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Supplement

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for
Occupational Safety
and
Health Standards
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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. NIOSH also recommends preventive measures designed to reduce or eliminate the adverse health effects of these hazards. In formulating these recommendations, NIOSH evaluates all known and available scientific information relevant to the potential hazard. The recommendations are then published and transmitted to the Occupational Safety and Health Administration (OSHA) or the Mine Safety and Health Administration (MSHA) of the U.S. Department of Labor 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, alerts, and technical guidelines are other types of NIOSH documents that complement the Institute's recommendations for standards. These documents provide safety and health assessments of specific problems associated with a given agent or hazard, and they recommend appropriate control and monitoring methods. Although these documents do not supplant the more comprehensive criteria documents, they are prepared to assist OSHA or MSHA in the formulation of regulations.

NIOSH periodically presents testimony before various Congressional committees and at regulatory hearings convened by OSHA or MSHA. The testimony always includes the current NIOSH policy concerning the hazard in question.

NIOSH Current Intelligence Bulletins (CIBs) review and evaluate new and emerging information on occupational hazards. These bulletins may draw attention to a formerly unrecognized hazard, report new data on a known hazard, or disseminate information on hazard control.

The recommendations listed in this summary are based on existing NIOSH policy as previously published in any of the forms listed above. The intent of this table is to provide a rapid reference to 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

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Definitions of Abbreviations and Terms

Action level	the exposure concentration at which employers must initiate certain provisions of the NIOSH recommended standard such as periodic measurements of worker exposure, training of workers, and medical monitoring
Ca	agent recommended by NIOSH to be treated as a potential human carcinogen
CD	criteria document
CFR	Code of Federal Regulations
CIB	Current Intelligence Bulletin
CNS	central nervous system
dBA	decibels measured on 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
MSHA	Mine Safety and Health Administration
mW/cm ²	milliwatts per square centimeter
NIOSH	National Institute for Occupational Safety and Health
nm	nanometer
OSHA	Occupational Safety and Health Administration
PCBs	polychlorinated biphenyls
PCDDs	polychlorinated dibenzo- <i>p</i> -dioxins
PCDFs	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
WL	working level
WLM	working level month

NIOSH RECOMMENDATIONS FOR OCCUPATIONAL SAFETY AND HEALTH STANDARDS, 1988

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/ Standard	NIOSH		
		REL [†] /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 monitoring required; 29 CFR 1910.1014	Ca; use 29 CFR 1910.1014	Potential for cancer in humans; has produced tumors of the liver, bladder, lungs, pancreas, and skin in animals	None
Acetylene (July 1976)	2,500 ppm (10% of lower explosive limit), 29 CFR 1915.12	No exposure >2,500 ppm (2,662 mg/m ³)	Asphyxia	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	Periodic chest X-ray required; make first-aid and medical kits available during use; prevent skin contact
Aldrin/dieldrin (Special Hazard Review, September 1978)	0.25 mg/m ³ , 8-hr TWA (Skin)	Ca; reduce exposure to lowest reliably detectable concentration	Potential for cancer in humans; has produced tumors of the lungs, liver, thyroid, and adrenal glands in animals	Aldrin/dieldrin no longer produced in U.S.; prevent skin contact
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 should not exceed 350 mg/m ³ TWA. (continued on next page)	Skin and nervous system effects	None

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Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/ Standard	NIOSH		
		REL [†] /Other Recommendations	Health Effect(s) Considered [‡]	Comments
		All are ceiling values (15 min) for individual alkanes or mixtures of alkanes: 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		
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; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1011	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 and eye irritation	Prevent eye contact
Anesthetic gases (see Waste anesthetic gases)				
Animal rendering processes (Occupational Hazard Assessment March 1981)	OSHA PELs for specific hazards are applicable	NIOSH RELs for specific hazards are applicable	Mechanical injuries, burns, heat stress, infections from biologic agents, chemical hazards	Guidelines have been presented for engineering controls and work practices to reduce injury and illness

