

# **Recommendation of Occupational Exposure Limits (2007–2008)**

**The Japan Society for Occupational Health**

**April 25, 2007**

The Japan Society for Occupational Health (JSOH) recommends the Occupational Exposure Limits (OELs) as reference values for preventing adverse health effects on workers caused by occupational exposure to chemical substances, continuous or intermittent noise, impulsive or impact noise, heat stress, cold stress, whole-body vibration, hand-arm vibration and time-varying electric, magnetic and electromagnetic fields and ultraviolet radiation.

## **Characteristics of OELs and Instructions for Users**

1. OELs should be applied by individuals well-trained and experienced in occupational health.
2. OELs cannot be applied in cases where exposure duration or work intensity exceeds the prerequisite conditions for setting an OEL.
3. OELs are set based on various information obtained from experiences in industries and experiments on humans and animals. However, the quantity and quality of information used in setting OELs is not always the same.
4. Types of health effects considered in setting OELs depend on the substances involved; an explicit health impairment provides the basis for OELs in certain substances, while health effects such as discomfort, irritation or CNS suppressive effects afford the basis in others. Thus, OELs cannot be used simply as a relative scale of toxicity.
5. Due to the variance in individual susceptibilities, discomfort, deterioration of pre-existing ill health or occupational disease may be induced at levels of exposure below the OELs, even though the chances of this should be remote.
6. Because OELs do not represent a definitive borderline between safe and hazardous conditions, it is not correct to conclude that working environments above OEL are the direct and sole cause of health impairment in workers, or vice versa.
7. OELs cannot be applied as reference values in non-occupational environments.
8. OELs will be revised when JSOH considers it necessary.
9. JSOH welcomes the submission, by concerned parties or individuals, of opinions based on scientific aspects of OELs.
10. In the reproduction of any Tables and/or Figures of OELs, JSOH requires that the full text of OELs be quoted to prevent misunderstanding and misuse.

## **I. Occupational Exposure Limits for Chemical Substances**

### **1. Definitions**

Exposure concentration is defined as the concentration of a chemical substance in air which will be inhaled by a worker during a job without the use of protective respiratory equipment.

Occupational Exposure Limit-Mean (OEL-M) for mean concentration of a chemical substance is defined as the reference value to the mean exposure concentration at or below which adverse health effects caused by the substance do not appear in most workers working for 8 hours a day, 40 hours a week under a moderate workload. Exposure above OEL-M should be avoided even where duration is short or work intensity is light. If mean levels and duration of exposure corresponding to segments of various jobs can be measured or estimated, then an overall exposure concentration can be determined

as the time-weighted average concentration.

Occupational Exposure Limit-Ceiling (OEL-C) of occupational exposure to a chemical substance is defined as the reference value to the maximal exposure concentration of the substance during a working day at or below which adverse health effects do not appear in most workers. The main reason why OEL-C is recommended for some substances is that the toxicity in question can induce immediate adverse effects such as irritation or CNS suppressive effects. However, it is quite difficult in practice to measure the momentary maximal exposure concentration. Short-term measurement lasting for 5 minutes or less at the time when the highest exposure concentration is expected may be used as a substitute for the measurement of maximal exposure concentration.

## 2. Variability of exposure concentration

Exposure concentration fluctuates around the mean value. OEL-M should be referred to only when the fluctuation is not large. Allowable range of fluctuation depends on the substance. In practical terms, the mean exposure concentration for a period of 15 minutes during which maximum exposure concentration is expected should not exceed 1.5 times OEL-M, unless otherwise notified.

## 3. Skin absorption

“S” marks in Tables I-1 and I-2 show that a significant dose from the view of systemic health effects or absorption of the substance concerned may be absorbed through the skin when the substance is in contact with the skin. OELs are set at conditions under which no skin absorption will take place.

## 4. Interaction with other working conditions

Other working conditions, such as work intensity, heat stress and abnormal atmospheric pressure, must be

considered, since their co-existence could cause an increase in the inhaled dose of a chemical substance, thereby intensifying its effects on workers' health.

## 5. OEL for exposure to mixture of chemical substances

OEL-M values listed in Table I-1 and I-2 are applicable in cases where the substance exists alone. When workers are exposed to a mixture of chemical substances and there is no reliable evidence to the contrary that the effects of the chemicals are assumed to be additive, the effects should be assumed as additive. The users should refer not to each OEL-M value, but rather to the following equation:

$$I = C_1/T_1 + C_2/T_2 + \dots + C_i/T_i + \dots + C_n/T_n$$

$C_i$  = mean exposure concentration for each component  $i$

$T_i$  = OEL-M for each component  $i$

Any value of  $I$  exceeding 1 indicates an exposure that is above OEL.

**Table I-1.** Occupational exposure limits for chemical substances

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m <sup>3</sup>			Airway	Skin	
Acetaldehyde [75-07-0]	CH <sub>3</sub> CHO	50*	90*		2B			'90
Acetic acid [64-19-7]	CH <sub>3</sub> COOH	10	25					'78
Acetic anhydride [108-24-7]	(CH <sub>3</sub> CO) <sub>2</sub> O	5*	21*					'90
Acetone [67-64-1]	CH <sub>3</sub> COCH <sub>3</sub>	200	470					'72
Acrylaldehyde [107-02-8]	CH <sub>2</sub> =CHCHO	0.1	0.23					'73
Acrylamide [79-06-1]	CH <sub>2</sub> =CHCONH <sub>2</sub>	—	0.1	S	2A			'04
Acrylonitrile [107-13-1]	CH <sub>2</sub> =CHCN	2	4.3	S	2A			'88
Allyl alcohol [107-18-6]	CH <sub>2</sub> =CHCH <sub>2</sub> OH	1	2.4	S				'78
2-Aminoethanol [141-43-5]	H <sub>2</sub> NCH <sub>2</sub> CH <sub>2</sub> OH	3	7.5					'65
Ammonia [7664-41-7]	NH <sub>3</sub>	25	17					'79
Aniline [62-53-3]	C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>	1	3.8	S				'88
<i>o</i> -Anisidine [90-04-0]	H <sub>3</sub> COC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub>	0.1	0.5	S	2B			'96
<i>p</i> -Anisidine [104-94-9]	H <sub>3</sub> COC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub>	0.1	0.5	S				'96
Antimony and compounds (as Sb except Stibine) [7440-36-0]	Sb	—	0.1		2B			'91
Arsenic and compounds (as As)	As	(Table III-2)			1			'00
Arsine [7784-42-1]	AsH <sub>3</sub>	0.01	0.032					'92
		0.1*	0.32*					
Benzene [71-43-2]	C <sub>6</sub> H <sub>6</sub>	(Table III-2)		S	1			'97
Beryllium and compounds (as Be) [7440-41-7]	Be	—	0.002		2A	1	2	'63
Boron trifluoride [7637-07-2]	BF <sub>3</sub>	0.3	0.83					'79
Bromine [7726-95-6]	Br <sub>2</sub>	0.1	0.65					'64
Bromoform [75-25-2]	CHBr <sub>3</sub>	1	10.3					'97
2-Bromopropane [75-26-3]	CH <sub>3</sub> CHBrCH <sub>3</sub>	1	5	S				'99
Buprofezin [69327-76-0]	C <sub>16</sub> H <sub>23</sub> N <sub>3</sub> OS	—	2					'90
Butane (all isomers)	C <sub>4</sub> H <sub>10</sub>	500	1200					'88
1-Butanol [71-36-3]	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> OH	50*	150*	S				'87
2-Butanol [78-92-2]	CH <sub>3</sub> CH(OH)CH <sub>2</sub> CH <sub>3</sub>	100	300					'87
Butyl acetate [123-86-4]	CH <sub>3</sub> COO(CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	100	475					'94

