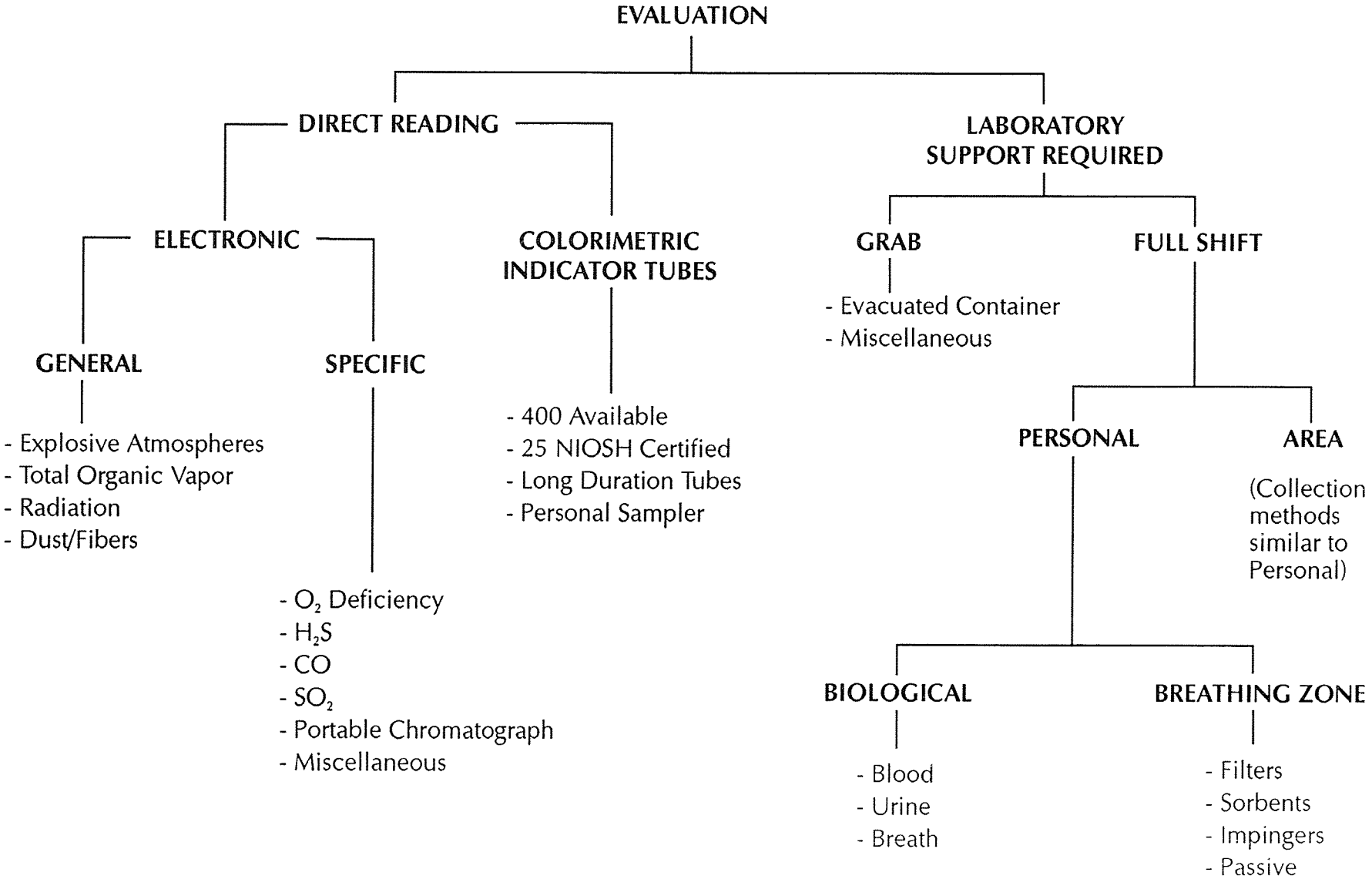
Evaluation of Industrial Hygiene Hazards



PARTICLE SIZE TERMINOLOGY

Micrometer (µm). Unit of length equal to one millionth of a meter. Also known as "micron." Equal to 1/25,400 of an inch.

