APPENDIX A

CHEMICALS NOTED FOR SKIN ABSORPTION (OSHA AND ACGIH DESIGNATED ONLY)

TABLE A-1. OSHA PELS AND ACGIH TLVS WITH SKIN DESIGNATIONS/NOTATIONS					
Substance	**CAS Number[1]**	**OSHA PELs[2]**		**ACGIH TLVs[3]**	
		1910	**1926/1915**	**TWA**	**STEL/C[4]**
Acetone cyanohydrin, as CN	75-86-5				C 5 mg/m^3
Acetonitrile	75-05-8			20 ppm	
Acrolein	107-02-8				C 0.1 ppm
Acrylamide	79-06-1	0.3 mg/m^3	SAME	0.03 mg/m^3	
Acrylic acid	79-10-7			2 ppm	
Acrylonitrile; see 1910.1045	107-13-1			2 ppm	
Adiponitrile	111-69-3			2 ppm	
Aldrin	309-00-2	0.25 mg/m^3	SAME	0.05 mg/m^3	
Allyl alcohol	107-18-6	2 ppm; 5 mg/m^3	SAME	0.5 ppm	
Allyl bromide	106-95-6			0.1 ppm	0.2 ppm
Allyl chloride	107-05-1			1 ppm	2 ppm
4-Aminodiphenyl; see 1910.1011	92-67-1			(L)	
Ammonium perfluorooctanoate	3825-26-1			0.01 mg/m^3	
Aniline and homologs	62-53-3	5 ppm; 19 mg/m^3	SAME	2 ppm	
Anisidine (o-, p-isomers)	29191-52-4	0.5 mg/m^3	SAME	0.5 mg/m^3	
ANTU (alpha Naphthylthiourea)	86-88-4			0.3 mg/m^3	
Azinphos-methyl	86-50-0	0.2 mg/m^3	SAME	0.2 mg/m^3 (IFV)	
Benzene; see 1910.1028. See Table Z-2 for the limits applicable in the operations or sectors excluded in 1910.1028(d)	71-43-2			0.5 ppm	2.5 ppm
Benzidine; See 1910.1010	92-87-5			(L)	
Benzotrichloride	98-07-7				C 0.1 ppm
Beryllium and beryllium compounds (as Be)	7440-41-7			0.00005 mg/m^3 I	
Bromoform	75-25-2	0.5 ppm; 5 mg/m^3	SAME	0.5ppm	

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Substance	**CAS Number[1]**	**OSHA PELs[2]**		**ACGIH TLVs[3]**	
		1910	**1926/1915**	**TWA**	**STEL/C[4]**
2-Butoxyethanol	111-76-2	50 ppm; 240 mg/m^3	SAME	20ppm	
n-Butylamine	109-73-9	(C)5 ppm; (C)15 mg/m^3	SAME		C 5ppm
tert-Butyl chromate (as CrO_3); see 1910.1026	1189-85-1				C 0.1 mg/m^3
n-Butyl glycidyl ether (BGE)	2426-08-6			3 ppm	
o-sec-Butylphenol	89-72-5			5 ppm	
Captafol	2425-06-1			0.1 mg/m^3	
Carbaryl (Sevin)	63-25-2			0.5 mg/m^3 (IFV)	
Carbon disulfide	75-15-0		20 ppm; 60 mg/m^3	1 ppm	
Carbon tetrachloride	56-23-5		10 ppm; 65 mg/m^3	5 ppm 31 mg/m^3	10 ppm
Catechol	120-80-9			5 ppm	
Chlordane	57-74-9	0.5 mg/m^3	SAME	0.5 mg/m^3	
Chlorinated camphene	8001-35-2	0.5 mg/m^3	SAME	0.5 mg/m^3	1 mg/m^3
Chloroacetone	78-95-5				C 1 ppm
Chloroacetyl chloride	79-04-9			0.05 ppm	0.15 ppm
o-Chlorobenzylidene malononitrile	2698-41-1				C 0.05 ppm
Chlorodiphenyl (42% Chlorine) (PCB)	53469-21-9	1 mg/m^3	SAME	1 mg/m^3	
Chlorodiphenyl (54% Chlorine) (PCB)	11097-69-1	0.5 mg/m^3	SAME	0.5 mg/m^3	
1-Chloro-2-propanol	127-00-4			1 ppm	
2-Chloro-1-propanol	78-89-7			1 ppm	
beta-Chloroprene	126-99-8	25 ppm; 90 mg/m^3	SAME	10 ppm	
2-Chloropropionic acid	598-78-7			0.1 ppm	
Chlorpyrifos	2921-88-2			0.1 mg/m^3 (IFV)	
Citral	5392-40-5			5 ppm (IFV)	
Coumaphos	56-72-4			0.05 mg/m^3 (IFV)	

TABLE A-1. OSHA PELS AND ACGIH TLVS WITH SKIN DESIGNATIONS/NOTATIONS					
Substance	**CAS Number[1]**	**OSHA PELs[2]**		**ACGIH TLVs[3]**	
		1910	**1926/1915**	**TWA**	**STEL/C[4]**
Cresol, all isomers	1319-77-3	5 ppm; 22 mg/m^3	SAME	20 mg/m^3 (IFV)	
Crotonaldehyde	4170-30-3				C 0.3 ppm
Cumene	98-82-8	50 ppm; 245 mg/m^3	SAME	50ppm	
Cyanides (as CN)	(4)	5 mg/m^3	SAME (1915 no skin designation)		
Cyclohexanol	108-93-0			50 ppm	
Cyclohexanone	108-94-1			20 ppm	50 ppm
Cyclonite	121-82-4		1.5 mg/m^3	0.5 mg/m^3	
2,4-D (Dichlorophen-oxyacetic acid)[5]	94-75-7	10 mg/m^3			
Decaborane	17702-41-9	0.05 ppm; 0.3 mg/m^3	SAME	0.05 ppm	0.15 ppm
Demeton (Systox)	8065-48-3	0.1 mg/m^3	SAME	0.05 mg/m^3 (IFV)	
Demeton-S-methyl	919-86-8			0.05 mg/m^3 (IFV)	
Diazinon	333-41-5			0.01 mg/m^3 (IFV)	
2-N-Dibutylaminoethanol	102-81-8			0.5 ppm	
Dibutyl phenol phosphate	2528-36-1			0.3 ppm	
Dibutyl phosphate	107-66-4			5 mg/m^3 (IFV)	
Dichloroacetic acid	79-43-6			0.5 ppm	
3,3'-Dichlorobenzidine; see 1910.1007	91-94-1			(L)	
1,4-Dichloro-2-butene	764-41-0			0.005 ppm	
Dichlorodiphenyltri-chloroethane (DDT)	50-29-3	1 mg/m^3	SAME		
Dichloroethyl ether	111-44-4	(C)15 ppm; (C)90 mg/m^3	SAME	5 ppm	10 ppm
1,3-Dichloropropene	542-75-6			1 ppm	
Dichlorvos (DDVP)	62-73-7	1 mg/m^3	SAME	0.1 mg/m^3 (IFV)	
Dicrotophos	141-66-2			0.05 mg/m^3 (IFV)	
Dieldrin	60-57-1	0.25 mg/m^3	SAME	0.1 mg/m^3 (IFV)	
Diesel fuel, as total	68334-30-5; 68476-30-2;			100 mg/m^3(IFV)	

