

MATERIAL SAFETY DATA SHEET



HAYNES INTERNATIONAL, INC.
Titanium Alloys

SAFETY DEPARTMENT
3786 SECOND STREET
ARCADIA, LOUISIANA 71001-9701
NORTH AMERICA INFORMATION: 1-828-692-5791
EUROPE INFORMATION: 011-44-161-230-7777

<p>MSDS IDENTIFICATION NUMBER H3098-7 This replaces H3098-6</p>	<p>PREVIOUS REVISION DATE April 6, 2009 DATE REVISED September 11, 2009</p>	<p>EMERGENCY PHONE NUMBERS HAYNES: 765-456-6894 CHEMTREC: 800-424-9300 (24-hour contact for Health & Transportation Emergencies)</p>
--	---	---

This Material Safety Data Sheet (MSDS) provides information on a specific group of manufactured metal products. Since these metal products share a common physical nature and constituents, the data presented are applicable to all alloys identified. This document was prepared to meet the requirements of OSHA's Hazard Communication Standard, 29 CFR 1910.1200, the Canadian Workplace Hazardous Materials Information System (WHMIS), and European Economic Community (EEC) Directives. Ingredients reportable per Section 313 of SARA are marked with an (*); See Section 15 for an explanation. The following titanium alloys are found on this MSDS:

T100 ALLOYS

HAYNES[®] Ti-3Al-2.5V alloy

HAYNES[®] Ti-6Al-4V alloy

HAYNES[®] Ti-15-3 alloy

HAYNES[®] Ti Grade 7 alloy

HMIS

Health	1*	O**
Flammability	4*	O**
Reactivity	3*	O**

* Dust/Fume
 **Solid

EMERGENCY OVERVIEW

Titanium alloys exist as a silver grey solid or as a dust or fume. Exposure to dust or fume may cause irritation of the eyes, skin and respiratory tract. Fine particulates dispersed in air present an explosion hazard.

Under normal handling and use of the solid form of this material there are few health hazards. Cutting, welding, melting, grinding, etc., of these materials will produce dust, fume, or particulate containing the component elements of these materials. Exposure to the dust, fume, or particulate may present significant health hazards which are referable to the elemental constituents in Section 3.

1. PRODUCT IDENTIFICATION

<p>CHEMICAL NAME: See Section 3 for Alloy Designations</p>	<p>CHEMICAL FAMILY: Alloy</p>
<p>TRADE NAME: See Alloys listed in Section 3</p>	<p>FORMULA: Alloys composed of varying concentrations of elements listed in Section 3.</p>

HAYNES and HASTELLOY are registered trademarks of Haynes International, Inc.