Non-Respirable. Particles 10 µm in diameter and larger. These particles will be deposited in the respiratory system long before they reach the alveolar sacs - the most important area in the lungs.

Respirable. Particles less than 10 µm in diameter. Since these particles are likely to reach the alveoli in great quantities, they are potentially more harmful than larger particles.

States of Matter

Particulate Contaminants

The most common particulate contaminants include dusts, fumes, mists, and fibers.

Dusts. These are solid particles generated by handling, crushing, grinding, rapid impact, detonation, and decrepitation (breaking apart by heating) of organic or inorganic materials, such as rock, ore, metal, coal, wood, and grain.

Dust is a term used in industry to describe airborne solid particles that range in size from 0.1 to 25 micrometers (μm).

Fumes. These are formed when the material from a volatilized solid condenses in cool air. The solid particles that are formed make up a fume that is extremely fine - usually less than 1.0 μm in diameter. In most cases, the hot vapor reacts with the air to form an oxide. Gases and vapors are not fumes, although the terms are often mistakenly used interchangeably.

Welding, metalizing, and other operations involving vapors from molten metals may produce fumes.

Mists. These are suspended liquid droplets generated by condensation of liquids from the vapor back to the liquid state or by breaking up a liquid into a dispersed state, such as by splashing or atomizing. The term mist is applied to a finely divided liquid suspended in the atmosphere. Examples include oil mist produced during cutting and grinding operations, acid mists from electroplating, acid or alkali mists from pickling operations, and spray mist from spray finishing operations.

Fibers. These are solid particles having a slender, elongated structure with length several times as great as their diameter. Examples include asbestos, fibrous talc, and fiberglass. Airborne fibers may be found in construction activities, mining, friction product manufacturing and fabrication, and demolition operations.

GAS AND VAPOR CONTAMINANTS

Gases. These are formless fluids that expand to occupy the space or enclosure in which they are confined. Gases are a state of matter in which the molecules are unrestricted by cohesive forces. Examples are arc-welding gases, internal combustion engine exhaust gases, and air.

Vapors. These are the volatile form of substances that are normally in the solid or liquid state at room temperature and pressure. Evaporation is the process by which a liquid is changed into the vapor state and mixed with the surrounding atmosphere.

Some of the most common exposures to vapors in industry occur from organic solvents. Solvents with low boiling points form vapors readily at room temperature. Solvent vapors enter the body mainly by inhalation, although some skin absorption can occur.

UNITS OF CONCENTRATION

ppm: This means parts per million parts of contaminated air on a volumetric basis. It is used for expressing the concentration of a gas or vapor.

mg/m^3: This means milligrams of a substance per cubic meter of air. The term is most commonly used for expressing concentrations of dusts, metal fumes, or other particles in the air.

mppcf: This means millions of particles of a particulate per cubic foot of air. This term is not widely used today.

f/cc: This means the number of fibers per cubic centimeter of air. This term is used for expressing the concentration of airborne asbestos fibers.

The concentration of a gas or vapor in air is usually expressed in parts per million (ppm), but may be converted to mg/m^3 at a temperature of 25°C and a pressure of 760 mm Hg through use of the following relationship:

$$mg/m^3 = ppm \times (Molecular\ Weight / 24.45)$$

For example:

A 50 ppm concentration of carbon monoxide (CO, molecular weight = 28) is equivalent to a concentration of 57.26 mg/m^3 at 25°C and 760 mm Hg pressure.

Note also that:

$$Concentration\ (ppm) = Concentration\ (\%) \times 10{,}000$$

For example:

A concentration of a gas or vapor equal to 0.01% is equivalent to a concentration of 100 ppm.

THRESHOLD LIMIT VALUES (TLVs)

- Refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect.

- List of "Threshold Limit Values and Biological Exposure Indices" is published annually by the American Conference of Governmental Industrial Hygienists (ACGIH).