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		1910	**1926/1915**	**TWA**	**STEL/C[4]**
hydrocarbons	68476-31-3; 68476-34-6; 77650-28-3				
Diethanolamine	111-42-2			1 mg/m^3 (IFV)	
Diethylamine	109-89-7			5 ppm	15 ppm
2-Diethylaminoethanol	100-37-8	10 ppm; 50 mg/m^3	SAME (1915 no skin designation)	2 ppm	
Diethylene triamine	111-40-0		(C)10 ppm; (C)42 mg/m^3	1 ppm	
Diisopropylamine	108-18-9	5 ppm; 20 mg/m^3	SAME	5 ppm	
Dimethyl acetamide	127-19-5	10 ppm; 35 mg/m^3	SAME	10 ppm	
bis(2-Dimethylaminoethyl)ether (DMAEE)	3033-62-3			0.05 ppm	0.15 ppm
Dimethylaniline (N,N-Dimethylaniline)	121-69-7	5 ppm; 25 mg/m^3	SAME	5 ppm	10 ppm
Dimethyl carbamoyl chloride	79-44-7			0.005 ppm	
Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate (Naled)	300-76-5			0.1 mg/m^3 (IFV)	
Dimethyl disulfide	624-92-0			0.5 ppm	
Dimethylformamide	68-12-2	10 ppm; 30 mg/m^3	SAME	10 ppm	
1,1-Dimethylhydrazine	57-14-7	0.5 ppm; 1 mg/m^3	SAME	0.01 ppm	
Dimethyl sulfate	77-78-1; 77-78-3	1 ppm; 5 mg/m^3	SAME	0.1 ppm	
Dinitrobenzene (all isomers)	528-29-0; 99-65-0; 100-25-4	1 mg/m^3	SAME	0.15 ppm	
Dinitro-o-cresol	534-52-1	0.2 mg/m^3	SAME	0.2 mg/m^3	
Dinitrotoluene	25321-14-6	1.5 mg/m^3	SAME	0.2 mg/m^3	
Dioxane (Diethylene	123-91-1	100 ppm;	SAME	20 ppm	

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		1910	**1926/1915**	**TWA**	**STEL/C[4]**
dioxide)		360 mg/m^3			
Dioxathion	78-34-2			0.1 mg/m$^{3(IFV)}$	
Dipropylene glycol methyl ether (2-Methoxymethylethoxy)propanol)	34590-94-8	100 ppm; 600 mg/m^3	SAME	100 ppm	150 ppm
Diquat	2764-72-9; 85-00-7; 6385-62-2			0.5 mg/m$^{3\ (I);}$ 0.1 mg/m$^{3(\ R)}$	
Disulfoton	298-04-4			0.05 mg/m$^{3\ (IFV)}$	
Endosulfan	115-29-7		0.1 mg/m^3	0.1 mg/m$^{3(IFV)}$	
Endrin	72-20-8	0.1 mg/m^3	SAME	0.1 mg/m^3	
Epichlorohydrin	106-89-8	5 ppm; 19 mg/m^3	SAME	0.5 ppm	
EPN	2104-64-5	0.5 mg/m^3	SAME	0.1 mg/m$^{3\ (I)}$	
Ethion	563-12-2			0.05 mg/m$^{3\ (IFV)}$	
2-Ethoxyethanol (Cellosolve)	110-80-5	200 ppm; 740 mg/m^3	SAME	5 ppm	
2-Ethoxyethyl acetate (Cellosolve acetate)	111-15-9	100 ppm; 540 mg/m^3	SAME	5 ppm	
Ethyl acrylate	140-88-5	25 ppm; 100 mg/m^3	SAME	5ppm	15ppm
Ethylamine	75-04-7			5 ppm	15 ppm
Ethyl bromide	74-96-4			5 ppm	
Ethyl chloride	75-00-3			100 ppm	
Ethylene chlorohydrin	107-07-3	5 ppm; 16 mg/m^3	SAME		C 1 ppm
Ethylenediamine	107-15-3			10 ppm	
Ethylene dibromide	106-93-4		(C)25 ppm; (C)190 mg/m^3	—	—
Ethylene glycol dinitrate	628-96-6	(C)0.2 ppm; (C)1 mg/m^3	SAME	0.05 ppm	
Ethyleneimine; see 1910.1012	151-56-4			0.05 ppm	0.1 ppm
N-Ethylmorpholine	100-74-3	20 ppm; 94 mg/m^3	SAME	5 ppm	

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Substance	**CAS Number[1]**	**OSHA PELs[2]**		**ACGIH TLVs[3]**	
		1910	**1926/1915**	**TWA**	**STEL/C[4]**
Fenamiphos	22224-92-6			0.05 mg/m^3 (IFV)	
Fensulfothion	115-90-2			0.01 mg/m^3 (IFV)	
Fenthion	55-38-9			0.05 mg/m^3 (IFV)	
Fonofos	944-22-9			0.1 mg/m^3 (IFV)	
Formamide	75-12-7			10 ppm	
Furfural	98-01-1	5 ppm; 20 mg/m^3	SAME	2 ppm	
Furfuryl alcohol	98-00-0			10 ppm	15 ppm
Heptachlor	76-44-8	0.5 mg/m^3	SAME	0.05 mg/m^3	
Heptachlor epoxide	1024-57-3			0.05 mg/m^3	
Hexachlorobenzene	118-74-1			0.002 mg/m^3	
Hexachlorobutadiene	87-68-3			0.02 ppm	
Hexachloroethane	67-72-1	1 ppm; 10 mg/m^3	SAME	1 ppm	
Hexachloronaphthalene	1335-87-1	0.2 mg/m^3	SAME	0.2 mg/m^3	
Hexafluoroacetone	684-16-2			0.1 ppm	
Hexamethyl phosphoramide	680-31-9			—	
n-Hexane	110-54-3			50 ppm	
2-Hexanone (Methyl n-butyl ketone)	591-78-6			5 ppm	10 ppm
Hydrazine	302-01-2	1 ppm; 1.3 mg/m^3	SAME	0.01 ppm	
Hydrogen cyanide[6]	74-90-8	10 ppm; 11 mg/m^3	SAME		C 4.7 ppm
Hydrogen fluoride (as F)	7664-39-3			0.5 ppm	C 2 ppm
2-Hydroxypropryl acrylate	999-61-1			0.5 ppm	
Isooctyl alcohol	26952-21-6			50 ppm	
2-Isopropoxyethanol	109-59-1			25 ppm	
n-Isopropylaniline	768-52-5			2 ppm	
Kerosene/Jet fuels, as total hydrocarbon vapor	8008-20-6; 64742-81-0			200 mg/m^3 P	
Lindane	58-89-9	0.5 mg/m^3	SAME	0.5 mg/m^3	
Malathion Total dust	121-75-5	15 mg/m^3	SAME	1 mg/m^3 (IFV)	

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Substance	**CAS Number[1]**	**OSHA PELs[2]**		**ACGIH TLVs[3]**	
		1910	**1926/1915**	**TWA**	**STEL/C[4]**
Manganese cyclopentadienyl tricarbonyl, as Mn	12079-65-1			0.1 mg/m^3	
Mercury (as Hg)	7439-97-6	0.1mg/m^3	0.1 mg/m^3	0.1 mg/m^3	
Mercury (elemental and inorganic forms)	7439-97-6	0.1mg/m^3	0.1mg/m^3	0.025 mg/m3	
Mercury (organo) alkyl compounds (as Hg)	7439-97-6	0.01mg/m^3	0.01 mg/m^3	0.01 mg/m^3	0.03 mg/m^3
Mercury (vapor) (as Hg)	7439-97-6	0.1mg/m^3	0.1 mg/m^3		
2-Methoxyethanol; (Methyl cellosolve)	109-86-4	25 ppm; 80 mg/m^3	SAME	0.1 ppm	
2-Methoxyethyl acetate (Methyl cellosolve acetate)	110-49-6	25 ppm; 120 mg/m^3	SAME	0.1 ppm	
Methyl acrylate	96-33-3	10 ppm; 35 mg/m^3	SAME	2 ppm	
Methylacrylonitrile	126-98-7			1 ppm	
Methyl alcohol	67-56-1			200 ppm	250 ppm
Methyl bromide	74-83-9	(C)20 ppm; (C)80 mg/m^3	SAME	1 ppm	
Methyl chloride	74-87-3			50 ppm	100 ppm
o-Methylcyclohexanone	583-60-8	100 ppm; 460 mg/m^3	SAME	50 ppm	75 ppm
2-Methylcyclopentadienyl manganese tricarbonyl, as Mn	12108-13-3			0.2 mg/m^3	
Methyl demeton	8022-00-2			0.05 mg/m^3 IFV	
4,4'-Methylene bis(2-chloroaniline)	101-14-4			0.01 ppm	
4,4'-Methylene dianiline	101-77-9			0.1 ppm	
Methyl hydrazine (Monomethyl hydrazine)	60-34-4	(C)0.2 ppm; (C)0.35 mg/m^3	SAME	0.01 ppm	
Methyl iodide	74-88-4	5 ppm; 28 mg/m^3	SAME	2 ppm	
Methyl isobutyl carbinol	108-11-2	25 ppm; 100 mg/m^3	SAME	25 ppm	40 ppm
Methyl isocyanate	624-83-9	0.02 ppm;	SAME	0.02 ppm	