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m <sup>3</sup>			Airway	Skin	
<i>t</i> -Butyl alcohol [75-65-0]	(CH <sub>3</sub> ) <sub>3</sub> COH	50	150					'87
Butylamine [109-73-9]	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> NH <sub>2</sub>	5*	15*	S				('94)
Cadmium and compounds (as Cd) [7440-43-9]	Cd	—	0.05		1 $\Psi$			'76
Calcium cyanide (as CN) [592-01-8]	Ca(CN) <sub>2</sub>	—	5*	S				'01
Carbaryl [63-25-2]	C <sub>12</sub> H <sub>11</sub> NO <sub>2</sub>	—	5	S				'89
Carbon dioxide [124-38-9]	CO <sub>2</sub>	5000	9000					'74
Carbon disulfide [75-15-0]	CS <sub>2</sub>	10	31	S				'74
Carbon monoxide [630-08-0]	CO	50	57					'71
Carbon tetrachloride [56-23-5]	CCl <sub>4</sub>	5	31	S	2B			'91
Chlorine [7782-50-5]	Cl <sub>2</sub>	0.5*	1.5*					'99
Chlorobenzene [108-90-7]	C <sub>6</sub> H <sub>5</sub> Cl	10	46					'93
Chlorodifluoromethane [75-45-6]	CHClF <sub>2</sub>	1000	3500					'87
Chloroethane [75-00-3]	C <sub>2</sub> H <sub>5</sub> Cl	100	260					'93
Chloroform [67-66-3]	CHCl <sub>3</sub>	3	14.7	S	2B			'05
Chloromethane [74-87-3]	CH <sub>3</sub> Cl	50	100					'84
Chloropicrin [76-06-2]	Cl <sub>3</sub> CNO <sub>2</sub>	0.1	0.67					'68
Chloromethyl methyl ether (technical grade) [107-30-2]	CH <sub>3</sub> OCH <sub>2</sub> Cl	—	—		2A			'92
Chromium and compounds (as Cr) [7440-47-3]	Cr					2	1	'89
Chromium Metal		—	0.5					
Chromium (III) compounds		—	0.5					
Chromium (VI) compounds		—	0.05					
Certain Chromium (VI) compounds		—	0.01		1 $\Psi$			
Cobalt and compounds (as Co) [7440-48-4]	Co	—	0.05		2B	1	1	'92
Cresol (all isomers)	C <sub>6</sub> H <sub>4</sub> CH <sub>3</sub> (OH)	5	22	S				'86
Cyclohexane [110-82-7]	C <sub>6</sub> H <sub>12</sub>	150	520					'70
Cyclohexanol [108-93-0]	C <sub>6</sub> H <sub>11</sub> OH	25	102					'70
Cyclohexanone [108-94-1]	C <sub>6</sub> H <sub>10</sub> O	25	100					'70
Diazinon [333-41-5]	C <sub>12</sub> H <sub>21</sub> N <sub>2</sub> O <sub>3</sub> PS	—	0.1	S				'89
Diborane [19287-45-7]	B <sub>2</sub> H <sub>6</sub>	0.01	0.012					'96
Dibutyl phthalate [84-74-2]	C <sub>6</sub> H <sub>4</sub> (COOC <sub>4</sub> H <sub>9</sub> ) <sub>2</sub>	—	5				2	'96
<i>o</i> -Dichlorobenzene [95-50-1]	C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>	25	150					'94
<i>p</i> -Dichlorobenzene [106-46-7]	C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>	10	60		2B			'98
Dichlorodifluoromethane [75-71-8]	CCl <sub>2</sub> F <sub>2</sub>	500	2500					'87
3,3'-Dichloro-4,4'-diaminodiphenylmethane (MBOCA) [101-14-4]	CH <sub>2</sub> (C <sub>6</sub> H <sub>3</sub> NH <sub>2</sub> Cl) <sub>2</sub>	—	0.005	S	2A			'93
1,1-Dichloroethane [75-34-3]	Cl <sub>2</sub> CHCH <sub>3</sub>	100	400					'93
1,2-Dichloroethane [107-06-2]	ClCH <sub>2</sub> CH <sub>2</sub> Cl	10	40		2B			'84
2,2'-Dichloroethyl ether [111-44-4]	(ClCH <sub>2</sub> CH <sub>2</sub> ) <sub>2</sub> O	15	88	S				'67
1,2-Dichloroethylene [540-59-0]	ClCH=CHCl	150	590					'70
Dichloromethane [75-09-2]	CH <sub>2</sub> Cl <sub>2</sub>	50	170	S	2B			'99
		100*	340*					
2,2-Dichloro-1,1,1-trifluoroethane [306-83-2]	CF <sub>3</sub> CHCl <sub>2</sub>	10	62					'00
Diethyl phthalate [84-66-2]	C <sub>6</sub> H <sub>4</sub> (COOC <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>	—	5					'95
Diethylamine [109-89-7]	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> NH	10	30					'89
Di(2-ethylhexyl)phthalate [117-81-7]	C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>	—	5		2B			'95
<i>N,N</i> -Dimethyl acetamide [127-19-5]	(CH <sub>3</sub> ) <sub>2</sub> NCOCH <sub>3</sub>	10	36	S				'90
Dimethyl sulfate [77-78-1]	(CH <sub>3</sub> ) <sub>2</sub> SO <sub>4</sub>	0.1	0.52	S	2A			'80
Dimethylamine [124-40-3]	(CH <sub>3</sub> ) <sub>2</sub> NH	10	18					'79
<i>N,N</i> -Dimethylaniline [121-69-7]	C <sub>6</sub> H <sub>5</sub> N(CH <sub>3</sub> ) <sub>2</sub>	5	25	S				'93
<i>N,N</i> -Dimethylformamide (DMF) [68-12-2]	(CH <sub>3</sub> ) <sub>2</sub> NCHO	10	30	S	2B			'74

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m <sup>3</sup>			Airway	Skin	
1,2-Dinitrobenzene [528-29-0]	C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> ) <sub>2</sub>	0.15	1	S				'94
1,3-Dinitrobenzene [99-65-0]	C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> ) <sub>2</sub>	0.15	1	S				'94
1,4-Dinitrobenzene [100-25-4]	C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> ) <sub>2</sub>	0.15	1	S				'94
1,4-Dioxane [123-91-1]	C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>	10	36	S	2B			'84
Diphenylmethane-4,4'-diisocyanate (MDI) [101-68-8]	CH <sub>2</sub> (C <sub>6</sub> H <sub>4</sub> NCO) <sub>2</sub>	—	0.05			1		'93
Dusts		(Table I-3)						'80
Etofenprox [80844-07-1]	C <sub>25</sub> H <sub>28</sub> O <sub>3</sub>	—	3					'95
Ethyl acetate [141-78-6]	CH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub>	200	720					'95
Ethyl benzene [100-41-4]	C <sub>6</sub> H <sub>5</sub> C <sub>2</sub> H <sub>5</sub>	50	217		2B			'01
Ethyl ether [60-29-7]	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	400	1200					('97)
Ethylamine [75-04-7]	C <sub>2</sub> H <sub>5</sub> NH <sub>2</sub>	10	18					'79
Ethylene glycol monoethyl ether [110-80-5]	C <sub>2</sub> H <sub>5</sub> OCH <sub>2</sub> CH <sub>2</sub> OH	5	18	S				'85
Ethylene glycol monoethyl ether acetate [111-15-9]	C <sub>2</sub> H <sub>5</sub> OCH <sub>2</sub> CH <sub>2</sub> OCOCH <sub>3</sub>	5	27	S				'85
Ethylene glycol monomethyl ether [109-86-4]	CH <sub>3</sub> OCH <sub>2</sub> CH <sub>2</sub> OH	5	16	S				'85
Ethylene glycol monomethyl ether acetate [110-49-6]	CH <sub>3</sub> OCH <sub>2</sub> CH <sub>2</sub> OCOCH <sub>3</sub>	5	24	S				'85
Ethylene oxide [75-21-8]	C <sub>2</sub> H <sub>4</sub> O	1	1.8		1 <sup>ψ</sup>		2	'90
Ethylenediamine [107-15-3]	H <sub>2</sub> NCH <sub>2</sub> CH <sub>2</sub> NH <sub>2</sub>	10	25	S		2	1	'91
Ethylenimine [151-56-4]	C <sub>2</sub> H <sub>5</sub> N	0.5	0.88	S				('90)
Fenitrothion [122-14-5]	C <sub>9</sub> H <sub>12</sub> NO <sub>3</sub> PS	—	1	S				'81
Fenobucarb [3766-81-2]	C <sub>12</sub> H <sub>17</sub> NO <sub>2</sub>	—	5	S				'89
Fenthion [55-38-9]	C <sub>10</sub> H <sub>15</sub> O <sub>3</sub> PS <sub>2</sub>	—	0.2	S				'89
Flutolanil [66332-96-5]	C <sub>17</sub> H <sub>16</sub> NO <sub>2</sub> F <sub>3</sub>	—	10					'90
Formaldehyde [50-00-0]	HCHO	(Table I-2)						'07
Formic acid [64-18-6]	HCOOH	5	9.4					'78
Fthalide [27355-22-2]	C <sub>8</sub> H <sub>2</sub> Cl <sub>4</sub> O <sub>2</sub>	—	10					'90
Furfural [98-01-1]	C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>	2.5	9.8	S				('89)
Furfuryl alcohol [98-00-0]	C <sub>4</sub> H <sub>3</sub> OCH <sub>2</sub> OH	5	20					'78
Gasoline [8006-61-9]		100 <sup>b</sup>	300 <sup>b</sup>		2B			'85
Glutaraldehyde [111-30-8]	OHC(CH <sub>2</sub> ) <sub>3</sub> CHO	0.03*				1	1	'06
Heptane [142-82-5]	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>5</sub> CH <sub>3</sub>	200	820					'88
Hexane [110-54-3]	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> CH <sub>3</sub>	40	140	S				'85
Hexane-1,6-diisocyanate (HDI) [822-06-0]	OCN(CH <sub>2</sub> ) <sub>6</sub> NCO	0.005	0.034			1		'95
Hydrazine anhydride and Hydrazine hydrate [302-01-2 and 7803-57-8]	N <sub>2</sub> H <sub>4</sub> and N <sub>2</sub> H <sub>4</sub> ·H <sub>2</sub> O	0.1	0.13 and 0.21	S	2B		2	'98
Hydrogen chloride [7647-01-0]	HCl	5*	7.5*					'79
Hydrogen cyanide [74-90-8]	HCN	5	5.5	S				'90
Hydrogen fluoride [7664-39-3]	HF	3*	2.5*					'00
Hydrogen selenide [7783-07-5]	SeH <sub>2</sub>	0.05	0.17					'63
Hydrogen sulfide [7783-06-4]	H <sub>2</sub> S	5	7					'01
Iodine [7553-56-2]	I <sub>2</sub>	0.1	1				2	'68
Indium and compounds [7440-74-6]	In	(Table II-1)						'07
Isobutyl alcohol [78-83-1]	(CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> OH	50	150					'87
Isopentyl acetate [123-92-2]	CH <sub>3</sub> COO(CH <sub>2</sub> ) <sub>2</sub> CH(CH <sub>3</sub> ) <sub>2</sub>	100	530					'70
Isopentyl alcohol [123-51-3]	(CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> CH <sub>2</sub> OH	100	360					'66
Isopropyl alcohol [67-63-0]	CH <sub>3</sub> CH(OH)CH <sub>3</sub>	400*	980*					'87
Isoprothiolane [50512-35-1]	C <sub>12</sub> H <sub>18</sub> O <sub>4</sub> S <sub>2</sub>	—	5					'93
Lead and compounds (as Pb except alkyl lead compounds) [7439-92-1]	Pb	—	0.1		2B			'82
Lithium hydroxide [1310-65-2]	LiOH	—	1					'95
Malathion [121-75-5]	C <sub>10</sub> H <sub>16</sub> O <sub>6</sub> PS <sub>2</sub>	—	10	S				'89