Antimony (September 1978)	0.5 mg/m ³ , 8-hr TWA	0.5 mg/m ³ TWA	Irritation, cardiovascular and lung effects	Periodic chest X-ray, pulmonary function testing, and electrocardiogram required
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)	Lung and lymphatic cancer, dermatitis	Periodic chest X-ray required
Arsine (CIB, August 1979)	0.2 mg/m ³ (0.05 ppm), 8-hr TWA	Ca; 2 µg/m ³ (0.002 mg/m ³) ceiling (15 min) (see arsenic criteria document)	Sudden extensive hemolysis, cancer	Warn workers about working with arsenic compounds in presence of freshly formed hydrogen
Asbestos (January 1972; revised December 1976; revised March 1984 as part of NIOSH testimony at Congressional hearing; reaffirmed June 1984 as NIOSH testimony at OSHA hearing)	200,000 fibers/m ³ (fibers >5 µm long), 8-hr TWA; action level of 100,000 fibers/m ³ , 8-hr TWA; 29 CFR 1910.1001	Ca; 100,000 fibers/m ³ (fibers >5µm long), 8-hr TWA in a 400-liter air sample	Lung cancer, mesothelioma, asbestosis	Periodic chest X-ray and pulmonary function testing required
Asphalt fumes (September 1977)	None	5 mg/m ³ ceiling (15 min) measured as total particulates	Eye and respiratory irritation	Medical monitoring 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)	1 ppm, 8-hr TWA; 5 ppm short-term exposure limit (15 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

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²Health effects cited are for humans unless otherwise noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/ Standard	NIOSH		
		REL [†] /Other Recommendations	Health Effect(s) Considered [§]	Comments
Benzidine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1010	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 Congener Dyes," January 1983)	No PEL for benzidine- based dyes	Ca; reduce exposure to lowest feasible concentration; replace with less toxic materials	Bladder cancer	Stringent workplace controls and medical monitoring 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	Periodic 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; do not exceed 0.5 µg Be/m ³	Lung cancer, berylliosis	Periodic chest X-ray and pulmonary function testing required
Boron trifluoride (December 1976)	1 ppm (3 mg/m ³) ceiling	No exposure limit recom- mended because of the absence of a reliable monitoring method; use appropriate engineering and work-practice controls to reduce exposure to lowest feasible concentration	Respiratory effects	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 concentration	Hematopoietic cancer, teratogenicity, reproductive system effects	Use appropriate engineering and work-practice controls; restrict access to areas where 1,3-butadiene is used

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 concentration	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	Warn workers of possible effects on reproductive system and permit 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; in presence of polycyclic aromatic hydrocarbons: Ca; 0.1 mg/m ³ TWA	Lung, cardiovascular, and skin effects; cancer of the lymphatic/bone-marrow complex when exposed to carbon black in the presence of polycyclic aromatic hydrocarbons	Periodic chest X-ray, 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	Advise workers of potential effects on reproductive system
Carbon monoxide (August 1972; Alert, August 1984)	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 (45-liter, 60-min sample)	Liver cancer	REL based on lowest 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	Periodic chest X-ray required

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NIOSH

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/ Standard	REL [†] /Other Recommendations	Health Effect(s) Considered [§]	Comments
Chloroethane (CIB, August 1978)	1,000 ppm (2,600 mg/m ³), 8-hr TWA	Handle with caution in the workplace	Central nervous system effects, possible liver and/or kidney effects	Exposures should be minimized because of structural similarity to carcinogenic chloroethanes
Chloroform (September 1974; revised June 1976)	50 ppm (240 mg/m ³) ceiling	Ca; 2 ppm (9.78 mg/m ³) ceiling (45 liter, 60 min sample)	Potential for cancer in humans; has produced cancer of the liver and kidneys in animals; 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 monitoring 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	Periodic chest X-ray and pulmonary function testing required; counsel pregnant workers 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
Chromium(VI) (December 1975)	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); periodic chest X-ray required
Chrysene (Special Hazard Review, June 1978)	0.2 mg/m ³ , 8-hr TWA	Ca; control as an occupational carcinogen	Liver and skin cancer	Document also contains control recommendations for polycyclic aromatic hydrocarbons

