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Recommendation of occupational exposure limits (2022–2023)

The Japan Society for Occupational Health **May 25, 2022**

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 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:

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

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.]	OEL		Skin absorption	Class of carcino-genicity	Class of sensitizing potential		Repro-ductive Toxicants	Year of pro-posal
	ppm	mg/m³			Airway	Skin		
Acetaldehyde [75-07-0]	10*	18*		2B				'21
Acetic acid [64-19-7]	10	25						'78
Acetic anhydride [108-24-7]	5*	21*						'90
Acetone [67-64-1]	200	475						'72
Acrylaldehyde [107-02-8]	0.1	0.23						'73
Acrylamide [79-06-1]	—	0.1	S	2A		2	2	'04
Acrylonitrile [107-13-1]	2	4.3	S	2A$^{\psi}$				'88
Allyl alcohol [107-18-6]	1	2.4	S					'78
2-Aminoethanol [141-43-5]	3	7.5						'65
Ammonia [7664-41-7]	25	17						'79
Aniline [62-53-3]	1	3.8	S			1		'88
o-Anisidine [90-04-0]	0.1	0.5	S	2B				'96
p-Anisidine [104-94-9]	0.1	0.5	S					'96
Antimony and compounds (as Sb except stibine) [7440-36-0]	—	0.1						('13)
Arsenic and compounds (as As) [7440-38-2]	(Table III-2)			1			1	'00
Arsine [7784-42-1]	(Table I-2)							'22
Atrazine [1912-24-9]		2					3	'15
Benomyl [17804-35-2]		1				2	2$^{\#}$	'18
Benzene [71-43-2]	(Table III-2)		S	1				'97
Benzyl alcohol [100-51-6]	—	25*				2		'19
Beryllium and compounds (as Be) [7440-41-7]	—	0.002		1$^{\psi}$	1	2		'63
Boron trifluoride [7637-07-2]	0.3	0.83						'79
Bromine [7726-95-6]	0.1	0.65						'64
Bromoform [75-25-2]	1	10.3						'97
1-Bromopropane [106-94-5]	0.5	2.5		2B			2	'12

Substance [CAS No.]	OEL		Skin absorption	Class of carcino-genicity	Class of sensitizing potential		Repro-ductive Toxicants	Year of pro-posal
	ppm	mg/m^3			Airway	Skin		
2-Bromopropane [75-26-3]	0.5	2.5	S	2B			1	’21
Buprofezin [69327-76-0]	—	2						’90
Butane (all isomers) [106-97-8]	500	1,200						’88
1-Butanol [71-36-3]	50*	150*	S					’87
2-Butanol [78-92-2]	100	300						’87
Butyl acetate [123-86-4]	100	475						’94
t-Butyl alcohol [75-65-0]	50	150						’87
Butylamine [109-73-9]	5*	15*	S					(’94)
n-butyl-2,3-epoxy-propyl ether [2426-08-6]	0.25	1.3		2B		2	3	’16
Cadmium and compounds (as Cd) [7440-43-9]	—	0.05		1^{ψ}			1	’76
Calcium cyanide (as CN) [592-01-8]	—	5*	S					’01
Carbaryl [63-25-2]	—	5	S					’89
Carbon dioxide [124-38-9]	5,000	9,000						’74
Carbon disulfide [75-15-0]	1	3.13	S				$1^{\#}$	’15
Carbon monoxide [630-08-0]	50	57					1	’71
Carbon tetrachloride [56-23-5]	5	31	S	2B				’91
Chlorine [7782-50-5]	0.5*	1.5*						’99
Chlorobenzene [108-90-7]	10	46						’93
Chlorodifluoromethane [75-45-6]	1,000	3,500					2	’87
Chloroethane [75-00-3]	100	260						’93
Chloroform [67-66-3]	3	14.7	S	2B				’05
Chloromethane [74-87-3]	50	100					2	’84
Chloromethyl methyl ether (technical grade) [107-30-2]	—	—		2A				’92
Chloropicrin [76-06-2]	0.1	0.67						’68
Chromium and compounds (as Cr) [7440-47-3]					2	1	3	’89
Chromium metal	—	0.5						
Chromium (III) compounds	—	0.5						
Chromium (VI) compounds	—	0.05						
Certain chromium (VI) compounds	—	0.01		1				
Cobalt and compounds (without tungsten carbide) [7440-48-4]	—	0.05		2B	1	1		’92
Cresol (all isomers)	5	22	S					’86
Cumene [98-82-8]	10	50	S	2B				’19
Cyclohexane [110-82-7]	150	520						’70
Cyclohexanol [108-93-0]	25	102						’70
Cyclohexanone [108-94-1]	25	100						’70
Diazinon [333-41-5]	—	0.1	S	2B				’89
Diborane [19287-45-7]	0.01	0.012						’96
Dibutyl phthalate [84-74-2]	—	5				2		’96
o-Dichlorobenzene [95-50-1]	25	150						’94
p-Dichlorobenzene [106-46-7]	10	60		2B			3	’98
1,4-Dichloro-2-butene [764-41-0]	0.002			2B				’15
3,3’-Dichloro-4,4’-diaminodiphenylmethane (MBOCA) [101-14-4]	—	0.005	S	$2A^{\psi}$				’12
Dichlorodifluoromethane [75-71-8]	500	2,500						’87
1,1-Dichloroethane [75-34-3]	100	400						’93
1,2-Dichloroethane [107-06-2]	10	40		2B				’84
2,2’-Dichloroethyl ether [111-44-4]	15	88	S					’67
1,2-Dichloroethylene [540-59-0]	150	590						’70
Dichloromethane [75-09-2]	50 100*	173 347*	S	2A				’99
2,4-Dichlorophenoxyacetic acid (2,4-D) [94-75-7]	—	2	S				2	’19

Substance [CAS No.]	OEL		Skin absorption	Class of carcino-genicity	Class of sensitizing potential		Repro-ductive Toxicants	Year of pro-posal
	ppm	mg/m^3			Airway	Skin		
1,2-Dichloropropane [78-87-5]	1	4.6		1		2		’13
2,2-Dichloro-1,1,1-trifluoroethane [306-83-2]	10	62						’00
Diethylamine [109-89-7]	10	30						’89
Di(2-ethylhexyl) phthalate [117-81-7]	—	5		2B			1[#]	’95
Diethyl phthalate [84-66-2]	—	5						’95
N,N-Dimethyl acetamide [127-19-5]	10	36	S	2B			2	’90
Dimethylamine [124-40-3]	2	3.7					3	’16
N,N-Dimethylaniline [121-69-7]	5	25	S					’93
N,N-Dimethylformamide (DMF) [68-12-2]	10	30	S	2A			2	’74
Dimethyl sulfate [77-78-1]	0.1	0.52	S	2A[ψ]				’80
Dimethyl terephthalate [120-61-6]		8						’20
1,2-Dinitrobenzene [528-29-0]	0.15	1	S					’94
1,3-Dinitrobenzene [99-65-0]	0.15	1	S					’94
1,4-Dinitrobenzene [100-25-4]	0.15	1	S					’94
1,4-Dioxane [123-91-1]	1	3.6	S	2B				’15
Diphenylmethane-4,4’-diiso-cyanate (MDI) [101-68-8]	—	0.05			1			’93
Dusts			(Table I-3)					
2,3-Epoxypropyl methacrylate (Glycidyl methacrylate, GMA) [106-91-2]	0.01	0.06	S	2A		2	3	’18
Ethyl acetate [141-78-6]	200	720						’95
Ethylamine [75-04-7]	10	18						’79
Ethylbenzene [100-41-4]	20	87	S	2B			2	’20
Ethylenediamine [107-15-3]	10	25	S		2	2		’91
Ethylene glycol monobutyl ether [111-76-2]	20*	97*	S				2	’17
Ethylene glycol monoethyl ether [110-80-5]	5	18	S				2	’85
Ethylene glycol monoethyl ether acetate [111-15-9]	5	27	S				2	’85
Ethylene glycol monomethyl ether [109-86-4]	0.1	0.31	S				1	’09
Ethylene glycol monomethyl ether acetate [110-49-6]	0.1	0.48	S				1	’09
Ethylene oxide [75-21-8]	1	1.8		1[ψ]		2	1	’90
Ethylenimine [151-56-4]	0.05	0.09	S	2B			3	’18
Ethyl ether [60-29-7]	400	1,200						(’97)
2-Ethy1-1-hexanol [104-76-7]	1	5.3					3	’16
Ethylidene norbornene [16219-75-3]	2	10					3	’18
Etofenprox [80844-07-1]	—	3						’95
Fenitrothion [122-14-5]	(Table I-2)		S			2[†]		’22
Fenobucarb [3766-81-2]	—	5	S					’89
Fenthion [55-38-9]	—	0.2	S					’89
Flutolanil [66332-96-5]	—	10						’90
Formaldehyde [50-00-0]	0.1 0.2*	0.12 0.24*		2A	2	1		’07
Formic acid [64-18-6]	5	9.4						’78
Fthalide [27355-22-2]	—	10						’90
Furfural [98-01-1]	2.5	9.8	S					(’89)
Furfuryl alcohol [98-00-0]	5	20		2B				’78
Gasoline [8006-61-9]	100[b]	300[b]		2B				’85
Glyphosate [1071-83-6]	—	1.5		2B			3	’21
Glutaraldehyde [111-30-8]	0.03*				1	1		’06
Heptane [142-82-5]	200	820						’88
Hexachlorobutadiene [87-68-3]	0.01	0.12	S					’13
Hexachloroethane [67-72-1]	(Table I-2)		S[†]	2B[†]				’22
Hexane [110-54-3]	40	140	S					’85

