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Recommendation of Occupational Exposure Limits (2013–2014)

The Japan Society for Occupational Health **May, 14, 2013**

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 and ionizing 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 work-load. 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:

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

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^3			Airway	Skin	
Acetaldehyde [75-07-0]	CH_3CHO	50*	90*		2B			'90
Acetic acid [64-19-7]	CH_3COOH	10	25					'78
Acetic anhydride [108-24-7]	$(CH_3CO)_2O$	5*	21*					'90
Acetone [67-64-1]	CH_3COCH_3	200	470					'72
Acrylaldehyde [107-02-8]	CH_2=CHCHO	0.1	0.23					'73
Acrylamide [79-06-1]	CH_2=$CHCONH_2$	—	0.1	S	2A		2†	'04
Acrylonitrile [107-13-1]	CH_2=CHCN	2	4.3	S	2A$^\Psi$			'88
Allyl alcohol [107-18-6]	CH_2=$CHCH_2OH$	1	2.4	S				'78
2-Aminoethanol [141-43-5]	$H_2NCH_2CH_2OH$	3	7.5					'65
Ammonia [7664-41-7]	NH_3	25	17					'79
Aniline [62-53-3]	$C_6H_5NH_2$	1	3.8	S			1†	'88
o-Anisidine [90-04-0]	$H_3COC_6H_4NH_2$	0.1	0.5	S	2B			'96
p-Anisidine [104-94-9]	$H_3COC_6H_4NH_2$	0.1	0.5	S				'96
Antimony and compounds† (as Sb except Stibine) [7440-36-0]	Sb	—	0.1					('13)
Arsenic and compounds (as As) [7440-38-2]	As	(Table III-2)			1			'00
Arsine [7784-42-1]	AsH_3	0.01	0.032					'92
		0.1*	0.32*					
Benzene [71-43-2]	C_6H_6	(Table III-2)		S	1			'97
Beryllium and compounds (as Be) [7440-41-7]	Be	—	0.002		2A$^\Psi$	1	2	'63
Boron trifluoride [7637-07-2]	BF_3	0.3	0.83					'79
Bromine [7726-95-6]	Br_2	0.1	0.65					'64
Bromoform [75-25-2]	$CHBr_3$	1	10.3					'97
1-Bromopropane [106-94-5]	$CH_3CH_2CH_2Br$	0.5	2.5					'12
2-Bromopropane [75-26-3]	$CH_3CHBrCH_3$	1	5	S				'99
Buprofezin [69327-76-0]	$C_{16}H_{23}N_3OS$	—	2					'90
Butane (all isomers) [106-97-8]	C_4H_{10}	500	1,200					'88

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m^3			Airway	Skin	
1-Butanol [71-36-3]	$CH_3CH_2CH_2CH_2OH$	50*	150*	S				’87
2-Butanol [78-92-2]	$CH_3CH(OH)CH_2CH_3$	100	300					’87
Butyl acetate [123-86-4]	$CH_3COO(CH_2)_3CH_3$	100	475					’94
t-Butyl alcohol [75-65-0]	$(CH_3)_3COH$	50	150					’87
Butylamine [109-73-9]	$CH_3CH_2CH_2CH_2NH_2$	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]	$Ca(CN)_2$	—	5*	S				’01
Carbaryl [63-25-2]	$C_{12}H_{11}NO_2$	—	5	S				’89
Carbon dioxide [124-38-9]	CO_2	5,000	9,000					’74
Carbon disulfide [75-15-0]	CS_2	10	31	S				’74
Carbon monoxide [630-08-0]	CO	50	57					’71
Carbon tetrachloride [56-23-5]	CCl_4	5	31	S	2B			’91
Chlorine [7782-50-5]	Cl_2	0.5*	1.5*					’99
Chlorobenzene [108-90-7]	C_6H_5Cl	10	46					’93
Chlorodifluoromethane [75-45-6]	$CHClF_2$	1,000	3,500					’87
Chloroethane [75-00-3]	C_2H_5Cl	100	260					’93
Chloroform [67-66-3]	$CHCl_3$	3	14.7	S	2B			’05
Chloromethane [74-87-3]	CH_3Cl	50	100					’84
Chloromethyl methyl ether (technical grade) [107-30-2]	CH_3OCH_2Cl	—	—		2A			’92
Chloropicrin [76-06-2]	Cl_3CNO_2	0.1	0.67					’68
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)	$C_6H_4CH_3(OH)$	5	22	S				’86
Cyclohexane [110-82-7]	C_6H_{12}	150	520					’70
Cyclohexanol [108-93-0]	$C_6H_{11}OH$	25	102					’70
Cyclohexanone [108-94-1]	$C_6H_{10}O$	25	100					’70
Diazinon [333-41-5]	$C_{12}H_{21}N_2O_3PS$	—	0.1	S				’89
Diborane [19287-45-7]	B_2H_6	0.01	0.012					’96
Dibutyl phthalate [84-74-2]	$C_6H_4(COOC_4H_9)_2$	—	5				2	’96
o-Dichlorobenzene [95-50-1]	$C_6H_4Cl_2$	25	150					’94
p-Dichlorobenzene [106-46-7]	$C_6H_4Cl_2$	10	60		2B			’98
3,3’-Dichloro-4,4'-diaminodiphenylmethane (MBOCA) [101-14-4]	$CH_2(C_6H_3NH_2Cl)_2$	—	0.005	S	2A$^{\Psi}$			’12
Dichlorodifluoromethane [75-71-8]	CCl_2F_2	500	2,500					’87
1,1-Dichloroethane [75-34-3]	Cl_2CHCH_3	100	400					’93
1,2-Dichloroethane [107-06-2]	$ClCH_2CH_2Cl$	10	40		2B			’84
2,2'-Dichloroethyl ether [111-44-4]	$(ClCH_2CH_2)_2O$	15	88	S				’67
1,2-Dichloroethylene [540-59-0]	ClCH=CHCl	150	590					’70
Dichloromethane [75-09-2]	CH_2Cl_2	50	170	S	2B			’99
		100*	340*					
1,2-Dichloropropane† [78-87-5]	$ClCH_2CHClCH_3$	(Table I-2)						’13
2,2-Dichloro-1,1,1-trifluoroethane [306-83-2]	CF_3CHCl_2	10	62					’00
Diethylamine [109-89-7]	$(C_2H_5)_2NH$	10	30					’89
Di(2-ethylhexyl)phthalate [117-81-7]	$C_{24}H_{38}O_4$	—	5		2B			’95
Diethyl phthalate [84-66-2]	$C_6H_4(COOC_2H_5)_2$	—	5					’95

