turk, Amos, Safety in Working with Chemicals, Macmillan Publishing Co., NY, 1978.

5. Kaufman, James A., Laboratory Safety Guidelines, Dow Chemical Co., Box 1713, Midland, MI 48640, 1977.

6. National Institutes of Health, NIH Guidelines for the Laboratory use of Chemical Carcinogens, NIH Pub. No. 81–2385, GPO, Washington, DC 20402, 1981.

7. National Research Council, Prudent Practices for Disposal of Chemicals from Laboratories, National Academy Press, Washington, DC, 1983.

8. National Research Council, Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, Washington, DC, 1981.

9. Renfrew, Malcolm, Ed., Safety in the Chemical Laboratory, Vol. IV, *J. Chem. Ed.*, American Chemical Society, Easlon, PA, 1981.

10. Steere, Norman V., Ed., Safety in the Chemical Laboratory, *J. Chem. Ed.* American Chemical Society, Easlon, PA, 18042, Vol. I, 1967, Vol. II, 1971, Vol. III 1974.

11. Steere, Norman V., Handbook of Laboratory Safety, the Chemical Rubber Company Cleveland, OH, 1971.

12. Young, Jay A., Ed., Improving Safety in the Chemical Laboratory, John Wiley & Sons, Inc. New York, 1987.

(b) Hazardous Substances Information:

1. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, 6500 Glenway Avenue, Bldg. D–7 Cincinnati, OH 45211–4438 (latest edition).

2. Annual Report on Carcinogens, National Toxicology Program U.S. Department of Health and Human Services, Public Health Service, U.S. Government Printing Office, Washington, DC, (latest edition).

3. Best Company, Best Safety Directory, Vols. I and II, Oldwick, N.J., 1981.

4. Bretherick, L., Handbook of Reactive Chemical Hazards, 2nd edition, Butterworths, London, 1979.

5. Bretherick, L., Hazards in the Chemical Laboratory, 3rd edition, Royal Society of Chemistry, London, 1986.

6. Code of Federal Regulations, 29 CFR part 1910 subpart Z. U.S. Govt. Printing Office, Washington, DC 20402 (latest edition).

7. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, World Health Organization Publications Center, 49 Sheridan Avenue, Albany, New York 12210 (latest editions).

8. NIOSH/OSHA Pocket Guide to Chemical Hazards. NIOSH Pub. No. 85–114, U.S. Government Printing Office, Washington, DC, 1985 (or latest edition).

9. Occupational Health Guidelines, NIOSH/ OSHA NIOSH Pub. No. 81–123 U.S. Government Printing Office, Washington, DC, 1981.

10. Patty, F.A., Industrial Hygiene and Toxicology, John Wiley & Sons, Inc., New York, NY (Five Volumes).

11. Registry of Toxic Effects of Chemical Substances, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Revised Annually, for sale from Superintendent of Documents U.S. Govt. Printing Office, Washington, DC 20402.

12. The Merck Index: An Encyclopedia of Chemicals and Drugs. Merck and Company Inc. Rahway, N.J., 1976 (or latest edition).

13. Sax, N.I. Dangerous Properties of Industrial Materials, 5th edition, Van Nostrand Reinhold, NY., 1979.

14. Sittig, Marshall, Handbook of Toxic and Hazardous Chemicals, Noyes Publications, Park Ridge, NJ, 1981.

(c) Information on Ventilation:

1. American Conference of Governmental Industrial Hygienists Industrial Ventilation (latest edition), 6500 Glenway Avenue, Bldg. D–7, Cincinnati, Ohio 45211–4438.

2. American National Standards Institute, Inc. American National Standards Fundamentals Governing the Design and Operation of Local Exhaust Systems ANSI Z 9.2– 1979 American National Standards Institute, N.Y. 1979.

3. Imad, A.P. and Watson, C.L. Ventilation Index: An Easy Way to Decide about Hazardous Liquids, Professional Safety pp 15–18, April 1980.

4. National Fire Protection Association, Fire Protection for Laboratories Using Chemicals NFPA–45, 1982.

Safety Standard for Laboratories in Health Related Institutions, NFPA, 56c, 1980.

Fire Protection Guide on Hazardous Materials, 7th edition, 1978. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

5. Scientific Apparatus Makers Association (SAMA), Standard for Laboratory Fume Hoods, SAMA LF7–1980, 1101 16th Street, NW., Washington, DC 20036.

(d) Information on Availability of Referenced Material:

1. American National Standards Institute (ANSI), 1430 Broadway, New York, NY 10018.

2. American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.

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