This MSDS is also available in French

2. HAZARDS IDENTIFICATION

<p>PRIMARY ROUTE(S) OF EXPOSURE</p>	<p>INHALATION: Inhalation of metal dust, fume, or powder may result from melting, gross handling, casting, welding, cutting, grinding, crushing, or similar operations. Inhaled particulate may irritate the respiratory tract.</p>																				
	<p>INGESTION: Hand, clothing, food, and drink contact with metal dust, fume, or powder can cause ingestion of particulate during hand to mouth activities such as drinking, smoking, nail biting, etc. Titanium is not readily absorbed through the gastrointestinal (GI) tract. Vanadium may cause diarrhea and cramping. Chromium may severely irritate the GI tract and damage kidneys.</p>																				
	<p>SKIN: Skin contact with metal dust, fume, or powder may cause, in some sensitive individuals, an allergic response if elements such as chromium, aluminum, vanadium, and tin are present. In the form of metal dust or powder, skin contact or abrasion may also cause irritation or dermatitis.</p>																				
	<p>EYES: Particulate metal (dust, fume, or powder) can cause eye irritation and inflammation of the conjunctiva. Avoid inserting fingers into the eye socket if the hand or clothing is contaminated with metal particulate.</p>																				
	<p>CHRONIC EFFECTS: There is some evidence that repeated inhalation of titanium dust can cause deposits of titanium in the lungs which could produce lung fibrosis and chronic bronchitis. These changes have not been shown to be carcinogenic.</p>																				
<p>EFFECTS OF OVEREXPOSURE TO METAL DUST, FUME OR PARTICULATE MATERIAL CONSISTING OF SECTION 3 CONSTITUENTS AND/OR COMPOUNDS</p>	<p>SECTION 3</p> <table border="1"> <thead> <tr> <th>CONSTITUENT/ COMPOUND</th> <th>ACUTE:</th> <th>CHRONIC</th> </tr> </thead> <tbody> <tr> <td>Titanium & Titanium Oxide</td> <td>Titanium compounds are relatively inert. Dust and fume particulates are considered as nuisance dust.</td> <td>Titanium dioxide - slight lung fibrosis.</td> </tr> <tr> <td>Aluminum & Aluminum Oxides</td> <td>Aluminum particles - eye irritant. Dust and fume particles are classified as nuisance dust.</td> <td>None known at this time.</td> </tr> <tr> <td>Vanadium & Vanadium Pentoxide</td> <td>Irritant to mucous membranes. Metallic taste, green tongue, cough, throat and eye irritation, eczema.</td> <td>Nasal catarrh, nose bleeds, chronic respiratory problems.</td> </tr> <tr> <td>Chromium & Chromium Oxide</td> <td>Allergic reactions in some people. Respiratory irritant.</td> <td>Chromium oxide LISTED AS A HUMAN CARCINOGEN BY IARC AND NTP.</td> </tr> <tr> <td>Tin</td> <td>Eye and skin irritation.</td> <td>Benign pneumoconiosis (stannosis).</td> </tr> </tbody> </table>			CONSTITUENT/ COMPOUND	ACUTE:	CHRONIC	Titanium & Titanium Oxide	Titanium compounds are relatively inert. Dust and fume particulates are considered as nuisance dust.	Titanium dioxide - slight lung fibrosis.	Aluminum & Aluminum Oxides	Aluminum particles - eye irritant. Dust and fume particles are classified as nuisance dust.	None known at this time.	Vanadium & Vanadium Pentoxide	Irritant to mucous membranes. Metallic taste, green tongue, cough, throat and eye irritation, eczema.	Nasal catarrh, nose bleeds, chronic respiratory problems.	Chromium & Chromium Oxide	Allergic reactions in some people. Respiratory irritant.	Chromium oxide LISTED AS A HUMAN CARCINOGEN BY IARC AND NTP.	Tin	Eye and skin irritation.	Benign pneumoconiosis (stannosis).
	CONSTITUENT/ COMPOUND	ACUTE:	CHRONIC																		
	Titanium & Titanium Oxide	Titanium compounds are relatively inert. Dust and fume particulates are considered as nuisance dust.	Titanium dioxide - slight lung fibrosis.																		
	Aluminum & Aluminum Oxides	Aluminum particles - eye irritant. Dust and fume particles are classified as nuisance dust.	None known at this time.																		
	Vanadium & Vanadium Pentoxide	Irritant to mucous membranes. Metallic taste, green tongue, cough, throat and eye irritation, eczema.	Nasal catarrh, nose bleeds, chronic respiratory problems.																		
	Chromium & Chromium Oxide	Allergic reactions in some people. Respiratory irritant.	Chromium oxide LISTED AS A HUMAN CARCINOGEN BY IARC AND NTP.																		
Tin	Eye and skin irritation.	Benign pneumoconiosis (stannosis).																			