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Substance	**CAS Number[1]**	**OSHA PELs[2]**		**ACGIH TLVs[3]**	
		1910	**1926/1915**	**TWA**	**STEL/C[4]**
		0.05 mg/m^3			
1-Methyl naphthalene	90-12-0			0.5 ppm	
2-Methyl naphthalene	91-57-6			0.5 ppm	
Methyl parathion	298-00-0			0.02 mg/m^3 (IFV)	
Methyl vinyl ketone	78-94-4				C 0.2 ppm
Monochloroacetic acid	79-11-8			0.5 ppm (IFV)	
Monocrotophos	6923-22-4			0.05 mg/m^3 (IFV)	
Monomethyl aniline (N-Methyl aniline)	100-61-8	2 ppm; 9 mg/m^3	SAME	0.5 ppm 2.2 mg/m^3	
Morpholine	110-91-8	20 ppm; 70 mg/m^3	SAME	20 ppm	
Naphthalene[7]	91-20-3			10 ppm	15 ppm
Natural rubber latex, as inhalable allergenic proteins	9006-04-6			0.0001 mg/m^3 I	
Nicotine	54-11-5	0.5 mg/m^3	SAME	0.5 mg/m^3	
p-Nitroaniline	100-01-6	1 ppm; 6 mg/m^3	SAME	3 mg/m^3	
Nitrobenzene	98-95-3	1 ppm; 5 mg/m^3	SAME	1 ppm	
p-Nitrochlorobenzene	100-00-5	1 mg/m^3	SAME	0.1 ppm	
4-Nitrodiphenyl; see 1910.1003	92-93-3			(L)	
Nitroglycerin	55-63-0	(C)0.2 ppm; (C)2 mg/m^3	SAME	0.05 ppm	
N-Nitrosodimethylamine; see 1910.1016	62-75-9			(L)	
Nitrotoluene (all isomers)	88-72-2; 99-08-1; 99-99-0	5 ppm; 30 mg/m^3	SAME	2 ppm	
Octachloronaphthalene	2234-13-1	0.1 mg/m^3	SAME	0.1 mg/m^3	0.3 mg/m^3
Paraquat, respirable dust	4685-14-7; 1910-42-5; 2074-50-2	0.5 mg/m^3 0.1 mg/m3 (R)	SAME		
Parathion	56-38-2	0.1 mg/m^3	SAME (1915 no skin designation)	0.05 mg/m^3 (IFV)	

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Substance	**CAS Number[1]**	**OSHA PELs[2]**		**ACGIH TLVs[3]**	
		1910	**1926/1915**	**TWA**	**STEL/C[4]**
Pentachloronaphthalene	1321-64-8	0.5 mg/m^3	SAME	0.5 mg/m^3	
Pentachlorophenol	87-86-5	0.5 mg/m^3	SAME	0.5 mg/m^3	
2,4-Pentanedione	123-54-6			25 ppm	
Phenol	108-95-2	5 ppm; 19 mg/m^3	SAME	5 ppm	
Phenothiazine	92-84-2			5 mg/m^3	
p-Phenylene diamine	106-50-3	0.1 mg/m^3	SAME	0.1 mg/m^3	
Phenyl glycidyl ether (PGE)	122-60-1			0.1 ppm	
Phenylhydrazine	100-63-0	5 ppm; 22 mg/m^3	SAME	0.1 ppm	
Phenyl mercaptan	108-98-5			0.1 ppm	
Phorate	298-02-2			0.05 mg/m^3 (IFV)	
Phosdrin (Mevinphos)	7786-34-7	0.1 mg/m^3	SAME	0.01 mg/m^3(IFV)	
Picric acid	88-89-1	0.1 mg/m^3	SAME (1915 no skin designation)	0.1mg/m^3	
Propargyl alcohol	107-19-7		1 ppm	1 ppm	
Propylene glycol dinitrate	6423-43-4			0.05 ppm	
Propylene imine	75-55-8	2 ppm; 5 mg/m^3	SAME	0.2 ppm	0.4 ppm
Sodium fluoroacetate	62-74-8	0.05 mg/m^3	SAME	0.05 mg/m^3	
Sulprofos	35400-43-2			0.1 mg/m^3 (IFV)	
TEDP (Sulfotepp)	3689-24-5	0.2 mg/m^3	SAME	0.1 mg/m^3 (IFV)	
Temephos	3383-96-8			1 mg/m^3 (IFV)	
TEPP (Tetraethyl pyrophosphaate)	107-49-3	0.05 mg/m^3	SAME	0.01 mg/m^3 (IFV)	
Terbufos	13071-79-9			0.01 mg/m^3 (IFV)	
1,1,2,2-Tetrachloro-ethane	79-34-5	5 ppm; 35 mg/m^3	SAME	1 ppm	
Tetrachloronaphthalene	1335-88-2	2 mg/m^3	SAME	2 mg/m^3	
Tetraethyl lead (as Pb)	78-00-2	0.075 mg/m^3	0.1 mg/m^3	0.1 mg/m^3	
Tetrahydrofuran	109-99-9			50 ppm	100 ppm
Tetramethyl lead (as Pb)	75-74-1	0.075 mg/m^3	0.15 mg/m^3	0.15 mg/m^3	

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Substance	**CAS Number[1]**	**OSHA PELs[2]**		**ACGIH TLVs[3]**	
		1910	**1926/1915**	**TWA**	**STEL/C[4]**
Tetramethyl succinonitrile	3333-52-6	0.5 ppm; 3 mg/m^3	SAME	0.5 ppm	
Tetryl (2,4,6-Trinitro-phenylmethyl-nitramine)	479-45-8	1.5 mg/m^3	SAME	1.5mg/m^3	
Thallium, soluble compounds (as Tl)	7440-28-0	0.1 mg/m^3	SAME	0.02 mg/m^3 (I)	
Thioglycolic acid	68-11-1			1 ppm	
Tin, organic compounds (as Sn)	7440-31-5			0.1 mg/m^3	0.2 mg/m^3
o-Tolidine	119-93-7			—	
Toluene-2,4-diisocyanate (TDI)[8]	584-84-9	(C)0.02 ppm; (C)0.14 mg/m^3		0.005 ppm	0.02ppm
o-Toluidine	95-53-4	5 ppm; 22 mg/m^3	SAME	2 ppm	
m-Toluidine	108-44-1			2 ppm	
p-Toluidine	106-49-0			2 ppm	
1,1,2-Trichloroethane	79-00-5	10 ppm; 45 mg/m^3	SAME	10 ppm	
Trichloronaphthalene	1321-65-9	5 mg/m^3	SAME	5 mg/m^3	
1,2,3-Trichloropropane[9]	96-18-4			10 ppm	
Triethylamine	121-44-8			1 ppm	3 ppm
Trimellitic anhydride	552-30-7			0.0005 mg/m^3 IFV	0.002 mg/m^3 IFV
2,4,6-Trinitrotoluene (TNT)	118-96-7	1.5 mg/m^3	SAME	0.1 mg/m^3	
Triorthocresyl phosphate	78-30-8			0.1 mg/m^3	
Vinyl cyclohexene dioxide	106-87-6			0.1 ppm	
m-Xylene α,α'-diamine	1477-55-0				C 0.1 mg/m^3
Xylidine	1300-73-8	5 ppm; 25 mg/m^3	SAME	0.5 ppm (IFV)	

[1] The chemical abstracts service (CAS) number is for information only. For an entry covering more than one metal compound measured as the metal, the CAS number for the metal is given - not CAS numbers for the individual compounds.