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m <sup>3</sup>			Airway	Skin	
Maleic anhydride [108-31-6]	C <sub>4</sub> H <sub>2</sub> O <sub>3</sub>	0.1	0.4			2	2	'00
		0.2*	0.8*					
Manganese and compounds (as Mn except organic compounds) [7439-96-5]	Mn	—	0.3 <sup>c</sup>					'85
Man-made mineral fibers								'03
Continuous filament glass fibers**			1 (fiber/ml)					
Glass wool fibers**, Rock wool fibers**, Slag wool fibers**			1 (fiber/ml)					
Ceramic fibers**, Micro glass fibers**			—		2B			
Mepronil [55814-41-0]	C <sub>17</sub> H <sub>19</sub> NO <sub>2</sub>	—	5					'90
Mercury vapor [7439-97-6]	Hg		0.025					'98
Methanol [67-56-1]	CH <sub>3</sub> OH	200	260	S				'63
Methyl acetate [79-20-9]	CH <sub>3</sub> COOCH <sub>3</sub>	200	610					'63
Methyl acrylate [96-33-3]	C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>	2	7					'04
Methyl bromide [74-83-9]	CH <sub>3</sub> Br	1	3.89	S				'03
Methyl ethyl ketone [78-93-3]	C <sub>2</sub> H <sub>5</sub> COCH <sub>3</sub>	200	590					'64
Methyl isobutyl ketone [108-10-1]	CH <sub>3</sub> COCH <sub>2</sub> CH(CH <sub>3</sub> ) <sub>2</sub>	50	200					'84
Methyl <i>n</i> -butyl ketone [591-78-6]	CH <sub>3</sub> CO(CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	5	20	S				'84
Methylamine [74-89-5]	CH <sub>3</sub> NH <sub>2</sub>	10	13					'79
Methylcyclohexane [108-87-2]	CH <sub>3</sub> C <sub>6</sub> H <sub>11</sub>	400	1600					'86
Methylcyclohexanol [25639-42-3]	CH <sub>3</sub> C <sub>6</sub> H <sub>10</sub> OH	50	230					'80
Methylcyclohexanone	CH <sub>3</sub> C <sub>6</sub> H <sub>9</sub> O	50	230	S				'87
4,4'-Methylene dianiline [101-77-9]	CH <sub>2</sub> (C <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> ) <sub>2</sub>	—	0.4	S	2B			'95
<i>N</i> -Methyl-2-pyrrolidone [872-50-4]	C <sub>5</sub> H <sub>9</sub> NO	1	4	S				'02
Methyltetrahydrophthalic anhydride [11070-44-3]	C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>	0.007	0.05			1		'02
		0.015*	0.1*					
Nickel [7440-02-0]	Ni	—	1		2B	2	1	'67
Nickel carbonyl [13463-39-3]	Ni(CO) <sub>4</sub>	0.001	0.007					'66
Nitric acid [7697-37-2]	HNO <sub>3</sub>	2	5.2					'82
<i>p</i> -Nitroaniline [100-01-6]	H <sub>2</sub> NC <sub>6</sub> H <sub>4</sub> NO <sub>2</sub>	—	3	S				'95
Nitrobenzene [98-95-3]	C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>	1	5	S	2B			('88)
<i>p</i> -Nitrochlorobenzene [100-00-5]	C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>	0.1	0.64	S				'89
Nitrogen dioxide [10102-44-0]	NO <sub>2</sub>		(pending)					'61
Nitroglycerin [55-63-0]	CH <sub>2</sub> ONO <sub>2</sub>	0.05*	0.46*	S				'86
	CHONO <sub>2</sub>							
	CH <sub>2</sub> ONO <sub>2</sub>							
Nitroglycol [628-96-6]	O <sub>2</sub> NOCH <sub>2</sub> CH <sub>2</sub> ONO <sub>2</sub>	0.05	0.31	S				'86
Nonane [111-84-2]	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH <sub>3</sub>	200	1050					'89
Octane [111-65-9]	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> CH <sub>3</sub>	300	1400					'89
Oil mist, mineral		—	3		1 <sup>ψ</sup>			'77
Ozone [10028-15-6]	O <sub>3</sub>	0.1	0.20					'63
Parathion [56-38-2]	(C <sub>2</sub> H <sub>5</sub> O) <sub>2</sub> PSOC <sub>6</sub> H <sub>4</sub> NO <sub>2</sub>	—	0.1	S				('80)
Pentachlorophenol [87-86-5]	C <sub>6</sub> Cl <sub>5</sub> OH	—	0.5	S				('89)
Pentane [109-66-0]	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	300	880					'87
Pentyl acetate [628-63-7]	CH <sub>3</sub> COO(CH <sub>2</sub> ) <sub>4</sub> CH <sub>3</sub>	100	530					'70
Phenol [108-95-2]	C <sub>6</sub> H <sub>5</sub> OH	5	19	S				'78
<i>o</i> -Phenylenediamine [95-54-5]	C <sub>6</sub> H <sub>4</sub> (NH <sub>2</sub> ) <sub>2</sub>	—	0.1				1	'99
<i>m</i> -Phenylenediamine [108-45-2]	C <sub>6</sub> H <sub>4</sub> (NH <sub>2</sub> ) <sub>2</sub>	—	0.1				1	'99
<i>p</i> -Phenylenediamine [106-50-3]	C <sub>6</sub> H <sub>4</sub> (NH <sub>2</sub> ) <sub>2</sub>	—	0.1				1	'97
Phosgene [75-44-5]	COCl <sub>2</sub>	0.1	0.4					'69
Phosphine [7803-51-2]	PH <sub>3</sub>	0.3*	0.42*					'98
Phosphoric acid [7664-38-2]	H <sub>3</sub> PO <sub>4</sub>	—	1					('90)
Phosphorus (yellow) [7723-14-0]	P <sub>4</sub>	—	0.1					('88)
Phosphorus pentachloride [10026-13-8]	PCl <sub>5</sub>	0.1	0.85					'89
Phosphorus trichloride [7719-12-2]	PCl <sub>3</sub>	0.2	1.1					'89
Phthalic anhydride [85-44-9]	C <sub>8</sub> H <sub>4</sub> O <sub>3</sub>	0.33*	0.2*			1		'98
Platinum, soluble salts (as Pt) [744006-4]	Pt	—	0.001			1	1	'00