Coal gasification plants (September 1978)	OSHA PELs for specific hazards are applicable	NIOSH RELs for specific hazards are applicable	Various effects depending on substances present; skin cancer	Extensive work-practice and control procedures recommended.
Coal liquefaction, (Occupational Hazard Assessment, 2 volumes, March 1981)	OSHA PELs for specific hazards are applicable	NIOSH RELs for specific hazards are applicable	Various effects depending on substances present; skin cancer	Extensive work-practice and control procedures recommended.
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 periodic chest X-ray 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 an exposure limit	Dermatitis, potential for pulmonary fibrosis	Includes recommendations for engineering controls, work practices, protective equipment, worker education, and environmental and medical monitoring
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, bladder cancer	Periodic chest X-ray required; use 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	Check for oxygen-deficient atmospheres and toxic gases before entry
Cotton dust (September 1974; reaffirmed September 1983 as part of NIOSH testimony at OSHA hearing)	Lint-free respirable cotton dust in yarn manufacturing and cotton washing operations, 200 µg/m ³ , 8-hr TWA; lint-free respirable cotton dust in textile mill waste house operations or (continued on next page)	200 µg/m ³ lint-free cotton dust	Pulmonary disease (byssinosis)	Pulmonary function testing required

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Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/ Standard	NIOSH		
		REL [†] /Other Recommendations	Health Effect(s) Considered [§]	Comments
	lower-grade washed cotton in yarn manufacturing, 500 µg/m ³ , 8-hr TWA; lint-free respirable cotton dust in slashing and weaving processes, 750 mg/m ³ ; 29 CFR 1910.1043 Cotton waste processing operations of waste recycling (sorting, blending, cleaning, and willowing) and garnetting, 1 mg/m ³ ; 29 CFR 1910.1000			
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
DDT (Special Hazard Review, September 1978)	1 mg/m ³ , 8-hr TWA (Skin)	Ca; lowest reliably detectable concentration (currently 0.5 mg/m ³ TWA by NIOSH-validated method)	Potential for cancer in humans; has produced tumors of the liver, lungs, and lymphatic system in animals	Prevent skin contact
2,4-Diaminoanisole and its salts (CIB, January 1978)	None	Ca; reduce exposure to lowest feasible concentration	Potential for cancer in humans; has 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; handle with caution in the workplace and minimize exposures	Potential for cancer in humans; has produced tumors of the bladder, stomach, and mammary glands in animals	Substitute less toxic dyes wherever possible

Dibromochloropropane (January 1978)	1 ppb, 8-hr TWA; 29 CFR 1910.1044	10 ppb (0.1 mg/m ³) TWA (NIOSH recommendation superseded by OSHA standard promulgated in 1978)	Sterility, renal and liver effects	Regulated by OSHA as a carcinogen
3,3'-Dichlorobenzidine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1007	Ca; use 29 CFR 1910.1007	Potential for cancer in humans; has produced tumors of the liver, bladder, and lungs in animals	None
1,1-Dichloroethane (CIB, August 1978)	100 ppm (400 mg/m ³), 8-hr TWA	Handle with caution in the workplace	Central nervous system effects, possible liver and/or kidney damage	Exposures should be minimized because of structural similarity to carcinogenic chloroethanes
Dieldrin (see Aldrin/dieldrin)				
Diesel exhaust (CIB, July 1988)	OSHA and MSHA PELs for individual components of diesel exhaust are applicable	Ca; reduce exposure to lowest feasible concentration	Lung cancer, respiratory system effects, eye irritation	Typical components of diesel exhaust include carbon dioxide, carbon monoxide, formaldehyde, nitrogen dioxide, nitric oxide, sulfur dioxide, respirable dust, and polynuclear aromatic hydrocarbons
Di-2-ethylhexyl phthalate (DEHP) (Special Hazard Review, March 1983)	5 mg/m ³ , 8-hr TWA	Ca; reduce exposure to lowest feasible concentration	Potential for cancer in humans; has 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 are in µg/m ³ and all ceilings are 10 min (each value is equivalent to 5 ppb TWA and 20 ppb ceiling): TDI, 35 TWA, 140 ceiling; MDI, 50 TWA, 200 ceiling; hexamethylene diisocyanate (continued on next page)	Respiratory effects and sensitization, pulmonary irritation	Periodic chest X-ray and pulmonary function testing required

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Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	NIOSH		
		REL [†] /Other Recommendations	Health Effect(s) Considered [§]	Comments
		(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. Control other diisocyanates to 20 ppb ceiling and 5 ppb TWA		
4-Dimethylaminoazobenzene (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1015	Ca; use 29 CFR 1910.1015	Potential for cancer in humans; has 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
Dinitrotoluenes (CIB, July 1985)	1.5 mg/m ³ , 8-hr TWA (Skin)	Ca; reduce exposure to lowest feasible concentration	Potential for cancer in humans; has 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; has 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-Tetrachlorodibenzo- <i>p</i> -dioxin)				