[2] The OSHA PELs provided under "1910" refer to General Industry, 29 CFR 1910.1000 Table Z-1; "1926" refers to Construction, 29 CFR 1926.55, Appendix A; and "1915" refers to Shipyards, 29 CFR 1915.1000. The PELs are 8-hour time-weighted average (TWA) concentrations unless otherwise noted; a (C) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples. If an entry is only listed in mg/m^3, the value is

exact; when listed with a ppm entry, it is approximate. "SAME" indicates the value for 1926 and 1915 is equal to that listed for 1910 unless otherwise noted.

[3] The ACGIH TLVs are from the ACGIH publication *2012 TLVs® and BEIs® Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices*. "TWA" refers to 8-hour, TWA concentrations; "STEL" refers to "short-term exposure limit," a 15-minute TWA concentration; "C" indicates ceiling limit; a concentration that should not be exceeded during any part of the working exposure; "I" indicates inhalable fraction (particle aerodynamic diameter ranging from 0 to 100 micrometers; "IFV" indicates inhalable fraction and vapor; "(L)" indicates exposures by all routes should be carefully controlled to levels as low as possible; "P" indicates application restricted to conditions in which there are negligible aerosol exposures; and "R" indicates respirable fraction (particle aerodynamic diameter ranging from 0 to 10 micrometers).

[4] Values in this column are STEL values unless noted as ceiling limits with a "C" preceding the value.

[5] See ACGIH 2012 NIC—proposed change to 10 mg/m^3 I (TWA) with skin designation.

[6] ACGIH separates this listing into "hydrogen cyanide" and "cyanide salts," while OSHA does not differentiate between the two. Only the hydrogen cyanide TLV is listed here.

[7] See ACGIH 2012 NIC—proposed change to 5 ppm (TWA) with skin designation, no STEL.

[8] See ACGIH 2012 NIC—proposed change to 0.001 ppm IFV (TWA), 0.003 ppm IFV (STEL), skin designation.

[9] See ACGIH 2012 NIC—proposed change to 0.05 ppm (TWA), removal of skin designation.

APPENDIX B

BIOLOGICAL EXPOSURE GUIDELINES (ACGIH BEI AND OSHA EXPANDED STANDARDS ONLY)

TABLE B-1. ADOPTED BIOLOGICAL EXPOSURE INDICES (BEIs) – ACGIH (2012)					
Chemical	**CAS No.**	**Determinant**	**Sampling Time**	**BEI®**	**Notation**
B = Background	*Ns = Nonspecific*	*Nq = Nonquantitative*		*Sq = Semi-quantitative*	
Acetone	67-64-1	Acetone in urine	End of shift	50 mg/L	Ns
Acetylcholinesterase inhibiting pesticides	N/A	Cholinesterase activity in red blood cells	Discretionary	70% of individual's baseline	Ns
Aniline	62-53-3	Aniline in urine[1]	End of shift	—	Nq
		Aniline released from hemoglobin in blood	End of shift	—	Nq
		p-Aminophenol in urine[1]	End of shift	50 mg/L	B, Ns, Sq
Arsenic, elemental and soluble inorganic compounds (excludes gallium arsenide and arsine)	7440-38-2	Inorganic arsenic plus methylated metabolites in urine	End of workweek	35 µg As/L	B
Benzene	71-43-2	S-Phenylmercapturic acid in urine	End of shift	25 µg/g creatinine	B
		t,t-Muconic acid in urine	End of shift	500 µg/g creatinine	B
1,3-Butadiene	106-99-0	1,2 Dihydroxy-4-(N-acetylcyteinyl)-butane in urine	End of shift	2.5 mg/L	B, Sq
		Mixture of N-1- and N-2-(hydroxybutenyl) valine hemoglobin (Hb) adducts in blood	Not critical	2.5 pmol/g Hb	Sq
2-Butoxyethanol	111-76-2	Butoxyacetic acid (BAA) in urine[1]	End of shift	200 mg/g creatinine	—
Cadmium and inorganic compounds	7440-43-9	Cadmium in urine	Not critical	5 µg/g creatinine	B
		Cadmium in blood	Not critical	5 µg/L	B
Carbon disulfide	75-15-0	2-Thioxothiazolidine-4-carboxylic acid (TTCA) in urine	End of shift	0.5 mg/g creatinine	B, Ns

TABLE B-1. ADOPTED BIOLOGICAL EXPOSURE INDICES (BEIs) – ACGIH (2012)					
Chemical	**CAS No.**	**Determinant**	**Sampling Time**	**BEI®**	**Notation**
B = Background	*Ns = Nonspecific*	*Nq = Nonquantitative*		*Sq = Semi-quantitative*	
Carbon monoxide	630-08-0	Carboxyhemoglobin in blood	End of shift	3.5% of hemoglobin	B, Ns
		Carbon monoxide in end-exhaled air	End of shift	20 ppm	B, Ns
Chlorobenzene	108-90-7	4-Chlorocatechol in urine[1]	End of shift at end of workweek	100 mg/g creatinine	Ns
		p-Chlorophenol in urine[1]	End of shift at end of workweek	20 mg/g creatinine	Ns
Chromium (VI), water soluble fume	N/A	Total chromium in urine	End of shift at end of workweek	25 µg/L	—
		Total chromium in urine	Increase during shift	10 µg/L	—
Cobalt	7440-48-4	Cobalt in urine	End of shift at end of workweek	15 µg/L	B
		Cobalt in blood	End of shift at end of workweek	1 µg/L	B, Sq
Cyclohexanol	108-93-0	1,2-Cyclohexanediol in urine[1]	End of shift at end of workweek	—	Nq, Ns
		Cyclohexanol in urine[1]	End of shift	—	Nq, Ns
Cyclohexanone	108-94-1	1,2-Cyclohexanediol in urine[1]	End of shift at end of workweek	80 mg/L	Ns, Sq
		Cyclohexanol in urine[1]	End of shift	8 mg/L	Ns, Sq
Dichloromethane	75-09-2	Dichloromethane in urine	End of shift	0.3 mg/L	Sq
N,N-Dimethylacetamide	127-19-5	N-Methylacetamide in urine	End of shift at end of workweek	30 mg/g creatinine	—

TABLE B-1. ADOPTED BIOLOGICAL EXPOSURE INDICES (BEIs) – ACGIH (2012)					
Chemical	**CAS No.**	**Determinant**	**Sampling Time**	**BEI®**	**Notation**
B = Background	*Ns = Nonspecific*	*Nq = Nonquantitative*		*Sq = Semi-quantitative*	
N,N-Dimethylformamide (DMF)	68-12-2	N-Methylformamide in urine	End of shift	15 mg/L	—
		N-Acetyl-S-(N-methylcarbamoyl) cysteine in urine	Prior to last shift of workweek	40 mg/L	Sq
2-Ethoxyethanol (EGEE) and 2-Ethoxyethyl acetate (EGEEA)	110-80-5; 111-15-9	2-Ethoxyacetic acid in urine[1]	End of shift at end of workweek	100 mg/g creatinine	—
Ethyl benzene[3]	100-41-4	Sum of mandelic acid and phenylglyoxylic acid in urine	End of shift at end of workweek	(0.7 g/g creatinine)	Ns (Sq)
		(Ethyl benzene in end-exhaled air)	(Not critical)	(—)	(Sq)
Fluorides	109-86-4	Fluoride in urine	Prior to shift	2 mg/L	B, Ns
		Fluoride in urine	End of shift	3 mg/L	B, Ns
Furfural	98-01-1	Furoic acid in urine[1]	End of shift	200 mg/L	Ns
n-Hexane	110-54-3	2,5-Hexanedion in urine[2]	End of shift at end of workweek	0.4 mg/L	—
Lead[4]	7439-92-1	Lead in blood	Not critical	30 µg/100 ml	—
Mercury[5]	N/A	(Total inorganic mercury in urine)	Prior to shift	(35 µg/g creatinine)	(B)
		(Total inorganic mercury in blood)	(End of shift at end of workweek)	(15 µg/L)	(B)
Methanol	67-56-1	Methanol in urine	End of shift	15 mg/L	B, Ns
Methemoglobin inducers	N/A	Methemoglobin in blood	During or end of shift	1.5% of hemoglobin	B, Ns, Sq
2-Methoxyethanol (EGME) and 2-Methoxyethyl acetate (EGMEA)	109-86-4 and 110-49-6	2-Methoxyacetic acid in urine	End of shift at end of workweek	1 mg/g creatinine	—
Methyl n-butyl ketone	591-78-6	2,5-Hexanedione in urine[2]	End of shift at end of workweek	0.4 mg/L	—