Substance [CAS No.]	OEL		Skin absorption	Class of carcino-genicity	Class of sensitizing potential		Repro-ductive Toxicants	Year of pro-posal
	ppm	mg/m^3			Airway	Skin		
Hexane-1,6-diisocyanate (HDI) [822-06-0]	0.005	0.034			1			’95
Hydrazine (anhydrous) and Hydrazine hydrate [302-01-2/7803-57-8]	0.1	0.13 and 0.21	S	2A		1		’98
Hydrogen chloride [7647-01-0]	2*	3.0*						’14
Hydrogen cyanide [74-90-8]	5	5.5	S					’90
Hydrogen fluoride [7664-39-3]	3*	2.5*	S					(’20)
Hydrogen selenide [7783-07-5]	0.05	0.17						’63
Hydrogen sulfide [7783-06-4]	5	7						’01
Indium and compounds [7440-74-6]	(Table II-1)			2A				’07
Iodine [7553-56-2]	0.1	1				2		’68
Isobutyl alcohol [78-83-1]	50	150						’87
Isopentyl alcohol [123-51-3]	100	360						’66
Isoprene [78-79-5]	3	8.4		2B				’17
Isopropyl acetate [108-21-4]	100							’17
Isopropyl alcohol [67-63-0]	400*	980*						’87
Isoprothiolane [50512-35-1]	—	5						’93
Lead and compounds (as Pb except alkyl lead compounds) [7439-92-1]	—	0.03		2B			1[#]	’16
Lithium hydroxide [1310-65-2]	—	1						’95
Malathion [121-75-5]	—	10	S	2B				’89
Maleic anhydride [108-31-6]	0.1 0.2*	0.4 0.8*			2	2		(’15)
Manganese and its compounds (as Mn except organic compounds) [7439-96-5]	—	0.1 (Total particulate matter) 0.02 (Respirable particulate matter)					2	’21
Man-made mineral fibers**								’03
Ceramic fibers, Micro glass fibers	—	—		2B				
Continuous filament glass fibers, Glass wool fibers, Rock wool fibers, Slag wool fibers		1 (fiber/*ml*)						
Mepronil [55814-41-0]	—	5						’90
Mercury vapor [7439-97-6]	—	0.025					2	’98
Methacrylic acid [79-41-4]	2	7.0						’12
Methanol [67-56-1]	200	260	S				2	’63
Methyl acetate [79-20-9]	200	610						’63
Methyl acrylate [96-33-3]	2	7		2B		2		’04
Methylamine [74-89-5]	5	6.5						’19
Methyl bromide [74-83-9]	1	3.89	S					’03
Methyl *n*-butyl ketone [591-78-6]	5	20	S					’84
Methylcyclohexane [108-87-2]	400	1,600						’86
Methylcyclohexanol [25639-42-3]	50	230						’80
Methylcyclohexanone [1331-22-2]	50	230	S					’87
Methyl methacrylate [80-62-6]		8.3			2	2		’12
4,4’-Methylenedianiline [101-77-9]	—	0.4	S	2B				’95
Methyl ethyl ketone [78-93-3]	200	590						’64
Methyl isobutyl ketone [108-10-1]	50	205		2B				’84
N-Methyl-2-pyrrolidone [872-50-4]	1	4	S					’02
Methyltetrahydrophthalic anhydride [11070-44-3]	0.007 0.015*	0.05 0.1*			1			’02
Nickel [7440-02-0]	—	1			2	1	3	’11
Nickel carbonyl [13463-39-3]	0.001	0.007						’66

Substance [CAS No.]	OEL		Skin absorption	Class of carcino-genicity	Class of sensitizing potential		Repro-ductive Toxicants	Year of pro-posal
	ppm	mg/m^3			Airway	Skin		
Nickel compounds (total dusts) (as Ni)				2B			3	’11
[7440-02-0],								
Nickel compounds, soluble		0.01						’11
Nickel compounds, not soluble		0.1						’11
Nickel smelting dusts [7440-02-0]	(Table III-2)			1				’11
Nitric acid [7697-37-2]	2	5.2						’82
p-Nitroaniline [100-01-6]	—	3	S					’95
Nitrobenzene [98-95-3]	1	5	S	2B				(’88)
p-Nitrochlorobenzene [100-00-5]	0.1	0.64	S					’89
Nitrogen dioxide [10102-44-0]	(pending)							’61
Nitroglycerin [55-63-0]	0.05*	0.46*	S					’86
Nitroglycol [628-96-6]	0.05	0.31	S					’86
Nonane [111-84-2]	200	1,050						’89
Octane [111-65-9]	300	1,400						’89
Oil mist, mineral	—	3		1^{ψ}				’77
Ozone [10028-15-6]	0.1	0.2						’63
Parathion [56-38-2]	—	0.1	S					(’80)
Pentachlorophenol [87-86-5]	—	0.5	S				2	(’89)
Pentane [109-66-0]	300	880						’87
Pentyl acetate, all isomers	50	266.3						’08
[628-63-7; 123-92-2; 626-38-0; 620-11-1;	100*	532.5*						
625-16-1; 624-41-9; 926-41-0]								
Perfluorooctanoic acid [335-67-1]		0.005^{c}		2B			$1^{\#}$	’08
Phenol [108-95-2]	5	19	S				3	’78
m-Phenylenediamine [108-45-2]	—	0.1				3		’99
o-Phenylenediamine [95-54-5]	—	0.1		2B		3		’99
p-Phenylenediamine [106-50-3]	—	0.1				1		’97
Phosgene [75-44-5]	0.1	0.4						’69
Phosphine [7803-51-2]	0.3*	0.42*						’98
Phosphoric acid [7664-38-2]	—	1						(’90)
Phosphorus (yellow) [7723-14-0]	—	0.1						(’88)
Phosphorus pentachloride [10026-13-8]	0.1	0.85						’89
Phosphorus trichloride [7719-12-2]	0.2	1.1						’89
Phthalic anhydride [85-44-9]	0.33*	2*			1			’98
o-Phthalodinitrile [91-15-6]		0.01	S					’09
Picric acid	—	—				2		’14
Platinum, soluble salts (as Pt)	—	0.001			1	1		’00
[7440-06-4]								
Polychlorobiphenyls	—	0.01	S	1^{ψ}			1	’06
Potassium cyanide (as CN) [151-50-8]	—	5*	S					’01
Potassium hydroxide [1310-58-3]	—	2*						’78
Propyl acetate [109-60-4]	200	830						’70
Propyleneimine (2-Methylaziridine)	0.2	0.45	S	2B				’17
Pyridaphenthion [119-12-0]	—	0.2	S					’89
Rhodium (soluble compounds, as Rh)								
[7440-16-6]	—	0.001				2		’07
Selenium and compounds (as Se, except	—	0.1						’00
SeH_2 and SeF_6) [7782-49-2]								
Silane [7803-62-5]	100*	130*						’93
Silicon carbide whisker	—	0.1		2A				’19
[409-21-2; 308076-74-6]		(fiber/m*l*)						
Silver and compounds (as Ag) [7440-22-4]	—	0.01						’91
Sodium cyanide (as CN) [143-33-9]	—	5*	S					’01
Sodium hydroxide [1310-73-2]	—	2*						’78

Substance [CAS No.]	OEL		Skin absorption	Class of carcino-genicity	Class of sensitizing potential		Repro-ductive Toxicants	Year of pro-posal
	ppm	mg/m^3			Airway	Skin		
Styrene [100-42-5]	(Table I-2)		S	2A[ψ†]			2	’22
Sulfur dioxide [7446-09-5]	(pending)							’61
Sulfuric acid [7664-93-9]	—	1*						’00
Sulfur monochloride [10025-67-9]	1*	5.5*						’76
1,1,2,2-Tetrachloroethane [79-34-5]	1	6.9	S	2B				’84
Tetrachloroethylene [127-18-4]	(pending)		S	2B			3	’72
Tetraethoxysilane [78-10-4]	10	85						’91
Tetraethyl lead (as Pb) [78-00-2]	—	0.075	S					’65
Tetrahydrofuran [109-99-9]	50	148	S	2B				’15
Tetramethoxysilane [681-84-5]	1	6						’91
Thiuram [137-26-8]		0.1				1		’08
Titanium dioxide (as Ti) [13463-67-7]	(Table I-2)			2B				’22
Titanium dioxide (nanoparticle)	—	0.3						’13
Toluene [108-88-3]	50	188	S				1	(’13)
Toluene diisocyanates	0.005	0.035		2B	1	2		’92
[26471-62-5]	0.02*	0.14*						
Trichlorhon [52-68-6]		0.2	S					’10
o-Toluidine [95-53-4]	1	4.4	S	1[ψ]				’91
1,1,1-Trichloroethane [71-55-6]	200	1,090						’74
1,1,2-Trichloroethane [79-00-5]	10	55	S					(’78)
Trichloroethylene [79-01-6]	25	135		1[ψ]		1	3	’97
Trichlorofluoromethane [75-69-4]	1,000*	5,600*						’87
1,1,2-Trichloro-1,2,2-trifluoroethane [76-13-1]	500	3,800						’87
Tricyclazole [41814-78-2]	—	3						’90
Trimellitic anhydride [552-30-7]		0.0005	S		1			’15
		0.004*						
1,2,3-Trimethylbenzene [526-73-8]	25	120						’84
1,2,4-Trimethylbenzene [95-63-6]	25	120						’84
1,3,5-Trimethylbenzene [108-67-8]	25	120						’84
Trinitrotoluene (all isomers)	—	0.1	S					’93
Turpentine	50	280				1		’91
Vanadium compounds							2	
Ferrovanadium dust [12604-58-9]	—	1						’68
Vanadium pentoxide [1314-62-1]	—	0.05		2B				’03
Vinyl chloride [75-01-4]	(Table III-2)			1[ψ]				’17
Xylene (all isomers and their mixture)	50	217						’01
Xylene for industrial use							2	
Xylene (*ortho*-, *meta*-, *para*-xylene and their mixture)							3	
Zinc oxide nanoparticle [1314-13-2]	—	0.5						’21

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 to 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-carcinogenic 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 units.
   [c]: Not applicable to women of child bearing potential.
   [#]: Precaution should be taken for exposure lower than the 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.
   [†]: Provisional.