Electrical energy and electrocutions (Alerts, December 1984, July 1985, July 1986, October 1986, December 1986, December 1987; revised in written comments to OSHA, February 1988)	Electrical protective devices, 29 CFR 1910.137; design safety standards for electrical systems, 29 CFR 1910.302-.330; safety-related work practices, 29 CFR 1910.331-.360; safety related maintenance, 29 CFR 1910.361-.380; safety requirements for special equipment, 29 CFR 1910.381-.398	Numerous work practice and control recommendations for reducing the risk of electrocutions and related injuries	Injury and death	Prompt emergency medical care can be lifesaving for workers who have contacted electrical energy; immediate cardiopulmonary resuscitation followed by advanced cardiac life support has been shown to save lives
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; minimize occupational exposure	Respiratory cancer; mutagenesis; reproductive, skin, kidney, liver, and respiratory effects	Prevent skin contact
2-Ethoxyethanol (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, heart, liver, spleen, and reproductive, respiratory, and central nervous systems	Warn workers of potential for reproductive abnormalities and cancer; hazardous liquid; prevent skin contact

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Potential Hazard and Source for NIOSH Recommendation*	NIOSH			
	OSHA PEL/ Standard	REL [†] /Other Recommendations	Health Effect(s) Considered [§]	Comments
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 are at risk
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; has produced tumors of the liver and lung in animals	Stringent workplace controls and medical monitoring 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; 5 ppm excursion limit (15 min); 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; use in encapsulated form in industry; minimize worker exposure	Potential for cancer and teratogenicity in humans; has produced tumors of the liver, thyroid, and lymphatic system in animals	Inform workers of carcinogenic and teratogenic hazards; give special attention 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	Follow appropriate work-practice guidelines and provide shoring
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 in diameter and ≥10 μm long); 5 mg/m ³ TWA (total fibrous glass)	Eye, skin, and respiratory effects	NIOSH recommends that this REL also apply to other manmade 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 management	Lung effects; polymer fume fever	Monitor workroom air 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; revised February 1987 in written comments to OSHA)	1 ppm, 8-hr TWA; 2 ppm short-term exposure limit (15 min); 29 CFR 1910.1048	Ca; 0.016 ppm, 8-hr TWA; 0.1 ppm ceiling (15 min) (this limit represents the lowest reliably quantifiable concentration)	Nasal cancer	Implement medical monitoring; protect skin
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 monitoring	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
Gallium arsenide (Alert, October 1987)	10 µg As/m ³ , 8-hr TWA; 29 CFR 1910.1018	Ca; 2 µg As/m ³ ceiling (15 min); see arsenic CD	Cancer	Gallium arsenide may dissociate in the body, releasing gallium and inorganic arsenic
Glycidyl ethers (June 1978; revised in CIB, October 1978)	All values in ppm (mg/m ³): 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) ceiling; (continued on next page)	All are ceiling values (15 min) in ppm (mg/m ³): AGE, 9.6 (45); BGE, 5.6 (30); DGE, 0.2 (1) Ca; IGE, 50 (240); PGE, 1 (5)	DGE: Potential for cancer in humans; has produced skin tumors in animals. DGE and other glycidyl ethers: skin and mucous membrane effects, sensitization potential, possible hematopoietic and reproductive system effects	Possible additive effects with mixtures; medical monitoring