TABLE B-1. ADOPTED BIOLOGICAL EXPOSURE INDICES (BEIs) – ACGIH (2012)					
Chemical	**CAS No.**	**Determinant**	**Sampling Time**	**BEI®**	**Notation**
B = Background	*Ns = Nonspecific*	*Nq = Nonquantitative*		*Sq = Semi-quantitative*	
Methyl chloroform	71-55-6	Methyl chloroform in end-exhaled air	Prior to last shift of workweek	40 ppm	—
		Trichloroacetic acid in urine	End of workweek	10 mg/L	Ns, Sq
		Total trichloroethanol in urine	End of shift at end of workweek	30 mg/L	Ns, Sq
		Total trichloroethanol in blood	End of shift at end of workweek	1 mg/L	Ns
4,4'-Methylene bis(2-chloroaniline) (MBOCA)	101-14-4	Total MBOCA in urine	End of shift	—	Nq
Methyl ethyl ketone (MEK)[6]	78-93-3	MEK in urine	End of shift	2 mg/L	(—)
Methyl isobutyl ketone (MIBK)	108-10-1	MIBK in urine	End of shift	1 mg/L	(—)
N-Methyl-2-pyrrolidone	872-50-4	5-Hydroxy-N-methyl-2-pyrrolidone in urine	End of shift	100 mg/L	(—)
Naphthalene[7]	91-20-3	1-Naphthol[1] + 2-Naphthol[1]	End of shift	—	Nq, Ns
Nitrobenzene	98-95-3	Total p-nitrophenol in urine	End of shift at end of workweek	5 mg/g creatinine	Ns
		Methemoglobin in blood	End of shift	1.5% of hemoglobin	B, Ns, Sq
Parathion	56-38-2	Total p-nitrophenol in urine	End of shift	0.5 mg/g creatinine	Ns
		Cholinesterase activity in red cells	Discretionary	70% of individual's baseline	B, Ns, Sq
Pentachlorophenol (PCP)[8]	87-86-5	(Total PCP in urine)	(Prior to last shift of workweek)	(2 mg/g creatinine)	(B)
		(Free PCP in plasma)	(End of shift)	(5 mg/L)	(B)

TABLE B-1. ADOPTED BIOLOGICAL EXPOSURE INDICES (BEIs) – ACGIH (2012)					
Chemical	**CAS No.**	**Determinant**	**Sampling Time**	**BEI®**	**Notation**
B = Background	*Ns = Nonspecific*	*Nq = Nonquantitative*		*Sq = Semi-quantitative*	
Phenol	108-95-2	Phenol in urine[1]	End of shift	250 mg/g creatinine	B, Ns
Polycyclic aromatic hydrocarbons (PAHs)	varies with the compound or mixture	1-Hydroxypyrene (1-HP) in urine[1]	End of shift at end of workweek	—	Nq
2-Propanol	67-63-0	Acetone in urine	End of shift at end of workweek	40 mg/L	B, Ns
Styrene	100-42-5	Mandelic acid plus phenylglyoxylic acid in urine	End of shift	400 mg/g creatinine	Ns
		Styrene in venous blood	End of shift	0.2 mg/L	Sq
Tetrachloroethylene	127-18-4	Tetrachloroethylene in end-exhaled air	Prior to shift	3 ppm	—
		Tetrachloroethylene in blood	Prior to shift	0.5 mg/L	—
Tetrahydrofuran	109-99-9	Tetrahydrofuran in urine	End of shift	2 mg/L	—
Toluene	108-88-3	Toluene in blood	Prior to last shift of workweek	0.02 mg/L	—
		Toluene in urine	End of shift	0.03 mg/L	—
		o-Cresol in urine[1]	End of shift	0.3 mg/g creatinine	B
Toluene diisocyanate[9]	584-84-9; 91-08-7	Toluene diamine in urine[1]	End of shift	5 µg/g creatinine	Ns
Trichloroethylene	79-01-6	Trichloroacetic acid in urine	End of shift at end of workweek	15 mg/L	Ns
		Trichloroethanol in blood[2]	End of shift at end of workweek	0.5 mg/L	Ns
		Trichloroethylene in blood	End of shift at end of workweek	—	Sq
		Trichloroethylene in end-exhaled air	End of shift at end of workweek	—	Sq

TABLE B-1. ADOPTED BIOLOGICAL EXPOSURE INDICES (BEIs) – ACGIH (2012)					
Chemical	**CAS No.**	**Determinant**	**Sampling Time**	**BEI®**	**Notation**
B = Background	*Ns = Nonspecific*	*Nq = Nonquantitative*		*Sq = Semi-quantitative*	
Uranium	7440-61-1	Uranium in urine	End of shift	200 µg/L	—
Xylenes (technical or commercial grade)	95-47-6; 108-38-3; 106-42-3; 1330-20-7	Methylhippuric acids in urine	End of shift	1.5 g/g creatinine	—

[1] Denotes with hydrolysis.
[2] Denotes without hydrolysis; n-hexane, methyl n-butyl ketone and trichloroethylene.
[3] 2012 Notice of Intended Changes (NIC) revises ethyl benzene entry as follows: Sum of mandelic and phenylglyoxylic acids in urine; end of shift at end of workweek; 0.15 g/g creatinine; Ns.
[4] Note: Women of childbearing potential, whose blood Pb exceeds 10 µg/dl, are at risk of delivering a child with a blood Pb over the current Centers for Disease Control guideline of 10 µg/dl. If the blood Pb of such children remains elevated, they may be at increased risk of cognitive deficits. The blood Pb of these children should be closely monitored and appropriate steps should be taken to minimize the child's exposure to environmental lead. (CDC: Preventing Lead Poisoning in Young Children, October 1991; See BEI® and TLV® *Documentation* for Lead).
[5] 2012 NIC revises mercury entry as follows: Mercury in urine; prior to shift; 20 µg Hg/g creatinine.
[6] 2012 NIC revises methyl ethyl ketone entry as follows: Methyl ethyl ketone in urine; end of shift; 2 mg/L; Ns.
[7] 2012 NIC revises naphthalene entry as follows: 1-Naphthol (with hydrolysis) + 2-Naphthol (with hydrolysis); end of shift; no BEI®; Nq, Ns.
[8] 2012 NIC revises pentachlorophenol entry as follows: Pentachlorophenol (with hydrolysis) in urine; discretionary; no BEI®; Nq.
[9] 2012 NIC revises toluene diisocyanate entry as follows: Toluene diamine in urine (with hydrolysis) (sum of 2,4- and 2,6- isomers); end of shift; 5 µg/g creatinine; Ns.