3. COMPOSITION/INFORMATION ON INGREDIENTS

NOMINAL PERCENT OF ELEMENTAL CONSTITUENTS FOR THE ALLOYS SHOWN (HAYNES METAL NUMBER, IF APPLICABLE, SHOWN IN PARENTHESES)										EXPOSURE LIMITS (as Mg/m ³) ²		
Constituent(s)	Ti-3Al-2.5V (4400)	Ti-6Al-4V (4500)	Ti-15-3 (4150)	Ti Grade 7					CAS NUMBER	NIOSH ¹ RTECS NUMBER	OSHA PEL ³	ACGIH TLV [®] -TWA ⁴
Aluminum (Al)*	3.0	6.0	3.0						7429-90-5	BD0330000	Total Dust, as Al: 15, Respirable Dust, as Al: 5 ⁵	Welding Fume, as Al: 5
Chromium (Cr)*	-	-	3.0						7440-47-3	BG4200000	Metal: 1 Chromium (II & III) Compounds, as Cr: 0.5 Chromium (VI) Compounds, as Cr(VI) : 0.005	Metal and Cr. III compounds, as Cr: 0.5; Water-Soluble Cr VI compounds, as Cr(VI): 0.05 Water Insoluble CR VI cp, as Cr (VI): 0.01
Iron (Fe)	0.30 Max	0.30 Max	0.25 Max	0.30 Max					1309-37-1	N07400000	Oxide Fume: 10	Oxide Dust and Fume, as Fe: 5
Tin (Sn)	-	-	3.0						7440-31-5	-	Metals as Sn: 2.0 Oxides as Sn: 2.0	Metals, as Sn: 2.0 Oxides and inorganic compounds, as Sn: 2.0
Titanium (Ti)	94.5	90.0	76.0	99					7440-32-6	XR1700000	Total Oxide: 15	Total Oxide: 10
Vanadium (V)	3	4.0	15.0						7440-62-2	YW1355000	Respirable Dust as V ₂ O ₅ : 0.5 ⁵ Ceiling Fume, as V ₂ O ₅ : 0.1 Ceiling	Respirable Dust & Fume, as V ₂ O ₅ : 0.05 ⁵
Palladium				0.12-0.25								
Density (lb/cu in)	0.162	0.160	0.172	0.163								
Melting Point (EF)	-3100	-3000	-2900	3030								
* Reportable ingredients per Section 313 of SARA. (See Section 15)										See Section 16 for Footnotes		