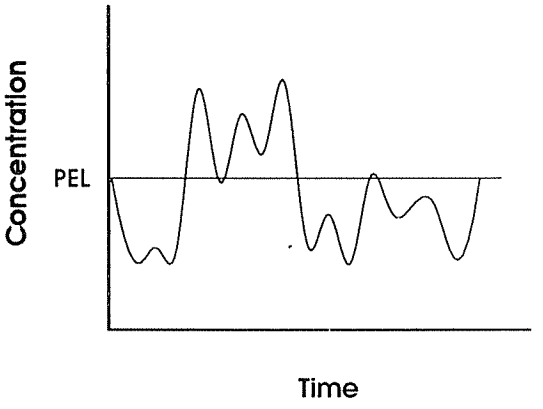
- ACGIH is not an official government agency. Membership is limited to professional personnel in government agencies or educational institutions engaged in occupational safety and health programs.

- The term "TLV" is a copyrighted trademark of the ACGIH.

- TLVs are not mandatory federal or state employee exposure standards.

CATEGORIES OF TLVS

Time-Weighted Average (TLV-TWA) is the time-weighted average concentration for a normal 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. As shown in the accompanying figure, time-weighted averages permit excursions above the limit provided they are compensated by equivalent excursions below the limit during the workday.



Short-Term Exposure Limit (TLV-STEL) is the maximal concentration to which workers can be exposed for a short period of time without suffering from any of the following:

1. Irritation,
2. Chronic or irreversible tissue change, or
3. Narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency.

The STEL is a 15-minute time-weighted average (TWA) exposure which should not to be exceeded at any time during a work day, even if the 8-hour time-weighted average is within the TLV-TWA. Exposures above the TLV-TWA up to the STEL should not be longer than 15 minutes and should not occur more than four times per day. There should be at least 60 minutes between successive exposures in this range.

The STEL is not a separate independent exposure limit, rather it supplements the time-weighted average limit where there are recognized acute effects from a substance whose toxic effects are primarily of a chronic nature.

Ceiling (TLV-C) is the concentration that should not be exceeded even instantaneously. A ceiling limit is applied to substances which are predominantly fast acting.

Skin Notation

Nearly one-fourth of the substances in the TLV list are followed by the designation "Skin." This refers to potential exposure through the cutaneous route, including mucous membranes and the eyes, usually by direct contact with the substance. This designation is intended to suggest appropriate measures for the prevention of cutaneous absorption.

PERMISSIBLE EXPOSURE LIMITS (PELS)

- OSHA's legally allowed concentrations of airborne contaminants in the workplace.
- Derived primarily from ACGIH TLVs.
- Three types: 8-hour TWA, STEL, and C.

OSHA PEL Definitions

Time-Weighted Average (TWA) is the employee's average airborne exposure in any 8-hour work shift of a 40-hour work week which shall not be exceeded.

Short-Term Exposure Limit (STEL) is the employee's 15-minute time-weighted average exposure which shall not be exceeded at any time during a work day unless another time limit is specified in a parenthetical notation below the limit. If another time period is specified, the time-weighted average exposure over that time period shall not be exceeded at any time during the working day.

Ceiling (C) is the employee's exposure which shall not be exceeded during any part of the work day. If instantaneous monitoring is not feasible, then the ceiling shall be assessed as a 15-minute time-weighted average exposure which shall not be exceeded at any time over a working day.

NOTE: Table Z-2 of 29 CFR Part 1910 (or other Parts) contains "acceptable ceiling concentrations" which are exposure limits except for a time period, and up to a concentration not exceeding the maximum duration and concentration allowed in the column under "Acceptable maximum peak above the acceptable ceiling concentration for an 8-Hour shift."

Time-Weighted Average

In adopting the TLVs of the ACGIH, OSHA also adopted the concept of the time-weighted average concentration for a workday. The 8-hour Time-Weighted Average (TWA) is the average concentration of a chemical in air over an eight-hour exposure period.

In general:

$$TWA = \frac{C_a T_a + C_b T_b + \ . \ . \ . \ C_n T_n}{8}$$

Where:

T_a is the time of the first exposure period.

C_a is the concentration of contaminant in period "a."

T_b is another time period during the shift.

C_b is the concentration during period "b."

C_n is the concentration during the "n^{th} " time period.

T_n is the "n^{th} " time period.