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

Substance [CAS No.]	OEL		Skin absorption	Class of carcinogenicity	Class of sensitizing potential		Reproductive Toxicants	Year of proposal
	ppm	mg/m^3			Airway	Skin		
Arsenic and compounds (as As) [7440-38-2]	(Table III-2)‡			1‡			1‡	’00
Arsine [7784-42-1]	0.1*	0.32*						’22
Fenitrothion [122-14-5]	—	0.2	S‡			2		’22
Hexachloroethane [67-72-1]	1	9.7	S	2B				’22
Styrene [100-42-5]	10	42.6	S‡	2Aψ			2‡	’22
Titanium dioxide (as Ti) [13463-67-7]	—	2 (Total particulate matter) 1.5 (Respirable particulate matter)		2B‡				’22
Titanium dioxide (nanoparticle) [13463-67-7]	—‡	0.3‡						’13

Note: see Table I-1
‡: Not provisional

Table I-3. Occupational exposure limits for dusts[a]

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 (asbestos-free, technical grade)†, Carbon black, Coal, Cork dust, Cotton dust, Iron oxide, Grain dust, Joss stick material dust, Marble, Portland cement, Zinc oxide	1	4
Class 3	Limestone‡, Inorganic and organic dusts other than Classes 1 and 2[b]	2	8
Asbestos***		(Table III-2)	

1. a, OELs for dusts are set to prevent from Class 2 pneumoconiosis, while no other toxicities are considered
   b, OEL for ‘inorganic and organic dusts other than Classes 1 and 2’ is a reference value assigned for dusts that are insoluble or poorly soluble in water to prevent from pneumoconiosis caused by inhaling large amount of those; thus, be aware that unknown toxocity may be developed even below this value
2. *: Respirable crystalline silica and respirable dust consist of particles captured by the following collection efficiency, $R(d_{ae})$.
   $R(d_{ae}) = 0.5[1 + \exp(-0.06 d_{ae})]\ [1 - F(x)]$
   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, $\Sigma = 1.5$
   **: 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 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.
3. ‡: Do not include asbestos nor ≥ 1% crystalline silica.
4. ψ: Substance whose OEL is set based on non-carcinogenic health effects; see III.
5. OEL for wood dust is under consideration.
6. †: Provisional

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) is 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
Cadmium and its compounds	blood	Cadmium	5 µg/*l*	Not critical	’21
	urine	Cadmium	5 µg/g·Cr	Not critical	’21
Carbon disulfide	urine	2-Thiothiazolidine-4-carboxylic acid	0.5 mg/g·Cr	End of shift (Avoid sizable intake of brassica vegetables)	’15
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’-diaminodiphenyl-methane (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
Ethylbenzene	urine	Mandelic acid	150 mg/g·Cr	End of shift	’21
	urine	Mandelic acid + Phenylglyoxylic acid	200 mg/g·Cr	End of shift at end of workweek	’21
	urine	Ethylbenzene	15 µg/*l*	End of shift	’21
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	15 µg/100 m*l*	Not critical	’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 ’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	Styrene	20 µg/*l*†	End of shift at end of workweek	’22
	urine	Mandelic acid + Phenylglyoxylic acid	160 mg/g·Cr†	End of shift at end of workweek	’22
Tetrahydrofuran	urine	Tetrahydrofuran	2 mg/*l*	End of shift	(’15)
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*	Within 2 h prior to end of shift at end of work week	’99
Trichloroethylene	urine	Trichloroacetic acid	10 mg/*l*†	End of shift at end of workweek	’22
	blood	Trichloroethylene	Semi-quantitative†	End of shift at end of workweek	’22
	end-exhaled air	Trichloroethylene	Semi-quantitative†	End of shift at end of workweek	’22
Xylene	urine	total (*o*-, *m*-, *p*-) methylhippuric acid	800 mg/*l*	End of shift at end of work week	’06

†: Provisional
See the JSOH website for brief summary of OEL documentation at https://www.sanei.or.jp/english/oels/index.html

III. Occupational Carcinogens

JSOH classifies occupational carcinogens based primarily on the epidemiological evidences[1)], but the results of the animal experiments and their extrapolation to humans are also considered. Although the classification is defined by strength of the evidence, it does not reflect the carcinogenic potency.

JSOH considers the classification of occupational carcinogens proposed by the International Agency for Research on Cancer (IARC)[2)] to be appropriate in principle. JSOH also discussed the classification of several agents based on other information sources and finalized the list of occupational carcinogens in Table III-1a, b, and c. *Group 1* includes agents that are carcinogenic to humans. *Group 2* indicates the agents that are probably or possibly carcinogenic to humans, classifying them into two sub-groups based on the degree of evidence: *Group 2A* is assigned to the agents with more sufficient evidence (probably carcinogenic to humans) and *Group 2B* to those with less evidence (possible 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, as shown in Table III-2. JSOH does not recommend either the reference value as a safe 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 experienced in occupational health to avoid or minimize the risk of occupational cancer.

The occupational carcinogens may have OEL, as in Table I-1. These values must be interpreted 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, whereas others did not. In the latter case, the substances are indicated as ψ in Table I-1[3)].

1) Epidemiological evidences include serum epidemiology and molecular epidemiology

2) Including mechanistic evidences

3) See Table I-1 for Group 1 and Group 2A carcinogens.

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, stratified by sex, age, and exposure situation (single, repeated). A dose and dose-rate effectiveness factor (DDREF) of 1 was primarily adopted, and REID levels with a DDREF of 2 were also calculated for comparison. The reference values were calculated based on exposure-response relationship of low-linear energy transfer (X-ray and γ-ray), indicating that the values should not be applied in cases of internal exposure.

Table III-1a. *Group 1* carcinogens

Substance	CAS No.	Year of proposal
4-Aminobiphenyl	92-67-1	’81, ’86
Arsenic and inorganic arsenic compounds*	7440-38-2	’81, ’86, (’00)
Asbestos	1332-21-4	’81, ’86, (’00)
Benzene	71-43-2	’81, ’86, (’97), (’19)
Benzidine	92-87-5	’81, ’86
Benzo [a] pyrene	50-32-8	’86, ’17
Benzotrichloride	98-07-7	’81, ’86, (’01)
Beryllium and compounds*	7440-41-7	’86, ’16
Bis (chloromethyl) ether	542-88-1	’81, ’86
1,3-Butadiene	106-99-0	’91, ’95, ’01
Cadmium and compounds*	7440-43-9	’86, ’91, ’96
Chromium (VI) compounds	18540-29-9	’81, ’86
Coal-tar pitch volatiles	—	’81, ’86, (’04)
Coal-tars	8007-45-2	’81, ’86, (’04)
1,2-Dichloropropane	78-87-5	’13, ’14
Erionite	12510-42-8	’91
Ethylene oxide	75-21-8	’86, ’90, ’96
Ionizing radiation	—	’12
Mineral oils (untreated and mildly treated)	—	’81, ’86, ’91
2-Naphthylamine	91-59-8	’81, ’86
Nickel smelting dusts*	7440-02-0	’81, ’86, ’91, (’09)
Polychlorinated biphenyls (PCB)	1336-36-3, 53469-21-9, 11097-69-1	’86, ’91, ’16
Shale oils	68308-34-9	’95
Silica (crystalline)	14808-60-7	’91, ’01
Soots	—	’81, ’86
Sulphur dichlorodiethyl	505-60-2	’86
Talc containing asbestiform fibers	14807-96-6	’91
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	1746-01-6	’86, ’00
Tobacco smoke	—	’10
o-Toluidine	95-53-4	’86, ’95, ’01, ’16
Trichloroethylene	79-01-6	’96, ’15
UV radiation from welding	—	’21
Vinyl chloride	75-01-4	’81, ’86
Welding fume	—	’21
Wood dust	—	’98

*Evaluation does not necessarily apply to all individual chemicals within the group.
( ) in the year of proposal indicates year of reconsideration resulting in no classification change.
† Provisional