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m^3			Airway	Skin	
N,N-Dimethyl acetamide [127-19-5]	$(CH_3)_2NCOCH_3$	10	36	S				'90
Dimethylamine [124-40-3]	$(CH_3)_2NH$	10	18					'79
N,N-Dimethylaniline [121-69-7]	$C_6H_5N(CH_3)_2$	5	25	S				'93
N,N-Dimethylformamide (DMF) [68-12-2]	$(CH_3)_2NCHO$	10	30	S	2B			'74
Dimethyl sulfate [77-78-1]	$(CH_3)_2SO_4$	0.1	0.52	S	2A$^{\Psi}$			'80
1,2-Dinitrobenzene [528-29-0]	$C_6H_4(NO_2)_2$	0.15	1	S				'94
1,3-Dinitrobenzene [99-65-0]	$C_6H_4(NO_2)_2$	0.15	1	S				'94
1,4-Dinitrobenzene [100-25-4]	$C_6H_4(NO_2)_2$	0.15	1	S				'94
1,4-Dioxane [123-91-1]	$C_4H_8O_2$	10	36	S	2B			'84
Diphenylmethane-4,4'-diiso-cyanate (MDI) [101-68-8]	$CH_2(C_6H_4NCO)_2$	—	0.05			1		'93
Dusts		(Table I-3)						'80
Ethyl acetate [141-78-6]	$CH_3COOC_2H_5$	200	720					'95
Ethylamine [75-04-7]	$C_2H_5NH_2$	10	18					'79
Ethyl benzene [100-41-4]	$C_6H_5C_2H_5$	50	217		2B			'01
Ethylenediamine [107-15-3]	$H_2NCH_2CH_2NH_2$	10	25	S		2	2	'91
Ethylene glycol monoethyl ether [110-80-5]	$C_2H_5OCH_2CH_2OH$	5	18	S				'85
Ethylene glycol monoethyl ether acetate [111-15-9]	$C_2H_5OCH_2CH_2OCOCH_3$	5	27	S				'85
Ethylene glycol monomethyl ether [109-86-4]	$CH_3OCH_2CH_2OH$	0.1	0.31	S				'09
Ethylene glycol monomethyl ether acetate [110-49-6]	$CH_3OCH_2CH_2OCOCH_3$	0.1	0.48	S				'09
Ethylene oxide [75-21-8]	C_2H_4O	1	1.8		1$^{\Psi}$		2	'90
Ethylenimine [151-56-4]	C_2H_5N	0.5	0.88	S	2B			('90)
Ethyl ether [60-29-7]	$(C_2H_5)_2O$	400	1,200					('97)
Etofenprox [80844-07-1]	$C_{25}H_{28}O_3$	—	3					'95
Fenitrothion [122-14-5]	$C_9H_{12}NO_5PS$	—	1	S				'81
Fenobucarb [3766-81-2]	$C_{12}H_{17}NO_2$	—	5	S				'89
Fenthion [55-38-9]	$C_{10}H_{15}O_3PS_2$	—	0.2	S				'89
Flutolanil [66332-96-5]	$C_{17}H_{16}NO_2F_3$	—	10					'90
Formaldehyde [50-00-0]	HCHO	0.1 0.2*	0.12 0.24*		2A	2	1	'07
Formic acid [64-18-6]	HCOOH	5	9.4					'78
Fthalide [27355-22-2]	$C_8H_2Cl_4O_2$	—	10					'90
Furfural [98-01-1]	$C_5H_4O_2$	2.5	9.8	S				('89)
Furfuryl alcohol [98-00-0]	$C_4H_3OCH_2OH$	5	20					'78
Gasoline [8006-61-9]		100[b]	300[b]		2B			'85
Glutaraldehyde [111-30-8]	$OHC(CH_2)_3CHO$	0.03*				1	1	'06
Heptane [142-82-5]	$CH_3(CH_2)_5CH_3$	200	820					'88
Hexachlorobutadiene[†] [87-68-3]	$Cl_2C=C_2Cl_2=CCl_2$	(Table I-2)		S				'13
Hexane [110-54-3]	$CH_3(CH_2)_4CH_3$	40	140	S				'85
Hexane-1,6-diisocyanate (HDI) [822-06-0]	$OCN(CH_2)_6NCO$	0.005	0.034			1		'95
Hydrazine (anhydrous) and Hydrazine hydrate [302-01-2/7803-57-8]	N_2H_4 and $N_2H_4{\cdot}H_2O$	0.1	0.13 and 0.21	S	2B		1	'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_2	0.05	0.17					'63
Hydrogen sulfide [7783-06-4]	H_2S	5	7					'01

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m^3			Airway	Skin	
Indium and compounds [7440-74-6]	In	(Table II-1)			2A†			'07
Iodine [7553-56-2]	I_2	0.1	1				2	'68
Isobutyl alcohol [78-83-1]	$(CH_3)_2CHCH_2OH$	50	150					'87
Isopentyl alcohol [123-51-3]	$(CH_3)_2CHCH_2CH_2OH$	100	360					'66
Isopropyl alcohol [67-63-0]	$CH_3CH(OH)CH_3$	400*	980*					'87
Isoprothiolane [50512-35-1]	$C_{12}H_{18}O_4S_2$	—	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]	$C_{10}H_{16}O_6PS_2$	—	10	S				'89
Maleic anhydride [108-31-6]	$C_4H_2O_3$	0.1	0.4			2	2	'00
		0.2*	0.8*					
Manganese and compounds (as Mn except organic compounds) [7439-96-5]	Mn		0.2					'08
Man-made mineral fibers								'03
Ceramic fibers**, Micro glass fibers**		—	—		2B			
Continuous filament glass fibers**		1 (fiber/m*l*)						
Glass wool fibers**, Rock wool fibers**, Slag wool fibers**		1 (fiber/m*l*)						
Mepronil [55814-41-0]	$C_{17}H_{19}NO_2$	—	5					'90
Mercury vapor [7439-97-6]	Hg	—	0.025					'98
Methacrylic acid [79-41-4]	$CH_2=C(CH_3)COOH$	2	7.0					'12
Methanol [67-56-1]	CH_3OH	200	260	S				'63
Methyl acetate [79-20-9]	CH_3COOCH_3	200	610					'63
Methyl acrylate [96-33-3]	$CH_2=CHCOOCH_3$	2	7				2	'04
Methylamine [74-89-5]	CH_3NH_2	10	13					'79
Methyl bromide [74-83-9]	CH_3Br	1	3.89	S				'03
Methyl n-butyl ketone [591-78-6]	$CH_3CO(CH_2)_3CH_3$	5	20	S				'84
Methylcyclohexane [108-87-2]	$CH_3C_6H_{11}$	400	1,600					'86
Methylcyclohexanol [25639-42-3]	$CH_3C_6H_{10}OH$	50	230					'80
Methylcyclohexanone [1331-22-2]	$CH_3C_6H_9O$	50	230	S				'87
Methyl methacrylate [80-62-6]	$CH_2=C(CH_3)COOCH_3$		8.3			2	2	'12
4,4'-Methylenedianiline [101-77-9]	$CH_2(C_6H_4NH_2)_2$	—	0.4	S				
Methyl ethyl ketone [78-93-3]	$C_2H_5COCH_3$	200	590					'64
Methyl isobutyl ketone [108-10-1]	$CH_3COCH_2CH(CH_3)_2$	50	200					'84
N-Methyl-2-pyrrolidone [872-50-4]	C_5H_9NO	1	4	S				'02
Methyltetrahydrophthalic anhydride [11070-44-3]	$CH_3C_6H_7(CO)_2O$	0.007	0.05			1		'02
		0.015*	0.1*					
Nickel [7440-02-0]	Ni	—				2	1	'11
Nickel carbonyl [13463-39-3]	$Ni(CO)_4$	0.001	0.007					'66
Nickel compounds (Total dusts) (as Ni, except Nickel carbonyl and Nickel smelting dust)		(Table III-1)	(Table III-2)					
		(Table III-1)			2B			'11
Nickel compounds, soluble			0.01					'11
Nickel compounds, not soluble			0.1					'11
Nitric acid [7697-37-2]	HNO_3	2	5.2					'82
p-Nitroaniline [100-01-6]	$H_2NC_6H_4NO_2$	—	3	S				'95
Nitrobenzene [98-95-3]	$C_6H_5NO_2$	1	5	S	2B			('88)
p-Nitrochlorobenzene [100-00-5]	$C_6H_4ClNO_2$	0.1	0.64	S				'89
Nitrogen dioxide [10102-44-0]	NO_2	(pending)						'61
Nitroglycerin [55-63-0]	$(O_2NOCH_2)_2CHONO_2$	0.05*	0.46*	S				'86
Nitroglycol [628-96-6]	$O_2NOCH_2CH_2ONO_2$	0.05	0.31	S				'86
Nonane [111-84-2]	$CH_3(CH_2)_7CH_3$	200	1,050					'89
Octane [111-65-9]	$CH_3(CH_2)_6CH_3$	300	1,400					'89
Oil mist, mineral		–	3		1Ψ			'77