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m <sup>3</sup>			Airway	Skin	
Polychlorobiphenyls	C <sub>12</sub> H <sub>(10-n)</sub> Cl <sub>n</sub>	—	0.01	S	2A			'06
Potassium cyanide (as CN) [151-50-8]	KCN	—	5*	S				'01
Potassium hydroxide [1310-58-3]	KOH	—	2*					'78
Propyl acetate [109-60-4]	CH <sub>3</sub> COO(CH <sub>2</sub> ) <sub>2</sub> CH <sub>3</sub>	200	830					'70
Propylene imine [75-55-8]	C <sub>3</sub> H <sub>7</sub> N	2	4.7	S	2B			'67
Pyridaphenthion [119-12-0]	C <sub>14</sub> H <sub>17</sub> N <sub>2</sub> O <sub>4</sub> PS	—	0.2	S				'89
Rhodium [7440-16-6] (Soluble compounds, as Rh)	Rh	Table I-2						'07
Selenium and compounds (as Se, except SeH <sub>2</sub> and SeF <sub>6</sub> ) [7782-49-2]	Se	—	0.1					'00
Silane [7803-62-5]	SiH <sub>4</sub>	100*	130*					'93
Silver and compounds (as Ag) [7440-22-4]	Ag	—	0.01					'91
Sodium cyanide (as CN) [143-33-9]	NaCN	—	5*	S				'01
Sodium hydroxide [1310-73-2]	NaOH	—	2*					'78
Styrene [100-42-5]	C <sub>6</sub> H <sub>5</sub> CH=CH <sub>2</sub>	20	85	S	2B			'99
Sulfur dioxide [7446-09-5]	SO <sub>2</sub>	(pending)						'61
Sulfur monochloride [10025-67-9]	S <sub>2</sub> Cl <sub>2</sub>	1*	5.5*					'76
Sulfuric acid [7664-93-9]	H <sub>2</sub> SO <sub>4</sub>	—	1*		(pending)			'00
1,1,2,2-Tetrachloroethane [79-34-5]	Cl <sub>2</sub> CHCHCl <sub>2</sub>	1	6.9	S				'84
Tetrachloroethylene [127-18-4]	Cl <sub>2</sub> C=CCl <sub>2</sub>	(pending)		S	2B			'72
Tetraethoxysilane [78-10-4]	Si(OC <sub>2</sub> H <sub>5</sub> ) <sub>4</sub>	10	85					'91
Tetraethyl lead (as Pb) [78-00-2]	Pb(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub>	—	0.075	S				'65
Tetrahydrofuran [109-99-9]	C <sub>4</sub> H <sub>8</sub> O	200	590					'78
Tetramethoxysilane [681-84-5]	Si(OCH <sub>3</sub> ) <sub>4</sub>	1	6					'91
Toluene [108-88-3]	C <sub>6</sub> H <sub>5</sub> CH <sub>3</sub>	50	188	S				'94
Toluene diisocyanates	C <sub>6</sub> H <sub>3</sub> CH <sub>3</sub> (NCO) <sub>2</sub>	0.005	0.035		2B	1	2	'92
		0.02*	0.14*					
<i>o</i> -Toluidine [95-53-4]	CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> NH <sub>2</sub>	1	4.4	S	2B			'91
1,1,2-Trichloro-1,2,2-trifluoroethane [76-13-1]	Cl <sub>2</sub> FC <sub>2</sub> ClF <sub>2</sub>	500	3800					'87
1,1,1-Trichloroethane [71-55-6]	Cl <sub>3</sub> CCH <sub>3</sub>	200	1100					'74
1,1,2-Trichloroethane [79-00-5]	Cl <sub>2</sub> CHCH <sub>2</sub> Cl	10	55	S				('78)
Trichloroethylene [79-01-6]	Cl <sub>2</sub> C=CHCl	25	135		2B			'97
Trichlorofluoromethane [75-69-4]	CCl <sub>3</sub> F	1000*	5600*					'87
Tricyclazole [41814-78-2]	C <sub>9</sub> H <sub>7</sub> N <sub>3</sub> S	—	3					'90
Trimellitic anhydride [552-30-7]	C <sub>9</sub> H <sub>4</sub> O <sub>5</sub>	—	0.04			1		'98
			0.1*					
1,2,3-Trimethylbenzene [526-73-8]	C <sub>6</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub>	25	120					'84
1,2,4-Trimethylbenzene [95-63-6]	C <sub>6</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub>	25	120					'84
1,3,5-Trimethylbenzene [108-67-8]	C <sub>6</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub>	25	120					'84
Trinitrotoluene (all isomers)	C <sub>6</sub> H <sub>2</sub> CH <sub>3</sub> (NO <sub>2</sub> ) <sub>3</sub>	—	0.1	S				'93
Turpentine		50	280				2	'91
Vanadium compounds								
Vanadium pentoxide [1314-62-1]	V <sub>2</sub> O <sub>5</sub>	—	0.05					'03
Ferrovanadium dust [12604-58-9]	FeV dust	—	1					'68
Vinyl chloride [75-01-4]	CH <sub>2</sub> =CHCl	2.5 <sup>a</sup>	6.5 <sup>a</sup>		1 <sup>ψ</sup>			'75
Xylene (all isomers and their mixture)	C <sub>6</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>2</sub>	50	217					'01
Zinc oxide fume [1314-13-2]	ZnO	(pending)						'69

- Notes: 1. ppm: parts of vapors and gases per million of substance in air by volume at 25°C and atmospheric pressure (760 torr, 1,013 hPa); OELs in ppm are converted to those in mg/m<sup>3</sup>, in which the values are rounded off with 2 significant digits.
2. ( ) in the year of proposal column indicates that revision was done in the year without change of the OEL value.
3. \*: Occupational Exposure Limit-Ceiling; exposure concentration must be kept below this level.
- \*\*\*: Fibers longer than 5 μm and with an aspect ratio equal to or greater than 3:1 as determined by the membrane filter method at 400 × magnification phase contrast illumination.
- ψ: Substance whose OEL is set based on non-caninogenic health effects; see III.
- <sup>a</sup>: Exposure concentration should be kept below a detectable limit though OEL is set at 2.5 ppm provisionally.
- <sup>b</sup>: OEL for gasoline is 300 mg/m<sup>3</sup>, and an average molecular weight is assumed to be 72.5 for conversion to ppm unit.
- <sup>c</sup>: Respirable dust; see Note 1 in Table I-3.

**Table I-2** Occupational exposure limits for chemical substances (Provisional values)

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m <sup>3</sup>			Airway	Skin	
Formaldehyde [50-00-0]	HCHO	0.1 0.2*	0.12 0.24*		2A	2	1	'07
Rhodium [7440-16-6] (Soluble compounds, as Rh)	Rh		0.001			1	1	'07

Note: see Table I-1.

**Table I-3.** Occupational exposure limits for dusts

I. Respirable crystalline silica <sup>#, †, ‡, ¶, *</sup> OEL-C 0.03 mg/m <sup>3</sup>			
II. Dusts other than I			
	Dusts	OEL (mg/m <sup>3</sup> )	
		Respirable dust*	Total dust**
Class 1	Activated charcoal, Alumina, Aluminum, Bentonite, Diatomite, Graphite, Kaolinite, Pagodite, Pyrites, Pyrite cinder, Talc <sup>†</sup>	0.5	2
Class 2	Dusts containing less than 10% free silica, Bakelite, Carbon black, Coal, Cork dust, Cotton dust, Iron oxide, Grain dust, Joss stick material dust, Marble, Portland cement, Titanium oxide, Wood dust, Zinc oxide	1	4
Class 3	Limestone <sup>‡</sup> , Inorganic and organic dusts other than Classes 1 and 2	2	8
Asbestos <sup>***, †</sup>		(Table III-2)	

Notes: 1. \*: Respirable dust is defined as that which penetrates a particle size separator with the following characteristics:

$$P = 1 - \frac{D^2}{D_0^2} \quad (D \leq D_0), \quad P = 0 \quad (D > D_0)$$

where  $P$  = penetration rate

$D$  = aerodynamic particle diameter ( $\mu\text{m}$ )

$D_0 = 7.07 \mu\text{m}$ .

Respirable crystalline silica consists of particles captured by the following collection efficiency,  $R$  ( $d_{ac}$ ).

$$R(d_{ac}) = 0.5[1 + \exp(-0.06d_{ac})] \cdot [1 - F(x)]$$

$d_{ac}$ : aerodynamic diameter of particle ( $\mu\text{m}$ ),  $F(x)$ : cumulative probability function of the standardized normal variable

$$x = \ln(d_{ac}/\Gamma) / \ln(\Sigma), \quad \ln \text{ natural logarithm, } \Gamma = 4.25 \mu\text{m}, \Sigma = 1.5$$

- \*\* : Total dust comprises particles with a flow speed of 50 to 80 cm/sec at the entry of a particle sampler.
- \*\*\* : Fibers longer than  $5 \mu\text{m}$  and with an aspect ratio equal to or greater than 3:1 as determined by the membrane filter method at  $400 \times$  magnification (4 mm objective) phase contrast illumination.
- † : Dusts which are listed as occupational carcinogens in Table III.
- ‡ : Do not include asbestos nor  $\geq 1\%$  crystalline silica.
- ¶ : Substance whose OEL is set based on non-carcinogenic health effects; see III.

## II. Occupational Exposure Limits Based on Biological Monitoring

### 1. Definition

Biological monitoring in the occupational setting consists of (1) measuring the concentration of a chemical substance or its metabolite(s) in biological specimens, and/or (2) determining early health effects by using biological specimens which are predictors or warning signs of the occurrence of adverse health effects.

Occupational Exposure Limit Based on Biological Monitoring (OEL-B) are defined as the reference values

to the data obtained by biological monitoring at or below (depending on agents, above) which the adverse health effects do not appear in most workers who are exposed to the chemical substances.

### 2. Characteristics of OEL-B

(1) In setting OEL-B, consideration is given to the exposure-effect and/or exposure-response relationships between biological monitoring values and health effects, or to the relationship between biological monitoring

values and OEL-Ms.

(2) There is a possibility that exposure concentration of chemical substances in the workplace will not closely associate with biological monitoring values due to various factors, e.g., intra- and inter-individual variation in metabolism, social habits such as smoking and alcohol consumption, working conditions, working time, skin absorption, use of personal protective equipment, and possible exposure to the substances outside the workplace. Biological monitoring values could exceed OEL-B even though exposure to the chemical substances is below OEL-M, and vice versa. Both OEL-M and

OEL-B must be satisfied at the workplace.

(3) Biological specimens should be collected at the time that is most likely to represent the particular exposure to the substances concerned, or at the time most likely to predict occurrence of the particular adverse health effects. Only biological monitoring values measured under this condition can be referred to OEL-B.

(4) OEL-B is applied to cases of single-substance absorption. For exposure to a mixture of substances, interactions in terms of absorption, metabolism, accumulation, excretion and health effects must also be considered.