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		REL [†] /Other Recommendations	Health Effect(s) Considered [§]	Comments
	isopropyl glycidyl ether (IGE), 50 (240), 8-hr TWA; phenyl glycidyl ether (PGE), 10 (60), 8-hr TWA			
Glycol ethers (CIB, May 1983)	2-Methoxyethanol, 25 ppm (80 mg/m ³), 8-hr TWA (Skin); 2-ethoxyethanol, 200 ppm (740 mg/m ³), 8-hr TWA (Skin)	Reduce exposure to lowest feasible concentration	Male and female reproductive effects, teratogenicity	Prevent skin contact
Grain dust (Technical Guide-line, September 1983; reaffirmed June 1984 as part of NIOSH testimony at OSHA hearing; revised in Arbete Och Halsa, 1988:14 [in press])	Many general aspects (e.g., protective equipment, dust control, etc.) covered under the numerous OSHA regulations for general industry and grain-handling facilities (29 CFR 1910 and 1917); final rule published in Federal Register 52 (251): 49592-49631, Dec. 31, 1987	Various recommendations for control of combustible dusts and ignition sources, machine guarding, isolation and lock-outs, bin entry, training, and personal protective equipment; settled grain dust not to exceed 1/64 of an inch to reduce risk of explosion	Injury and death, chronic bronchitis, asthma, and chronic obstructive pulmonary disease	Health hazards from exposure to fumigants, pesticides, and grain dust; safety hazards from confined spaces and explosions; reducing exposure to grain dust will decrease exposure to agents that elicit adverse health effects
Hexachloroethane (CIB, August 1978)	1 ppm (10 mg/m ³), 8-hr TWA (Skin)	Ca; reduce exposure to lowest feasible concentration	Potential for cancer in humans; has produced liver tumors in animals	Prevent skin contact
Hot environments (June 1972; revised April 1986)	None	Sliding scale limits based on environmental and metabolic heat loads	Heat-induced illnesses	Recommendations include acclimatization, strict work practices, protective equipment, and medical monitoring
Hydrazines (June 1978)	All values in ppm (mg/m ³): hydrazine, 1 (1.3), 8-hr TWA (Skin); 1,1-dimethylhydrazine, 0.5 (1.0), 8-hr TWA (Skin); phenylhydrazine, 5 (22), 8-hr TWA (Skin); 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; has produced tumors of the lung, liver, blood vessels, and intestines in animals; blood, liver, and skin effects	Blood and urine monitoring and periodic chest X-ray required; bowel examination for workers above 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 CN (5 mg CN/m ³) ceiling (10 min)	Thyroid, blood, and respiratory system effects	Concurrent measurement required for HCN when measuring for cyanide salt; make available trained first-aid personnel and first-aid kits during use; prevent skin and eye contact
Hydrogen fluoride (March 1976)	3 ppm, 8-hr TWA	2.5 mg F/m ³ (3 ppm) TWA; 5.0 mg F/m ³ (6 ppm) ceiling (15 min)	Skin, eye, and airway irritation; bone effects	Periodic pelvic X-ray to detect changes in the osseous system (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
Hydroquinone (April 1978)	2 mg/m ³ , 8-hr TWA	0.44 ppm (2 mg/m ³) 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/m ³), 8-hr TWA	400 ppm (984 mg/m ³) TWA; 800 ppm (1,968 mg/m ³) ceiling (15 min)	Mucous membrane irritation, possible cancer threat in manufacturing process	Stringent work practices and medical monitoring for manufacturing workers required
Kepona (January 1976)	None	Ca; 1 μ g/m ³ TWA	Liver cancer, nervous system effects	Liver function testing required
Ketones (June 1978)	All are 8-hr TWA values in ppm (mg/m ³): acetone, 1,000 (2,400); methyl ethyl ketone, 200 (590); methyl n-propyl ketone, 200 (700) methyl n-butyl ketone, 100 (410); (continued on next page)	All are TWA values in ppm (mg/m ³): acetone, 250 (590); methyl ethyl ketone, 200 (590); methyl n-propyl ketone, 150 (530); methyl n-butyl ketone, 1 (4); methyl n-amyl ketone, 100 (465); methyl isobutyl (continued on next page)	Irritation; liver, kidney, and nervous system effects	Urinalysis required; warn exposed workers about nervous system effects of methyl n-butyl ketone

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	methyl n-amyl 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)	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)		
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 not covered by existing regulations
Lead, inorganic (January 1973; revised May 1978)	50 µg Pb/m ³ , 8-hr TWA; determine by formula for exposures >8 hr; 29 CFR 1910.1025	<100 µg Pb/m ³ TWA; air level to be maintained so that worker blood lead remains ≤60 µg/100 g of whole blood	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" is 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	Institute tetanus toxoid inoculations and first-aid programs
Malathion (June 1976)	15 mg/m ³ , 8-hr TWA (Skin)	15 mg/m ³ TWA	Nervous system effects	Prevent skin contact; blood monitoring required

Mechanical power presses, injuries and amputations resulting from (CIB, May 1987)	29 CFR 1910.217	Various recommendations for the safe use of mechanical power presses, specifically those operated by foot or dual palm-button controls	Amputations and other injuries	Injuries and amputations among press operators occur with alarming frequency
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	Emphasize work practices, sanitation, and environmental and medical monitoring
2-Methoxyethanol (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 chloromethyl ether (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring 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 concentration)	Potential for cancer in humans; has produced liver and lung tumors in animals	Periodic 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 concentration	Potential for cancer in humans; has 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 concentration	Bladder cancer, skin and liver effects	Prevent skin contact