Table III-1b. *Group 2A* carcinogens

Substance	CAS No.	Year of proposal
Acrylamide	79-06-1	'91, '95, ('04)
Acrylonitrile	107-13-1	'86
Benzal chloride	98-87-3	'91, '01
Benzyl chloride	100-44-7	'91, '01
Chloromethyl methyl ether (technical grade)	107-30-2	'92, ('01)
4-Chloro-*o*-toluidine	95-69-2	'91, '01
CI Direct Black 38**	1937-37-7	'86, '91, '95, '01, ('15)
CI Direct Blue 6**	2602-46-2	'86, '91, '95, '01, ('15)
CI Direct Brown 95**	16071-86-6	'86, '91, '95, '01, ('15)
Cobalt metal with tungsten carbide	7440-48-4, 12070-12-1	'16
Creosotes	8001-58-9	'91
1,2-Dibromoethane	106-93-4	'86, '95, '01
3,3'-Dichloro-4,4'-diaminodiphenylmethane (MBOCA)	101-14-4	'93, ('12)
Dichloromethane	75-09-2	'91, '14, '15
Diethyl sulphate	64-67-5	'86
N,N-Dimethylformamide	68-12-2	'91, '20
Dimethyl sulphate	77-78-1	'86
Dimethylcarbamoyl chloride	79-44-7	'86, '91
Epichlorohydrin	106-89-8	'86, '91
2,3-Epoxypropyl methacrylate (Glycidyl methacrylate, GMA)	106-91-2	'18
Formaldehyde	50-00-0	'86, '91, ('07), ('17)
Glycidol	556-52-5	'01
Hydrazine (Hydrazine anhydrous and Hydrazine hydrate)	302-01-2, 7803-57-8	'86, ('98), '19
Indium and compounds (inorganic, hardly soluble)	7440-74-6	'13, ('17)
2-Nitrotoluene	88-72-2	'18
PAHs (Cyclopenta [c,d] pyrene, Dibenz [a,h] anthracene, Dibenz [a,j] acridine, Dibenzo [a,l] pyrene, 1-Nitropyrene, 6-Nitrochrysene)	27208-37-3, 53-70-3, 224-42-0, 191-30-0, 5522-43-0, 7496-02-8	'16
1,3-Propane sultone	1120-71-4	'91, '17
Silicon carbide whisker	409-21-2, 308076-74-6	'19
Styrene†	100-42-5	'91, '22
Styrene oxide	96-09-3	'92, ('18)
1,2,3-Trichloropropane	96-18-4	'01
Tris (2,3-dibromopropyl) phosphate	126-72-7	'91
Vinyl bromide	593-60-2	'91
Vinyl fluoride	75-02-5	'98

**Dyes metabolized to benzidine.
†Provisional
( ) in the year of proposal indicates year of reconsideration resulting in no classification change.

Table III-1c. *Group 2B* carcinogens

Substance	CAS No.	Year of proposal
Acetamide	60-35-5	’91
Acetoaldehyde	75-07-0	’91, (’21)
Acrylic acid methyl	96-33-3	’19
o-Aminoazotoluene	97-56-3	’91
p-Aminoazobenzene	60-09-3	’91
2-Amino-4-chlorophenol	95-85-2	’19
Amitrole	61-82-5	’86
Antimony trioxide	1309-64-4	’91, (’13)
o-Anisidine (o-anisidine hydrochloride)	90-04-0	’91, (’96), (’22)
Anthraquinone	84-65-1	’15
Auramine (technical grade)	492-80-8	’86
Benzofuran	271-89-6	’15
Benzophenone	119-61-9	’15
Benzoyl chloride	98-88-4	’16
Benzyl violet 4B	1694-09-3	’91
2,2-Bis (bromomethyl) propane-1,3-diol	3296-90-0	’01
Bitumens	8052-42-4	’91
1-Bromo-3-chloropropane	109-70-6	’20
Bromodichloromethane	75-27-4	’95
1-Bromopropane	106-94-5	’17
2-Bromopropane	75-26-3	’21
1-*tert*-Butoxy-2-propanol	57018-52-7	’18
n-Butyl-2,3-epoxypropyl ether	2426-08-6	’16
β-Butyrolactone	3068-88-0	’95
Carbon black	1333-86-4	’91
Carbon tetrachloride	56-23-5	’86
Catechol	120-80-9	’01
Chlordane	57-74-9	’01
Chlordecone (Kepone)	143-50-0	’01
Chlorendic acid	115-28-6	’91
Chlorinated paraffins	—	’91
p-Chloroaniline	106-47-8	’95
4-Chlorobenzotrifluoride	98-56-6	’20
Chloroform	67-66-3	’86, (’05)
1-Chloro-2-methylpropene	513-37-1	’01
3-Chloro-2-methylpropene	563-47-3	’01, (’17)
Chlorophenoxy acetic acid herbicides*	—	’86
p-Chloro-*o*-phenylenediamine	95-83-0	’91
Chloroprene	126-99-8	’01
Chlorothalonil	1897-45-6	’01
CI acid red 114	6459-94-5	’95
CI basic red 9	569-61-9	’95
CI direct blue 15	2429-74-5	’95
CI direct blue 218	28407-37-6	’21
Citrus red No.2	6358-53-8	’91
Cobalt and compounds (Without tungsten carbide)*	7440-48-4	’95, (’16)
p-Cresidine	120-71-8	’91
Crotonaldehyde	4170-30-3	’21
Cumene	98-82-8	’15, (’19)
Dantron	117-10-2	’15
N,*N*’-Diacetyl benzidine	613-35-4	’91
2,4-Diaminoanisole	615-05-4	’91

Substance	CAS No.	Year of proposal
4,4’-Diaminodiphenyl ether	101-80-4	’91
2,4-Diaminotoluene	95-80-7	’91
Diazinon	333-41-5	’18
1,2-Dibromo-3-chloropropane	96-12-8	’91
2,3-Dibromopropan-1-ol	96-13-9	’01
p-Dichlorobenzene	106-46-7	’91, (’98)
3,3’-Dichlorobenzidine	91-94-1	’86
1,4-Dichloro-2-butene	764-41-0	’15
3,3’-Dichloro-4,4’-diaminodiphenyl ether	28434-86-8	’91
1,2-Dichloroethane	107-06-2	’91
1,4-Dichloro-2-nitrobenzene	89-61-2	’19
2,4-Dichloro-1-nitrobenzene	611-06-3	’19
1,3-Dichloropropene (technical grade)	542-75-6	’91
1,3-Dichloro-2-propanol	96-23-1	’15
Dichlorvos	62-73-7	’01
Diepoxybutane	1464-53-5	’91
Diethanolamine	111-42-2	’15
Di (2-ethylhexyl) phthalate	117-81-7	’91
1,2-Diethylhydrazine	1615-80-1	’91
Diglycidyl resorcinol ether	101-90-6	’91
Diisopropyl sulfate	2973-10-6	’95
N,N-Dimethylacetamide	127-19-5	’19
p-Dimethylaminoazobenzene	60-11-7	’91
2,6-Dimethylaniline	87-62-7	’95
3,3’-Dimethylbenzidine (*o*-Tolidine)	119-93-7	’91
1,1-Dimethylhydrazine	57-14-7	’91
N,N-Dimethyl-*p*-toluidine	99-97-8	’17
3,3’-Dimethoxybenzidine (*o*-Dianisidine)	119-90-4	’86
2,4-(or 2,6-) Dinitrotoluene	121-14-2	’98
1,4-Dioxane	123-91-1	’86, (’15)
Diphenylamine†	122-39-4	’22
Disperseblue 1	2475-45-8	’91
DDT	50-29-3	’86, (’17)
1,2-Epoxybutane	106-88-7	’01
Ethyl acrylate	140-88-5	’91, (’19)
Ethylbenzene	100-41-4	’01, (’20)
2-Ethylhexyl acrylate	103-11-7	’19
Ethyl methanesulphonate	62-50-0	’91
Ethylene thiourea	96-45-7	’86
Ethylenimine	151-56-4	’01, (’18)
(2-Formylhydrazino)-4-(5-nitro-2-furyl) thiazole	3570-75-0	’91
Furan	110-00-9	’01
Furfuryl alcohol	98-00-0	’19
Gasoline	8006-61-9	’01
Glycidaldehyde	765-34-4	’91
Glyphosate	1071-83-6	’21
HC blue No. 1	2784-94-3	’95
Heptachlor	76-44-8	’01
Hexachlorocyclohexanes	319-84-6	’91
Hexachloroethane†	67-72-1	’22
Hexamethylphosphoramide	680-31-9	’01
Isophorone†	78-59-1	’22
Isoprene	78-79-5	’95, (’17)
Lead and compounds (Except alkyl lead)*	7439-92-1	’91, (’16)
Magenta (Containing CI basic red 9)	632-99-5	’95
Magnetic fields, extremely low-frequency	—	’15