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m^3			Airway	Skin	
Ozone [10028-15-6]	O_3	0.1	0.2					’63
Parathion [56-38-2]	$(C_2H_5O)_2PSOC_6H_4NO_2$	—	0.1	S				(’80)
Pentachlorophenol [87-86-5]	C_6Cl_5OH	—	0.5	S				(’89)
Pentane [109-66-0]	$CH_3(CH_2)_3CH_3$	300	880					’87
Pentyl acetate, All isomers [628-63-7; 123-92-2; 626-38-0; 620-11-1; 625-16-1; 624-41-9; 926-41-0]	$CH_3COOC_5H_{11}$	50 100*	266.3 532.5*					’08
Perfluorooctanoic acid [335-67-1]	$C_7F_{15}COOH$		0.005[c]					’08
Phenol [108-95-2]	C_6H_5OH	5	19	S				’78
m-Phenylenediamine [108-45-2]	$C_6H_4(NH_2)_2$	—	0.1				3	’99
o-Phenylenediamine [95-54-5]	$C_6H_4(NH_2)_2$	—	0.1				3	’99
p-Phenylenediamine [106-50-3]	$C_6H_4(NH_2)_2$	—	0.1				1	’97
Phosgene [75-44-5]	$COCl_2$	0.1	0.4					’69
Phosphine [7803-51-2]	PH_3	0.3*	0.42*					’98
Phosphoric acid [7664-38-2]	H_3PO_4	—	1					(’90)
Phosphorus (yellow) [7723-14-0]	P_4	—	0.1					(’88)
Phosphorus pentachloride [10026-13-8]	PCl_5	0.1	0.85					’89
Phosphorus trichloride [7719-12-2]	PCl_3	0.2	1.1					’89
Phthalic anhydride [85-44-9]	$C_6H_4(CO)_2O$	0.33*	2*			1		’98
o-Phthalodinitrile [91-15-6]	$C_6H_4(CN)_2$	0.01	S					’09
Platinum, soluble salts (as Pt) [7440-06-4]	Pt	—	0.001			1	1	’00
Polychlorobiphenyls	$C_{12}H_{(10-n)}Cl_n$	—	0.01	S	2A[ψ]			’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]	$CH_3COO(CH_2)_2CH_3$	200	830					’70
Propylene imine [75-55-8]	C_3H_7N	2	4.7	S				’67
Pyridaphenthion [119-12-0]	$C_{14}H_{17}N_2O_4PS$	—	0.2	S				’89
Rhodium (Soluble compounds, as Rh) [7440-16-6]	Rh	—	0.001				2	’07
Selenium and compounds (as Se, except SeH_2 and SeF_6) [7782-49-2]	Se	—	0.1					’00
Silane [7803-62-5]	SiH_4	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]	$C_6H_5CH=CH_2$	20	85	S	2B			’99
Sulfur dioxide [7446-09-5]	SO_2	(pending)						’61
Sulfuric acid [7664-93-9]	H_2SO_4	—	1*		(pending)			’00
Sulfur monochloride [10025-67-9]	S_2Cl_2	1*	5.5*					’76
1,1,2,2-Tetrachloroethane [79-34-5]	$Cl_2CHCHCl_2$	1	6.9	S				’84
Tetrachloroethylene [127-18-4]	$Cl_2C=CCl_2$	(pending)		S	2B			’72
Tetraethoxysilane [78-10-4]	$Si(OC_2H_5)_4$	10	85					’91
Tetraethyl lead (as Pb) [78-00-2]	$Pb(C_2H_5)_4$	—	0.075	S				’65
Tetrahydrofuran [109-99-9]	C_4H_8O	200	590					’78
Tetramethoxysilane [681-84-5]	$Si(OCH_3)_4$	1	6					’91
Thiuram [137-26-8]	$C_6H_{12}N_2S_4$		0.1				1	’08
Titanium dioxide[†] (nanoparticle as Ti) [13463-67-7]	TiO_2	(Table I-2)						’13
Toluene [108-88-3]	$C_6H_5CH_3$	50	188	S				’94
Toluene diisocyanates [26471-62-5]	$C_6H_3CH_3(NCO)_2$	0.005 0.02*	0.035 0.14*		2B	1	2	’92
Trichlorhon [52-68-6]	$C_4H_8Cl_3O_4P$		0.2	S				’10
o-Toluidine [95-53-4]	$CH_3C_6H_4NH_2$	1	4.4	S	2A			’91
1,1,1-Trichloroethane [71-55-6]	Cl_3CCH_3	200	1,100					’74