4. FIRST AID MEASURES	
INHALATION	Breathing difficulty caused by inhalation of dust or fume requires removal to fresh air. If breathing has stopped, perform artificial respiration and obtain medical assistance at once.
INGESTION	Never give anything by mouth to an unconscious person. Contact a poison control center. Unless the poison control center advises otherwise, inducement of vomiting is not necessary unless large amounts are ingested. Obtain medical assistance at once.
SKIN	Skin cuts and abrasions can be treated by standard first aid. Do not shake clothing. Skin contamination with dust or powder can be removed by washing with soap and water. If irritation persists, obtain medical assistance.
EYES	Do not allow victim to rub or keep eyes tightly shut. Dust or powder should be flushed from the eyes with copious amounts of clean water. If irritation persists obtain medical assistance.
5. FIRE FIGHTING MEASURES	
FLASH POINT (WITH TEST METHOD) LIMITS V/V%	None
FLAMMABLE (EXPLOSIVE) LIMITS LEL: None	UEL: None
EXTINGUISHING MEDIA	These alloys are noncombustible. Use extinguishing media appropriate to the surrounding fire.
SPECIAL FIREFIGHTING PROCEDURES	If these materials are reduced to powder form, caution must be used to prevent fire or explosion. To extinguish a metal powder fire, use a suitable class "D" fire extinguishing powder (for example - talc, table salt).
UNUSUAL FIRE AND EXPLOSION HAZARDS	No unusual fire or explosion hazards are associated with the solid wrought product forms of these materials. However, most finely divided forms (i.e., waste products such as grindings, machining chips and powders) of titanium alloys are flammable in air. Flammability is dependent upon particle size and surface area. Coarse particles (greater than 100 µm) show no tendency to ignite.
HAZARDOUS COMBUSTION PRODUCTS	Various metal oxides, carbon dioxide, carbon monoxide.
6. ACCIDENTAL MATERIAL RELEASE CONTROL MEASURES	
In solid form this material poses no special clean-up problems. If this material is in powder or dust form, clean-up should be conducted with a vacuum system utilizing a high efficiency particulate air (HEPA) filtration system. Caution should be taken to minimize airborne generation of powder or dust and avoid contamination of air and water. Properly label all materials collected in waste container. Follow applicable OSHA regulations (29 CFR 1910.120), and Canadian Workplace Hazardous Materials Information System (WHMIS) Regulations.	
7. HANDLING AND STORAGE	
HANDLING PRECAUTIONS	This product must be handled according to the size, shape, and quantity of material involved. Solid metal may require use of hoists, cranes, etc. Powders should be moved or transported to minimize spill or release potential.
STORAGE PRECAUTIONS	In solid form this material poses no special problems. Store metal and metal powder in a dry area. Do not store adjacent to mineral acids. Fine metal powder and fine particulate waste should be stored wet (>20% water), kept away from heat or an open flame and labeled as a flammable solid. Dry fine powders should be labeled as a pyroforic material.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION			
ENGINEERING CONTROLS	Local exhaust ventilation should be used to control exposure to airborne dust and fume emissions near the source (during melting, welding, cutting, grinding, etc.) below the exposure limits cited in Section 3.		
RESPIRATORY PROTECTION	Use NIOSH approved respirators as specified by an Industrial Hygienist or qualified Safety professional. Lung function tests are recommended for users of negative pressure devices. Use a fume respirator or an air supplied respirator where local exhaust or ventilation does not keep exposure below the exposure limits for air contamination.		
PROTECTIVE GLOVES	Wear gloves to prevent metal cuts and skin abrasions particularly during handling of wrought forms, solid metal sheet, strip, or tube.		
EYE PROTECTION	Wear safety glasses when risk of eye injury is present particularly during machining, grinding, welding, powder handling, etc. Contact lenses should not be worn if working with metal dust and powders.		
OTHER PROTECTIVE EQUIPMENT	Protective clothing such as uniforms, disposable coveralls, safety shoes, etc., may be required during metal handling operations as appropriate to the circumstances of exposure.		
RECOMMENDED MONITORING PROCEDURES	<table border="0"> <tr> <td>ENVIRONMENTAL SURVEILLANCE: Exposure to the elements identified in Section 3 can be best determined by having air samples taken in the employee breathing zone, work area or department.</td> <td>MEDICAL SURVEILLANCE: Lung function tests, chest x-rays and routine physical examinations may be useful to determine effects of dust or fume exposure.</td> </tr> </table>	ENVIRONMENTAL SURVEILLANCE: Exposure to the elements identified in Section 3 can be best determined by having air samples taken in the employee breathing zone, work area or department.	MEDICAL SURVEILLANCE: Lung function tests, chest x-rays and routine physical examinations may be useful to determine effects of dust or fume exposure.
ENVIRONMENTAL SURVEILLANCE: Exposure to the elements identified in Section 3 can be best determined by having air samples taken in the employee breathing zone, work area or department.	MEDICAL SURVEILLANCE: Lung function tests, chest x-rays and routine physical examinations may be useful to determine effects of dust or fume exposure.		
9. PHYSICAL AND CHEMICAL PROPERTIES			
MELTING POINT: See Section 3	VAPOR DENSITY (AIR=1): Not Applicable		
SUBLIMES @: Not Applicable	SPECIFIC GRAVITY: See Section 3		
BOILING POINT: Not Applicable	pH = Not Applicable		
EVAPORATION RATE: Not Applicable	SOLUBILITY IN WATER = None		
VAPOR PRESSURE (mmHg): Not Applicable	% VOLATILES BY VOLUME: None		
APPEARANCE AND COLOR: Solid - Silver Gray Color or No Color			
10. STABILITY AND REACTIVITY			
GENERAL REACTIVITY	In their wrought product form, these alloys are stable. However, finely divided DRY PARTICLES of titanium alloys are classified as PYROFORIC materials. Pyroforic materials spontaneously ignite and burn when in contact with air.		
INCOMPATIBILITY (MATERIALS TO AVOID)	Avoid contact with strong mineral acids and oxidizing agents which may generate hydrogen gas; the evolution of hydrogen may be an explosion hazard. Extreme caution is recommended in handling titanium alloys exposed to red fuming nitric acid; the reaction residue is considered an explosive.		
HAZARDOUS DECOMPOSITION PRODUCTS	Various elemental metals and metal oxides may be generated from welding, cutting, grinding, melting, or dross handling operations. Refer to Section 3 for permissible exposure limits. The permissible exposure limits given in MSDS HW-7031 for Welding Products and Thermal Spray Wire also apply.		
HAZARDOUS POLYMERIZATION	Does not occur.		