Substance	CAS No.	Year of proposal
Malathion	121-75-5	’18
Man-made mineral fibers (Ceramic fibers, Micro glass fibers)	—	’91, ’03
Melamine	108-78-1	’19
2-Mercaptobenzothiazole	149-30-4	’19
4,4’-Methylene bis (2-methylaniline)	838-88-0	’91
4,4’-Methylenedianiline	101-77-9	’91, (’95)
Methyl isobutyl ketone	108-10-1	’15
Methyl mercuries	7439-97-6	’95
2-Methyl-1-nitroanthraquinone	129-15-7	’91
N-Methyl-*N*-nitrosourethane	615-53-2	’91
N-Methylolacrylamide†	924-42-5	’22
α-Methylstyrene	98-83-9	’15
Mirex	2385-85-5	’01
Molybdenum trioxide	1313-27-5	’17
β-Myrcene	123-35-3	’18
Naphthalene	91-20-3	’15
Nickel compounds (Except nickel carbonyl and nickel smelting dusts)*	7440-02-0	’81, ’86, ’91, (’09)
2-Nitroanisole	91-23-6	’98, (’22)
4-Nitroanisole	100-17-4	’19
Nitrobenzene	98-95-3	’98
o-Nitrochlorobenzene	88-73-3	’19
p-Nitrochlorobenzene	100-00-5	’19
Nitrilotriacetic acid and its salts	139-13-9	’91
Nitrogen mustard-*N*-oxide	126-85-2	’91
5-Nitroacenaphtene	602-87-9	’91
Nitromethane	75-52-5	’01
2-Nitropropane	79-46-9	’91
N-Nitrosodiethanolamine	1116-54-7	’01
N-Nitroso-*N*-phenylhydroxylamine ammonium salt (Cupferron)	135-20-6	’21
N-Nitrosomorpholine	59-89-2	’91
Oil orange SS	2646-17-5	’91
PAHs (Benz[a]anthracene, Benz[j]aceanthrylene, Benzo[b]fluoranthene, Benzo[c]phenanthrene, Benzo[j]fluoranthene, Benzo[k]fluoranthene, Chrysene, Dibenz[a, h]acridine, Dibenz[c, h] acridine, Dibenzo[a, h]pyrene, Dibenzo[a, i]pyrene, 7H-Dibenzo[c, g]carbazole, 1,3-Dinitropyrene, 1, 6-Dinitropyrene, 1,8-Dinitropyrene, 5-Methylchrysene, 3-Nitrobenzanthrone, 4-Nitropyrene)	56-55-3, 202-33-5, 205-99-2, 195-19-7, 205-82-3, 207-08-9, 218-01-9, 226-36-8, 224-53-3, 189-64-0, 189-55-9, 194-59-2, 75321-20-9, 42397-64-8, 42397-65-9, 3697-24-3, 17117-34-9, 57835-92-4	’16
Perfluorooctanoic acid	335-67-1	’17
Phenyl glycidyl ether	122-60-1	’91
o-Phenylenediamine and its dihydrochloride	95-54-5, 615-28-1	’19

Substance	CAS No.	Year of proposal
Polybrominated biphenyls	59536-65-1	’91, (’17)
Polychlorophenols (technical grades)	—	’86
Ponceau 3R	3564-9-8	’91
Ponceau MX	3761-53-3	’91
β-Propiolactone	57-57-8	’91
Propylene imine (2-Methylaziridine)	75-55-8	’91, (’17)
Propylene oxide	75-56-9	’91, ’95
Pyridine	110-86-1	’18
Quinoline	91-22-5	’18
Radiofrequency electromagnetic fields	—	’15
1,1,2,2-Tetrachloroethane	79-34-5	’15
Tetrachloroethylene	127-18-4	’91, (’01)
Tetrafluoroethylene	116-14-3	’01, (’17)
2,4,6-Trichlorophenol	88-06-2	’18
Tetrabromobisphenol A	79-94-7	’19
Tetrahydrofuran	109-99-9	’19
Tetranitromethane	509-14-8	’98
4,4’-Thiodianiline	139-65-1	’91
Thiourea	62-56-6	’95
Titanium dioxide	13463-67-7	’15
Toluene diisocyanates (TDI)	26471-62-5	’91
Trimethylolpropane Triacrylate (technical grade)	15625-89-5	’19
Trypane blue	72-57-1	’91
Urethane	51-79-6	’91
Vanadium pentoxide	1314-62-1	’15
Vinylidene chloride	75-35-4	’18
Vinyl acetate	108-05-4	’98
4-Vinylcyclohexene	100-40-3	’95
4-Vinylcyclohexene diepoxide	106-87-6	’95

*Evaluation does not necessarily apply to all individual chemicals within the group.
†Provisional
( ) in the year of proposal indicates year of reconsideration resulting in no classification change.
Styrene is proposed to be excluded from Group 2B†.

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 inorganic arsenic compounds	10^{-3}	3 μg/m^3	Average relative risk model	’00
	10^{-4}	0.3 μg/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 other than chrysotile	10^{-3}	0.03 fibers/m*l*		
	10^{-4}	0.003 fibers/m*l*		
Benzene	10^{-3}	1 ppm	Average relative risk model	’97, (’19)
	10^{-4}	0.1 ppm		
Ionizing radiation	(Table III-3)			’12
Nickel smelting dusts (as Ni)	10^{-3}	10 μg/m^3	Average relative risk model	’09
	10^{-4}	1 μg/m^3		
Vinyl chloride	10^{-3}	1.5 ppm	Average relative risk model	’17
	10^{-4}	0.15 ppm		

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 at first exposure				
	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 at first exposure				
	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}	0.7	0.9	1.2	1.7	2.6

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

(a) Male

REID	age at first exposure				
	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 at first exposure				
	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 at first exposure				
	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 at first exposure				
	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 at first exposure				
	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 at first exposure				
	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	35.1	53.3
10^{-4}	1.7	2.0	2.6	3.5	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 at first exposure				
	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 at first exposure				
	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 at first exposure				
	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 at first exposure				
	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 at first exposure				
	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 at first exposure				
	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

The occupational sensitizers to the airway and skin are enlisted in Table IV.

1. Definition of sensitizers

Respiratory sensitizers are substances that can induce respiratory sensitization* by inhalation.

Skin sensitizers are substances that can induce skin sensitization by skin contact.

* Rhinitis, asthma, hypersensitivity pneumonitis, eosinophilic pneumonia, etc.

2. Classification of sensitizers

Occupational sensitizers are recommended for respiratory tract and skin. 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 possibly induce allergic reactions in humans.

Recommendation of occupational exposure limits for the occupational sensitizers does not necessarily consider either prevention of induction or elicitation.

Respiratory sensitization might be severe to human health.

The absence of any substance from the list does not indicate that the substance is not a sensitizer.

3. Respiratory sensitizers

Group 1

There is a clear association between respiratory symptoms and occupational exposure. Case reports of positive inhalation challenge tests, serological studies, or prick tests are reported in at least two different research organizations.

In addition, there is at least one epidemiological study which indicates a clear association between respiratory symptoms and occupational exposure.

Group 2

There is a clear association between respiratory symptoms and occupational exposure. Case reports of positive inhalation challenge tests, serological studies, or prick tests are reported in at least two different research organizations.

However, there is no epidemiological study.

Group 3

(1) Positive animal tests which fulfill all conditions as below are reported in at least two different research organizations.

(i) induction and elicitation are performed by inhalation, nasal, or bronchial administration.
(ii) detections of elicitation are performed by either bronchial alveolar lavage fluid (BALF), cell fractionation or histopathological studies. One among respiratory function studies, detections of antibodies or analyses of cytokines are performed.
(iii) both only induction group and only elicitation group are set up as negative controls.
(iv) clear positive control is integrated

or

(2) Positive animal tests which fulfill all conditions as stated above are reported in only one research organization. Positive appropriate animal test which does not fulfill all conditions is also reported in other research organizations.

* The conditions other than those stated above ((i)~(iv)) might also provide an evidence for an animal sensitizer.

4. Skin sensitizers

Group 1

Case reports which show a clear association between skin symptoms and skin tests* are reported in at least two different research organizations.

In addition, an epidemiological study which clearly indicates associations among occupational exposures, and skin symptoms and tests, is reported in at least one research organization. Skin tests should be appropriately performed with controls.

* Skin tests include patch, prick, and scratch tests.

Group 2

Case reports which show a clear association between skin symptoms and skin tests are reported in at least two different research organizations.

However, there is no epidemiological study.

Group 3

Positive appropriate animal tests: guinea pig maximization test (GPMT), and the Buehler guinea pig test (OECD Guideline 406) or Local Lymph Node Assay (LLNA) (OECD 429) are reported in at least one research organization.

Response of $\geq$30% is considered positive in GPMT, while that of $\geq$15% is considered positive in Buehler test. Stimulation index (SI) should be $\geq$3 in LLNA. Other animal tests which are validated would be considered.