TABLE B-2. OSHA GENERAL INDUSTRY STANDARD-SPECIFIC BIOLOGICAL MONITORING REQUIREMENTS (29 CFR 1910)			
OSHA Standard	**Substance**	**Analyte(s)**	**Monitoring Frequency**
Note: *This table provides a summary of biological monitoring requirements. For detailed information, refer to the listed standard.*			
1910.1017	Vinyl chloride	Serum specimen testing for: • Total bilirubin • Alkaline phosphatase • Serum glutamic oxalacetic transaminase (SGOT) • Serum glutamic pyruvic transaminase (SGPT) • Gamma glustamyl transpeptidase	For workers exposed above the action level: • Initial medical examination • Every 6 months for each employee who has been employed in vinyl chloride or polyvinyl chloride manufacturing for 10 years or longer. • Annually for all other employees. • After exposure during emergency situations.
1910.1025	Lead	Blood sample testing for: • Blood lead • Zinc protoporphyrin (ZPP)	For workers who are or may be exposed at or above the action level for more than 30 days per year: • At least every six months • At least every two months for each worker whose last blood sampling and analysis indicated a blood lead level at or above 40 µg/100 g of whole blood (continuing until two consecutive blood samples and analyses indicate a blood lead level below 40 µg/100 g of whole blood). • Within two weeks after receipt of results indicating a blood lead level exceeding the numerical criterion for medical removal (60 µg/100 g of whole blood). • At least monthly during the removal period of each worker removed from exposure to lead due to an elevated blood lead level.
		Blood sample testing for: • Blood lead • Hemoglobin and hematocrit determinations, red cell indices, and examination of smear morphology. • ZPP • Blood urea nitrogen • Serum creatinine • Regular urinalysis with microscopic examination.	For workers who are or may be exposed at or above action level for more than 30 days per year: • Initial exam • Annually, if blood lead level is at or above 40 µg/100 g of whole blood at any time in the preceding 12 months.

TABLE B-2. OSHA GENERAL INDUSTRY STANDARD-SPECIFIC BIOLOGICAL MONITORING REQUIREMENTS (29 CFR 1910)			
OSHA Standard	**Substance**	**Analyte(s)**	**Monitoring Frequency**
Note: *This table provides a summary of biological monitoring requirements. For detailed information, refer to the listed standard.*			
		Pregnancy testing or laboratory evaluation of male fertility, if requested by worker.	• As soon as possible upon notification by worker of development of signs/symptoms of lead intoxication, worker desires medical advice on effects of current/past exposure on ability to procreate a healthy child, or worker has demonstrated difficulty in breathing during a respirator fitting test or during use. • As medically appropriate for worker removed from exposure due to risk of material impairment of health or otherwise limited pursuant to final medical determination.
1910.1027	Cadmium	Urine testing for: • Cadmium in urine (CdU), standardized to grams of creatinine (g/Cr) • Beta-2 microglobulin in urine (B(2)-M), standardized to grams of creatinine (g/Cr), with pH specified Blood sample testing for: • Cadmium in blood (CdB), standardized to liters of whole blood (lwb) During required periodic medical examinations workers should be additionally tested for: • Blood urea nitrogen • Complete blood count • Serum creatinine • Urinalysis – additional testing for albumin, glucose, and total and low molecular weight proteins.	For currently and/or previously exposed workers, as specified in the standard: • Initial exam • At least annually • Within one year after initial exam, and at least biennially thereafter. • At varying follow-up frequencies depending on whether currently or previously exposed and biological monitoring findings, as specified in the standard. • After acute exposure during emergency situations. • Upon termination, as specified in the standard.

TABLE B-2. OSHA GENERAL INDUSTRY STANDARD-SPECIFIC BIOLOGICAL MONITORING REQUIREMENTS (29 CFR 1910)			
OSHA Standard	**Substance**	**Analyte(s)**	**Monitoring Frequency**
Note: *This table provides a summary of biological monitoring requirements. For detailed information, refer to the listed standard.*			
1910.1028	Benzene	Complete blood count testing for: • Leukocyte count with differential • Quantitative thrombocyte count • Hematocrit • Hemoglobin • Erythrocyte count and erythrocyte indices After exposure during emergency situations: • Urinary phenol test (to be performed on end-of-shift urine sample within 72 hours of the emergency exposure).	For workers exposed under the exposure scenarios specified in the standard: • Initial exam • Annually • Complete blood count repeated within two weeks of initial or periodic examination results indicating abnormal blood conditions specified in the standard. After exposure during emergency situations: • Complete blood count tests monthly for three months following exposure if phenol test is ≥ 75 mg phenol/Liter of urine.
1910.1029	Coke oven emissions	Urinalysis testing for: • Sugar • Albumin • Hematuria Urinary cytology examination	For workers working in regulated areas at least 30 days per year: • Initial exam • Annual urinalysis testing • Annual urinalysis testing plus urinary cytology examination for workers ≥ 45 years old or with ≥ five years employment in regulated areas. • Upon termination if worker has not had examination within preceding six months.
1910.1030	Bloodborne pathogens	Blood sample testing for: • Hepatitis B virus (HBV) and human immunodeficiency virus (HIV) (source individual) • HBV and HIV (exposed individual)	Immediately after an exposure incident: • Source individual - As soon as feasible, provided consent is obtained as necessary. • Exposed worker - As soon as feasible after consent is obtained. If consent is not obtained for HIV serologic testing at time of baseline blood collection, the sample shall be preserved for at least 90 days, during which time it shall be tested as soon as feasible if consent is obtained.

TABLE B-2. OSHA GENERAL INDUSTRY STANDARD-SPECIFIC BIOLOGICAL MONITORING REQUIREMENTS (29 CFR 1910)			
OSHA Standard	**Substance**	**Analyte(s)**	**Monitoring Frequency**
Note: *This table provides a summary of biological monitoring requirements. For detailed information, refer to the listed standard.*			
1910.1044	1,2-Dibromo-3-chloropropane (DBCP)	Serum specimen testing for: • Serum follicle stimulating hormone (FSH) • Serum luteinizing hormone (LH) • Serum total estrogen (females) Sperm count After exposure during emergency situations: • Sperm count or above hormone tests if worker has vasectomy or is unable to produce semen.	For workers in regulated areas: • Initial exam • Annually After exposure during emergency situations: • As soon as practicable after exposure and repeated three months after exposure.
1910.1045	Acrylonitrile	Test of the intestinal tract, including fecal occult blood screening (for all workers 40 years of age or older, and for any other affected workers for whom, in the opinion of the physician, such testing is appropriate).	For workers who are or will be exposed at or above the action level: • Initial exam • Annually • Upon termination if worker has not had examination within preceding six months.

TABLE B-2. OSHA GENERAL INDUSTRY STANDARD-SPECIFIC BIOLOGICAL MONITORING REQUIREMENTS (29 CFR 1910)			
OSHA Standard	**Substance**	**Analyte(s)**	**Monitoring Frequency**
Note: *This table provides a summary of biological monitoring requirements. For detailed information, refer to the listed standard.*			
1010.1047	Ethylene oxide (EtO)	Complete blood count testing for: • White cell count (including differential cell count). • Red cell count • Hematocrit • Hemoglobin	For workers who are or may be exposed at or above the action level for at least 30 days per year: • Initial exam • Annually • At termination, or at reassignment to an area without such exposures. After exposure during emergency situations, as medically appropriate. As soon as possible after notification by a worker: • Of development of signs or symptoms indicating possible overexposure. • That worker desires medical advice concerning the effects of current or past exposure to EtO on the worker's ability to produce a healthy child.
1910.1050	Methylenedianiline (MDA)	• Liver function tests • Urinalysis	For workers exposed at or above the action level for at least 30 days per year, subject to dermal exposure at least 15 days per year, or whom employers have reason to believe are being dermally exposed: • Initial exam • Annually After exposure during emergency situations and when workers develop signs/symptoms of exposure: • Initial exam • Repeat liver function tests on physician's advice. If tests are normal, repeat two to three weeks after initial tests. If both are normal, no further testing is required.

TABLE B-2. OSHA GENERAL INDUSTRY STANDARD-SPECIFIC BIOLOGICAL MONITORING REQUIREMENTS (29 CFR 1910)			
OSHA Standard	**Substance**	**Analyte(s)**	**Monitoring Frequency**
Note: *This table provides a summary of biological monitoring requirements. For detailed information, refer to the listed standard.*			
1910.1051	1,3-Butadiene (BD)	Complete blood count with differential and platelet count.	Annually for workers exposed at or above the action level for at least 30 days per year; or at or above the PELs for at least 10 days per year; Annually for workers even after transfer to non-BD exposure jobs (regardless of when transferred) if work history suggests BD exposure: o At or above the PELs on ≥ 30 days per year for 10 or more years. o At or above the action level for ≥ 60 days per year for 10 or more years. o Above 10 ppm for ≥ 30 days in any past year. After exposure during emergency situations • As quickly as possible, but no later than 48 hours after an emergency exposure, then monthly for three months.