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		REL [†] /Other Recommendations	Health Effect(s) Considered [‡]	Comments
Methyl parathion (September 1976)	None	0.2 mg/m ³ TWA	Central nervous system effects	Prevent skin contact; blood monitoring required
Monohalomethanes (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; reduce exposures to methyl chloride, methyl bromide, and methyl iodide to the lowest feasible concentrations	Potential for cancer in humans; has produced tumors of the kidney, forestomach, and lung in animals; methyl chloride should also be considered a potential teratogen	Prevent skin contact
alpha-Naphthylamine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1004	Ca; use 29 CFR 1910.1004	Bladder cancer	None
beta-Naphthylamine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1009	Ca; use 29 CFR 1910.1009	Bladder cancer	None
Niax [®] Catalyst ESN (joint NIOSH/OSHA CIB, May 1978)	Minimize exposure to Niax [®] Catalyst ESN and its components and dimethylamino-propionitrile and bis[2-(dimethylamino) ethyl] ether	Minimize exposure to Niax [®] Catalyst ESN and its components, dimethylamino-propionitrile and bis[2-(dimethylamino) ethyl] ether	Urological disorders, nervous system effects	Use work-practice and engineering controls to reduce exposure
Nickel carbonyl (Special Hazard Review, May 1977)	1 ppb (7 µg/m ³), 8-hr TWA	Ca; 1 ppb (7 µg/m ³) TWA (lowest detectable concentration)	Lung and nasal cancer	Periodic chest X-ray, pulmonary function testing, and urine monitoring required

Nickel, inorganic compounds (May 1977)	1 mg Ni/m ³ , 8-hr TWA	Ca; 15 µg Ni/m ³ TWA	Lung and nasal cancer, skin effects	Periodic chest X-ray and pulmonary function testing required
Nitric acid (March 1976)	2 ppm (5 mg/m ³), 8-hr TWA	2 ppm (5 mg/m ³) TWA	Dental erosion, nasal/lung irritation	Prevent skin and eye contact; periodic chest X-ray required
Nitriles (September 1978)	Acetonitrile, 40 ppm (70 mg/m ³), 8-hr TWA; tetramethyl succinonitrile, 0.5 ppm (3 mg/m ³), 8-hr TWA (Skin)	All are TWA values in ppm (mg/m ³): acetonitrile, 20 (34); n-butyronitrile, 8 (22); isobutyronitrile, 8 (22); propionitrile, 6 (14); malononitrile, 3 (8); adiponitrile, 4 (18); succinonitrile, 6 (20). All are ceiling values (15 min) in ppm (mg/m ³): acetone cyanohydrin, 1 (4); glycolonitrile, 2 (5); tetramethylsuccinonitrile, 1 (6). When present as mixtures or with other sources of cyanide, consider exposures additive and calculate environmental limit	Hepatic, renal, respiratory, cardiovascular, gastrointestinal, and nervous system effects	Periodic chest X-ray and pulmonary function testing required; make trained personnel and first-aid kits available during use; prevent skin and eye contact
4-Nitrobiphenyl (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1003	Ca; use 29 CFR 1910.1003	Potential for cancer in humans; has 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 effects, blood effects	Pulmonary function testing required