Table IV. Occupational sensitizers

Airway	
Group 1	Beryllium*, Cobalt*, Colophony (Rosin)*, Diphenylmethane-4,4'-diisocyanate (MDI), Glutaraldehyde, Hexane-1,6-diisocyanate, Methyltetrahydrophthalic anhydride, *o*-Phthalaldehyde, 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, Benzyl alcohol, Chlorothalonil, Chromium*, Cobalt*, Colophony (Rosin)*, 2,4-Dinitrochlorobenzene (DNCB), Epichlorohydrin, Formaldehyde, Glutaraldehyde, Hydrazine*, Mercury*, Methacrylic acid 2-hydroxyethyl ester (2-Hydroxyethyl methacrylate), 4,4'-Methylenedianiline, Nickel*, *p*-Phenylenediamine, *o*-Phthalaldehyde, Platinum*, Resorcinol, Sodium ethylmercury 2-Sulfidobenzoate (Thimerosal), Thiuram, Trichloroethylene, Tri (propylene glycol) diacrylate, *N*,*N*',*N*''-Tris (β-hydroxyethyl)-hexahydro-1,3,5-triazine, Turpentine*, *m*-Xylylendiamine
Group 2	Acrylamide, Benomyl, Benzyl alcohol, Beryllium*, Buthyl acrylate, *N*-butyl-2,3-epoxy-propyl ether, Copper*, Dibutyl phthalate, Dichloropropane, Dicyclohexylcarbodiimide, Diethanolamine, 2,3-Epoxypropyl methacrylate (Glycidyl methacrylate, GMA), Ethyl acrylate, Ethylenediamine, Ethylene glycol dimethacrylate, Ethylene oxide, Fenitrothion[†], 1,6-Hexanediol diacrylate, Hydroquinone, 2-Hydroxyethyl acrylate[†], 2-Hydroxyethyl methacrylate, Iodine*, Maleic anhydride, Methyl acrylate, Methyl methacrylate, 2-n-octyl-4-isothiazolin-3-one[†], Picric acid, Polyvinyl chloride plasticizers*, Rodium*, Toluene diamine*, Toluene diisocyanates*, Usnic acid
Group 3	*m*-Chloroaniline, Dimethylamine, Isophoronediisocyanate, *o*-Phenylenediamine, *m*-Phenylenediamine

*Evaluation does not necessarily apply to all individual chemicals within the group. [†]Provisional.
The revised definition of "Occupational sensitizer" has been applied to the substances proposed in 1998 or later, and the substances listed before 1998 are not fully re-examined at this time; please note that OEL values are not necessarily recommended for all the substances listed here. See JSOH web site for brief summary of OEL documentation at https://www.sanei.or.jp/english/oels/index.html

V. Reproductive Toxicants

The JSOH classifies reproductive toxicants based on the evidence of reproductive toxicity obtained from epidemiological studies and other studies in humans, as well as that from experimental studies in animals. The classification is made based on the strength of evidence for adverse effects on reproduction in humans, without reflecting the potency of such adverse effects. Namely, the classification does not necessarily indicate that exposures to the classified substances at the present 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, including those on offspring. Effects on 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 the reproductive functions referred to above are suspected to be 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. Effects on post-weaning growth, behavior, function, sexual maturation, carcinogenesis, accelerated aging, and other processes that are clearly demonstrated in the offspring as a result of parental exposure, 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* and 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 and other human studies shall be classified.

Sufficient evidence that demonstrates reproductive toxicity in humans is required, where sufficient refers to 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 co-exposure to other substances or potential confounding factors, in an appropriate manner; b) the study is supported by many non-epidemiological study reports such as those on clinical cases or accidental exposures, indicating reproductive toxicity, and is therefore considered as sufficient evidence of toxicity in humans. Animal experimental data are considered as supportive

Table V. Reproductive toxicants

Group 1	Arsenic and compounds, 2-Bromopropane, Cadmium and compounds, Carbon disulfide, Carbon monoxide#, Di (2-ethylhexyl) phthalate#, Ethylene glycol monomethyl ether, Ethylene glycol monomethyl ether acetate, Ethylene oxide, Lead and compounds#, Perfluorooctanoic acid (PFOA)#, Polychlorobiphenyls (PCB), Toluene
Group 2	Acrylamide, Benomyl#, 1-Bromopropane, Chlorodifluoromethane, Chloromethane, 2,4-Dichlorophenoxyacetic acid (2,4-D), *N*,*N*-Dimethylacetamide, *N*,*N*-Dimethylformamide (DMF), Ethyl benzene, Ethylene glycol monobutyl ether, Ethylene glycol monoethyl ether, Ethylene glycol monoethyl ether acetate, Inorganic mercury (including mercury vapor), Manganese and its compounds (as Mn except organic manganese compounds), Methanol, Pentachlorophenol (PCP), Styrene, Vanadium and compounds, Xylene for industrial use
Group 3	Atrazine, *n*-Butyl-2,3-epoxypropylether, Chromium and compounds, *p*-Dichlorobenzene, 2,3-Epoxypropyl methacrylate (Glycidyl methacrylate, GMA), Ethyleneimine, 2-Ethyl-1-hexanol, Ethylidene norbornene, Glyphosate, Nickel and compounds, Phenol, Tetrachloroethylene, Trichloroethylene, Xylene (*ortho*-, *meta*-, *para*-xylene, and their mixture)

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.
†Provisional
See JSOH web site for brief summary of OEL documentation at https://www.sanei.or.jp/english/oels/index.html

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 based on animal experiments, specifically, evidence showing obvious adverse effects on reproduction in animals, identified by appropriately conducted animal experimental studies, thereby reasonably indicating the reproductive toxicity of the substance in humans. When judgment is based on the results of animal experiments, it is required that the observed effects should not be consequential of secondary non-specific effects of other general toxicities, and the identified mechanism of action should be non-species-specific, and therefore, relevant for extrapolation to humans. In addition, those observed changes which are small, and exert only non-significant effects on the life or function of the subject, are not considered satisfactory for the requirement.
Group 3: Substances with limited evidence has been demonstrated shall be classified.

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

3. Classified reproductive toxicants

Table V. lists the substances classified in each reproductive toxicant group, according to the previously mentioned judgment criteria. The judgment for substances with JSOH-recommended OEL, is based on information described in the documentation for Recommendation of OEL by JSOH and other relevant information; however, substances excluded from the table could meet the classification criteria of reproductive toxicity. There may be some substances for which reproductive toxicity might be observed below the OEL-M or OEL-B; in such cases, precautionary notice is given by adding a symbol (#) next to the substances in Table V.

VI. 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. VI 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 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 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 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 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'.

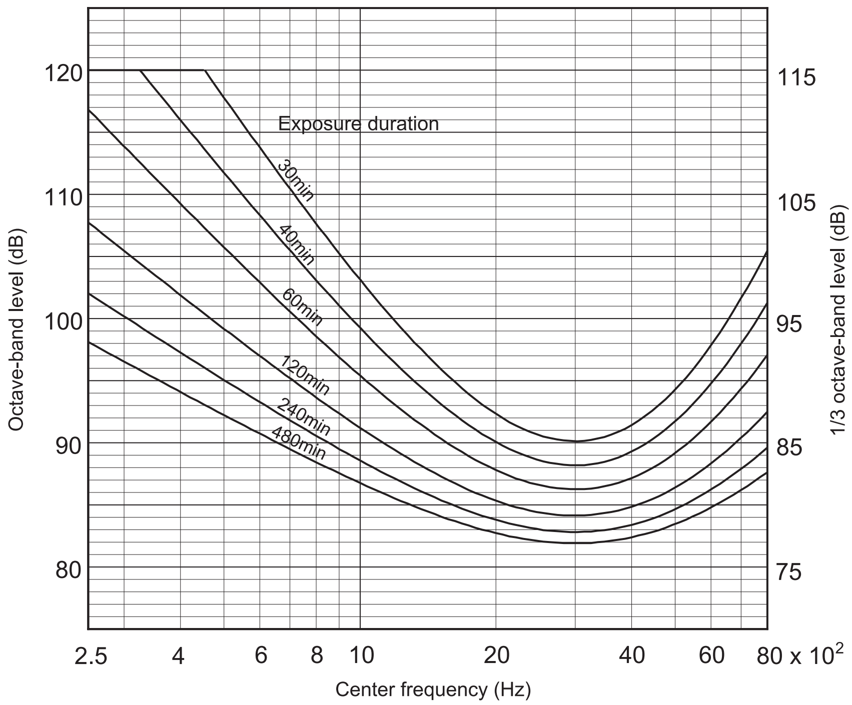

Fig. VI. Occupational exposure limits for continuous or intermittent noise.

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		

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. VII-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. VII-1 with the adjustment value in Fig. VII-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. VII-3 (A) and (B). In Fig. VII-3 (A), A duration is defined as the duration between T_O and T_D. In Fig. VII-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 exists. 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.

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.

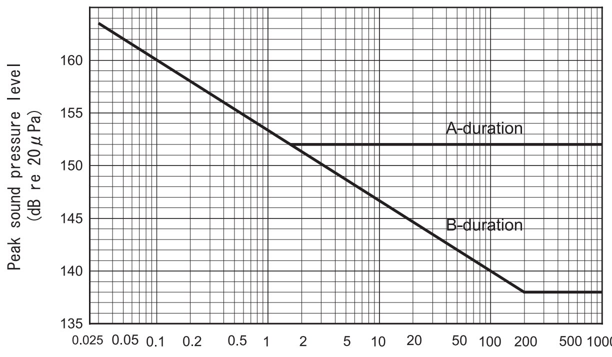

Fig. VII-1. Occupational exposure limits for impulsive or impact noise.

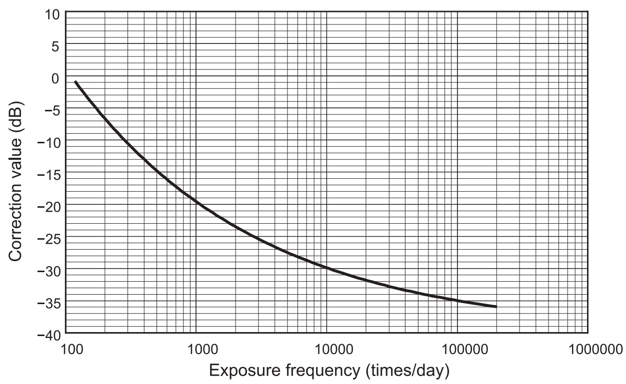

Fig. VII-2. Correction values corresponding to exposure frequency a day.