11. TOXICOLOGICAL INFORMATION

TOXICITY DATA	<p><u>Titanium</u></p> <p>Tumorigenicity: Rat, intramuscular: 114 mg/kg administered intermittently for 77 weeks caused lymphomax including Hodgkin's disease and tumors at site of injection.</p>
	<p>Vanadium</p> <p>Human, inhalation, TD_{Lo} = 4 µg/kg, affected the lungs, thorax, or respiration (sputum, cough) and sense organs.</p>
	<p>Teratology: No Data</p>
	<p>Reproduction: Titanium: Rat, oral: 158 mg/kg (multigeneration of females) caused fetotoxicity and fetal death.</p>
	<p>Mutagenicity: No Data</p>
CARCINOGENIC REFERENCES	<p>Hexavalent chromium oxides that are found in welding fumes are considered carcinogens because they are so classified by IARC and/or NTP. Detailed information from these sources may be obtained from the following: IARC Monographs on the evaluation of carcinogenic risk of Chemicals to Man; and the NTP annual report on carcinogens, NTP Public Information Office, MD B204 Box 12233, Research Triangle Park, NC 27709.</p>
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE	<p>Individuals who may have had an allergic reaction or sensitivity to metals such as chromium, aluminum, titanium, tin and vanadium may encounter skin rash or dermatitis if skin contact with this product occurs. Persons with impaired pulmonary function, airway diseases and conditions such as asthma, emphysema, chronic bronchitis, etc., may incur further disability if excessive concentrations of dust or fume are inhaled. If prior damage or disease to the Neurologic (nervous), Circulatory, Hematologic (blood) or Renal (kidney) systems has occurred, proper screening or examinations should be conducted on individuals who may be exposed to further risk if handling and use of this material causes excessive exposure.</p>

12. ECOLOGICAL INFORMATION

In solid form this material poses no special environmental problems. Metal powders or dusts may have significant impact on air and water quality. Airborne emissions, spills and releases to the environment (discharge to streams, sewer systems, ground water, surface soil, etc.) should be controlled immediately. If such potential for a spill or release exists it is advisable to develop an emergency spill response plan. In water, chromium III oxide is expected to eventually precipitate to sediments. In air, chromium III oxide is primarily removed by fallout and precipitation. Soils with a high chromium content (>0.2%) are expected to be infertile. The half-life of chromium in soils may be several years.

13. DISPOSAL CONSIDERATIONS

Titanium alloys are recyclable and every measure should be made to reclaim rather than dispose. If necessary, dispose of waste material in accordance with state or federal regulations. For specific labeling, packing, storage, transportation, and disposal procedures, contact an Environmental Engineer or a consultant familiar with waste disposal regulations.

14. TRANSPORTATION INFORMATION (Not Meant to be All Inclusive)

As a wrought product, these alloys are not regulated by the U.S. Department of Transportation (DOT) and the International Air Transport Association (IATA).

The following information should be used by individuals with "Function-specific Training" required by 49 CFR 172.704, and Dangerous Goods Regulations published by the International Air Transport Association (IATA).