To illustrate the formula prescribed above, assume that a substance has an 8-hour time-weighted average PEL of 100 ppm. Assume that an employee is subject to the following exposure:

Two hours exposure at 150 ppm
Two hours exposure at 75 ppm
Four hours exposure at 50 ppm

Substituting this information in the formula, we have:

$$TWA = \frac{(150)(2) + (75)(2) + (50)(4)}{8} = \mathbf{81.25\ ppm}$$

Since 81.25 ppm is less than 100 ppm, the 8-hour time-weighted average limit, the exposure is acceptable.

Substance/ Standard	
Exposure Limits	
Notification of Use	
Exposure Monitoring	
Methods of Compliance	
Respiratory Protection	
Housekeeping	EXPANDED HEALTH - WORK PRACTICE STANDARDS
Hygiene Facilities	
Medical Surveillance	
Information and Training	
Signs and Labels	
Recordkeeping	
Observation of Monitoring	
Regulated Areas	
Effective Date of Standard	
OSHA Instruction	Revised 11/94

Substance/ Standard	Asbestos 1910.1001		14 Carcinogens 1910.1003 - .1016		Vinyl Chloride 1910.1017	
Exposure Limits (PELs)	C	TWA - 0.1 Fibers/cc Excursion - 1.0 Fibers/cc	–		C	TWA - 1 ppm Ceiling - 5 ppm
Notification of Use	–		*	* under Section F - Reports - Operations	*	* under Section N - Reports - Regulated Areas
Exposure Monitoring	D	≥ 1/6 Months @ > PEL	-		D	≥ 1/3 Months @ ≥ AL ≥ 1/ Month @ ≥ PEL
Methods of Compliance	F		*	* under Section C - Requirements for Areas Containing	F	
Respiratory Protection	G		*	* under Section C	G	
Protective Clothing	H		*	* under Section C	*	* under Section H - Hazardous Operations
Housekeeping	K		*	* under Section D - General Regulated Area Requirements	-	
Hygiene Facilities	I		*	* under Section D	-	
Medical Surveillance	L		G		K	
Information and Training	*	* under Section J - Communication of Hazards to Employees	*	* under Section E - Signs, Information and Training	J	
Signs and Labels	*	* under Section J	*	* under Section E	L	
Recordkeeping	M		*	* under Section G - Medical Surveillance	M	
Observation of Monitoring	N		-		*	* under Section D - Monitoring
Regulated Areas	E		*	* under Sections C and D	E	
Effective Date of Standard	10/11/94		06/27/74		10/4/74	
OSHA Instruction						

Substance/ Standard	Arsenic 1910.1018		Lead 1910.1025		Cadmium 1910.1027	
Exposure Limits (PELs)	C	TWA - 10 µg/m³	C	TWA - 50 µg/m³	C	TWA - 5µg/m³
Notification of Use	D		-		-	
Exposure Monitoring	E	≥ 1/6 Months @ > AL ≥ 1/3 Months @ ≥ PEL	D	≥ 1/6 Months @ ≥ AL ≥ 1/3 Months @ ≥ PEL	D	≥ 1/6 Months @ ≥ AL
Methods of Compliance	G		E		F	
Respiratory Protection	H		F		G	Also under Section H - Emergency Situations
Protective Clothing	J		G		I	
Housekeeping	K		H		K	
Hygiene Facilities	M		I		J	
Medical Surveillance	N		J	also under Section K - Medical Removal Protection	L	
Information and Training	O		L		*	* under Section M - Communication of Cadmium Hazards to Employees
Signs and Labels	P		M		*	* under Section M
Recordkeeping	Q		N		N	
Observation of Monitoring	R		O		O	
Regulated Areas	F		-		E	
Effective Date of Standard	05/05/78		11/13/78		12/14/92	
OSHA Instruction	CPL 2-2.22		CPL 2-2.26A			