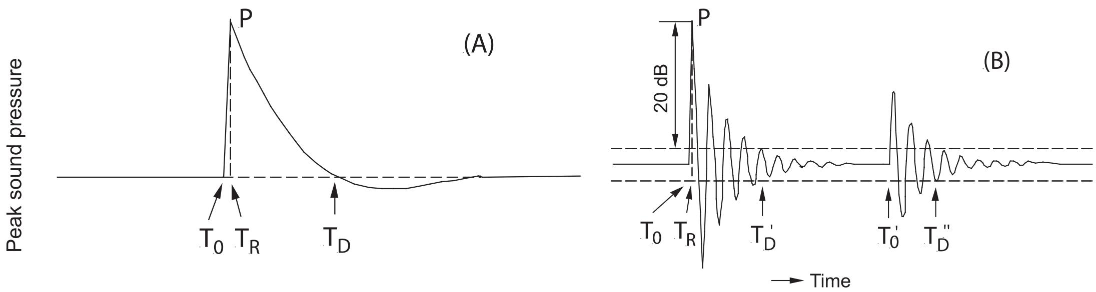

Fig. VII-3. Measurement for impulsive or impact noise.

VIII. Occupational Exposure Limits for Heat Stress

1. Occupational Exposure Limits

Permissible heat exposure limits were proposed as Table VIII-1 on the presumption that any unfavorable physiological response should not be caused by the heat stress.

2. Application

These exposure limits show the condition for which the workers work without health impairment or decrease in work efficiency for one hour of continuous work or two hours of intermittent work. The workers mentioned here are healthy adult male workers, adapted themselves to hot environment, well used to the work, wearing usual summer clothes, and taking enough water and salt.

Hot environment means the condition in which the regulation of body temperature is mainly performed by the evaporation responding to the complex of ambient temperature, humidity, and heat radiation.

Adaptation is the effect of the vicarious physiological change of the worker working under hot environment.

The thermal adaptation is obtained by usually working for one week under hot environment. If hot environment exposure is ceased, the adaptation effect is lost immediately and usually disappears in two weeks. Therefore, it is necessary to pay attention to the workers' condition when their adaptation is not enough or when they return to work after two or more days off.

The unfavorable physiological response is the state that physiological burdens such as increase of the heart rate, a rise in temperature, the increase of the quantity of water loss continue increasing.

Therefore, if the physiological burden on worker continues increasing under hot environment, some engineering measures should be taken or other measures like wearing cool clothes and reducing work load should be performed to decrease heat strain. The heat stress consists of factors such as environmental thermal condition, heat production through metabolism and heat exposure time.

The work load means metabolic energy used at the work. We expressed the degree in Relative Metabolic Rate (RMR) and classified in five categories as shown in Table VIII-2. RMR is calculated by the following expression.

$$\text{RMR} = \frac{(\text{energy consumption on exertion}) - (\text{energy consumption at rest})}{(\text{basal metabolic rate})}$$

RMR values according to common movements are displayed in Table VIII-3. This table should be referred to estimate the work load.

In an ordinary industrial setting, many of the works are manually performed continuously with the work load of around RMR 1.0. And most of the work loads are not more than RMR 2. However, it is considered possible to work continuously for one hour by the work load of RMR 4, we set one hour continuous work as the basic work unit for the work load up to RMR 4. Furthermore, although the work exceeding RMR 4 may exist, we assumed those work must be performed intermittently, as it is difficult to continue for one hour.

Therefore, regarding the working hour mentioned here, we classify the work into continuous work or intermittent work. We assumed one-hour work as the evaluation unit for continuous work and proposed the method of evaluating the environment in one-hour continuous work for normal eight hours. Likewise, we assumed two-hour work as the evaluation unit for intermittent work and proposed the method of evaluating the environment in two-hour intermittent work similarly. We adopted these methods in order to make it applicable to the real industrial workshop and to make it possible to evaluate in a short time.

3. Thermal index and method for measuring workload

We decided to use the environmental index corresponding to the physiological response by the heat stress for an evaluation of the hot environment. As the best method now, we adopted Wet Bulb Globe Temperature (WBGT) as the simple and practical index for the thermal condition.

Calculation of thermal index

Methods for the measurement of thermal index are described elsewhere. WBGT is calculated as follows.

Calculation of WBGT

(1) Inside the room or outdoors without sunlight radiation
WBGT = 0.7NWB + 0.3GT

(2) Outdoors with sunlight radiation
WBGT = 0.7NWB + 0.2GT + 0.1DB
NWB (natural wet bulb temperature): Wet bulb temperature (without breathing forcibly and not surrounding the bulb part to prevent heat radiation) measured with being exposed to natural air flow
GT (globe thermometer temperature): Temperature measured by globe thermometer of 6 inches in diameters
DB (dry bulb temperature): Dry bulb temperature measured by covering the bulb part to prevent the direct effect of heat radiation without interfering spontaneous air flow

At measurement, it is important to comprehensively evaluate the thermal load affected by the ambient thermal condition and artificial heat production in the workplace. The actual situation including the workers' condition should be fully understood such as the work position, the work intensity, the time and frequency of the heat exposure. We estimate the actual work condition as follows.

In the case of continuous work, the thermal condition of the workplace should be defined as the highest one-hour value of WBGT in a daily working hour.

In the case of two-hour intermittent work, the thermal condition of the workplace should be defined by two-hour time-weighted value of WBGT.

Two-hour time-weighted value of WBGT = ($WBGT_1 \times t_1 + WBGT_2 \times t_2 + ... + WBGT_n \times t_n$) /120 minutes
$WBGT_1$, $WBGT_2$... $WBGT_n$: Each value of WBGT at work or at break
t_1, t_2... t_n: Each value of time at work or at break (minute)

The method to calculate work load of two-hour intermittent work is as follows.

If the workers are engaged in heavy/moderate work load for more than one hour, we define it as moderate workload.

If the workers are engaged in light work load for more than one hour, and the rest in moderate workload, we define it as light work load.

If the workers are engaged in light work load for more than one hour, and the rest in heavy workload, we define it as moderate work load.

When each of the work load is of concern, we calculate the two-hour load average of the work load as follows.

Two-hour load average of the work load = ($WL_1 \times t_1 + WL_2 \times t_2 + \dots + WL_n \times t_n$) /120 minutes
WL_1, WL_2 … WLn: Each value of work load at each work or at break
t_1, t_2... t_n: Each time at work or at break (minute)

4. Year of proposal: 1982

Table VIII-1. Occupational Exposure Limits for heat stress

Workload	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

Table VIII-2. Workload and metabolic energy (kcal/h)

Workload	Metabolic energy (kcal/h)
RMR ~1 (Very Light, ~130 kcal/h)	~130
RMR ~2 (Light, ~ 190 kcal/h)	~190
RMR ~3 (Moderate, ~ 250 kcal/h)	~250
RMR ~4 (Moderate, ~ 310 kcal/h)	~310
RMR ~5 (Heavy, ~ 370 kcal/h)	~370

Table VIII-3. Classification of RMR by work

RMR	Principal motion sites	Motion	Examples of works
0 − 0.5 0.5 − 1.0	hand	moving mechanically moving consciously	call handling (seated) 0.4, data entry 0.5, gauge monitoring (seated) 0.5 straightening (hammer tapping, 98 times/min) 0.9, vehicle driving 1.0
1.0 − 2.0 2.0 − 3.0	hand movement with some upper limb movement	hand movement with some forearm movement forearm hand movement with some upper arm movement	lathe work (pairing, 0.83 minutes/unit) 1.1, surveillance work (standing) 1.2, walking slowly on level ground (45 m/min) 1.5 walking (ordinary, 71 m/min) 2.1, concrete polishing (lightly) 2.0, circular saw work 2.5, stair walking (down, 50 m/min) 2.6
3.0 − 4.0 4.0 − 5.5	upper limb	normal movement relatively big movement with power	chinning grinder (grinding 150 kg parts, 6 min/unit) 3.0, riding bicycle (level ground, 170 m/min) 3.4, walking (fast, 95 m/min) 3.5 riveting (1.3 /min) 4.2, filing (36 cm file, 150 times/min) 4.2, rough saw 5.0
5.5 − 6.5	whole body lifting, turning, pulling, pushing, throwing, moving up-and-down, scraping	normal movement	tapping (poking 7 kg, 16-20 times/min) 5.7, shoveling (6 kg, 18 times/min) 6.5, stair walking (up, 45 m/min) 6.5
6.5 − 8.0		relatively big movement with equal power	hammering (6.8 kg, 26 times/min) 7.8
8.0 − 9.5		especially momentary	pile up (15 kg, 10 times/min) 9.0
10.0 − 12.0	whole body (same as above)	physically strenuous work with a bit of leeway; may continue for sometime	pushing at full power 10.0 pickaxe (concrete bursts) 10.5 shovel (72 times/min.) 11.0
≥12.0	physically strenuous work such as construction work	concentrate on whole body movement and can tolerate only for less than one minute	hammering (4.5 kg, 29 times/min) 19.3

IX. Occupational Exposure Limits for Cold Stress

Workers should wear appropriate clothing to protect themselves from cold stress in cold environments. The values of thermal insulation of the combination of clothing are shown in Table IX-1.

