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**NIOSH
Recommendations
for
Occupational Safety
and
Health Standards**

September 1986

**U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
National Institute for Occupational Safety and Health
Centers for Disease Control
Atlanta, Georgia 30333**

INTRODUCTION

Acting under the authority of the Occupational Safety and Health Act of 1970 (Public Law 91-596), the National Institute for Occupational Safety and Health (NIOSH) develops, and periodically revises, recommendations for limits of exposure to potentially hazardous substances or conditions in the workplace. It also recommends preventive measures designed to reduce or eliminate adverse health effects associated with these hazards. In formulating these recommendations, NIOSH evaluates all known and available scientific information relevant to the potential hazard. These recommendations are then published and transmitted to the Department of Labor, Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA) for use in promulgating legal standards.

NIOSH recommendations are published in a variety of documents. Criteria Documents specify a NIOSH Recommended Exposure Limit (REL) and appropriate preventive measures designed to reduce or eliminate adverse health effects. Special Hazard Reviews, Occupational Hazard Assessments, and Technical Guidelines are other types of documents published by NIOSH to complement the Institute's recommendations for standards. These documents provide assessments, from a safety and health standpoint, of specific problems associated with a given agent or hazard and recommend appropriate control and surveillance methods.

Although these documents do not supplant the more comprehensive Criteria Document, they are prepared in such a way as to assist OSHA in the formulation of regulations. NIOSH also periodically presents testimony before various Congressional committees and at regulatory hearings convened by OSHA. The testimony presented always includes the current NIOSH policy concerning the particular hazard in question.

NIOSH also publishes documents known as Current Intelligence Bulletins (CIB) which review and evaluate emerging information on occupational hazards. These bulletins are based on the rapid evaluation of new and changing information on a particular hazard in light of existing knowledge.

The "NIOSH Recommendations for Occupational Safety and Health Standards" are based on existing NIOSH policy as previously published in any of the forms listed above. The intent of this table is to provide, in rapid-reference form, the most recent NIOSH REL or other recommendation for each potential hazard. The current OSHA Permissible Exposure Limit (PEL) or standard is also presented. Unless otherwise noted in the table, the NIOSH recommendations were originally published in Criteria Documents.

Note to Readers:

Copies of NIOSH publications are generally available from the U.S. Government Printing Office and the National Technical Information Service. Single copies of these publications may be obtained (while the supply lasts) from:

Publications Dissemination
Division of Standards Development
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National Institute for Occupational Safety and Health
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Definitions of abbreviations and terms used in this publication:

Action level	the exposure concentration at which certain provisions of the NIOSH recommended standard must be initiated, such as periodic measurements of worker exposure, training of workers, and medical surveillance
Ca	NIOSH recommends that the substance be treated as a potential human carcinogen
CFR	Code of Federal Regulations
CIB	Current Intelligence Bulletin
dBA	decibel, weighted according to the A scale, which approximates the response of the human ear
ECG	electrocardiogram
J/cm ²	joules per square centimeter
μm	micrometer
μg/m ³	micrograms per cubic meter
mg/m ³	milligrams per cubic meter
mppcf	millions of particles per cubic foot
mW/cm ²	milliwatts per square centimeter
nm	nanometer
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PCB's	polychlorinated biphenyls
PCDD's	polychlorinated dibenzo- <i>p</i> -dioxins
PCDF's	polychlorinated dibenzofurans
PEL	Permissible Exposure Limit (OSHA)
ppb	parts per billion
ppm	parts per million
REL	Recommended Exposure Limit (NIOSH)
(Skin)	potential contribution to overall exposure by the cutaneous route including mucous membranes and eyes
TCDD	2,3,7,8-tetrachlorodibenzo- <i>p</i> -dioxin
TWA	time-weighted average

**SUMMARY OF OSHA REGULATIONS AND NIOSH RECOMMENDATIONS
FOR OCCUPATIONAL SAFETY AND HEALTH STANDARDS, 1986**

NIOSH				
Potential Hazard*	OSHA PEL'S/ Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
2-Acetylaminofluorene (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1014	Ca Use 29 CFR 1910.1014	Potential for cancer in humans; produced tumors of the liver, bladder, lungs, pancreas, and skin in animals	None
Acetylene (July 1976)	2,500 ppm (10% of lower explosive limit)	No exposure > 2,500 ppm (2,662 mg/m ³)	Asphyxia	Employers to check for and inform workers of contaminants such as arsine and phosphine
Acrylamide (October 1976)	0.3 mg/m ³ , 8-hr TWA (Skin)	0.3 mg/m ³ TWA	Skin, eye, and nervous system effects	Prevent skin and eye contact
Acrylonitrile (January 1978; revised March 1978 as part of NIOSH testimony at OSHA hearing)	2 ppm, 8-hr TWA; 10 ppm ceiling (15 min) (Skin) 29 CFR 1910.1045	Ca 1 ppm, 8-hr TWA; 10 ppm ceiling (15 min) (Skin)	Brain tumors; lung and bowel cancer	Chest x ray required; first-aid and medical kits to be available during use; prevent skin contact
Aldrin/dieldrin (Special Hazard Review September 1978)	0.25 mg/m ³ , 8-hr TWA (Skin)	Ca Lowest reliably detectable level	Potential for cancer in humans; produced tumors of the lungs, liver, thyroid, and adrenal glands in animals	Aldrin/dieldrin no longer produced in U.S.; prevent skin contact

*Date recommendation was published or testimony presented is in parentheses.

†NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

‡Unless otherwise noted health effects cited are for humans.

NIOSH				
Potential Hazard*	OSHA PEL'S/Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
Alkanes (C5-C8) (March 1977)	All are 8-hr TWA values: Pentane: 1,000 ppm (2,950 mg/m ³); n-hexane: 500 ppm (1,800 mg/m ³); n-heptane: 500 ppm (2,000 mg/m ³); octane: 500 ppm (2,350 mg/m ³)	All are TWA values: Pentane: 120 ppm (350 mg/m ³); hexane: 100 ppm (350 mg/m ³); heptane: 85 ppm (350 mg/m ³); octane: 75 ppm (350 mg/m ³); Mixtures not to exceed 350 mg/m ³ TWA; All are ceiling values (15 min) singly or mixtures: pentane: 610 ppm (1,800 mg/m ³); hexane: 510 ppm (1,800 mg/m ³); heptane: 440 ppm (1,800 mg/m ³); octane: 385 ppm (1,800 mg/m ³); Action level set at 200 mg/m ³ for these substances	Skin and nervous system effects	None
Allyl chloride (September 1976)	1 ppm (3 mg/m ³), 8-hr TWA	1 ppm (3.1 mg/m ³) TWA; 3 ppm (9.3 mg/m ³) ceiling (15 min)	Liver, kidney, and lung effects	Urine, blood, and pulmonary function testing required
4-Aminodiphenyl (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent 29 CFR 1910.1011 Stringent workplace controls, recordkeeping, and medical surveillance required	Ca Use 29 CFR 1910.1011	Bladder cancer	None
Ammonia (July 1974)	50 ppm (35 mg/m ³), 8-hr TWA	50 ppm (34.8 mg/m ³) ceiling (5 min)	Respiratory irritation	Prevent eye contact
Anesthetic gases (see Waste anesthetic gases)				