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m^3			Airway	Skin	
1,1,2-Trichloroethane [79-00-5]	Cl_2CHCH_2Cl	10	55	S				('78)
Trichloroethylene [79-01-6]	$Cl_2C=CHCl$	25	135		2B			'97
Trichlorofluoromethane [75-69-4]	CCl_3F	1,000*	5,600*					'87
1,1,2-Trichloro-1,2,2-trifluoroethane [76-13-1]	$Cl_2FCCClF_2$	500	3,800					'87
Tricyclazole [41814-78-2]	$C_9H_7N_3S$	—	3					'90
Trimellitic anhydride [552-30-7]	$HOOCC_6H_3(CO)_2O$	—	0.04 0.1*			1		'98
1,2,3-Trimethylbenzene [526-73-8]	$C_6H_3(CH_3)_3$	25	120					'84
1,2,4-Trimethylbenzene [95-63-6]	$C_6H_3(CH_3)_3$	25	120					'84
1,3,5-Trimethylbenzene [108-67-8]	$C_6H_3(CH_3)_3$	25	120					'84
Trinitrotoluene (all isomers)	$C_6H_2CH_3(NO_2)_3$	—	0.1	S				'93
Turpentine		50	280				1	'91
Vanadium compounds								
Ferrovanadium dust [12604-58-9]	FeV dust	—	1					'68
Vanadium pentaoxide [1314-62-1]	V_2O_5	—	0.05					'03
Vinyl chloride [75-01-4]	$CH_2=CHCl$	2.5[a]	6.5[a]		1[Ψ]			'75
Xylene (all isomers and their mixture)	$C_6H_4(CH_3)_2$	50	217					'01
Zinc oxide fume [1314-13-2]	ZnO	(pending)						'69

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^3, 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.
   [a]: Exposure concentration should be kept below a detectable limit though OEL is set at 2.5 ppm provisionally.
   [b]: OEL for gasoline is 300 mg/m^3, and an average molecular weight is assumed to be 72.5 for conversion to ppm unit.
   [c]: Not applicable to women of child bearing potential.
   [†]: Provisional.

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

Substance [CAS No.]	Chemical formula	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Year of proposal
		ppm	mg/m^3			Airway	Skin	
1,2-Dichloropropane [78-87-5]	$ClCH_2CHClCH_3$	1	4.6		2A		2	'13
Hexachlorobutadiene [87-68-3]	$Cl_2C=C_2Cl_2=CCl_2$	0.01	0.12	S				'13
Titanium dioxide [13463-67-7]	TiO_2	—	0.3					'13

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^3, in which the values are rounded off with 2 significant digits.

Table I-3. Occupational exposure limits for dusts

I. Respirable crystalline silica[ψ, *]
OEL-C 0.03 mg/m^3
II. Dusts other than I

	Dusts	OEL (mg/m^3)	
		Respirable dust*	Total dust**
Class 1	Activated charcoal, Alumina, Aluminum, Bentonite, Diatomite, Graphite, Kaolinite, Pagodite, Pyrites, Pyrite cinder, Talc	0.5	2
Class 2	Dusts containing less than 3% cry stalline silica, Bakelite, Carbon black, Coal, Cork dust, Cotton dust, Iron oxide, Grain dust, Joss stick material dust, Marble, Portland cement, Titanium oxide, Zinc oxide	1	4
Class 3	Limestone[‡], Inorganic and organic dusts other than Classes 1 and 2	2	8
	Asbestos***, Wood dust	(Table III-2)	

1. *: Respirable crystalline silica and respirable dust consist of particles captured by the following collection efficiency, $R\ (d_{ae})$.
   $R\ (d_{ae})=0.5[1+\exp -(-0.06d_{ae})] \cdot [1-F(x)]$
   d_{ae}: aerodynamic diameter of particle (μm), F (x): cumulative distribution function of the standardized normal variable $x=\ln(d_{ae}/\Gamma)/\ln(\Sigma)$, ln natural logarithm, $\Gamma=4.25$ μm, $\Sigma=1.5$
2. **: Total dust comprises particles with a flow speed of 50 to 80 cm/sec at the entry of a particle sampler.
3. ***: 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 (4 mm objective) phase contrast illumination.
4. ‡: Do not include asbestos nor ≥1% crystalline sillica.
5. ψ: Substance whose OEL is set based on non-caninogenic 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
2-Butoxyethanol and 2-Butoxyethyl acetate	urine	Butoxyacetic acid	200 mg/g·Cr	End of shift	'08
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*	Within 2 h prior to end of shift at end of work week	'05
Chlorobenzene	urine	4-Chlorocatechol (hydrolysis)	120 mg/g·Cr	End of shift	'08
3,3'-Dichloro-4,4'-diaminodiphenylmethane (MBOCA)	urine	total MBOCA	50 μg/g·Cr	End of shift at end of workweek	'94
Dichloromethane	urine	Dichloromethane	0.2 mg/*l*	End of shift	'05
Hexane	urine	2,5-Hexanedione	3 mg/g·Cr (after acid hydrolysis)	End of shift at end of workweek	'94
	urine	2,5-Hexanedione	0.3 mg/g·Cr (without acid hydrolysis)	End of shift at end of workweek	'94
Indium and compounds	serum	Indium	3 μg/*l*	Not critical	'07
Lead and compounds (except alkyl lead compounds)	blood	Lead[†]	(Table II-2)		'13
	blood	Protoporphyrin	200 μg/100 m*l*·RBC 80 μg/100 m*l*·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
Methanol	urine	Methanol	20 mg/*l*	End of shift	'10
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
Phenol	urine	Phenol	250 mg/g·Cr	End of shift	'08
Polychlorobiphenyls (PCBs)	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
Tetrahydrofuran	urine	Tetrahydrofuran	2 mg/*l*	End of shift	'08
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
	urine	Trichloroacetic acid	50 mg/*l*		
Xylene	urine	total (o-, m-, p-) methylhippuric acid	800 mg/*l*	End of shift at end of work week	'05

[†]: provisional.

Table II-2. Occupational exposure limits based on biological monitoring (provisional)

Lead and compounds (except alkyl lead compounds)	blood	Lead	15 μg/100 m*l*	Not critical	'13

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 ψ in Table I-1**.

*, Epidemiological evidences include serum epidemiology and molecular epidemiology