Recommendations about clothing: Wear several layers of loose clothing. Layering provides better insulation. Make sure to protect the ears, face, hands, and feet in extremely cold weather. Boots should be waterproof and insulated. Avoid touching cold metal surfaces with bare skin.

The gloves are necessary to prevent frostbite of the hands. The appropriate gloves should be chosen, depending on work, and waterproof gloves in some cases. If the degree of the chilliness is severer, mittens are more effective.

The relationship between equivalent temperature and thermal insulation of clothing, during both light and moderate workloads is presented in Table IX-2.

When air temperature is lower, the worker should wear clothing with higher thermal insulation power. And also, when a workload is low, the worker should wear higher thermal insulation clothing, because the internal heat produced by the body is lower than in the case of a higher workload.

In the cold environment, the wind velocity becomes a critical factor as well as air temperature.

An equivalent chill temperature chart relating the air temperature and the wind velocity is presented in Table IX-3.

Maximum work period recommended for properly clothed workers, working 4-hour shifts, at air temperatures and workloads are shown in Table IX-4. The workload is expressed in RMR (Relative Metabolic Rate) with the identical case of occupational exposure limits for heat stress. Light workload is less than RMR 2, (less than 190 kca1/h, metabolic energy), and moderate workload is RMR 2-3 (about 250 kca1/h, metabolic energy).

There is much continuous light work (RMR l-2) and moderate work of RMR 3 in some cases. In the workload of these levels, physical loads to thermoregulation system by the cold stress, are bigger than the load to breathing and the circulatory system in the body function by the work.

The standard work conditions are for four hours shift work, taking a rest for at least 30 minutes after each shift work, wearing adequate cold-protective clothing to work in an almost windless environment.

Physical effects by cold chill index and equivalent temperature are shown in Table IX-5.

In cold environments, skin temperatures decrease particularly in the tip of the hands and feet. Body temperatures decrease, when heat production in the body is less than the heat radiation on the equilibrium of the internal heat balance.

Tremors and unconsciousness appear by hypothermia. Core temperature such as rectal temperature should keep above 36°C. Outbreak of more intense tremors is the danger signal that temperature is decreasing more, and one should promptly stop exposure to the cold.

Work efficiency decreases and is unsafe due to pain, tightening, and the chilliness of the peripheral parts such as hands and feet. Furthermore, the skin temperature of the toes is approximately 13°C, and 10°C at the fingers. Pain and numbness by cold is a danger signal, leading to frostbite.

Table IX-1. Thermal performance of clothing

Combination of clothing	Clo value
Underwear (top /bottom), shirt, trousers, coat, vest, socks, shoes	1.11
Underwear (top /bottom), thermal jumper, thermal trousers, socks, shoes	1.40
Underwear (top /bottom), shirt, trousers, coat, over jacket, cap, gloves, socks, shoes	1.60
Underwear (top /bottom), shirt, trousers, coat, over jacket, over trousers, socks, shoes	1.86
Underwear (top /bottom), shirt, trousers, coat, over jacket, over trousers, cap, gloves, socks, shoes	2.02
Underwear (top /bottom), over jacket, over trousers, thermal jumper, thermal trousers, socks, shoes	2.22
Underwear (top /bottom), over jacket, over trousers, thermal jumper, thermal trousers, cap, gloves, socks, shoes	2.55
Cold protective clothing	3~4.5
Sleeping bag	3~8

Table IX-2. Occupational exposure limits for cold stress (Maximal work duration in a 4-hour shift)

Temperature	Workload	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

Table IX-3. Cooling power of wind on exposed body areas air expressed as equivalent chill temperature

wind velocity (m/sec)	air temperature (°C)										
	0	−5	−10	−15	−20	−25	−30	−35	−40	−45	−50
	equivalent chill temperature (°C)										
calm	0	−5	−10	−15	−20	−25	−30	−35	−40	−45	−50
2	−1	−6	−11	−16	−21	−27	−32	−37	−42	−47	−52
3	−4	−10	−15	−21	−27	−32	−38	−44	−49	−55	−60
5	−9	−15	−21	−28	−34	−40	−47	−53	−59	−66	−72
8	−13	−20	−27	−34	−41	−48	−55	−62	−69	−76	−83
11	−16	−23	−31	−38	−46	−53	−60	−68	−75	−83	−90
15	−18	−26	−34	−42	−49	−57	−63	−73	−80	−88	−96
20	−20	−28	−36	−44	−52	−60	−68	−76	−84	−92	−100

Table IX-4. Occupational exposure limits for cold stress (Maximum work period recommended working 4-hour shift)

Air temperature	Workload		Maximum work period (min)
−10~−25°C	light workload	(RMR~2)	~50
	moderate workload	(RMR~3)	~60
−26~−40°C	light workload	(RMR~2)	~30
	moderate workload	(RMR~3)	~45
−41~−55°C	light workload	(RMR~2)	~20
	moderate workload	(RMR~3)	~30

Wind velocity is below 0.5 m/sec, in an almost windless environment.
The standard work conditions are for four hours by shift work taking a rest in a recovery room for at least 30 minutes after one work sequel to.

Table IX-5. Physical effects by cold chill index and equivalent temperature

Cold chill index	Equivalent air temperature (°C)	Physical effects
1,000	−14	Very cold
1,200	−22	Extremely cold
1,400~1,550	−30~−38	Frostbite of exposed skin in one hour
1,700~1,900	−45~−53	Dangerous outside activity such as walking, frostbite occurs on exposed part of the face in one minute
2,000~2,300	−61~−69	Frostbite occurs on exposed part of the face in 30 seconds

X. Occupational Exposure Limits for Whole Body Vibration

0.35 $m/s^2 A_{sum}$ (8)

XI. Occupational Exposure Limits for Hand-Arm Vibration

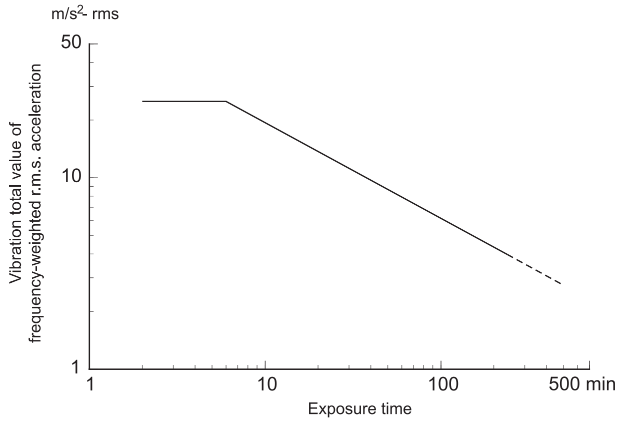

Fig. XI. Occupational exposure limits for hand-arm vibration using vibration total value of frequency-weighted r.m.s. acceleration.

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 r.m.s.)
≤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})	2T
Extremities	500 mT (4.08×10^5 Am^{-1})	5T

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

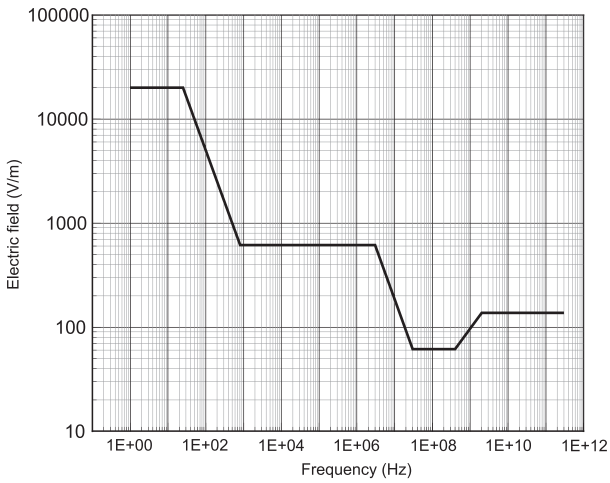

Fig. XII-1. OEL-Ms of time-varying electric fields

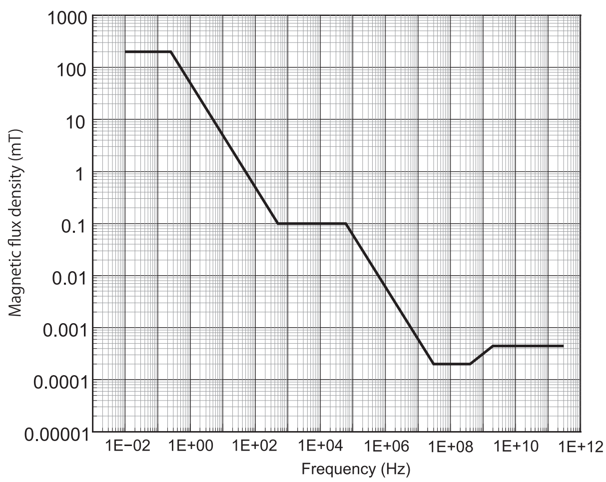

Fig. XII-2. OEL-Ms of static and time-varying magnetic fields

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:

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

where: E_{eff} = effective irradiance
E_λ = spectral irradiance at exposure
S (λ) = relative spectral effectiveness (Table XIII)
Δλ = 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		