TABLE B-2. OSHA GENERAL INDUSTRY STANDARD-SPECIFIC BIOLOGICAL MONITORING REQUIREMENTS (29 CFR 1910)			
OSHA Standard	**Substance**	**Analyte(s)**	**Monitoring Frequency**
Note: *This table provides a summary of biological monitoring requirements. For detailed information, refer to the listed standard.*			
1910.1052	Methylene chloride (MC)	The physician or other licensed healthcare professional shall determine the extent of any required laboratory surveillance based on the worker's observed health status and the medical and work history.	For workers exposed: at or above the action level for at least 30 days per year; at or above the eight-hour TWA PEL or the STEL for at least 10 days per year; or above the eight-hour TWA PEL or STEL for any length of time where a worker has been identified as being at risk from cardiac disease or some other serious MC-related health condition (and requests inclusion in the medical surveillance program): • Initial exam • Within 12 months of last surveillance for worker's age 45 years or older, or within 36 months of last surveillance for worker's less than 45 years old. • Upon termination, or reassignment to an area with MC exposure consistently at or below the action level and STEL if the worker has not had surveillance within the preceding six months. • Additional surveillance at frequency (other than above) when recommended in written medical opinion.
		After exposure during emergency situations (laboratory surveillance as indicated by the worker's health status).	After exposure during emergency situations.

APPENDIX C

PROCEDURES FOR COLLECTING WIPE SAMPLES

1. General Procedures for Collecting Wipe Samples

Preloading a group of vials with sampling filters (consult the CSI files to determine the appropriate sampling media to use) is a convenient method to carry the sample media to the worksite. Note: Smear tabs should be inserted with the tab end out. Clean disposable gloves should be worn when handling the filters and smear tabs. The gloves should not be powdered.

The following are general recommendations for taking wipe samples. Consult the CSI files for more specific instructions.

- Record each location where a wipe sample was taken. Photographs, sketches, diagrams and other means of noting sampling locations are helpful.

- A new set of clean, disposable, powder-free gloves should be used for each sample to avoid contamination of the filter by previous samples (and the possibility of false positives) and to prevent contact with the substance.

- Withdraw the filter from the vial with your fingers or clean tweezers. If a damp wipe sample is desired, moisten the filter with distilled water or other solvent as recommended. Note: For skin sampling use only distilled water. Other solvents may be appropriate for wiping surfaces depending upon the type of chemical being sampled.

- Depending on the purpose of the sample, it may be useful to determine the concentration of contamination (e.g., in micrograms of agent per area). For these samples, it is necessary to record the area of the surface wiped (e.g., 100 cm^2).

- Firm pressure should be applied when wiping.

- Using the filter, wipe an area about 100 cm^2, rubbing the entire area side to side, then up and down. In many cases (such as knobs and levers) it may not be possible to wipe 100 cm^2. Where a precise determination of the contaminant loading (concentration) is desired, prepare single-use 10-cm x 10-cm templates from cardstock or file folders.

- Place the filter in a sample vial, cap and number it, and note the number at the sample location. Include notes which will provide any additional relevant details regarding the nature of the sample (e.g., "Fred Worker's respirator, inside"; "Lunch table").

- At least one blank filter treated in the same fashion, but without wiping, should be submitted for each sampled area.

- Some substances (e.g., benzidine, hexavalent chromium, and 4,4'-methylenedianiline) are unstable and may require a solution to be added to the vial as soon as the wipe sample is placed in the vial or may require other special sample handling. If such instability is suspected, check the CSI file for sample handling instructions or contact the SLTC for guidance.

- Submit the samples, each sealed with a Form OSHA-21, and in accord with any special procedures located in OTM Section II Chapter 4 (Sample Shipping and Handling), to the SLTC. Properly document the samples by completing the OIS sampling worksheet.

Successful wipe sampling requires preparation and careful technique. It is best to practice these techniques in the office or other clean area before collecting samples in the field. Practice will enable the CSHO to get a sense of how much to wet the wipe, how delicate the wipes are, how to apply uniform pressure when wiping the surface, how to wipe evenly across the area to be sampled, how to fold the wipe to expose a clean surface for conducting a second pass, how to handle the wipes with tweezers or forceps, and how to avoid contaminating one's gloves while sampling.

2. Wipe Sampling Procedures for Hexavalent Chromium

Special wipe sampling techniques are necessary to prevent decomposition of hexavalent chromium (Cr(VI)) to trivalent chromium (Cr(III)) on the sampling media.

- For wipe sampling on smooth surfaces, use 37-mm diameter PVC filters with 5-µm pore size (MSA part # 625413).

- For wipe sampling on rough surfaces where PVC would be likely to tear, use 37-mm diameter binderless quartz fiber filters 0.45-mm thick (SKC part # 225-1809).

- For chrome plating operations, to prevent decomposition of Cr(VI) to Cr(III) use:

    - Binderless quartz fiber filters <u>coated</u> with 1percent sodium hydroxide (NaOH). These filters do not require extraction in the field and are preferred for sample stability. Caution: Do not use coated quartz fiber filters for any operation other than chromium plating.

    - PVC or uncoated binderless quartz fiber filters. <u>Immediately after sampling</u>, place the filter into a vial containing 5 mL of an aqueous stabilizing solution containing 10 percent sodium carbonate (Na_2CO_3) with 2 percent sodium bicarbonate ($NaHCO_3$) to eliminate the interference from the acid used in the chrome plating process.

- Always wear gloves when handling NaOH-treated filters due to their caustic nature. PVC or nitrile gloves are suggested based on review of chemical resistance data.

- Use clean polytetrafluoroethylene (PTFE)-coated (e.g., Teflon-coated) or plastic tweezers. Do not use metal tweezers to handle the filters as they will deposit Cr(VI) onto filters.

- Before sampling, label 20-mL glass scintillation vials with PTFE lined caps, one for each sample, and each with a unique sample number. These vials should be empty and dry. Exception: If using PVC or uncoated binderless quartz fiber filters for chrome plating operations, prefill the vials with 5 mL of stabilizing solution (10 percent Na_2CO_3 with 2 percent $NaHCO_3$).

- Prepare a diagram of the area or rooms to be wipe-sampled along with the locations of key surfaces.

- Use un-wetted filters to avoid interferences due to possible metals contamination in tap water.

- Wipe an area of known dimension such as a 10-cm x 10-cm square area.

- Record the surface area sampled on the OIS sampling worksheet when concentration determination is desired.

- Apply firm pressure when wiping. Start at the outside edge and progress toward the center making concentric squares of decreasing size. Fold the filter with the contaminant side inward and repeat.

- Without allowing the filter to come into contact with any other surface, fold the filter with the exposed side inward. Place the filter in a sample vial and cap.

- Place a corresponding number at the sample location on the diagram. Include notes with the sketch giving any further description that may prove useful when evaluating the sample results (e.g., a description of the surface sampled such as pencil, doorknob, safety glasses, lunch table, inside respirator, worker names, etc.).

- Submit at least one blank wipe filter, treated in the same fashion as the other samples, but without wiping.

- Record sample location, workers' names, surface area, work description, type of operation, PPE, and any other necessary information, along with any potential interferences on the OIS sampling worksheet.

- Submit the samples to the SLTC together with the OIS sampling worksheets as soon as possible after sampling. Ship any bulk samples separate from the surface samples. Note: Wipe samples taken in chromium plating and welding operations should be shipped to the SLTC within 24 hours after sampling by overnight delivery.