**Table II-1.** Occupational exposure limits based on biological monitoring

Substance	Assay material	Parameter	OEL-B	Sampling time	Year of proposal
Acetone	urine	Acetone	40 mg/l	Within 2 h prior to end of shift	'01
Cobalt and inorganic compounds (except cobalt oxides)	blood	Cobalt	3 µg/l	Within 2 h prior to end of shift at end of work week	'05
	urine	Cobalt	35 µg/l		'05
Chlorobenzene†	urine	4-Chlorocatechol (hydrolysis)	140 mg/g-Cr	End of shift at end of work week	'07
3,3'-Dichloro-4,4'-diaminodiphenylmethane (MBOCA)	urine	total MBOCA	50 µg/g-Cr	End of shift at end of work week	'94
Dichloromethane	urine	Dichloromethane	0.2 mg/l	End of shift	'05
Hexane	urine	2,5-Hexanedione	3 mg/g-Cr	End of shift at end of work week	'94
	urine	2,5-Hexanedione	0.3 mg/g-Cr (without acid hydrolysis)	End of shift at end of work week	'94
Indium and compounds†	serum	Indium	3 µg/l	Not critical	'07
Lead and compounds (except alkyl lead compounds)	blood	Lead	40 µg/100 ml	Not critical	'94
	blood	Protoporphyrin	200 µg/100 ml-RBC 80 µg/100 ml-blood	Not critical (After one month or more since consecutive exposure)	'94
	urine	δ-Aminolevulinic acid	5 mg/l	Not critical (After one month or more since consecutive exposure)	'94
Mercury and compounds (except alkyl mercury compounds)	urine	total inorganic mercury	35 µg/g-Cr	Not critical	'93
Methylethylketone	urine	Methylethylketone	5 mg/l	End of shift or A few hours after high exposure	'06
Methyl isobutyl ketone†	urine	Methyl isobutyl ketone	1.7 mg/l	End of shift	'07
Polychlorobiphenyls (PCB)	blood	total PCB	25 µg/l	Not critical	'06
Styrene†	urine	Mandelic acid + Phenylglyoxylic acid	430 mg/l	End of shift at end of work week	'07
	blood	Styrene	0.2 mg/l	End of shift at end of work week	'07
Toluene	blood	Toluene	0.6 mg/l	Within 2 h prior to end of shift at end of work week	'99
	urine	Toluene	0.06 mg/l		'99
Trichloroethylene	urine	total trichloro-compounds	150 mg/l	Within 2 h prior to end of shift at end of work week	'99
	urine	Trichloroethanol	100 mg/l		'99
Xylene	urine	Trichloroacetic acid	50 mg/l	End of shift at end of work week	'05
	urine	total (o-, m-, p-) methylhippuric acid	800 mg/l		

†: Provisional.



### III. Occupational Carcinogens

JSOH classifies the occupational carcinogens based primarily on the epidemiological evidences\*, but the results of the animal experiments and their extrapolation to human are also considered. The classification is made by strength of the evidence, but does not reflect the carcinogenic potency.

JSOH considers that the classification of occupational carcinogens proposed by the International Agency for Research on Cancer (IARC) is appropriate in principle. JSOH also discussed the classification of several chemical substances based on other information sources and finalized the list of occupational carcinogens in Table III-1. *Group 1* includes the substances which are carcinogenic to humans. *Group 2* indicates the substances which are probably or possibly carcinogenic to humans, classifying them into two sub-groups on the basis of degree of evidence: *Group 2A* is assigned to the substances with more sufficient evidence (probably carcinogenic to humans), *Group 2B* to those with less (possibly carcinogenic to humans).

Only when scientifically reasonable information is

available, JSOH will estimate a reference value corresponding to an individual excess lifetime risk of cancer due to exposure to a Group I carcinogen, and show it in Table III-2. JSOH does not recommend either the reference value as a safety exposure level or the individual excess lifetime risk as an acceptable risk level. The reference value should be applied only by experts well-trained and well-experienced in occupational health to avoid or minimize the risk of occupational cancer.

The occupational carcinogens may have OEL in Table I-1. These values must be used with caution. Some substances had epidemiological or experimental evidences that carcinogenicity was observed only at significantly higher concentrations than those for non-carcinogenic health effects, but the others did not. For the latter case, the substance is indicated as  $\psi$  in Table I-1\*\*.

\*, Epidemiological evidences include serum epidemiology and molecular epidemiology

\*\*, See Table I-1 for Group 1 carcinogens. Evaluation in progress for Group 2 carcinogens.

**Table III-1.** Occupational carcinogens#

<i>Group 1</i>	4-Aminobiphenyl, Arsenic and compounds*, Asbestos, Benzene, Benzidine, Benzotrchloride, Bis (chloromethyl) ether, 1,3-Butadiene, Cadmium and compounds*, Chromium (VI) compounds*, Coal-tar pitch volatiles, Coal-tars, Erionite, Ethylene oxide, Mineral oils (untreated and mildly treated), 2-Naphthylamine, Nickel compounds (except Ni metal)*, Silica (crystalline), Soots, Sulphur dichloroethyl, Talc containing asbestiform fibers, 2,3,7,8-Tetrachlorodibenzo- <i>p</i> -dioxin, Vinyl chloride, Wood dust
<i>Group 2A</i>	Acrylamide, Acrylonitrile, Benzal chloride, Benzo [a] pyrene, Benzyl chloride, Beryllium and compounds*, Chloromethyl methyl ether (technical grade), 4-Chloro- <i>o</i> -toluidine, Creosotes, 1,2-Dibromoethane, 3,3'-Dichloro-4,4'-diaminodiphenylmethane (MBOCA), Diethyl sulphate, Dimethyl sulphate, Dimethylcarbamoyl chloride, Direct Black 38, Direct Blue 6, Direct Brown 95, Epichlorohydrin, Formaldehyde, Glycidol, Polychlorinated biphenyls (PCB), Styrene oxide, <i>o</i> -Toluidine, 1,2,3-Trichloropropane, Tris (2,3-dibromopropyl) phosphate, Vinyl bromide, Vinyl fluoride
<i>Group 2B</i>	Acetamide, Acetaldehyde, <i>o</i> -Aminoazotoluene, <i>p</i> -Aminoazobenzene, Amitrole, Antimony trioxide, <i>o</i> -Anisidine, Auramine (technical grade), Benzyl violet 4B, 2,2-Bis (bromomethyl) propane-1,3-diol, Bitumens, Bromodichloromethane, $\beta$ -Butyrolactone, Carbon black, Carbon tetrachloride, Catechol, Chlordane, Chlordecone (Kepone), Chlorendic acid, Chlorinated paraffins, <i>p</i> -Chloroaniline, Chloroform, 1-Chloro-2-methylpropene, 3-Chloro-2-methylpropene, Chlorophenoxy acetic acid herbicides*, <i>p</i> -Chloro- <i>o</i> -phenylenediamine, Chloroprene, Chlorothalonil, CI acid red 114, CI basic red 9, CI direct blue 15, Citrus red No. 2, Cobalt and compounds*, <i>p</i> -Cresidine, <i>N,N'</i> -Diacetyl benzidine, 2,4-Diaminoanisole, 4,4'-Diaminodiphenyl ether, 2,4-Diaminotoluene, 1,2-Dibromo-3-chloropropane, 2,3-Dibromopropan-1-ol, <i>p</i> -Dichlorobenzene, 3,3'-Dichlorobenzidine, 3,3'-Dichloro-4,4'-diaminodiphenyl ether, 1,2-Dichloroethane, Dichloromethane, 1,3-Dichloropropane (technical grade), Dichlorvos, Diepoxybutane, Di (2-ethylhexyl) phthalate, 1,2-Diethylhydrazine, Diglycidyl resorcinol ether, Diisopropyl sulfate, <i>p</i> -Dimethylaminoazobenzene, 2,6-Dimethylaniline, 3,3'-Dimethylbenzidine ( <i>o</i> -Tolidine), <i>N,N</i> -Dimethylformamide, 1,1-Dimethylhydrazine, 3,3'-Dimethoxybenzidine ( <i>o</i> -Dianisidine), 2,4-(or 2,6-) Dinitrotoluene, 1,4-Dioxane, Disperseblue 1, DDT, 1,2-Epoxybutane, Ethyl acrylate, Ethylbenzene, Ethyl methanesulphonate, Ethylene dibromide, Ethylene thiourea, Ethylenimine (2-Formylhydrazino)-4-(5-nitro-2-furyl)thiazole, Furan, Gasoline, Glycidaldehyde, Hexachlorocyclohexanes, HC blue No. 1, Heptachlor, Hexamethylphosphoramide, Hydrazine, Isoprene, Lead and compounds (inorganic)*, Magenta (containing CI basic red 9), Man-made mineral fibers (Ceramic fibers, Micro glass fibers), 2-Methylaziridine (Propylene imine), 4,4'-Methylene bis (2-methylaniline), 4,4'-Methylenedianiline, Methyl mercuries, 2-Methyl-1-nitroanthraquinone, <i>N</i> -Methyl- <i>N</i> -nitrosourethane, Mirex, Nickel (metal), 2-Nitroanisole, Nitrobenzene, Nitrioltriacetic acid and its salts, Nitrogen mustard- <i>N</i> -oxide, 5-Nitroacenaphthene, Nitromethane, 2-Nitropropane, <i>N</i> -Nitrosodiethanolamine, <i>N</i> -Nitrosomorpholine, Oil orange SS, Phenyl glycidyl ether, Polychlorinated biphenyls, Polychlorophenols (technical grades) Ponceau 3R, Ponceau MX, 1,3-Propane sultone, $\beta$ -Propiolactone, Propylene oxide, Styrene, Tetrachloroethylene, Tetrafluoroethylene, Tetranitromethane 4,4'-Thiodianiline, Thiourea, Toluene diisocyanates, Trichloroethylene, Trypane blue, Urethane, Vinyl acetate 4-Vinylcyclohexene, 4-Vinylcyclohexene diepoxide

\*; Evaluation does not necessarily apply to all individual chemicals within the group.

#; Reevaluation in progress by carcinogen classification subcommittee.