Animal rendering processes (Occupational Hazard Assessment March 1981)	OSHA PEL's or NIOSH REL's for specific hazards are applicable		
Antimony (September 1978)	0.5 mg Sb/m ³ , 8-hr TWA	0.5 mg Sb/m ³ TWA	Mechanical injury; burns; heat stress; infections from biologic agents; chemical hazards
Arsenic, inorganic (September 1974; revised June 1975; reaffirmed July 1982 as part of NIOSH testimony at OSHA hearing)	10 µg As/m ³ , 8-hr TWA 29 CFR 1910.1018	Ca 2 µg As/m ³ ceiling (15 min)	Guidelines for engineering controls and work practices to reduce injury and illness presented Chest x ray, pulmonary function testing, and electrocardiogram required Chest x ray required
Arsine (CIB August 1979)	0.2 mg/m ³ (0.05 ppm), 8-hr TWA	Ca 2 µg As/m ³ (0.002 mg As/m ³) ceiling (15 min)	Sudden extensive hemolysis
Asbestos (January 1972; revised December 1976; revised March 1984 as part of NIOSH testimony at Congressional hearing; [Continued on next page])	200,000 fibers/m ³ , over 5 µm in length, 8-hr TWA; Action level of 100,000 fibers/m ³ , 8-hr TWA 29 CFR 1910.1001	Ca 100,000 fibers/m ³ , over 5 µm in length, 8-hr TWA in a 400-liter air sample	Workers to be warned of working with arsenic compounds in presence of freshly formed hydrogen Chest x ray and pulmonary function testing required

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NIOSH				
Potential Hazard*	OSHA PEL'S/ Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
reaffirmed June 1984 as NIOSH testimony at OSHA hearing)				
Asphalt fumes (September 1977)	None	5 mg/m ³ ceiling, measured as total particulate (15 min)	Eye and respiratory irritation	Medical surveillance required; prevent skin contact
Benzene (July 1974; revised August 1976; revised July 1977 as part of NIOSH testimony at OSHA hearing; revised March 1986 as part of NIOSH testimony at OSHA hearing)	10 ppm, 8-hr TWA; 25 ppm acceptable ceiling; 50 ppm maximum ceiling (10 min)	Ca 0.1 ppm (0.32 mg/m ³) 8-hr TWA; 1 ppm (3.2 mg/m ³) ceiling (15 min)	Cancer (leukemia)	Prevent skin contact
Benzidine (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent 29 CFR 1910.1010 Stringent workplace controls, recordkeeping, and medical surveillance required	Ca Use 29 CFR 1910.1010	Bladder, liver, and kidney cancer	None

Benzidine-based dyes (Special Hazard Review January 1980; revised in "Preventing health hazards from . . . benzidine congeners dyes" January 1983)	No PEL for benzidine-based dyes	Ca Reduce exposure to lowest feasible level; replace with less toxic materials	Bladder cancer	Stringent workplace controls and medical surveillance required. Urine monitoring for benzidine suggested
Benzoyl peroxide (June 1977)	5 mg/m ³ , 8-hr TWA	5 mg/m ³ TWA	Respiratory and eye irritation; skin effects	None
Benzyl chloride (August 1978)	5 mg/m ³ (1 ppm), 8-hr TWA	5 mg/m ³ ceiling (15 min)	Irritation; skin and eye effects	Chest x ray and pulmonary function testing required
Beryllium (June 1972; revised August 1977 as part of NIOSH testimony at OSHA hearing)	2 µg/m ³ , 8-hr TWA; 5 µg/m ³ acceptable ceiling; 25 µg/m ³ maximum ceiling (30 min)	Ca Not to exceed 0.5 µg Be/m ³	Lung cancer	Pulmonary function testing and chest x ray required
Boron trifluoride (December 1976)	1 ppm (3 mg/m ³) ceiling	No exposure limit recommended due to the absence of a reliable monitoring method	Respiratory effects	Appropriate engineering and work-practice controls to reduce exposure to lowest feasible level; pulmonary function testing required
1,3-Butadiene (CIB February 1984)	1,000 ppm (2,200 mg/m ³), 8-hr TWA	Ca Reduce exposure to lowest feasible level	Hematopoietic cancer; teratogenicity; reproductive system effects	Appropriate engineering and work-practice controls; restrict access to areas where 1,3-butadiene is used

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NIOSH

Potential Hazard*	OSHA PEL'S/ Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
Cadmium (August 1976; revised in CIB September 1984)	Fume: 0.1 mg/m ³ , 8-hr TWA; 0.3 mg/m ³ ceiling; dust: 0.2 mg/m ³ , 8-hr TWA; 0.6 mg/m ³ ceiling	Ca Reduce exposure to lowest feasible level	Lung cancer, prostatic cancer, renal system effects	None
Carbaryl (September 1976)	5 mg/m ³ , 8-hr TWA	5 mg/m ³ TWA	Central nervous system and reproductive system effects	Workers to be warned of possible effects on reproductive system and to have only minimum exposure during pregnancy; prevent skin and eye contact
Carbon black (September 1978)	3.5 mg/m ³ , 8-hr TWA	3.5 mg/m ³ TWA; Ca 0.1 mg/m ³ TWA in presence of polycyclic aromatic hydrocarbons	Lung, cardiovascular and skin effects; cancer of the lymphatic- bone marrow complex when exposed to carbon black in the presence of polycyclic aromatic hydrocarbons	Chest x rays, pulmonary function testing, and ECG required
Carbon dioxide (August 1976)	5,000 ppm (9,000 mg/m ³), 8-hr TWA	10,000 ppm (18,000 mg/m ³) TWA; 30,000 ppm (54,000 mg/m ³) ceiling (10 min)	Respiratory effects	None
Carbon disulfide (May 1977)	20 ppm, 8-hr TWA; 30 ppm acceptable ceiling; 100 ppm maximum ceiling (30 min)	1 ppm (3 mg/m ³) TWA; 10 ppm (30 mg/m ³) ceiling (15 min)	Cardiovascular, central nervous system, and reproductive system effects	Workers to be advised of potential effects on reproductive system
Carbon monoxide (August 1972)	50 ppm (55 mg/m ³), 8-hr TWA	35 ppm (40 mg/m ³), 8-hr TWA; 200 ppm (229 mg/m ³) ceiling (no defined time)	Cardiovascular effects	None