**, See Table I-1 for *Group 1* and *Group 2A* carcinogens.

Table III-1. Occupational carcinogens

Group 1	4-Aminobiphenyl, Arsenic and compounds*, Asbestos, Benzene, Benzidine, Benzotrichloride, Bis (chloromethyl) ether, 1,3-Butadiene, Cadmium and compounds*, Chromium (VI) compounds*, Coal-tar pitch volatiles, Coal-tars, Erionite, Ethylene oxide, Ionizing radiation Mineral oils (untreated and mildly treated), 2-Naphthylamine, Nickel compounds (nickel smelting dusts)*, Offset printing process†, Shale olis, Silica (crystalline), Soots, Sulphur dichlordiethyl, Tobacco smoke, Talc containing asbestiform fibers, 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin, Vinyl chloride, Wood dust
Group 2A	Acrylamide, Acrylonitrile, Benzal chloride, Benzo [a] pyrene, Benzyl chloride, Beryllium and compounds*, Chloromethyl methyl ether (technical grade), 4-Chloro-*o*-toluidine, Creosotes, 1,2-Dibromoethane, 3,3'-Dichloro-4,4'-diaminodiphenylmethane (MBOCA), 1,2-Dichloropropane†, Diethyl sulphate, Dimethyl sulphate, Dimethylcarbamoyl chloride, Direct Black 38, Direct Blue 6, Direct Brown 95, Epichlorohydrin, Formaldehyde, Glycidol, Indium compounds† (inorganic, hardly soluble), Polychlorinated biphenyls (PCB), Styrene oxide, *o*-Toluidine, 1,2,3-Trichloropropane, Tris (2,3-dibromopropyl) phosphate, Vinyl bromide, Vinyl fluoride
Group 2B	Acetamide, Acetoaldehyde, *o*-Aminoazotoluene, *p*-Aminoazobenzene, Amitrole, Antimony trioxide†, *o*-Anisidine, Auramine (technical grade), Benzyl violet 4B, 2,2-Bis (bromomethyl) propane-1,3-diol, Bitumens, Bromodich-loromethane, β-Butyrolactone, Carbon black, Carbon tetrachloride, Catechol, Chlordane, Chlordecone (Kepone), Chlorendic acid, Chlorinated paraffins, *p*-Chloroaniline, Chloroform, 1-Chloro-2-methylpropene, 3-Chloro-2-methylpropene, Chlorophenoxy acetic acid herbicides*, *p*-Chloro-*o*-phenylenediamine, Chloroprene, Chlorothalonil, CI acid red 114, CI basic red 9, CI direct blue 15, Citrus red No. 2, Cobalt and compounds*, *p*-Cresidine, *N,N'*-Diacetyl benzidine, 2,4-Diaminoanisole, 4,4'-Diaminodiphenyl ether, 2,4-Diaminotoluene, 1,2-Dibromo-3-chloropropane, 2,3-Dibromopropan-1-ol, *p*-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, *p*-Dimethylam inoazobenzene, 2,6-Dimethylaniline, 3,3'-Dimethylbenzidine (*o*-Tolidine), *N,N*-Dimethylformamide, 1,1-Dimethylhydrazine, 3,3'-Dimethoxybenzidine (*o*-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, *N*-Methyl-*N*-nitrosourethane, Mirex, Nickel compounds (except Nickel carbonyl and Nickel smelting dust)*, 2-Nitroanisole, Nitrobenzene, Nitrilotriacetic acid and its salts, Nitrogen mustard-*N*-oxide, 5-Nitroacenaphtene, Nitromethane, 2-Nitropropane, *N*-Nitrosodiethanolamine, *N*-Nitrosomorpholine, Oil orange SS, Phenyl glycidyl ether, Polybrominated biphenyls, Polychlorophenols (technical grades), Ponceau 3R, Ponceau MX, 1,3-Propane sultone, β-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.

†Provisional.

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^{-3}	3 $\mu g/m^3$	Average relative risk model	'00
	10^{-4}	0.3 $\mu g/m^3$		
Asbestos				
chrysotile	10^{-3}	0.15 fibers/m*l*	Average relative risk model	'00
	10^{-4}	0.015 fibers/m*l*		
containing asbestos fibers	10^{-3}	0.03 fibers/m*l*		
other than chrysotile	10^{-4}	0.003 fibers/m*l*		
Benzene	10^{-3}	1 ppm	Average relative risk model	'97
	10^{-4}	0.1 ppm		
Ionizing radiation	(Table III-3)			'12
Nickel smelting dusts (as Ni)	10^{-3}	10 $\mu g/m^3$	Average relative risk model	'09
	10^{-4}	1 $\mu g/m^3$		'09

Table III-3 indicates reference values corresponding to an individual excess lifetime risk of cancer for ionizing radiation. A series of the reference values, i.e. unit risk doses of ionizing radiation, are shown as Radiation Exposure Induced Death (REID) levels of 100, 50, 10, 1 for 1,000 population with stratified by sex, age and exposure situation (single, repeated). Dose and dose-rate effectiveness factor (DDREF) of 1 is being adopted primarily, and REID levels with DDREF of 2 are also calculated for comparison.

The reference values here are being calculated based on exposure-response relationship of low LET radiation, indicating that the values should not be applied in the case that internal exposure is considered.

Table III-3. Unit risk doses of ionizing radiation: Risk of Exposure-Induced Death (REID) levels of 100, 50, 10, 1, for 1,000 population

Single exposure (mS_V) DDREF=1

(a) Male

REID	Age 18	28	38	48	58
10^{-1}	892.2	1,075.5	1,342.1	1,760.8	2,441.8
5×10^{-2}	440.8	535.2	676.9	911.2	1,325.0
10^{-2}	87.4	106.8	136.7	189.0	291.6
10^{-3}	8.7	10.7	13.7	19.1	30.0
10^{-4}	0.9	1.1	1.4	1.9	3.0

(b) Female

REID	Age 18	28	38	48	58
10^{-1}	762.9	939.2	1,204.2	1,628.9	2,320.5
5×10^{-2}	374.1	462.3	597.7	821.7	1,207.9
10^{-2}	73.7	91.4	119.0	166.0	251.9
10^{-3}	7.3	9.1	11.9	16.6	25.5
10^{-4}	0.70	0.90	1.20	1.70	2.60

Repeated exposure until age 68 (from first exposure age to the end of age 67) (mSv/year) DDREF=1

(a) Male

REID	Age 18	28	38	48	58
10^{-1}	34.1	50.8	83.5	160.2	412.8
5×10^{-2}	16.4	24.5	40.3	77.5	203.9
10^{-2}	3.2	4.8	7.8	15.1	40.4
10^{-3}	0.3	0.5	0.8	1.5	4.0
10^{-4}	0.03	0.05	0.08	0.15	0.40

(b) Female

REID	Age 18	28	38	48	58
10^{-1}	28.6	42.7	70.1	133.0	342.4
5×10^{-2}	13.8	20.7	33.9	64.5	167.5
10^{-2}	2.7	4.0	6.6	12.6	33.0
10^{-3}	0.3	0.4	0.7	1.3	3.3
10^{-4}	0.03	0.04	0.07	0.13	0.33

Repeated 10 year exposure, (10 years from first exposure age) (mSv/year) DDREF=1

(a) Male

REID	Age 18	28	38	48	58
10^{-1}	101.7	126.8	168.1	245.8	412.8
5×10^{-2}	49.2	61.4	81.4	119.6	203.9
10^{-2}	9.6	12.0	15.9	23.4	40.4
10^{-3}	1.0	1.2	1.6	2.3	4.0
10^{-4}	0.10	0.12	0.16	0.23	0.40

(b) Female

REID	Age 18	28	38	48	58
10^{-1}	85.5	108.2	145.3	211.0	342.4
5×10^{-2}	41.5	52.5	70.5	102.6	167.5
10^{-2}	8.1	10.3	13.8	20.1	33.0
10^{-3}	0.8	1.0	1.4	2.0	3.3
10^{-4}	0.08	0.10	0.14	0.20	0.33

Repeated 5 year exposure, (5 years from first exposure age) (mSv/year) DDREF=1

(a) Male

REID	Age 18	28	38	48	58
10^{-1}	192.5	236.8	306.4	430.4	673.3
5×10^{-2}	93.3	115.0	149.3	211.4	337.9
10^{-2}	18.2	22.5	29.3	41.7	68.0
10^{-3}	1.8	2.2	2.9	4.2	6.8
10^{-4}	0.18	0.22	0.29	0.42	0.68