**Table III-2.** Reference values corresponding to an individual excess lifetime risk of cancer

Substance	Individual excess lifetime risk of cancer	Reference value	Method of estimation	Year of estimation	
Arsenic and compounds (as As)	10 <sup>-3</sup>	3 µg/m <sup>3</sup>	Average relative risk model	'00	
	10 <sup>-4</sup>	0.3 µg/m <sup>3</sup>			
Asbestos	chrysotile	10 <sup>-3</sup>	Average relative risk model	'00	
		10 <sup>-4</sup>			0.15 fibers/ml
	containing asbestos fibers other than chrysotile	10 <sup>-3</sup>			0.015 fibers/ml
		10 <sup>-4</sup>			0.03 fibers/ml
Benzene	10 <sup>-3</sup>	1 ppm	Average relative risk model	'97	
	10 <sup>-4</sup>	0.1 ppm			

#### IV. Occupational Sensitizers

This list of occupational sensitizers is recommended for the airway and skin (Table IV-1). The sensitizers are classified into Group 1 substances which induce allergic reactions in humans and Group 2 substances which

probably induce allergic reactions in humans.

Recommendation of occupational exposure limits for the occupational sensitizers does not necessarily consider either prevention of sensitization or allergic reaction.

**Table IV-1.** Occupational sensitizers

Airway	
<i>Group 1</i>	
Beryllium*, Cobalt*, Colophony (Rosin), Diphenylmethane-4,4'-diisocyanate (MDI), Glutaraldehyde, Hexane-1,6-diisocyanate, Methyltetrahydrophthalic anhydride, Phthalic anhydride, Platinum*, Rhodium†, Toluene diisocyanates, Trimellitic anhydride	
<i>Group 2</i>	
Chromium*, Ethylenediamine, Formaldehyde, Maleic anhydride, Methyl methacrylate, Nickel*, Piperazine	
Skin	
<i>Group 1</i>	
Chromium*, Cobalt*, Colophony (Rosin), Ethylenediamine, Formaldehyde, Glutaraldehyde, Mercury*, Nickel*, <i>o</i> -Phenylenediamine, <i>m</i> -Phenylenediamine, <i>p</i> -Phenylenediamine, Platinum*, Rhodium†	
<i>Group 2</i>	
Benzofuran*, Benzoyl peroxide, Beryllium*, Butyl acrylate, Copper*, Dibutyl phthalate, Dichloropropane, Ethylene oxide, Hydrazine*, Hydroquinone, Iodine*, Maleic anhydride, Methyl acrylate, Methyl methacrylate, Polyvinyl chloride, Resorcinol, Toluene diisocyanates, Turpentine	

\*: Evaluation does not necessarily apply to all individual chemicals within the group.

†: Provisional.

#### V. Occupational Exposure Limits for Continuous or Intermittent Noise

Occupational exposure limits (OELs) for continuous or intermittent noise exposure are recommended as follows to protect against noise-induced hearing loss.

##### 1. OELs for continuous or intermittent noise

Values in Fig. V-1 or Table V-1 show OELs, at or below which noise-induced permanent threshold shift (NIPTS) is expected to be below 10 dB at or below a frequency of 1 kHz, below 15 dB at 2 kHz, and below 20 dB at or more than 3 kHz after more than 10 years of continuous or intermittent noise exposure for 8 hours a day in most workers.

##### 2. Applicable noise

OELs can be applied to wide- and narrow-band noise with band width below 1/3 octave. OELs are temporarily applicable to pure tones regarded as narrow-band noise. Impulsive or impact noise is excluded from the application (see Section VI).

##### 3. Application method

(1) In the case of continuous noise exposure throughout the work-time, OELs corresponding to the exposure duration should be taken from Fig. V-1 or Table V-1.

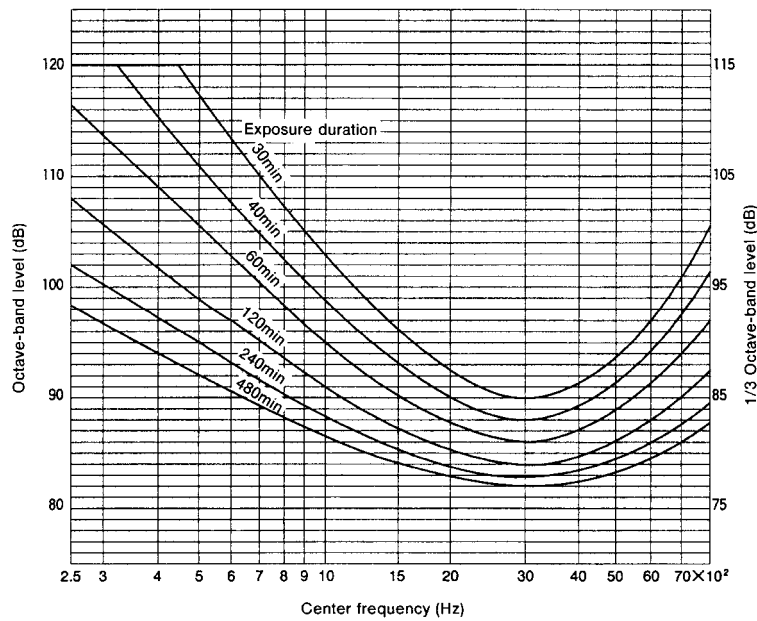


Fig. V-1. Occupational exposure limits for continuous or intermittent noise.

Table V-1. Occupational exposure limits for continuous or intermittent noise

Center frequency (Hz)	OELs by octave-band level (dB)					
	480 min	240 min	120 min	60 min	40 min	30 min
250	98	102	108	117	120	120
500	92	95	99	105	112	117
1000	86	88	91	95	99	103
2000	83	84	85	88	90	92
3000	82	83	84	86	88	90
4000	82	83	85	87	89	91
8000	87	89	92	97	101	105

(2) In the case of intermittent noise exposure, an equivalent exposure duration is considered to be the sum of exposure duration throughout the work-time minus an effective resting duration, and OELs corresponding to the equivalent exposure duration should be taken from Fig. V-1 or Table V-1. The effective resting duration is the duration when the noise levels are below 80 dB.

(3) In the case that noise is analyzed by an octave band filter, OELs corresponding to exposure duration are the values at the left ordinate of Fig. V-1 or in Table V-1. In the case that noise is analyzed by a narrower band filter with a band width of 1/3 octave or less, OELs are the values at the right ordinate of Fig. V-1 or the values subtracted 5 from the figures in Table V-1.

Table V-2. Occupational exposure limits for continuous or intermittent noise by A-weighted sound pressure

Exposure duration (hours-minutes)	OELs by A-weighted sound pressure (dBA)	Exposure duration (hours-minutes)	OELs by A-weighted sound pressure (dBA)
24-00	80	2-00	91
20-09	81	1-35	92
16-00	82	1-15	93
12-41	83	1-00	94
10-04	84	0-47	95
8-00	85	0-37	96
6-20	86	0-30	97
5-02	87	0-23	98
4-00	88	0-18	99
3-10	89	0-15	100
2-30	90		

**4. OELs by A-weighted sound pressure level**

Basically, frequency analysis of noise is recommended. In the case of evaluating with an A-weighted sound pressure level, OELs in Table V-2 should be used.

**5. Noise measurement**

For measurement methods, refer to ‘Japan Industrial Standard (JIS) Z 8731-1983 Methods of Measurement and Description of A-weighted Sound Pressure Level’.

### VI-i. Occupational Exposure Limits for Impulsive or Impact Noise

Occupational Exposure Limits (OELs) for impulsive or impact noise exposure in the workplace are recommended as follows to protect against noise-induced hearing loss.

#### 1. OELs for impulsive or impact noise

In the case that total frequency of exposure to impulsive or impact noise is at or below 100 times a day, the peak sound pressure level shown in Fig. VI-1 is recommended as the OEL corresponding to the duration of impulsive or impact noise explained in “3. Measurement method”.

In the case that total number of exposures to impulsive or impact noise is above 100 times a day, the sum of the peak sound pressure level in Fig. VI-1 with the adjustment value in Fig. VI-2 to correct the difference of exposure frequency is recommended as OEL. At or below these limits, NIPTS is expected to be below 10 dB at or below a frequency of 1 kHz, below 15 dB at 2 kHz, and below 20 dB at or more than 3 kHz after more than 10 years of impulsive or impact noise exposure in

most workers.

#### 2. Applicable noise

These OELs are applicable to impulsive or impact noise only. In the case of mixed exposure to both impulsive or impact noise and continuous or intermittent noise, both OELs should be satisfied.

#### 3. Measurement method

Impulsive or impact noises are classified by their oscilloscope-measured wave forms into two groups, as shown in Fig. VI-3 (A) and (B). In Fig. VI-3 (A), A duration is defined as the duration between  $T_0$  and  $T_D$ . In Fig. VI-3 (B), B duration is defined as either the duration between  $T_0$  and  $T_D$  if no reflection sound exists, or the sum of durations between  $T_0$  and  $T_D'$  and between  $T_0'$  and  $T_D''$  if reflection sound dose exist. In the case of (B),  $T_D'$  or  $T_D''$  is determined by the intersection of a wave envelope indicating sound pressure change with a line indicating a sound pressure 20 dB below peak sound pressure. This method is also applicable in the case of multiple reflection sounds.

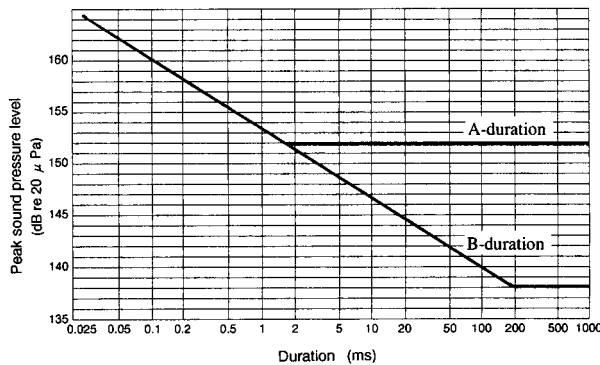


Fig. VI-1. Occupational exposure limits for impulsive or impact noise.