Carbon tetrachloride (December 1975; revised June 1976)	10 ppm, 8-hr TWA; 25 ppm acceptable ceiling; 200 ppm maximum ceiling (5 min in 4 hr)	Ca 2 ppm (12.6 mg/m ³) ceiling in a 45-liter sample (60 min)	Liver cancer	REL based on lower limit of detection at time of document publication
Chlorine (May 1976)	1 ppm (3 mg/m ³) ceiling	0.5 ppm (1.45 mg/m ³) ceiling (15 min)	Eye and respiratory irritation	Chest x rays required
Chloroethane (CIB August 1978)	1,000 ppm (2,600 mg/m ³), 8-hr TWA	To be handled in the workplace with caution	Central nervous system effects; possible liver and/or kidney effects	Exposures should be minimized due to the structural similarity to the carcinogenic chloroethanes
Chloroform (September 1974; revised June 1976)	50 ppm (240 mg/m ³) ceiling	Ca 2 ppm (9.78 mg/m ³) ceiling in a 45-liter sample (60 min)	Liver or kidney tumors and central nervous system effects	None
bis-Chloromethyl ether (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1008	Ca Use 29 CFR 1910.1008	Lung cancer	None
Chloroprene (August 1977)	25 ppm (90 mg/m ³), 8-hr TWA	Ca 1 ppm (3.6 mg/m ³) ceiling (15 min)	Lung and skin cancer; reproductive effects	Chest x ray and pulmonary function testing required; pregnant workers to be counseled about continuing work with chloroprene
Chromic acid (July 1973; revised—see Chromium (VI) December 1975)	1 mg/10 m ³ (100 µg/m ³) ceiling	25 µg/m ³ (0.025 mg/m ³) TWA; 50 µg/m ³ (0.05 mg/m ³) ceiling (15 min) as noncarcinogenic Cr (VI)	Nasal ulceration	None

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NIOSH				
Potential Hazard*	OSHA PEL'S/ Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
Chromium (VI) (December 1976)	1 mg/10 m ³ (100 µg/m ³) ceiling	Ca Carcinogenic Cr (VI): 1 µg/m ³ TWA; other Cr (VI): 25 µg/m ³ TWA; 50 µg/m ³ ceiling (15 min)	Lung cancer, skin ulcers, and lung irritation	Employer must demonstrate absence of carcinogenic Cr (VI); x ray required
Chrysene (Special Hazard Review June 1978)	0.2 mg/m ³ , 8-hr TWA	Ca To be controlled as an occupational carcinogen	Potential for cancer in humans; produced liver and skin tumors in animals	Document also contains control recommendations for polycyclic aromatic hydrocarbons
Coal gasification plants (September 1978)	OSHA PEL's or NIOSH REL's for specific hazards are applicable			
Coal liquefaction, volumes I and II (Occupational Hazard Assessment March 1981)	OSHA PEL's or NIOSH REL's for specific hazards are applicable			
Coal tar products (September 1977)	0.2 mg/m ³ , 8-hr TWA (benzene-soluble fraction) 29 CFR 1910.1002 (coal tar pitch volatiles)	Ca 0.1 mg/m ³ TWA (cyclohexane-extractable fraction)	Lung and skin cancer	Includes coal tar, creosote, and coal-tar pitch; pulmonary function testing and chest x rays required

Cobalt (Occupational Hazard Assessment October 1981)	0.1 mg/m ³ , 8-hr TWA	NIOSH has concluded that there is insufficient evidence to warrant recommending a new exposure limit	Dermatitis; potential for pulmonary fibrosis	Includes recommendations for engineering controls, work practices, protective equipment, worker education, monitoring, and medical surveillance
Coke oven emissions (February 1973; revised November 1975 as part of NIOSH testimony at OSHA hearing)	150 µg/m ³ , 8-hr TWA 29 CFR 1910.1029	Ca 0.5-0.7 mg/m ³ (500-700 µg/m ³) (total particulates) as screening level	Lung cancer	Chest x ray required; work practices to minimize exposure to emissions
Confined spaces, working in (December 1979)	Covered under numerous OSHA regulations for General Industry (29 CFR 1910)	Various recommendations including a permit system to prevent worker injury and death	Injury and death	None
Cotton dust (September 1974; reaffirmed September 1983 as part of NIOSH testimony at OSHA hearing)	Yarn manufacturing: 200 µg/m ³ , 8-hr TWA; slashing and weaving operations: 750 µg/m ³ , 8-hr TWA; all other operations: 500 µg/m ³ , 8-hr TWA 29 CFR 1910.1043	<200 µg/m ³ lint-free cotton dust	Pulmonary disease (byssinosis)	Pulmonary function testing required
Cresol (February 1978)	5 ppm (22 mg/m ³), 8-hr TWA (Skin)	2.3 ppm (10 mg/m ³) TWA	Skin, liver, kidney, and pancreas effects	Applies to mixtures of cresols and cresylic acid; prevent skin and eye contact; possible delayed effects

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Potential Hazard*	OSHA PEL's/ Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
DDT (Special Hazard Review September 1978)	1 mg/m³, 8-hr TWA (Skin)	Ca Lowest reliably detectable level; 0.5 mg/m³ TWA by NIOSH-validated method	Potential for cancer in humans; produced tumors of the liver, lungs, and lymphatic system in animals	Prevent skin contact
2,4-Diamino- anisole and its salts (CIB January 1978)	None	Ca Reduce exposure to lowest feasible level	Potential for cancer in humans; produced tumors of the thyroid, skin, and lymphatic system in animals	Prevent skin contact; engineering and work- practice controls are recommended
o-Dianisidine- based dyes (Joint NIOSH/OSHA Health Hazard Alert December 1980)	None	Ca Should be handled in the workplace with caution; exposures should be minimized	Potential for cancer in humans; produced tumors of the bladder, stomach, and mammary glands in animals	Substitute less toxic dyes wherever possible
Dibromochloro- propane (January 1978)	1 ppb, 8-hr TWA; eye and skin contact to be avoided 29 CFR 1910.1044	10 ppb (0.1 mg/m³) TWA (NIOSH recommendation superseded by OSHA standard promulgated in 1978)	Sterility; renal and liver effects	Regulated by OSHA as a carcinogen
3,3'-Dichloro- benzidine (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1007	Ca Use 29 CFR 1910.1007	Potential for cancer in humans; produced tumors of the liver, bladder, and lungs in animals	None

1,1-Dichloro-ethane (CIB August 1978)	100 ppm (400 mg/m ³), 8-hr TWA	To be handled in the workplace with caution	Central nervous system effects; possible liver and/or kidney damage	Exposures should be minimized due to the structural similarity to the carcinogenic chloroethanes
Dieldrin (see Aldrin/dieldrin)				
Di-2-Ethylhexyl Phthalate (DEHP)(Special Hazard Review March 1983)	5 mg/m ³ , 8-hr TWA	Ca Reduce exposure to lowest feasible level	Potential for cancer in humans; produced liver tumors in animals	DEHP, widely used in the quantitative fit testing of respirators, should be replaced with less toxic material such as refined corn oil
Diisocyanates (September 1978)	Toluene diisocyanate (TDI): 0.02 ppm (0.14 mg/m ³) ceiling; diphenylmethane diisocyanate (MDI): 0.02 ppm (0.2 mg/m ³) ceiling	All values given in µg/m ³ and all ceiling values for 10 min (each equivalent to 5 ppb TWA and 20 ppb ceiling): TDI: 35 TWA, 140 ceiling; MDI: 50 TWA, 200 ceiling; hexamethylene diisocyanate (HDI): 35 TWA, 140 ceiling; naphthalene diisocyanate (NDI): 40 TWA, 170 ceiling; isophorone diisocyanate (IPDI): 45 TWA, 180 ceiling; dicyclohexylmethane-4,4'-diisocyanate (hydrogenated MDI): 55 TWA, 210 ceiling; other diisocyanates to be controlled to 20 ppb ceiling and 5 ppb TWA	Respiratory effects and sensitization; pulmonary irritation	Chest x ray and pulmonary function testing required