(b) Female

REID	Age 18	28	38	48	58
10^{-1}	161.8	202.3	266.4	376.7	581.4
5×10^{-2}	78.6	98.3	129.7	184.1	287.1
10^{-2}	15.4	19.2	25.4	36.2	56.9
10^{-3}	1.5	1.9	2.5	3.6	5.7
10^{-4}	0.15	0.19	0.25	0.36	0.57

Single exposure (mSv) DDREF=2

(a) Male

REID	Age 18	28	38	48	58
10^{-1}	1,541.0	1,801.1	2,139.4	2,599.6	3,245.9
5×10^{-2}	797.0	946.9	1,153.4	1,455.7	1,911.2
10^{-2}	165.1	199.8	251.4	335.9	486.3
10^{-3}	16.7	20.3	25.8	25.8	53.3
10^{-4}	1.7	2.0	2.6	2.6	5.4

(b) Female

REID	Age 18	28	38	48	58
10^{-1}	1,403.1	1,692.1	2,084.0	2,646.2	3,436.8
5×10^{-2}	707.5	862.9	1,085.7	1,425.2	1,940.6
10^{-2}	142.8	176.1	226.6	309.8	453.4
10^{-3}	14.3	17.7	22.9	31.7	47.7
10^{-4}	1.4	1.8	2.3	3.2	4.8

Repeated exposure until age 68 (from first exposure age to the end of age 67) (mSv/year) DDREF=2

(a) Male

REID	Age 18	28	38	48	58
10^{-1}	63.5	93.4	150.2	276.5	650.5
5×10^{-2}	30.7	45.3	73.2	136.8	337.3
10^{-2}	6.0	8.8	14.4	27.2	70.2
10^{-3}	0.6	0.9	1.4	2.7	7.1
10^{-4}	0.06	0.09	0.14	0.27	0.71

(b) Female

REID	Age 18	28	38	48	58
10^{-1}	54.9	81.4	131.9	244.7	596.9
5×10^{-2}	26.6	39.5	64.2	120.1	301.3
10^{-2}	5.2	7.7	12.6	23.7	60.9
10^{-3}	0.5	0.8	1.3	2.4	6.1
10^{-4}	0.05	0.08	0.13	0.24	0.61

Repeated 10 year exposure, (10 years from first exposure age) (mSv/year) DDREF=2

(a) Male

REID	Age 18	28	38	48	58
10^{-1}	191.2	235.3	304.2	424.7	650.5
5×10^{-2}	93.2	115.1	149.9	212.5	337.3
10^{-2}	18.3	22.6	29.7	42.6	70.2
10^{-3}	1.8	2.3	3.0	4.3	7.1
10^{-4}	0.18	0.23	0.30	0.43	0.71

(b) Female

REID	Age 18	28	38	48	58
10^{-1}	165.2	207.5	274.3	387.7	596.9
5×10^{-2}	80.5	101.2	134.4	191.7	301.3
10^{-2}	15.8	19.9	26.5	38.0	60.9
10^{-3}	1.6	2.0	2.6	3.8	6.1
10^{-4}	0.16	0.20	0.26	0.38	0.61

Repeated 5 year exposure, (5 years from first exposure age) (mSv/year) DDREF=2

(a) Male

REID	Age 18	28	38	48	58
10^{-1}	358.0	433.6	545.5	726.9	1,032.7
5×10^{-2}	176.0	214.5	272.8	371.6	550.8
10^{-2}	34.8	42.6	54.7	76.1	118.5
10^{-3}	3.5	4.3	5.5	7.7	12.1
10^{-4}	0.35	0.42	0.55	0.77	1.21

(b) Female

REID	Age 18	28	38	48	58
10^{-1}	310.9	385.1	497.8	681.2	989.7
5×10^{-2}	152.1	189.1	246.1	341.5	510.3
10^{-2}	29.9	37.3	48.8	68.6	105.3
10^{-3}	3.0	3.7	4.9	6.9	10.6
10^{-4}	0.30	0.37	0.49	0.69	1.06

IV. Occupational Sensitizers

This table is the list of occupational sensitizers to the airway and skin (Tab1e IV). The sensitizers are classified into *Group 1* substances which induce allergic reactions in humans, *Group 2* substances which probably induce allergic reactions in humans, and *Group 3* substances which are considered possibly to induce allergic reactions in humans based on animal experiments.

Recommendation of occupational exposure limits for the occupational sensitizers does not necessarily consider either prevention of sensitization or allergic reaction. Any substance which is not included in the list does not indicate that the substance is not a sensitizer.

Table IV. Occupational sensitizers

Airway	
	Group 1
	Beryllium*, Cobalt*, Colophony (Rosin)*, Diphenylmethane-4,4'-diisocyanate (MDI), Glutaraldehyde, Hexane-1,6-diisocyanate, Methyltetrahydrophthalic anhydride, Phthalic anhydride, Platinum*, Toluene diisocyanates*, Trimellitic anhydride
	Group 2
	Chlorothalonil, Chromium*, Ethylenediamine, Formaldehyde, Maleic anhydride, Methyl methacrylate, Nickel*, Piperazine
Skin	
	Group 1
	Aniline, Benzoyl peroxide, Chlorothalonil, Chromium*, Cobalt*, Colophony (Rosin)*, 2,4-Dinitrochlorobenzene (DNCB), Epichlorohydrin, Formaldehyde, Glutaraldehyde, Hydrazine*, Mercury*, 4,4'-Methylenedianiline, Nickel*, *p*-Phenylenediamine, Platinum*, Resorcinol, Sodium ethylmercury 2-sulfidobenzoate (Thimerosal), Thiuram, Tri (propylene glycol) diacrylate, N,N',N''-Tris (β-hydroxyethyl)-hexahydro-1,3,5-triazine, Turpentine*, m-Xylylendiamine†
	Group 2
	Acrylamide, Benomyl, Beryllium*, Buthyl acrylate, Copper*, Dibutyl phthalate, Dichloropropane, Dicyclohexylcarbodiimide, Ethylene oxide, Ethylenediamine, Hydroquinone, Iodine*, Maleic anhydride, Methyl acrylate, Methyl methacrylate, Polyvinyl chloride plasticizers*, Rodium*, Toluene diamine*†, Toluene diisocyanates*, Usnic acid
	Group 3
	m-Chloroaniline, *o*-Phenylenediamine, *m*-Phenylenediamine

*Evaluation does not necessarily apply to all individual chemicals within the group. †Provisional.

V. Reproductive Toxicants (Provisional)

The Japan Society for Occupational Health (JSOH) classifies reproductive toxicants on the basis of evidence of reproductive toxicity obtained from epidemiological studies and other studies in humans, as well as those from experimental studies in animals. The classification is made by strength of the evidence for adverse effects on reproduction in humans, but does not reflect the potency of such adverse effects. Namely, the classification does not necessarily indicate that exposures to the classified substances at the present Occupational Exposure Limit (OEL-M) levels induce adverse effects on reproduction. The definition of reproductive toxicity and the classification criteria for judgment are as follows.