APPENDIX D

COMBUSTIBLE DUST BULK SAMPLING

Combustible dust sampling is conducted where the potential for rapid burning (deflagration) or violent burning with rapid release of pressure (explosion) is suspected due to the presence of accumulations of settled dust. **Non-ferrous metals are especially hazardous and must be collected according to regional CSHO safety and health program policies and procedures.** In general, a thickness greater than 1/32 of an inch is cause for concern when the surface area covered by settled dust exceeds 5% of the floor area in a given room. The 5% factor should not be used if the floor area exceeds 20,000 square feet (ft^2), in which case a 1,000 ft^2 layer of dust is the upper limit. Accumulations on overhead beams, joists, ducts, the tops of equipment, and other surfaces, including vertical surfaces, should be included when determining the dust coverage area. Note that the available surface area of bar joists is approximately five percent of the floor area and the equivalent surface area for steel beams can be as high as 10%. Further detail is included in the compliance directive for the Combustible Dust National Emphasis Program (CPL 03-00-008).

Examples of combustible dust include but are not limited to:

- Metal dust such as aluminum and magnesium
- Wood dust
- Coal and other carbon dusts
- Plastic dust and additives
- Biosolids
- Other organic dust such as sugar, flour, paper, soap, and dried blood
- Certain textile materials

Examples of industries that handle combustible dusts: agriculture, food products, chemicals, textiles, forest and furniture products, wastewater treatment, metal processing, tire and rubber manufacturing plants, paper products, pharmaceuticals, wastewater treatment, recycling operations (metal, paper, and plastic), and coal handling and processing facilities.

Examples of OSHA standards applicable to combustible dust hazards:

- 29 CFR 1910.22, Walking-Working Surfaces
- 29 CFR 1910.176(c), Materials Handling and Storage
- 29 CFR 1910.272, Grain Handling Facilities
- 29 CFR 1910.307, Electrical, Hazardous (Classified) Locations
- 29 CFR 1910.269(v)(11)(xii), Electric Power Generation, Transmission, Distribution
- 29 CFR 1910.1200, Hazard Communication Standard
- Section 5(a)(1) of the Occupational Safety and Health Act, the General Duty Clause, may used to cite deflagration, other fire, or explosion hazards where combustible dust hazards exist within dust control systems or other containers.

Personal Protective Equipment (PPE): To conduct combustible dust sampling, CSHOs shall wear non-spark producing clothing such as natural fiber (e.g., cotton). CSHOs should also be equipped with flame-resistant (FR) clothing as appropriate. Other PPE for the reduction of static electric discharge includes conductive gloves and electrostatic dissipative (ESD) footwear without metal eyelets. Note: CSHOs should not rely on ESD footwear as being effective in all environments. Accumulation of debris, wax, and

other high resistivity materials will compromise the conductivity of any floor. Conductive footwear should not be used where the potential for electric shock by line voltage exists.

Cameras: In areas classified as requiring intrinsically safe equipment, use only cameras that are intrinsically safe. If not available, either portray the scene with a sketch or use the zoom lens to take photos from a safe location. In areas that are not classified, the low energy levels produced by use of a regular camera will not normally present a hazard when dust concentrations in the air are below an OSHA PEL. If the dust levels in the air necessitate the use of a respirator, DO NOT USE YOUR CAMERA.

Safe Practices:

- If CSHOs find that there are potential combustible dust hazards, dust samples must be safely collected. Written statements should be taken from workers and employers regarding the properties of the combustible metals and any hazardous conditions present, such as but not limited to:

- Any history of fires/explosions/deflagrations involving combustible metals of concern (e.g. aluminum, magnesium, titanium, tantalum, niobium, zirconium, others). *If a fire, explosion, or deflagration has previously occurred at the establishment related to the handling of a combustible metal, document the occurrence and circumstances involved through the interview process. If a material has shown to be combustible at the establishment, there may not be a need for obtaining a bulk sample.*

- The experienced consistency/size fraction of the combustible metals of concern. *Interview the workers charged with emptying the collection bins beneath the dust collection devices. Document their experience regarding the particle size of the metal being collected. Common materials and their size are:*
    - *White granulated sugar: 450 to 600 microns*
    - *Table salt: 100 microns*
    - *Flour: 1 to 100 microns*
    - *Sand: 50 plus microns*
    - *Talcum powder: 10 microns*

- The results of any previous combustible metals sampling conducted or commissioned by the employer. *If the employer has previously conducted combustibility testing, obtain the results for the file.*

- Material Safety Data Sheet (MSDS) or Safety Data Sheet (SDS[1]) identification of metal material(s), SDS warnings or other instructions. *Obtain MSDSs or SDSs for the materials being utilized at the establishment for the file.*

- Do not collect a sample from an area unless a safe means of access is available.

- Take all precautions necessary to avoid the generation of a dust cloud while collecting a sample.

[1] The hazard communication standard was revised in 2012. Safety Data Sheets (SDSs) will replace MSDSs. SDSs have a standardized 16-section format with specific information required in each section. Manufacturers and importers have until June 1, 2015 to replace MSDSs with SDSs, and until then a mixture of MSDSs and SDSs may be received by employers.

- Use conductive nonsparking tools when collecting samples. If possible, bond and ground the tools.

- Do not use plastic bags, as they cannot be sealed tightly enough to avoid sample leakage or moisture loss, and may cause a bellows effect resulting in airborne exposure during sample handling.

Sample Collection Equipment may include:

- Natural bristle hand brushes for collecting settled dust.
- Non-sparking conductive dust pans (aluminum) for collecting settled dust.
- Non-spark producing sample container (1-Liter nonconductive plastic bottle, obtained locally or from the SLTC).
- Non-spark producing funnel for filling sample containers.
- Non-spark producing scoops for removing dust from cyclone containers or other ventilation equipment.

Sampling locations:

- Observe and document areas where the dust layer exceeds 1/32 inch in thickness, approximately the thickness of a small paper clip.

- Collect separate samples from:
    - Equipment and floors where dust has accumulated. Note that samples collected at floor level present a significantly reduced potential for dust cloud generation.

    - "High spaces" such as roof beams, open web beams, and other ceiling supports; tops of pipes, railings, ductwork, conduit, electrical boxes/panels and other horizontal surfaces located as high in the overhead as possible. Samples collected from elevated surfaces present a significantly greater potential for dust cloud generation from the inadvertent falling of material. High spaces are the preferred location for collecting samples, so long as there is a means of safe access.

    - The interior (i.e., bins and/or bags) of a dust collector.

    - Within ductwork.

- Avoid taking samples in close proximity of recognized ignition sources such as open flames, motors, electrical equipment, equipment bearings, etc.

Procedures:

- Use the correct equipment for collecting dust samples (see sample collection equipment above).

- Avoid contaminating the sample with other substances (some contaminants lead to underreporting of the explosiveness of the dust sampled).

- Collect at least 1 Liter of dust per sample.

    - One sample of each type dust is sufficient.

- Each type dust must be collected as separate sample.
- Dust from several locations can be pooled into one sample container IF it is all the same type of dust.
- Several tests are conducted from the same bulk sample.

- If possible, collect the sample from the highest elevated horizontal surfaces in the plant. Finer particles more easily ignite and tend to collect on elevated surfaces.

- Determine if there is a hybrid mixture of combustible dust with a flammable gas or vapor.

- If it is grain dust, send an additional sample for percent (%) combustible analysis.

- Affix an OSHA-21 sample identification seal to the container. To seal the bottle, apply one end of the seal to the center of the lid, and run the seal down the edge of the lid and as far down the side of the bottle as it will reach.

- Document where, when, and how dust is used and/or generated. Document the description of the operation and the requested tests on the OIS sampling worksheet as follows:

    - When requesting analyses for fire or explosion hazards that may result from housekeeping, 5(a)(1), or 29 CFR 1910.37 (Means of Egress) violations, write K_{st}.

    - Where 29 CFR 1910.307 (Hazardous Locations) violations are a concern, write "Potential Class II Dust." This test must be done to support a citation for Class II hazardous (classified) locations. Note: This test only applies to electrical ignition sources in Class II locations. When in doubt, contact the SLTC.

- The Area Director must review the sampling plan and the number of samples being submitted. A concurrence letter is required due to the resource-intensive nature of these laboratory tests.

- Ship the sample with the paperwork (including the MSDS/SDS) in a box to SLTC. Note: No special DOT shipping requirements apply; however, when shipping metal dusts, especially dusts involving aluminum or magnesium, CSHOs should verify with the shipping company whether any special shipping requirements apply.