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NIOSH				
Potential Hazard*	OSHA PEL'S/ Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
4-Dimethylamino-azobenzene (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1015	Ca Use 29 CFR 1910.1015	Potential for cancer in humans; produced tumors of the liver and bladder in animals	None
Dinitro-ortho-cresol (February 1978)	0.2 mg/m ³ , 8-hr TWA (Skin)	0.2 mg/m ³ TWA	Central nervous system and metabolic effects	Blood and urine monitoring required; prevent skin and eye contact; possible delayed effects
Dinitro-toluenes (CIB July 1985)	1.5 mg/m ³ , 8-hr TWA (Skin)	Ca Reduce exposure to lowest feasible level	Potential for cancer in humans; produced tumors of the liver, skin, and kidneys in animals; reproductive system effects	Prevent skin contact
Dioxane (September 1977)	100 ppm (360 mg/m ³), 8-hr TWA (Skin)	Ca 1 ppm (3.6 mg/m ³) ceiling (30 min)	Potential for cancer in humans; produced tumors of liver, lungs, and nasal cavity in animals; effects on liver and kidney	Blood and urine testing required; prevent skin contact
Dioxin (see 2.3.7.8-Tetrachloro-dibenzo- <i>p</i> -dioxin)				
Elevated workstations, emergency egress from (December 1975)	Sections under Subpart E, Means of Egress, General Industry Standards, and Subpart R, Special Industries (29 CFR 1910.261)	Various recommendations concerning means and availability of egress	Trauma and injury	None

Epichlorohydrin (September 1976; revised in CIB October 1978)	5 ppm (19 mg/m ³), 8-hr TWA	Ca Occupational exposure to epichlorohydrin to be minimized	Respiratory cancer; mutagenesis; reproductive effects; skin, kidney, liver, and respiratory effects	Prevent skin contact
2-Ethoxy-ethanol (see Glycol ethers)				
Ethyl chloride (see Chloroethane)				
Ethylene dibromide (August 1977; revised November 1983; reaffirmed February 1984 as part of NIOSH testimony at OSHA hearing)	20 ppm, 8-hr TWA; 30 ppm acceptable ceiling; 50 ppm maximum peak (5 min)	Ca 0.045 ppm (0.38 mg/m ³), 8-hr TWA; 0.13 ppm (1 mg/m ³) ceiling (15 min)	Potential for cancer in humans; mutagenesis; damage to skin, eyes, cardiovascular, liver, spleen, reproductive, respiratory, and central nervous systems	Workers to be warned of potential for reproductive abnormalities and cancer; hazardous liquid; prevent skin contact
Ethylene dichloride (March 1976; revised in CIB April 1978; revised September 1978)	50 ppm, 8-hr TWA; 100 ppm acceptable ceiling; 200 ppm maximum ceiling (5 min in 3 hr)	Ca 1 ppm (4 mg/m ³) TWA; 2 ppm (8 mg/m ³) ceiling (15 min)	Potential for cancer in humans; nervous system, respiratory, cardiovascular, and liver effects	Nursing infants of exposed mothers at risk

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NIOSH				
Potential Hazard*	OSHA PEL'S/Standard	REL'S†/Other Recommendations	Health Effect(s) Considered§	Comments
Ethyleneimine (NIOSH testimony at OSHA hearing September 1973)	0.5 ppm (1 mg/m ³), 8-hr TWA (Skin) 29 CFR 1910.1012	Ca Use 29 CFR 1910.1012	Potential for cancer in humans; produced tumors of the liver and lung in animals	Stringent workplace controls and medical surveillance required
Ethylene oxide (Special Hazard Review September 1977; revised July 1983 as part of NIOSH testimony at OSHA hearing)	1 ppm (1.8 mg/m ³), 8-hr TWA 29 CFR 1910.1047	Ca 5 ppm (9 mg/m ³) ceiling (10 min/day); <0.1 ppm (0.18 mg/m ³), 8-hr TWA	Peritoneal cancer; leukemia; mutagenesis; reproductive effects	Blood monitoring and medical counseling recommended
Ethylene thiourea (Special Hazard Review October 1978)	None	Ca Should be used in encapsulated form in industry; worker exposure to be minimized	Potential for cancer and teratogenicity in humans; produced tumors of the liver, thyroid, and lymphatic system in animals	Workers to be informed of carcinogenic and teratogenic hazards; special attention to be given to thyroid function tests
Excavations, development of draft construction safety standards for (Technical Guideline May 1983)	Many aspects covered under OSHA regulations governing excavations, trenching, and shoring practices in the construction industry (29 CFR 1926, Subpart P)	Many work-practice recommendations concerning safety standards for excavations	Injury and death	None
Fibrous glass (April 1977)	Nuisance dust PEL applies, 15 mg/m ³ total dust; 5 mg/m ³ respirable fraction	3 million fibers/m ³ TWA (fibers ≤ 3.5 μm diameter and ≥ 10 μm length); 5 mg/m ³ TWA (total fibrous glass)	Eye, skin, and respiratory effects	NIOSH recommends that this REL also apply to other synthetic fibers

Fluorides, inorganic (June 1975)	2.5 mg F/m ³ , 8-hr TWA	2.5 mg F/m ³ TWA	Kidney and bone effects	Urine monitoring required
Fluorocarbon polymers, decomposition products of (September 1977)	None	Various recommendations emphasizing good work practices, engineering controls, and medical surveillance	Lung effects; polymer fume fever	Workroom air to be monitored for inorganic fluorides and hydrogen fluoride
Formaldehyde (December 1976; revised in CIB April 1981; revised May 1986 as part of NIOSH testimony at OSHA hearing)	3 ppm, 8-hr TWA; 5 ppm acceptable ceiling; 10 ppm maximum ceiling (30 min)	Ca 0.1 ppm ceiling (15 min); represents the lowest reliably quantifiable concentration	Potential for cancer in humans; produced tumors of the nasal cavity in animals	Medical surveillance; skin protection
Foundries (September 1985)	Many aspects covered under the numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations emphasizing good work practices, engineering controls, and medical surveillance	Cancer; respiratory disease; heat-induced illness; noise-induced hearing loss; vibration-induced disorders; eye injuries; traumatic and ergonomic injuries	Recommendations limited to foundries that pour molten metal into sand molds
Furfuryl alcohol (March 1979)	50 ppm (200 mg/m ³), 8-hr TWA	50 ppm (200 mg/m ³) TWA	Respiratory effects	None