1. Definition of reproductive toxicity

Reproductive toxicity includes adverse effects on reproductive functions in males and females, as well as on the offspring. Effects on functions such as fertility, pregnancy, delivery, and lactation in women, and fertility/insemination in men are within the scope of the definition. Substances that have adverse effects on reproductive organs are also included within the classification criteria if it is suspected that the reproductive functions referred to above are affected. In the case of offspring, reproductive toxicity is defined as the effects on the development of the embryo/fetus including teratogenic insults by prenatal exposure to the substance and/or the effects on the infant by postnatal exposure via lactation due to transfer in breast milk. If effects on post-weaning growth, behavior, function, sexual maturation, carcinogenesis, accelerated aging, and other processes are clearly demonstrated in the offspring as a result of parental exposure, then such effects are considered as reproductive toxicity.

2. Classification and judgment criteria

1) Classification of reproductive toxicants: Reproductive toxicants shall be classified in *Group 1*, *Group 2*, or *Group 3*, defined as follows.

Group 1: Substances known to cause reproductive toxicity in humans.
Group 2: Substances presumed to cause reproductive toxicity in humans.
Group 3: Substances suspected to cause reproductive toxicity in humans.

2) Judgment criteria for the classification of reproductive toxicity:

Group 1: Substances for which sufficient evidence in humans has been obtained from epidemiological studies and other human studies shall be classified.

Sufficient evidence that demonstrates reproductive toxicity in humans is required, where sufficient means two or more reports of epidemiological studies conducted in an appropriate manner. A single epidemiological study can be used as the evidence for classification to this group if any of the following conditions are satisfied: a) the study takes into consideration both dose-response relationships and such as co-exposure to other substances, or potential confounding factors in an appropriate manner; b) the study is supported by many non-epidemiological study reports on, for example, clinical cases or accidental exposures, indicating reproductive toxicity and it can therefore be decided overall that there is sufficient evidence of toxicity in humans. Animal experimental data are considered as supportive information.

Group 2: Substances for which sufficient evidence demonstrating reproductive toxicity has been obtained in appropriate animal experiments, and thus presumed to cause reproductive toxicity in humans, shall be classified.

Judgment shall be made on the basis of animal experiments, namely, evidence showing obvious adverse effects on reproduction in animals, identified by appropriately conducted animal experimental studies, and thus reasonably indicating that the substance causes reproductive toxicity in humans. When judgment is made from the results of animal experiments, it is required that the observed effects should not be the consequences of secondary non-specific effects of other general toxicities, and that the identified mechanism of action be non-species-specific and therefore relevant for extrapolation to humans. In addition, if the observed changes are small and exert only non-significant effects on the life or function of the subject, then such changes are considered as not satisfying the requirement.

Group 3: Substances for which limited evidence has been demonstrated shall be classified.

Substances are allocated into this group when reproductive toxicities are suspected from reports in humans or from animal experiments. If information for reproductive toxicity is obtained from epidemiological studies, other human studies, and/or animal experiments, but such evidence is not considered to be sufficient for allocating the substance to *Group 1* or *Group 2*, then classification in *Group 3* should be considered.

3. Classified reproductive toxicants

Table V. lists the substances classified in each reproductive toxicant group according to the judgment criteria referred to above. The judgment is made for substances for which OEL value is recommended by JSOH based on information described in the documentation for Recommendation of Occupational Exposure Limits by JSOH and other relevant information; it does not mean that substances not included in the table do not meet the classification criteria of reproductive toxicity. There may be some substances for which reproductive toxicity might be observed below the level of OEL-M or OEL-B; in such cases, precautionary notice is given by adding a symbol mark "[#]" to substances in Table V-1.

Table V. Reproductive toxicants (provisional)

Group 1
Arsenic and compounds, 2-Bromopropane, Cadmium and compounds, Carbon disulfide, Di (2-ethylhexyl) phthalate[#], Ethylene glycol monomethyl ether, Ethylene glycol monomethyl ether acetate, Ethylene oxide, Lead and compounds, Polychlorobiphenyls, Toluene
Group 2
- (under consideration)
Group 3
- (under consideration)

Not all substances that may exert reproductive toxicity are identified.
[#]: Precaution should be given for lower exposure than OEL-M or OEL-B. As for reproductive toxicity, it is generally known that there is a sensitive period, during pregnancy for example, and such effects of this substance have been identified.

VI. Occupational Exposure Limits for Continuous or Intermittent Noise

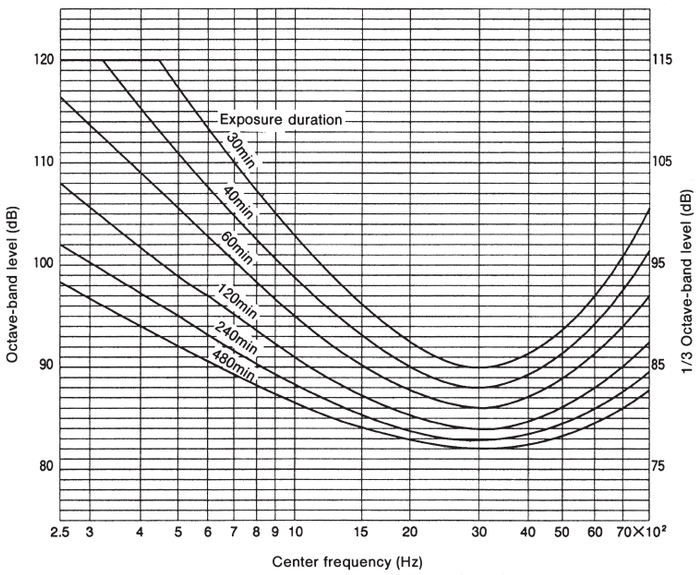

Fig. VI-1. Occupational exposure limits for continuous or intermittent noise.

Table VI-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

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

Exposure duration (hours-minutes)	OELs by A-weighted sound pressure level (dB)	Exposure duration (hours-minutes)	OELs by A-weighted sound pressure level (dB)
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		

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. VI-1 or Table VI-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 VII).

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. VI-1 or Table VI-1.

(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. VI-1 or Table VI-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. VI-1 or in Table VI-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. VI-1 or the values subtracted 5 from the figures in Table VI-1.

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 VI-2 should be used.

5. Noise measurement

For measurement methods, refer to 'Japan Industrial Standard (JIS) Z 8731–1999 Acoustics-Description and measurement of environmental noise.

VII-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 cerrect 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_O 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.

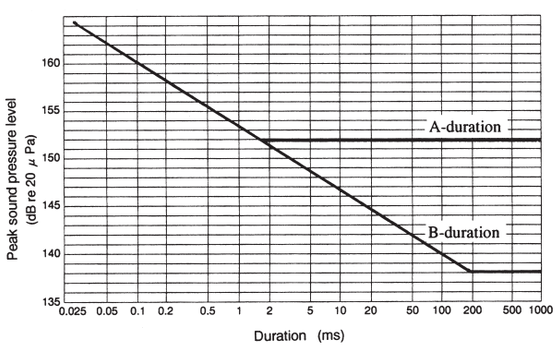

Fig. VII-1. Occupational exposure limits for impulsive or impact noise.