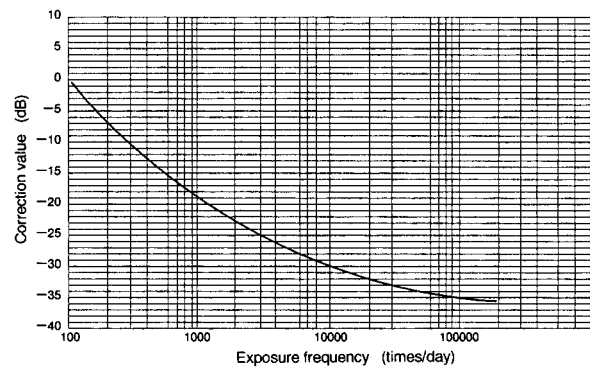


Fig. VI-2. Correction values corresponding to exposure frequency a day.

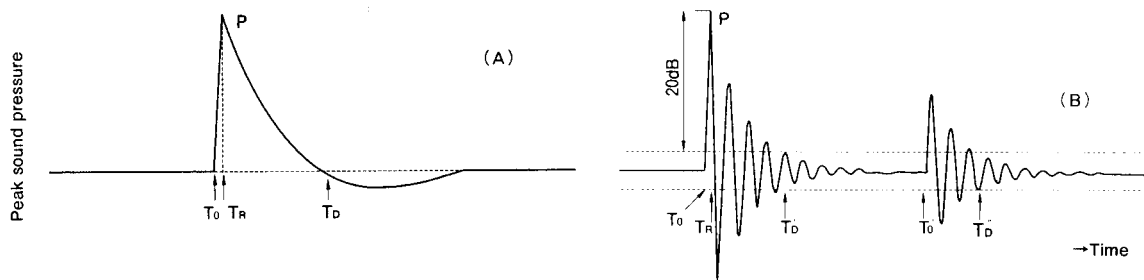


Fig. VI-3. Measurement for impulsive or impact noise.

**VI-ii. OEL for Impulsive or Impact Noise by A-Weighted Sound Pressure Level**

**1. Occupational exposure limit (OEL)**

In the case that total frequency of exposure to impulsive or impact noise is at or below 100 times a day, OEL is 120 dB at A-weighted sound pressure level. In the case that total frequency of exposure to impulsive or impact noise is above 100 times a day, the adjustment value in Fig. VI-2 corresponding to frequency of exposure should be added for OEL determination.

**2. Application**

OEL is applicable to type B wave in Fig. VI-3 only.

**3. Measurement method**

Maximum values should be measured by the Sound Level Meter (JIS C 1502) or the Precision Sound Level Meter (JIS C 1505) with use of an A-weighted frequency response and fast dynamic characteristic.

**VII. Occupational Exposure Limits for Heat Stress**

**Table VII-1.** Occupational exposure limits for heat stress

Work Load	OELs	
	WBGT (°C)	CET** (°C)
RMR* ~1 (Very light, ~130 kcal/h)	32.5	31.6
RMR ~2 (Light, ~ 190 kcal/h)	30.5	30.0
RMR ~3 (Moderate, ~ 250 kcal/h)	29.0	28.8
RMR ~4 (Moderate, ~ 310 kcal/h)	27.5	27.6
RMR ~5 (Heavy, ~ 370 kcal/h)	26.5	27.0

\*: Relative Metabolic Rate (RMR)=(Metabolic energy expenditure during work—Metabolic energy expenditure at rest)/Basal metabolic rate corresponding to the work period.

\*\* : Corrected effective temperature.

**VIII. Occupational Exposure Limits for Cold Stress**

**Table VIII-1.** Occupational exposure limits for cold stress (Maximal work duration in a 4-hour shift)

Temperature	Work load	Maximal work duration (min)
-10 ~ -25°C	Light work (RMR~2)	~ 50
	Moderate work (RMR~3)	~ 60
-26 ~ -40°C	Light work (RMR~2)	~ 30
	Moderate work (RMR~3)	~ 45
-41 ~ -55°C	Light work (RMR~2)	~ 20
	Moderate work (RMR~3)	~ 30

Note: Wind speed is assumed to be calm, less than 0.5 m/sec. Thirty-minute warm-up break must be set every work unit.

**IX. Occupational Exposure Limits for Whole Body Vibration**

**Table IX-1.** Occupational exposure limits for longitudinal and transverse vibration

Freq.*	Acceleration of longitudinal vibration m/s <sup>2</sup>							Acceleration of transverse vibration m/s <sup>2</sup>						
	8 h	4 h	2.5 h	1 h	25 min	16 min	1 min	8 h	4 h	2.5 h	1 h	25 min	16 min	1 min
1.0	0.63	1.06	1.40	2.36	3.55	4.25	5.60	0.224	0.355	0.50	0.85	1.25	1.50	2.0
1.25	0.56	0.95	1.26	2.12	3.15	3.15	5.00	0.224	0.355	0.50	0.85	1.25	1.50	2.0
1.6	0.50	0.85	1.12	1.90	2.80	3.35	4.50	0.224	0.355	0.50	0.85	1.25	1.50	2.0
2.0	0.45	0.75	1.00	1.70	2.50	3.00	4.00	0.224	0.355	0.50	0.85	1.25	1.50	2.0
2.5	0.40	0.67	0.90	1.50	2.24	2.65	3.55	0.280	0.450	0.63	1.06	1.6	1.9	2.5
3.15	0.355	0.60	0.80	1.32	2.00	2.35	3.15	0.355	0.560	0.8	1.32	2.0	2.36	3.15
4.0	0.315	0.53	0.71	1.18	1.80	2.12	2.80	0.450	0.710	1.0	1.70	2.5	3.0	4.0
5.0	0.315	0.53	0.71	1.18	1.80	2.12	2.80	0.560	0.900	1.25	2.12	3.15	3.75	5.0
6.3	0.315	0.53	0.71	1.18	1.80	2.12	2.80	0.710	1.12	1.6	2.65	4.0	4.75	6.3
8.0	0.315	0.53	0.71	1.18	1.80	2.12	2.80	0.900	1.40	2.0	3.35	5.0	6.0	8.0
10.0	0.40	0.67	0.90	1.50	2.24	2.65	3.55	1.12	1.80	2.5	4.25	6.3	7.5	10
12.5	0.50	0.85	1.12	1.90	2.80	3.35	4.50	1.40	2.24	3.15	5.30	8.0	9.5	12.5
16.0	0.63	1.06	1.40	2.36	3.55	4.25	5.60	1.80	2.80	4.0	6.70	10	11.8	16
20.0	0.80	1.32	1.80	3.00	4.50	5.30	7.10	2.24	3.55	5.0	8.5	12.5	15	20
25.0	1.0	1.70	2.24	3.75	5.60	6.70	9.00	2.80	4.50	6.3	10.6	16	19	25
31.5	1.25	2.12	2.80	4.75	7.10	8.50	11.2	3.55	5.60	8.0	13.2	20	23.6	31.5
40.0	1.60	2.65	3.55	6.00	9.00	10.6	14.0	4.50	7.10	10.0	17.0	25	30	40
50.0	2.0	3.35	4.50	7.50	11.2	13.2	18.0	5.60	9.00	12.5	21.2	31.5	37.5	50
63.0	2.5	4.25	5.60	9.50	14.0	17.0	22.4	7.10	11.2	16.0	26.5	40	45.7	63
80.0	3.15	5.30	7.10	11.8	18.0	21.2	28.0	9.00	14.0	20	33.5	50	60	80

\*: Center frequency (Hz) of 1/3 octave-band.

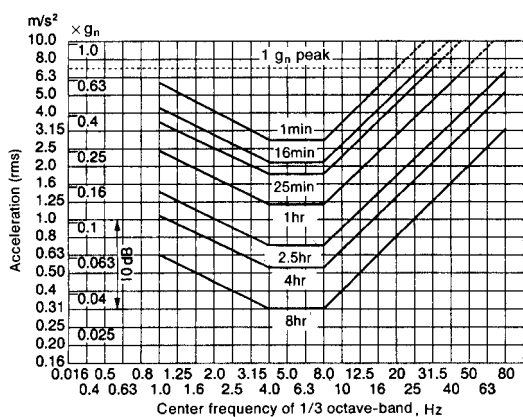


Fig. IX-1. Occupational exposure limits for longitudinal vibration.

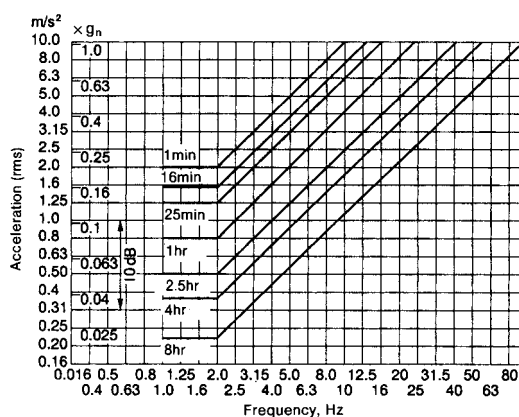


Fig. IX-2. Occupational exposure limits for transverse vibration.