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Potential Hazard*	NIOSH		
	OSHA PEL'S/ Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡
Glycidyl ethers (June 1978; revised in CIB October 1978)	All values in ppm (mg/m³): allyl glycidyl ether (AGE): 10 (45) ceiling; n-butyl glycidyl ether (BGE): 50 (270), 8-hr TWA; di-2,3-epoxypropyl ether (DGE): 0.5 (2.8), 8-hr TWA; isopropyl glycidyl ether (IGE): 50 (240), 8-hr TWA; phenyl glycidyl ether (PGE): 10 (60), 8-hr TWA	All are ceiling values (15 min) in ppm (mg/m³): AGE: 9.6 (45); BGE: 4.4 (30); DGE: 0.2 (1) Ca; IGE: 50 (240); PGE: 1 (5)	DGE: Potential for cancer in humans; produced skin tumors in animals; DGE and other glycidyl ethers: skin and mucous membrane effects; sensitization potential; possible hematopoietic and reproductive system effects
Glycol ethers (CIB May 1983)	2-Methoxyethanol: 25 ppm (80 mg/m³), 8-hr TWA (Skin); 2-ethoxyethanol: 200 ppm (740 mg/m³), 8-hr TWA (Skin)	Reduce exposure to lowest feasible level	Reproductive effects; teratogenicity
Grain elevators and feed mills, occupational safety in (Technical Guideline September 1983; reaffirmed June 1984 as part of NIOSH testimony at OSHA hearing)	Many general aspects (e.g., protective equipment, dust control, etc.) covered under the numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations for control of combustible dusts and ignition sources, machine guarding, isolation and lockouts, bin entry, training, and personal protective equipment	Injury and death Health hazards from exposure to fumigants, pesticides, and grain dust
Hexachloroethane (CIB August 1978)	1 ppm (10 mg/m³), 8-hr TWA (Skin)	Ca Reduce exposure to lowest feasible level	Potential for cancer in humans; produced liver tumors in animals
			None

Hot environments (June 1972; revised April 1986)	None	Sliding scale limits based upon environmental and metabolic heat loads	Heat-induced illnesses	Recommendations include acclimatization, strict work practices, protective equipment, and medical surveillance
Hydrazines (June 1978)	All values in ppm (mg/m ³): hydrazine: 1 (1.3), 8-hr TWA; 1,1-dimethylhydrazine: 0.5 (1.0), 8-hr TWA; phenylhydrazine: 5 (22), 8-hr TWA; methylhydrazine: 0.2 (0.35) ceiling	Ca All are ceiling values (120 min) in ppm (mg/m ³): hydrazine: 0.03 (0.04); 1,1-dimethylhydrazine: 0.06 (0.15); phenylhydrazine: 0.14 (0.6); methylhydrazine: 0.04 (0.08)	Potential for cancer in humans; produced tumors of the lung, liver, blood vessels, and intestines in animals; blood, liver, and skin effects	Blood and urine monitoring and chest x ray required; bowel examination for workers over age 40
Hydrogen cyanide and cyanide salts (October 1976)	Hydrogen cyanide: 10 ppm (11 mg/m ³), 8-hr TWA (Skin); cyanide: 5 mg CN/m ³ , 8-hr TWA (Skin)	4.7 ppm (5 mg CN/m ³) ceiling (10 min)	Thyroid, blood, respiratory system effects	Concurrent measurement required for HCN when measuring for cyanide salt; trained first-aid personnel and first-aid kits to be available during use; prevent skin and eye contact
Hydrogen fluoride (March 1976)	3 ppm, 8-hr TWA	3 ppm (2.5 mg F/m ³) TWA; 6 ppm (5.0 mg F/m ³) ceiling (15 min)	Skin, eye, and airway irritation; bone effects	Pelvic x ray (male workers only) and urine testing required
Hydrogen sulfide (May 1977)	20 ppm acceptable ceiling; 50 ppm maximum ceiling (10 min)	10 ppm (15 mg/m ³) ceiling (10 min)	Irritation; severe acute effects involving nervous and respiratory systems	Continuous monitoring required if potential exists for exposure to ≥ 70 mg/m ³ (47 ppm); evacuation required at this level

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NIOSH				
Potential Hazard*	OSHA PEL'S/ Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
Hydroquinone (April 1978)	2 mg/m³, 8-hr TWA	0.44 ppm (2 mg/m³) ceiling (15 min)	Eye and skin effects	Special provisions for darkroom use
Identification system for occupationally hazardous materials (December 1974)	Sections of Hazard Communication (29 CFR 1910.1200) and carcinogen standards may be applicable	Complete designation system for occupationally hazardous materials	None	Includes definition, safety data sheets, alert symbols, and label statements
Isopropyl alcohol (March 1976)	400 ppm (980 mg/m³), 8-hr TWA	400 ppm (984 mg/m³) TWA; 800 ppm (1,968 mg/m³) ceiling (15 min)	Mucous membrane irritation; possible cancer threat in manufacturing process	Stringent work practices and medical surveillance for manufacturing workers required
Kepone (January 1976)	None	Ca 1 µg/m³ TWA	Liver cancer; nervous system effects	Liver function testing required
Ketones (June 1978)	All are 8-hr TWA values in ppm (mg/m³): acetone: 1,000 (2,400); methyl ethyl ketone: 200 (590); methyl n-propyl ketone: 200 (700); methyl n-butyl ketone: 100 (410); methyl n-amy ketone: 100 (465); methyl isobutyl ketone: 100 (410); methyl isoamyl ketone: none; diisobutyl ketone: 50 (290); cyclohexanone: 50 (200); mesityl oxide: 25 (100); diacetone alcohol: 50 (240); isophorone: 25 (140)	All are TWA values in ppm (mg/m³): acetone: 250 (590); methyl ethyl ketone: 200 (590); methyl n-propyl ketone: 150 (530); methyl n-butyl ketone: 1 (4); methyl n-amy ketone: 100 (465); methyl isobutyl ketone: 50 (200); methyl isoamyl ketone: 50 (230); diisobutyl ketone: 25 (140); cyclohexanone: 25 (100); mesityl oxide: 10 (40); diacetone alcohol: 50 (240); isophorone: 4 (23)	Irritation; liver, kidney, and nervous system effects	Urinalysis required; workers exposed to methyl n-butyl ketone to be warned of nervous system effects

Land-based oil and gas well drilling, comprehensive safety recommendations for (Technical Guideline September 1983; reaffirmed March 1984 as part of NIOSH testimony at OSHA hearing)	Many aspects covered under the numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations for safe work practices and technologic improvements	Injury and death	Many tasks, types of equipment, and conditions are not covered by existing regulations
Lead, inorganic (January 1973; revised May 1978)	50 $\mu\text{g Pb}/\text{m}^3$, 8-hr TWA; over 8-hr exposure to be determined by formula 29 CFR 1910.1025	<100 $\mu\text{g Pb}/\text{m}^3$ TWA; air level to be maintained so that worker blood lead remains $\leq 60 \mu\text{g}/100\text{g}$	Kidney, blood, and nervous system effects	Blood monitoring required
Lockout/tagout, guidelines for controlling hazardous energy during maintenance and servicing (Technical Guideline September 1983)	Many aspects covered under OSHA regulations for general industry (29 CFR 1910) and construction standards (29 CFR 1926)	Work-practice recommendations for controlling hazardous energy during maintenance and servicing activities	Injury and death	"Energy" defined in this document as kinetic energy, potential energy, electrical energy, and thermal energy
Logging from felling to first haul (July 1976)	None	Extensive work-practice and personal protection recommendations	Primarily trauma and falls	Tetanus toxoid inoculations and first-aid programs to be instituted
Malathion (June 1976)	15 mg/m^3 , 8-hr TWA	15 mg/m^3 TWA	Nervous system effects	Prevent skin contact; blood monitoring required