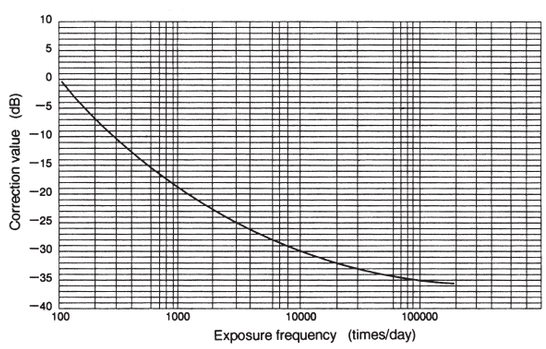

Fig. VII-2. Correction values corresponding to exposure frequency a day.

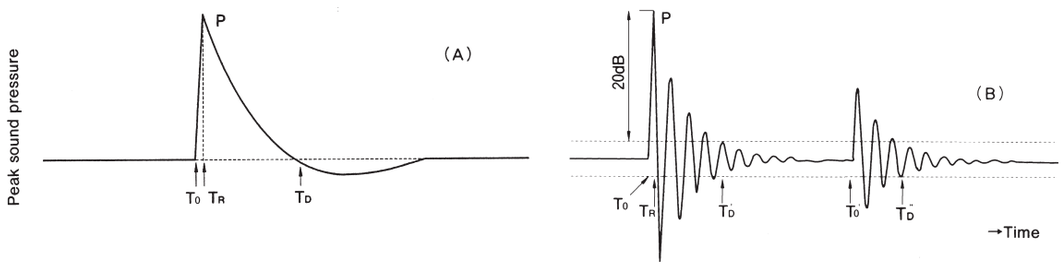

Fig. VII-3. Measurement for impulsive or impact noise.

VII-ii. Occupational Exposure Limit 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. VII-2 corresponding to frequency of exposure should be added for OEL determination.

2. Application

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

3. Measurement method

Maximum values should be measured by the Sound Level Meter (JIS C 1509-1-2005) with use of an A-weighted frequency response and fast dynamic characteristic.

VIII. Occupational Exposure Limits for Heat Stress

Table VIII. Occupational exposure limits for heat stress

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

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

IX. Occupational Exposure Limits for Cold Stress

Table IX. 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.

X. Occupational Exposure Limits for Whole Body Vibration

$0.35\ m/s^2 A_{sum}$ (8)†

XI. Occupational Exposure Limits for Hand-Arm Vibration

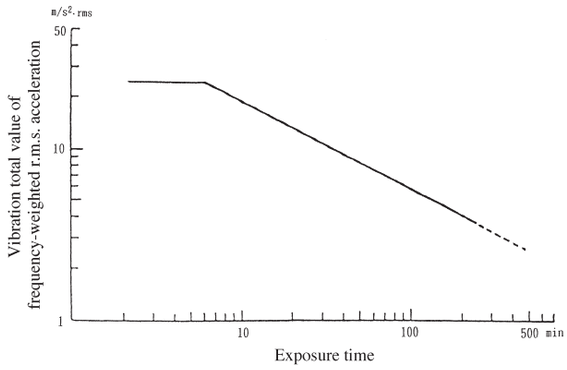

Fig. XI. Occupational exposure limits for hand-arm vibration using vibration total value of frequency-weighted r.m.s. acceleration.

Table XI. 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^2 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

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

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

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

Table XII-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	4.08×10^4/f Am^{-1}
1.0~25 Hz	20 kVm^{-1}	50/f mT	4.08×10^4/f Am^{-1}
25~500 Hz	500/f kVm^{-1}	50/f mT	4.08×10^4/f Am^{-1}
500~814 Hz	500/f kVm^{-1}	0.1 mT	81.4 Am^{-1}
0.814~60 kHz	614 Vm^{-1}	0.1 mT	81.4 Am^{-1}
60~100 kHz	614 Vm^{-1}	6/f mT	4,880/f Am^{-1}

*EF: electric field. †MF: magnetic field.

Table XII-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^{-1}	6/f μT	4.88/f Am^{-1}	
3.0~30 MHz	1,842/f Vm^{-1}	6/f μT	4.88/f Am^{-1}	
30~400 MHz	61.4 Vm^{-1}	0.2 μT	0.163 Am^{-1}	10 Wm^{-2}
400~2000 MHz	$3.07f^{0.5}$ Vm^{-1}	$0.01f^{0.5}$ μT	$8.14f^{0.5}$ mAm^{-1}	f/40 Wm^{-2}
2~300 GHz	137 Vm^{-1}	0.447 μT	0.364 Am^{-1}	50 Wm^{-2}

*EF: electric field. †MF: magnetic field.

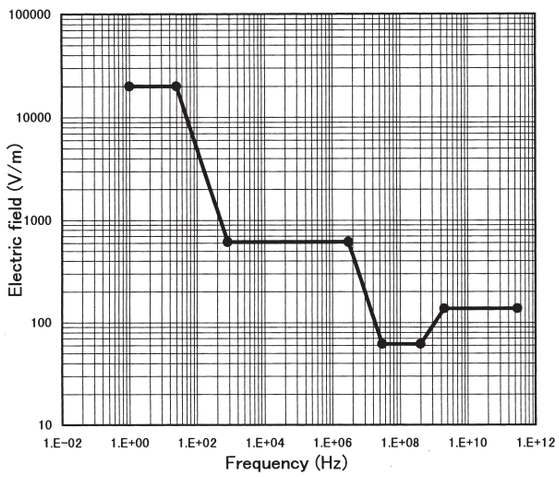

Fig. XII-1. OEL-Ms of time-varying electric fields.

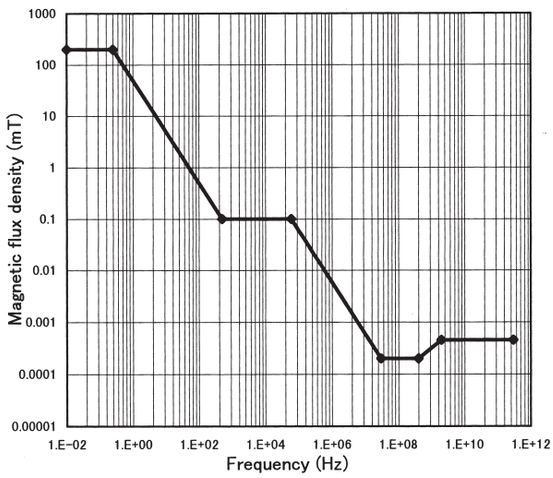

Fig. XII-2. OEL-Ms of static and time-varying magnetic fields.

XIII. 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^2 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:

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

where: E_{eff} = effective irradiance
E_λ = spectral irradiance at exposure
$S(\lambda)$ = relative spectral effectiveness (Table XIII)
$\Delta\lambda$ = band width

Table XIII. 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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