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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-Nitronaphthalene (CIB, December 1976)	None	Ca; reduce exposure to lowest feasible concentration	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 concentration	Potential for cancer in humans; has produced liver tumors in rats	Conduct medical monitoring with specific emphasis on liver function tests
N-Nitrosodimethylamine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1016	Ca; use 29 CFR 1910.1016	Potential for cancer in humans; has produced tumors of the liver, kidney, lung, and nasal cavity in animals	None
Noise (August 1972)	90 dBA, 8-hr TWA	85 dBA TWA; 115 dBA ceiling	Hearing damage	None
Organic solvents, (CIB, March 1987)	Numerous organic solvents covered under 29 CFR 1910.1000	REs exist for approximately 92 chemicals and mixtures that may be defined as organic solvents; see entry for specific solvent of interest	Neurotoxic effects including narcosis, anesthesia, CNS depression, respiratory arrest; impaired psychomotor function, manual dexterity, coordination, or body balance; peripheral neuropathy and toxic encephalopathy	None
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 heart effects	Periodic 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, 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, filling, laboratory functions, and thinning, tinting, and shading	Injury; a wide range of toxicities considered	Paint and allied coating products include paints, varnishes, lacquers, stains, putties, and paint and varnish removers
Parathion (June 1976)	0.1 mg/m ³ , 8-hr TWA (Skin)	0.05 mg/m ³ TWA	Nervous system effects	Prevent skin contact; blood monitoring required
Pentachloroethane (CIB, August 1978)	None	Handle with caution in the workplace	Central nervous system effects, possible liver and kidney effects	Exposures should be minimized because of structural similarity to carcinogenic chloroethanes
Pesticides, manufacture and formulation of (July 1978)	Follow current OSHA PELs or NIOSH RELs; institute stringent work-practice and medical monitoring requirements		Wide range of toxicities considered; cancer; nervous and reproductive system effects	Blood monitoring required for some groups; warn workers of reproductive effects for some compounds; prevent skin contact
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 concentration	Bladder cancer	Compound metabolizes to beta-naphthylamine, a known carcinogen
Phosgene (February 1976)	0.1 ppm (0.4 mg/m ³), 8-hr TWA (Skin)	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 periodic chest X-ray required
Polychlorinated biphenyls (September 1977)	42% chlorine, 1 mg/m ³ , 8-hr TWA (Skin); 54% chlorine, 0.5 mg/m ³ , 8-hr TWA (Skin)	Ca; 1 µg/m ³ TWA (the minimum reliably detectable concentration using the recommended sampling and analytical methods)	Potential for cancer in humans; has produced tumors of the liver and pituitary gland and leukemias in animals; skin, liver, and reproductive system effects	Blood testing required; warn female workers of child-bearing age and nursing mothers of potential adverse effects; prevent skin contact

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Polychlorinated biphenyls from electrical equipment fires or failures (CIB, February 1986)	42% chlorine, 1 mg/m ³ , 8-hr TWA (Skin); 54% chlorine, 0.5 mg/m ³ , 8-hr TWA (Skin)	Ca; reduce exposure to lowest feasible concentration	Potential for cancer in humans; has produced tumors of the liver and pituitary gland and leukemias in animals; skin, liver, and reproductive system effects	Fire-related incidents involving PCBs have resulted in widespread contamination of buildings with PCBs, and in some cases, with PCDFs and PCDDs, including TCDD. Emergency response personnel, maintenance or cleanup workers, or building occupants may be exposed to these compounds
Precast concrete products (Technical Guideline, June 1984)	Some aspects covered under the 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 monitoring required; 29 CFR 1910.1013	Ca; use 29 CFR 1910.1013	Potential for cancer in humans; has produced tumors of the liver, skin, and stomach in animals	None
Radon progeny in underground mines (October 1987)	MSHA standard is 1.0 WL with annual cumulative exposure of 4.0 WLM; see 30 CFR 57.5037 through 30 CFR 57.5047	Ca; 1.0 WLM/year with average workshift concentration ≤1/12 of 1.0 WL (or 0.083 WL)	Lung cancer	REL of 1.0 WLM/year is upper limit of cumulative exposure, and every effort shall be made to reduce exposures to the lowest possible levels
Refined petroleum solvents (July 1977)	Petroleum distillates (naphtha), 2,000 mg/m ³ (500 ppm), 8-hr TWA; Stoddard solvent, 2,900 mg/m ³ (500 ppm), 8-hr TWA	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 is 200 mg/m ³ TWA; action level for mineral spirits and Stoddard solvent is 350 mg/m ³ TWA; action level for kerosene is 100 mg/m ³ TWA; prevent skin contact