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Potential Hazard*	OSHA PEL'S/ Standard	NIOSH		
		REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
Mercury, inorganic (August 1973)	0.1 mg/m ³ acceptable ceiling	0.05 mg Hg/m ³ , 8-hr TWA	Central nervous system and mental effects	Work practices, sanitation, monitoring, and medical surveillance emphasized
2-Methoxy- ethanol (see Glycol ethers)				
Methyl alcohol (March 1976)	200 ppm (260 mg/m ³), 8-hr TWA	200 ppm (262 mg/m ³) TWA; 800 ppm (1,048 mg/m ³) ceiling (15 min)	Blindness; metabolic acidosis	None
Methyl chloro- methyl ether (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1006	Ca Use 29 CFR 1910.1006	Lung cancer	None
4,4'- Methylenebis- (2-chloroaniline) (MOCA) (Special Hazard Review September 1978)	Standard formally revoked by OSHA, August 1975	Ca 3 µg/m ³ TWA (lowest detectable limit)	Potential for cancer in humans; produced liver and lung tumors in animals	Chest x ray; blood and urine testing required
Methylene chloride (March 1976; revised April 1986 in CIB)	500 ppm, 8-hr TWA; 1,000 ppm acceptable ceiling; 2,000 ppm acceptable maximum peak for 5 min in any 2-hr period above the acceptable ceiling for an 8-hr shift	Ca Reduce exposure to lowest feasible limit	Potential for cancer in humans; produced tumors of the lung, liver, salivary, and mammary glands in animals	None

4,4'-Methylene- dianiline (CIB July 1986)	None	Ca Reduce exposure to lowest feasible limit	Bladder cancer; skin and liver effects	Prevent skin contact
Methyl parathion (September 1976)	None	0.2 mg/m ³ TWA	Central nervous system effects	Prevent skin contact; blood monitoring required
Monohalo- methanes (CIB September 1984)	Methyl chloride: 100 ppm, 8-hr TWA; 200 ppm ceiling; 300 ppm acceptable maximum peak for 5 min in any 3-hr period above the acceptable ceiling for an 8-hr shift; methyl bromide: 20 ppm (80 mg/m ³) ceiling (Skin); methyl iodide: 5 ppm (28 mg/m ³), 8-hr TWA (Skin)	Ca Exposure to methyl chloride, methyl bromide, and methyl iodide should be reduced to lowest feasible level	Potential for cancer in humans; produced tumors of the kidney, forestomach, and lung in animals; methyl chloride should also be considered a potential teratogen	None
alpha-Naphthyl- amine (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1004	Ca Use 29 CFR 1910.1004	Bladder cancer	None
beta-Naphthyl- amine (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1009	Ca Use 29 CFR 1910.1009	Bladder cancer	None

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Potential Hazard*	OSHA PEL'S/ Standard	NIOSH	
		REL'S†/Other Recommendations	Health Effect(s) Considered‡
Niax® Catalyst ESN (Joint NIOSH/ OSHA CIB May 1978)	OSHA and NIOSH recommend that exposure to Niax® Catalyst ESN and its components, dimethylaminopropionitrile and bis [2-(dimethylamino)ethyl] ether, be minimized		Urological disorders; nervous system effects
Nickel carbonyl (Special Hazard Review May 1977)	1 ppb (7 µg/m³), 8-hr TWA	Ca 1 ppb (7 µg/m³) TWA (lowest detectable level)	Lung and nasal cancer
Nickel, inorganic compounds (May 1977)	1 mg Ni/m³, 8-hr TWA	Ca 15 µg Ni/m³ TWA	Lung and nasal cancer; skin effects
Nitric acid (March 1976)	2 ppm (5 mg/m³), 8-hr TWA	2 ppm (5 mg/m³) TWA	Dental erosion; nasal/lung irritation
Nitriles (September 1978)	Acetonitrile: 40 ppm (70 mg/m³), 8-hr TWA; tetramethyl succinonitrile: 0.5 ppm (3 mg/m³), 8-hr TWA (Skin)	All are TWA values in ppm (mg/m³): acetonitrile: 20 (34); n-butyronitrile: 8 (22); isobutyronitrile: 8 (22); propionitrile: 6 (14); malononitrile: 3 (8); adiponitrile: 4 (18); succinonitrile: 6 (20). All ceiling values (15 min) in ppm (mg/m³): acetone cyanohydrin: 1 (4); glycolonitrile: 2 (5); tetramethyl succinonitrile: 1 (6). When present as mixtures or with other sources of cyanide, exposure to be considered additive and environmental limit to be calculated.	Hepatic, renal, respiratory, cardiovascular, gastrointestinal, and nervous system effects
			Prevent skin and eye contact; chest x ray required
			Chest x ray and pulmonary function testing required; trained personnel and first-aid kits to be available during use; prevent skin and eye contact

Chest x ray, pulmonary
function testing, and
urine monitoring
required

Chest x ray and pulmonary
function testing required

4-Nitrobiphenyl (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1003	Ca Use 29 CFR 1910.1003	Potential for cancer in humans; produced bladder tumors in animals	None
Nitrogen, oxides of (March 1976)	NO ₂ : 5 ppm (9 mg/m ³) ceiling; NO: 25 ppm (30 mg/m ³), 8-hr TWA	NO ₂ : 1 ppm (1.8 mg/m ³) ceiling (15 min); NO: 25 ppm (30 mg/m ³) TWA	Respiratory and blood effects	Pulmonary function testing required
Nitroglycerin and ethylene glycol dinitrate (EGDN) (June 1978)	Nitroglycerin: 2 mg/m ³ (0.2 ppm) ceiling (Skin); EGDN: 1 mg/m ³ (0.2 ppm) ceiling (Skin)	0.1 mg/m ³ ceiling (20 min) recommended limit for either substance alone or mixtures	Circulatory system effects	Prevent skin contact
2-Nitro- naphthalene (CIB December 1976)	None	Ca Reduce exposure to lowest feasible level	Bladder cancer	Compound metabolizes to beta-naphthylamine, a known carcinogen
2-Nitropropane (CIB April 1977; revised October 1980 in Joint OSHA/NIOSH Health Hazard Alert)	25 ppm (90 mg/m ³), 8-hr TWA	Ca Reduce exposure to lowest feasible level	Potential for cancer in humans; produced liver tumors in rats	Medical monitoring with specific emphasis on liver function tests
N-Nitroso- dimethylamine (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1016	Ca Use 29 CFR 1910.1016	Potential for cancer in humans; produced tumors of the liver, kidney, lung, and nasal cavity in animals	None

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Potential Hazard*	NIOSH		
	OSHA PEL's/ Standard	REL's†/Other Recommendations	Health Effect(s) Considered‡
Noise (August 1972)	90 dBA, 8-hr TWA	85 dBA TWA; 115 dBA ceiling	Hearing damage
Organotin compounds (November 1976)	0.1 mg/m ³ , 8-hr TWA	0.1 mg Sn/m ³ TWA	Eye, skin, liver, nervous system, and cardiovascular effects
Paint and allied coating products, manufacture of (September 1984)	Many aspects covered under the numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations for the handling of raw materials and finished products: dispersion of pigment or resin particles; thinning, tinting, and shading; filling; and laboratory functions	Injury and a wide range of toxicities considered
Parathion (June 1976)	0.1 mg/m ³ , 8-hr TWA (Skin)	0.05 mg/m ³ TWA	Nervous system effects
Pentachloroethane (CIB August 1978)	None	To be handled in the workplace with caution	Prevent skin contact; blood monitoring required
Pesticides, manufacture and formulation of (July 1978)	Current OSHA PEL's or previous NIOSH REL's to be followed; stringent work-practice and medical surveillance requirements to be instituted. Pesticides considered in groups based on toxicity.		Exposures should be minimized due to the structural similarity to the carcinogenic chloroethanes
			Blood monitoring required for some groups; workers to be warned of reproductive effects for some compounds; prevent skin contact