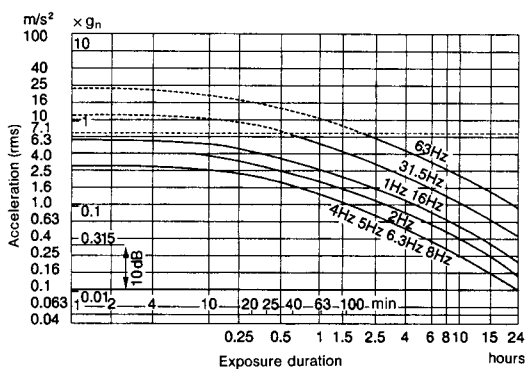


Fig. IX-3. Occupational exposure limits for longitudinal vibration and exposure duration.

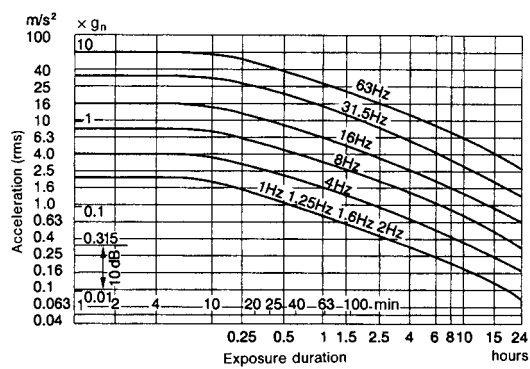


Fig. IX-4. Occupational exposure limits for transverse vibration.

### X. Occupational Exposure Limits for Hand-Arm Vibration

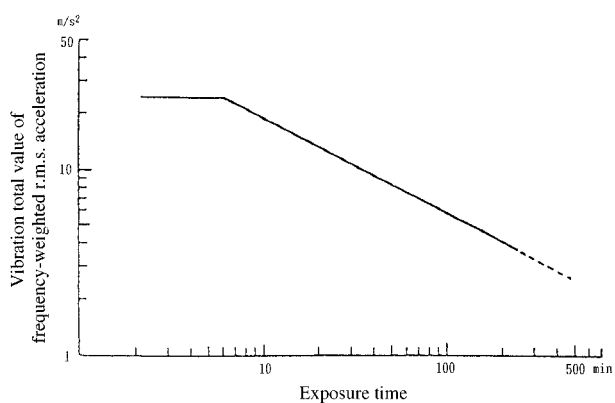


Fig. X-1. Occupational exposure limits for hand-arm vibration using vibration total value of frequency-weighted r.m.s. acceleration.

Table X-1. Occupational exposure limits for hand-arm vibration using vibration total value of frequency-weighted r.m.s. acceleration

Exposure time (min)	Vibration total value of frequency-weighted r.m.s. acceleration (m/s <sup>2</sup> rms)
≤6	25.0
10	19.4
15	15.8
30	11.2
60	7.92
90	6.47
120	5.60
150	5.01
180	4.57
210	4.23
240	3.96
270	3.73
300	3.54
330	3.38
360	3.23
390	3.11
420	2.99
450	2.89
480	2.80

## XI. Occupational Exposure Limits for Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz)

**Table XI-1.** Static magnetic fields  
(Frequency: 0~0.25 Hz)

	OEL-M	OEL-C
Head, trunk	200 mT ( $1.63 \times 10^5 \text{ Am}^{-1}$ )	2 T
Extremities	500 mT ( $4.08 \times 10^5 \text{ Am}^{-1}$ )	5 T

**Table XI-2.** Low frequency time-varying electric and magnetic fields  
(Frequency: 0.25 Hz~100 kHz)

Frequency (f)	EF	Magnetic flux density	MF
0.25~1.0 Hz		50/f mT	$4.08 \times 10^4/f \text{ Am}^{-1}$
1.0~25 Hz	20 kVm <sup>-1</sup>	50/f mT	$4.08 \times 10^4/f \text{ Am}^{-1}$
25~500 Hz	500/f kVm <sup>-1</sup>	50/f mT	$4.08 \times 10^4/f \text{ Am}^{-1}$
500~814 Hz	500/f kVm <sup>-1</sup>	0.1 mT	81.4 Am <sup>-1</sup>
0.814~60 kHz	614 Vm <sup>-1</sup>	0.1 mT	81.4 Am <sup>-1</sup>
60~100 kHz	614 Vm <sup>-1</sup>	6/f mT	4880/f Am <sup>-1</sup>

EF: electric field. MF: magnetic field.

**Table XI-3.** Radio-frequency electromagnetic fields  
(Frequency: 0.1 MHz~300 GHz)

Frequency (f)	EF	Magnetic flux density	MF	Power density
0.1~3.0 MHz	614 Vm <sup>-1</sup>	6/f μT	4.88/f Am <sup>-1</sup>	
3.0~30 MHz	1842/f Vm <sup>-1</sup>	6/f μT	4.88/f Am <sup>-1</sup>	
30~400 MHz	61.4 Vm <sup>-1</sup>	0.2 μT	0.163 Am <sup>-1</sup>	10 Wm <sup>-2</sup>
400~2000 MHz	$3.07f^{0.5} \text{ Vm}^{-1}$	$0.01f^{0.5} \mu\text{T}$	$8.14f^{0.5} \text{ mAm}^{-1}$	$f/40 \text{ Wm}^{-2}$
2~300 GHz	137 Vm <sup>-1</sup>	0.447 μT	0.364 Am <sup>-1</sup>	50 Wm <sup>-2</sup>

EF: electric field. MF: magnetic field.

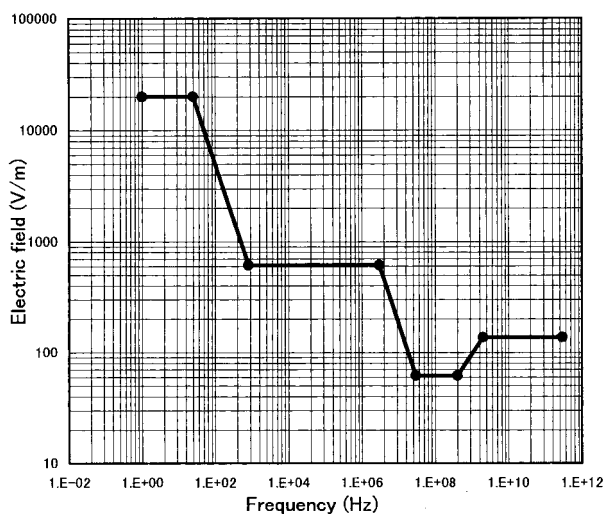


Fig. XI-1. OEL-Ms of time-varying electric fields

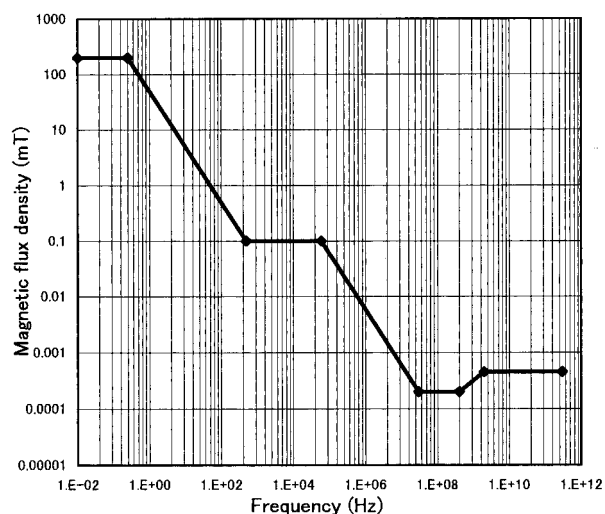


Fig. XI-2. OEL-Ms of static and time-varying magnetic fields

## XII. Occupational Exposure Limit for Ultraviolet Radiation

Occupational Exposure Limit for ultraviolet radiation with wavelengths between 180 nm and 400 nm is recommended to be 30 J/m<sup>2</sup> as effective irradiance integrated over 8 hours a day, to avoid acute effects on eye (cornea or conjunctiva) or the skin. This value is not applicable to laser radiation.

Effective irradiance is defined as follows:

$$E_{eff} = \sum_{\lambda=180\text{ nm}}^{400\text{ nm}} E_{\lambda} S(\lambda) \Delta\lambda$$

where:  $E_{eff}$  = effective irradiance

$E_{\lambda}$  = spectral irradiance at exposure

$S(\lambda)$  = relative spectral effectiveness (Table XII-1)

$\Delta\lambda$  = band width

Table XII-1. Ultraviolet radiation and relative spectral effectiveness

Wavelength (nm)	Relative spectral effectiveness	Wavelength (nm)	Relative spectral effectiveness	Wavelength (nm)	Relative spectral effectiveness
180	0.012	280	0.880	325	0.00050
190	0.019	285	0.770	328	0.00044
200	0.030	290	0.640	330	0.00041
205	0.051	295	0.540	333	0.00037
210	0.075	297	0.460	335	0.00034
215	0.094	300	0.300	340	0.00027
220	0.120	303	0.120	345	0.00023
225	0.150	305	0.060	350	0.00020
230	0.190	308	0.025	355	0.00016
235	0.230	310	0.015	360	0.00013
240	0.300	313	0.006	365	0.00011
245	0.360	315	0.003	370	0.000094
250	0.430	316	0.0023	375	0.000077
254	0.500	317	0.0020	380	0.000064
255	0.520	318	0.0016	385	0.000053
260	0.650	319	0.0012	390	0.000044
265	0.810	320	0.0010	395	0.000036
270	1.000	322	0.00067	400	0.000030
275	0.970	323	0.00054		



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