Silica, crystalline (November 1974)	Respirable quartz, 250 mppcf or $\frac{10\text{mg}/\text{m}^3}{\% \text{SiO}_2 + 5}$ $\frac{\% \text{SiO}_2 + 2}{\% \text{SiO}_2 + 2}$	Respirable free silica, 50 $\mu\text{g}/\text{m}^3$ TWA	Chronic lung disease (silicosis)	Periodic chest X-ray and 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 (15 min)	Nervous system effects; eye and respiratory system irritation; reproductive system effects	Prevent skin contact; warn workers 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-Tetrachloro- dibenzo- <i>p</i> -dioxin (TCDD) (CIB, January 1984)	None	Ca; reduce exposure to lowest feasible concentration	Potential for cancer in humans; has produced tumors at many sites in animals; chloracne	None
1,1,1,2-Tetrachloro- ethane (CIB, August 1978)	None	Handle with caution in the workplace	Central nervous system effects; possible liver and kidney effects	Exposures should be minimized because of structural similarity to carcinogenic chloroethanes
1,1,2,2-Tetrachloro- ethane (December 1976; revised in CIB, August 1978)	5 ppm (35 mg/m ³), 8-hr TWA (Skin)	Ca; reduce exposure to lowest feasible concentration	Potential for cancer in humans; has produced tumors of the liver in animals; liver, gastrointestinal, and nervous system effects	Prevent skin contact; blood monitoring required
Tetrachloroethylene (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 concentration	Potential for cancer in humans; has produced tumors of the liver in animals	None

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Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/ Standard	NIOSH		
		REL [†] /Other Recommendations	Health Effect(s) Considered [§]	Comments
Thiols: n-alkane mono thiols, cyclohexanethiol, and benzenethiol (September 1978)	Butylmercaptan (1-butane-thiol), 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 are 15 min ceilings in ppm (mg/m ³): 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). Control mixtures of thiols by calculating 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 µg/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; handle with caution in the workplace; 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 Dilsocyanates, 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 (10 min)	Respiratory effects	Periodic chest X-ray, blood tests, pulmonary function testing required

1,1,1-Trichloroethane (July 1976; revised August 1978 in CIB)	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; handle with caution	Central nervous system, liver, and cardiovascular effects	Medical warning of possible congenital abnormalities required; structurally similar to carcinogenic chloroethanes
1,1,2-Trichloroethane (CIB, August 1978)	10 ppm (45 mg/m ³), 8-hr TWA (Skin)	Ca; reduce exposure to lowest feasible concentration	Potential for cancer in humans; has produced liver tumors in animals; central nervous system effects	None
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; has produced liver tumors in animals; central nervous system effects	Warn workers of hazards; 25 ppm level can be achieved by use of existing engineering control technology
Trimellitic anhydride (CIB, February 1978)	None	Handle in the workplace as an extremely toxic substance	Pulmonary edema; immuno- logic sensitization; irritation of pulmonary tract, eyes, nose, and skin	Minimize 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 periodic chest X-ray required
Ultraviolet radiation (December 1972)	None	For spectral region of 315-400 nm: for periods >1,000 sec, 1.0 mW/cm ² ; for periods ≤1,000 sec, 1,000 mW-sec/cm ² (1.0 J/cm ²). For spectral region of 200-315 nm: consult criteria document	Skin and eye effects	Avoid skin and eye contact

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

[§]Health effects cited are for humans unless otherwise noted.

Hazard and NIOSH Recommendation*	NIOSH			
	OSHA PEL/ Standard	REL [†] /Other Recommendations	Health Effect(s) Considered [‡]	Comments
Vanadium pentoxide dust (August 1977)	Vanadium pentoxide dust, 0.5 mg/m ³ ceiling; vanadium pentoxide 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 periodic chest X-ray required
Vibration syndrome (CIB, March 1983)	None	Redesign jobs to minimize the use of vibrating hand tools; redesign powered hand tools 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 concentration	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	Vinyl chloride has produced liver cancer in humans; other vinyl halides 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 audio-visual performance decrements	Halogenated anesthetic agents include chloroform, enflurane, fluoroene, halothane, methoxy-flurane, and trichloro-ethylene; advise workers of potential effects; document abnormal outcomes of pregnancies of workers or spouses

Welding, brazing, and thermal cutting (April 1988)	Many aspects are covered under the following regulations: general industry (29 CFR 1910), construction (29 CFR 1926), ship repairing (29 CFR 1915), ship building (29 CFR 1916), longshoring (29 CFR 1917)	Existing RELs for specific chemical and physical agents are applicable; consider these RELs upper boundaries of exposure; implement recommendations emphasizing good work practices, engineering controls, and medical monitoring	Cancer, respiratory disease, heat-induced illness, noise- induced hearing loss, eye injuries, traumatic and ergonomic injuries	None
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/m ³ , 8-hr TWA (as ZnO fume)	5 mg ZnO/m ³ TWA; 15 mg ZnO/m ³ ceiling (15 min)	Metal fume fever	None

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