None

Chest x ray, blood and
urine monitoring, eye
tests, heart examination,
and nervous system testing
required; prevent skin and
eye contact

Paint and allied coating
products include paints,
varnishes, lacquers, stains,
putties, and paint and
varnish removers

Prevent skin contact;
blood monitoring
required

Exposures should be
minimized due to the
structural similarity to the
carcinogenic chloroethanes

Blood monitoring required
for some groups; workers
to be warned of reproductive
effects for some
compounds; prevent skin
contact

Hearing damage

Eye, skin, liver, nervous
system, and cardiovascular
effects

Injury and a wide range
of toxicities considered

Nervous system effects

Central nervous system
effects; possible liver
and kidney effects

Wide range of toxicities
considered; cancer; nervous
and reproductive
system effects

Phenol (July 1976)	5 ppm (19 mg/m ³), 8-hr TWA (Skin)	5.2 ppm (20 mg/m ³) TWA; 15.6 ppm (60 mg/m ³) ceiling (15 min)	Skin, eye, central nervous system, liver, and kidney effects	Prevent skin and eye contact
Phenyl-beta- naphthylamine (CIB December 1976)	None	Ca Reduce exposure to lowest feasible level	Bladder cancer	Compound metabolizes to beta-naphthylamine, a known carcinogen
Phosgene (February 1976)	0.1 ppm (0.4 mg/m ³), 8-hr TWA	0.1 ppm (0.4 mg/m ³) TWA; 0.2 ppm (0.8 mg/m ³) ceiling (15 min)	Respiratory effects	Pulmonary function testing and chest x ray required
Polychlorinated biphenyls (September 1977)	42% chlorine: 1 mg/m ³ , 8-hr TWA; 54% chlorine: 0.5 mg/m ³ , 8-hr TWA	Ca 1 µg/m ³ TWA (the minimum reliably detectable concentration using the recommended sampling and analytical methods)	Potential for cancer in humans; produced tumors of the liver, pituitary gland and leukemias in animals; skin, liver, and reproductive system effects	Blood testing required; female workers of child- bearing age and nursing mothers to be warned of potential adverse effects
Polychlorinated biphenyls (PCB's), potential health hazards from electrical equipment fires or failures (CIB February 1986)	42% chlorine: 1 mg/m ³ , 8-hr TWA; 54% chlorine: 0.5 mg/m ³ , 8-hr TWA	Ca Reduce exposure to lowest feasible limit	Potential for cancer in humans; produced tumors of the liver, pituitary gland and leukemias in animals; skin, liver, and reproductive system effects	Fire-related incidents involving PCB's have resulted in wide- spread contamination of buildings with PCB's and, in some cases, with PCDF's and PCDD's including TCDD. Emergency response personnel, maintenance or cleanup workers, or building occupants may be exposed to these compounds.

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NIOSH				
Potential Hazard*	OSHA PEL'S/ Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
Precast concrete products industry, comprehensive safety recommendations for (Technical Guideline June 1984)	Many aspects covered under numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations for safe work practices and worker training	Injury and death	Equipment, conditions, and many of the tasks specific to the industry are not covered under the existing regulations
beta-Propiolactone (NIOSH testimony at OSHA hearing September 1973)	No PEL Cancer-suspect agent Stringent workplace controls, recordkeeping, and medical surveillance required 29 CFR 1910.1013	Ca Use 29 CFR 1910.1013	Potential for cancer in humans; produced tumors of the liver, skin, and stomach in animals	None
Refined petroleum solvents (July 1977)	2,900 mg/m ³ (500 ppm), 8-hr TWA (Stoddard solvent)	Kerosene: 100 mg/m ³ TWA; all other solvents: 350 mg/m ³ TWA; 1,800 mg/m ³ ceiling (15 min)	Eye, nose, and throat irritation; dermatitis; nervous system effects	Blood and urine monitoring required; action level for petroleum ether, rubber solvent, naphtha: 200 mg/m ³ TWA; action level for mineral spirits and Stoddard solvent: 350 mg/m ³ TWA; action level for kerosene: 100 mg/m ³ TWA; prevent skin contact
Silica, crystalline (November 1974)	250/%SiO ₂ + 5 in mppcf, or 10 mg/m ³ /%SiO ₂ + 2 (respirable quartz)	50 µg/m ³ TWA, respirable free silica	Chronic lung disease (silicosis)	Chest x ray, pulmonary function testing required
Sodium hydroxide (September 1975)	2 mg/m ³ , 8-hr TWA	2 mg/m ³ ceiling (15 min)	Respiratory irritation	Prevent skin and eye contact

Styrene (September 1983)	100 ppm, 8-hr TWA; 200 ppm acceptable ceiling; 600 ppm maximum ceiling (5 min in 3 hr)	50 ppm (213 mg/m ³) TWA; 100 ppm (426 mg/m ³) ceiling	Nervous system effects; eye and respiratory system irritation; reproductive system effects	Prevent skin contact; workers to be warned of possible adverse reproductive effects
Sulfur dioxide (February 1974; revised May 1977 as part of NIOSH testimony at OSHA hearing)	5 ppm (13 mg/m ³), 8-hr TWA	0.5 ppm (1.3 mg/m ³) TWA	Respiratory effects	Pulmonary function testing required
Sulfuric acid (June 1974)	1 mg/m ³ , 8-hr TWA	1 mg/m ³ TWA	Pulmonary irritation	Prevent skin and eye contact
2,3,7,8-Tetra-chlorodibenzo- <i>p</i> -dioxin (TCDD) (CIB January 1984)	None	Ca Reduce exposure to lowest feasible level	Potential for cancer in humans; produced tumors at many sites in animals; chloracne	None
1,1,1,2-Tetra-chloroethane (CIB August 1978)	None	To be handled in the workplace with caution	Central nervous system effects; possible liver and kidney effects	Exposures should be minimized due to the structural similarity to the carcinogenic chloroethanes
1,1,2,2-Tetra-chloroethane (December 1976; revised in CIB August 1978)	5 ppm (35 mg/m ³), 8-hr TWA (Skin)	Ca Reduce exposure to lowest feasible level	Potential for cancer in humans; produced tumors of the liver in animals; liver, gastrointestinal, and nervous system effects	Prevent skin contact; blood monitoring required