Substance/ Standard	Benzene 1910.1028		Coke Oven Emissions 1910.1029		Cotton Dust 1910.1043	
Exposure Limits (PELs)	C	TWA - 1 ppm STEL - 5 ppm	C	TWA - 150 µg/m^3	C	TWA - 200; 500; 750 µg/m^3
Notification of Use	-		-		-	
Exposure Monitoring		≥ 1/12 Months @ ≥ AL ≥ 1/6 Months @ ≥ TWA STEL - As Necessary	E	≥ 1/3 Months	D	≥ 1/6 Months
Methods of Compliance	F		F		E	
Respiratory Protection	G		G		F	
Protective Clothing	H		H		-	
Housekeeping	-		-		*	* under Section G - Work Practices
Hygiene Facilities	-		I		-	
Medical Surveillance	I		J		H	
Information and Training	*	* under Section J - Communication of Benzene Hazards to Employees	K		I	
Signs and Labels	*	* under Section J	L		J	
Recordkeeping	K		M		K	
Observation of Monitoring	L		N		L	
Regulated Areas	D		D		-	
Effective Date of Standard	12/10/87		10/22/76		06/23/78	
OSHA Instruction			STD 1-4.3 & 1-6.4 CPL 2-2.28A			

Substance/ Standard	1,2 - Dibromo-3-Chloropropane 1910.1044		Acrylonitrile 1910.1045		Ethylene Oxide 1910.1047	
Exposure Limits (PELs)	C	TWA - 1 ppb	C	TWA - 2 ppm Ceiling - 10 ppm	C	TWA - 1 ppm Excursion - 5 ppm
Notification of Use	D		@	See Footnote Below	-	
Exposure Monitoring	F	≥ 1/3 Months @ < PEL ≥ 1/ Month @ ≥ PEL	E	≥ 1/3 Months @ ≥ AL ≥ 1/ Month @ ≥ PEL	D	≥ 1/6 Months @ ≥ AL ≥ 1/3 Months @ ≥ PEL
Methods of Compliance	G		G		F	Note: Section H - Emergency Situations
Respiratory Protection	H		H		G	
Protective Clothing	J		J		G	
Housekeeping	K		K		-	
Hygiene ‘cilities	L		M		-	
Medical Surveillance	M		N		I	
Information and Training	N		O		*	* under Section J - Communication of EtO Hazards to Employees
Signs and Labels	O		P		*	* under Section J
Recordkeeping	P		Q		K	
Observation of Monitoring	Q		R		L	
Regulated Areas	E		F		E	
Effective Date of Standard	03/17/78		09/29/78		08/21/84 Excursion - 06/06/88	
OSHA Instruction						

@ under Section D - Notification of Regulated Areas and Emergencies

Substance/ Standard		Formaldehyde 1910.1048		4,4'- Methylene - dianiline 1910.1050		
Exposure Limits (PELs)	C	TWA - 0.75 ppm STEL - 2 ppm	C	TWA - 10 ppb STEL - 100 ppb		
Notification of Use	-		-			
Exposure Monitoring	D	≥ 1/6 Months @ ≥ AL ≥ 1/12 Months @ ≥ STEL	E	≥ 1/6 Months @ ≥ AL ≥ 1/3 Months @ > TWA ≥ 1/3 Months @ > STEL		
Methods of Compliance	F	Note: Section K - Emergency Situations	G	Note: Section D - Emergency Situations		
Respiratory Protection	G		H			
Protective Clothing	H		I			
Housekeeping	J		L			
Hygiene Facilities	I		J			
Medical Surveillance	L		M			
Information and Training	N		*	* under Section K - Communication of Hazards to Employees		
Signs and Labels	*	* under Section M - Hazard Communication	*	* under Section K		
Recordkeeping	O		N			
Observation of Monitoring	*	* under Section D	O			
Regulated Areas	E		F			
Effective Date of Standard		02/02/88 (with exceptions)		09/09/92		
OSHA Instruction						