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Potential Hazard*	OSHA PEL'S/ Standard	NIOSH		
		REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
Tetrachloro- ethylene (July 1976; revised January 1978 in CIB)	100 ppm, 8-hr TWA; 200 ppm acceptable ceiling; 300 ppm maximum ceiling (5 min in 3 hr)	Ca Minimize workplace exposure levels; limit number of workers exposed	Potential for cancer in humans; produced tumors of the liver in animals	None
Thiols: n-alkane mono thiols, cyclohexanethiol, and benzenethiol (September 1978)	Butylmercaptan: (1-butanethiol) 10 ppm (35 mg/m ³), 8-hr TWA; ethylmercaptan (1-ethanethiol): 10 ppm (25 mg/m ³) ceiling; methylmercaptan (1-methanethiol): 10 ppm (20 mg/m ³) ceiling	All values in ppm (mg/m ³) ceilings (15 min): 1-methanethiol: 0.5 (1.0); 1-ethanethiol: 0.5 (1.3); 1-propanethiol: 0.5 (1.6); 1-butanethiol: 0.5 (1.8); 1-pentanethiol: 0.5 (2.1); 1-hexanethiol: 0.5 (2.4); 1-heptanethiol: 0.5 (2.7); 1-octanethiol: 0.5 (3.0); 1-nonanethiol: 0.5 (3.3); 1-decanethiol: 0.5 (3.6); 1-undecanethiol: 0.5 (3.9); 1-dodecanethiol: 0.5 (4.1); 1-hexadecanethiol: 0.5 (5.3); 1-octadecanethiol: 0.5 (5.9); cyclohexanethiol: 0.5 (2.4); benzenethiol: 0.1 (0.5); Mixtures of thiols to be controlled by calculation of equivalent concentrations	Irritation; eye, skin, blood, and nervous system effects	Blood and urine monitoring required; prevent skin contact

o-Tolidine (August 1978)	None	Ca 20 $\mu\text{g}/\text{m}^3$ ceiling (60 min)	Bladder cancer; nasal irritation	Urine testing required; quarterly urine monitoring recommended; prevent skin contact
o-Tolidine-based dyes (Joint NIOSH/OSHA Health Hazard Alert December 1980)	None	Ca Should be handled in the workplace with caution; minimize exposures	Bladder cancer	Substitute less toxic dyes wherever possible
Toluene (January 1974)	200 ppm, 8-hr TWA; 300 ppm acceptable ceiling; 500 ppm maximum ceiling (10 min)	100 ppm (375 mg/m^3), 8-hr TWA; 200 ppm (750 mg/m^3) ceiling (10 min)	Central nervous system depressant	None
Toluene diisocyanate (July 1973; revised—see Diisocyanates September 1978)	0.02 ppm (0.14 mg/m^3) ceiling	0.005 ppm (0.036 mg/m^3) TWA; 0.02 ppm (0.14 mg/m^3) ceiling (20 min)	Respiratory effects	Chest x ray, blood tests, pulmonary function testing required
1,1,1-Tri- chloroethane (July 1976)	350 ppm (1,900 mg/m^3), 8-hr TWA	350 ppm (1,910 mg/m^3) ceiling (15 min); action level set at 200 ppm (1,091 mg/m^3) TWA	Central nervous system, liver, and cardiovascular effects	Medical warning of possible congenital abnormalities required
1,1,2-Tri- chloroethane (CIB August 1978)	10 ppm (45 mg/m^3), 8-hr TWA (Skin)	Ca Reduce exposure to lowest feasible level	Potential for cancer in humans; produced liver tumors in animals; central nervous system effects	None

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NIOSH				
Potential Hazard*	OSHA PEL'S/Standard	REL'S†/Other Recommendations	Health Effect(s) Considered‡	Comments
Trichloroethylene (July 1973; revised in Special Hazard Review January 1978)	100 ppm, 8-hr TWA; 200 ppm acceptable ceiling; 300 ppm maximum ceiling (5 min in 2 hr)	Ca 25 ppm TWA	Potential for cancer in humans; produced liver tumors in animals; central nervous system effects	Workers to be warned of hazards; 25 ppm level can be achieved by use of existing engineering control technology
Trimellitic anhydride (CIB February 1978)	None	Should be handled in the workplace as an extremely toxic substance	Pulmonary edema; immunologic sensitization; irritation of pulmonary tract, eyes, nose, and skin	Limit exposure to as few workers as possible while minimizing workplace levels
Tungsten and cemented tungsten carbide (September 1977)	None	Insoluble tungsten: 5 mg W/m ³ TWA; soluble tungsten: 1 mg W/m ³ TWA; dust of cemented tungsten carbide (containing > 2% cobalt): 0.1 mg Co/m ³ TWA; dust of cemented tungsten carbide (containing > 0.3% nickel): 15 µg Ni/m ³ TWA	Lung and skin effects	Pulmonary function testing and chest x ray required
Ultraviolet radiation (December 1972)	None	For spectral region of 315-400 nm: 1.0 mW/cm ² for periods > 1,000 sec; for periods ≤ 1,000 sec, 1,000 mW · sec/cm ² (1.0 J/cm ²); for spectral region 200-315 nm: consult criteria document	Skin and eye effects	None
Vanadium (August 1977)	Vanadium pentoxide (dust): 0.5 mg/m ³ ceiling; (fume): 0.1 mg/m ³ ceiling; ferrovanadium: 1 mg/m ³ , 8-hr TWA	Vanadium compounds: 0.05 mg V/m ³ ceiling (15 min); metallic vanadium and vanadium carbide: 1 mg V/m ³ TWA	Eye, skin, and lung effects	Pulmonary function testing and chest x ray required

Vibration syndrome (CIB March 1983)	None	Jobs should be redesigned to minimize the use of vibrating handtools; powered handtools should be redesigned to minimize vibration	Vibration syndrome; adverse circulatory and neural effects in the fingers	None
Vinyl acetate (September 1978)	None	4 ppm (15 mg/m ³) ceiling (15 min)	Irritation	None
Vinyl chloride (March 1974; reaffirmed June 1974 as part of NIOSH testimony at OSHA hearing)	1 ppm, 8-hr TWA; 5 ppm ceiling (15 min) 29 CFR 1910.1017	Ca Lowest reliably detectable level	Liver cancer	Liver function testing required
Vinyl halides (September 1978)	None except for vinyl chloride	Ca Vinyl halides to be controlled as specified for vinyl chloride in 29 CFR 1910.1017 with eventual goal of zero exposure	Liver cancer for vinyl chloride; potential for cancer from the other vinyl halides that have produced liver and kidney tumors in animals	Vinyl halides include vinyl chloride, vinylidene chloride, vinyl bromide, vinyl fluoride, and vinylidene fluoride monomers
Waste anesthetic gases and vapors (March 1977)	None for substances when used as anesthetic agents	Halogenated anesthetic agents: 2 ppm ceiling (1 hr); nitrous oxide: 25 ppm TWA during periods of use	Reproductive system effects and audiovisual performance decrements	Workers to be advised of potential effects; abnormal outcome of pregnancies of workers and spouses to be documented
Xylene (May 1975)	100 ppm (435 mg/m ³), 8-hr TWA	100 ppm (434 mg/m ³) TWA; 200 ppm (868 mg/m ³) ceiling (10 min)	Central nervous system depressant; respiratory irritation	None
Zinc oxide (October 1975)	5 mg ZnO/m ³ , 8-hr TWA	5 mg ZnO/m ³ TWA; 15 mg ZnO/m ³ ceiling (15 min)	Metal fume fever	None

*Date recommendation was published or testimony presented is in parentheses.

†NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

§Unless otherwise noted health effects cited are for humans.

MMWR

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