Substance/ Standard	4,4' - Methylene - dianiline 1926.60		Lead 1926.62		Asbestos 1926.1101	
Exposure Limits (PELs)		TWA - 10 ppb STEL - 100 ppb	C	TWA - 50 µg/m^3	C	TWA 0.1 Fibers/cc Excursion - 1.0 Fibers/cc
Notification of Use	-		-		-	
Exposure Monitoring	F	≥ 1/6 Months @ ≥ AL ≥ 1/3 Months @ > TWA ≥ 1/3 Months @ > STEL	D	≥ 1/6 Months @ ≥ AL ≥ 1/3 Months @ > PEL	F	Initial exposure assessments; daily monitoring within regulated areas for Class I and Class II work; periodic monitoring for other classes
Methods of Compliance	H	Note: Section E - Emergency Situations	E		G	Note: Section O - Competent Person
Respiratory Protection	I		F	also under Section D - Exposure Assessment	H	
Protective Clothing	J		G	also under Section D	I	
Housekeeping	M		H		L	
Hygiene Facilities	K		I	also under Section D	J	
Medical Surveillance	N		J	also under Section D and Section K - Medical Removal Protection	M	
Information and Training	*	* under Section L - Communication of Hazards to Employees	L	also under Section D	*	* under section K - Communication of Hazards
Signs and Labels	*	* under Section L	M	* under Section M	*	* under Section K
Recordkeeping	O		N		N	
Observation of Monitoring	P		O		*	* under Section F - Monitoring
Regulated Areas	G	Note: Section D - Communication Among Employers	P		E	Note: Section D - Multi-employer worksites
Effective Date of Standard	09/09/92		06/03/93		10/11/94	
OSHA Instruction			CPL 2-2.58			

Substance/ Standard		Cadmium 1926.1127				
Exposure Limits (PELs)	C	TWA - 5 µg/m^3				
Notification of Use	-					
Exposure Monitoring	D	≥ AL as needed to assure accuracy of exposure levels				
Methods of Compliance	F					
Respiratory Protection	G	also under Section H - Emergency Situations				
Protective Clothing	I					
Housekeeping	K					
Hygiene Facilities	J					
Medical Surveillance	L					
Information and Training	*	* under Section M - Communication of Cadmium Hazards to Employees				
Signs and Labels	*	* under Section M				
Recordkeeping	N					
Observation of Monitoring	O					
Regulated Areas	E					
Effective Date of Standard		12/14/92				
OSHA Instruction						

Information on Other OSHA Health-Related Standards for General Industry

OSHA has published booklets and/or factsheets on a number of standards that are not covered in detail in the text of this product.

To obtain single copies of the OSHA-numbered publications in the following list, enclose a self-addressed mailing label with your request to:

U.S. Department of Labor - OSHA
Publications Office, Room N3101
200 Constitution Avenue, N.W.
Washington, D.C. 20210

To obtain single copies of the following factsheets, write to:

OSHA
200 Constitution Avenue, N.W.
Room N3647
Washington, D.C. 20210

Standard	Publication(s)
1910.120 - Hazardous Waste Operations and Emergency Response	OSHA 3114 - Hazardous Waste and Emergency Response Factsheet #31 - Hazardous Waste/Emergency Response
1910.1027 - Cadmium	OSHA 3136 - Occupational Exposure to Cadmium
1910.128 - Benzene	OSHA 3099 - Health Hazards for Benzene
1910.1030 - Bloodborne Pathogens	OSHA 3127 - Occupational Exposure to Bloodborne Pathogens OSHA 3128 - Bloodborne Pathogens and Acute Care Facilities OSHA 3129 - Controlling Occupational Exposure to Bloodborne Pathogens in Dentistry OSHA 3130 - Occupational Exposure to Bloodborne Pathogens: Precautions for Emergency Responders OSHA 3131 - Bloodborne Pathogens and Long-Term Care Workers OSHA 3134 - Exposición a Patogenos Transmitidos por la Sangre en el Trabajo Factsheet #46 - Bloodborne Pathogens Final Standard: Summary of Key Provisions
1910.1043 - Cotton Dust	Factsheet #23 - Cotton Dust
1910.1047 - Ethylene Oxide	Factsheet #17 - Ethylene Oxide
1910.1048 - Formaldehyde	Factsheet #27 - OSHA's Final Rule on Formaldehyde
1910.1050 - 4,4'-Methylene-dianiline	OSHA 3135 - 4,4'-Methylenedianiline (MDA) for General Industry
1910.1450 - Occupational Exposure to Hazardous Chemicals in Laboratories	OSHA 3119 - Exposure to Hazardous Chemicals in Laboratories Factsheet #33 - Occupational Exposure to Hazardous Chemicals in Laboratories