SHIPPING NAME	If alloy dust or powder is created, it may be a flammable solid or spontaneously combustible material (DOT hazard class 4.1 and 4.2, respectively). A sample of metal powder should be tested according to the U.N. manual of tests and criteria. See 49 CFR 173.124 (a) and (b).
IDENTIFICATION NUMBER	Not Available (Determine by test results)
HAZARD CLASS	Not Available (Determine by test results)
LABEL(S) REQUIRED	Not Available (Determine by test results)

15. REGULATORY INFORMATION

U.S. FEDERAL REGULATIONS

OSHA: Listed as air contaminants (29 CFR 1910.1000). Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

TSCA (Toxic Substance Control Act): Components of this material are listed on the TSCA inventory.

CERCLA: Hazardous Substance (40 CFR 302.4): Chromium

Extremely Hazardous Substance (40 CFR 355): Not Listed

SARA HAZARD CATEGORY: Listed below are the hazard categories for Sections 311 and 312 of the Superfund Amendment and Preauthorization Act of 1986 (SARA Title III):

Immediate Hazard: X

Delayed Hazard: X

Fire Hazard: -

Pressure Hazard: -

Reactivity Hazard: -

Chemicals subject to the reporting requirements of Section 313 or Title III of SARA and 40 CFR Part 372: Aluminum (as a fume or dust), chromium.

STATE REGULATIONS

California's Safe Drinking Water and Toxic Enforcement Act of 1986" (Proposition 65)

Welding, thermal cutting, and melting these products may produce hexavalent chromium compounds which are known to the State of California to cause cancer. State of California, Health and Welfare Agency, 1600 Ninth Street, Room 450, Sacramento, CA 95914, Telephone (961) 455-6955.

Pennsylvania Worker and Community Right to Know: Aluminum, Chromium, and Vanadium (fume or dust) are designated environmental hazards on the Hazardous Substance List. Title 34, Part XIII, Chapter 323.

EUROPEAN/ INTERNATIONAL REGULATIONS

European Labeling in Accordance with EC Directives

The following hazard classification and risk phrases required by directive 67/548/EEC apply only to welding fumes and particulate created by these products.

Classification: Carcinogen, Category 3; Sensitizers. Hazard Symbol: Xn

Risk Phrases: Limited evidence of a carcinogenic effect.

May cause sensitization by inhalation and skin contact.

May cause long-term adverse effects in the aquatic environment.

Safety Advice: Keep out of reach of children. Do not breathe dust.

Avoid contact with skin. Wear suitable protective clothing.

Wear suitable gloves. Avoid release to the environment.

Refer to special instructions/safety data sheet.

Canada WHIMS These products have been classified in accordance with the hazard criteria of the CPR, and the MSDS contains all of the information required by the CPR.

WHIMS Classification: Class D2B "Toxic Material"

16. OTHER INFORMATION

MSDS STATUS

This MSDS replaces the April 6, 2009 revision for Titanium Alloys.

The above information has been prepared by Shaw Environmental, Inc., under contract with Haynes International and is a compilation of information from various sources believed to be accurate. As the conditions or methods of use are beyond our control, we do not assume any responsibility and expressly disclaim any liability for any material described herein. Information contained herein is believed to be true and accurate, but all statements or suggestions are made without warranty, expressed or implied, regarding accuracy of the information, the hazards connected with the use of the material or the results to be obtained from the use thereof. Compliance with all applicable Federal, State, and local laws and regulations remain the responsibility of the user.

ADDITIONAL INFORMATION

The following is the label text which accompanies this product during shipment:

HAYNES HIGH PERFORMANCE - TITANIUM ALLOYS Ti-3Al-2.5V; Ti-6Al-4V; Ti-15-3; Ti Grade 7

WARNING! INHALATION OF DUST OR FUME MAY CAUSE SERIOUS LUNG INJURY. SKIN, EYE, AND MUCOUS MEMBRANE IRRITATION MAY OCCUR.

- The titanium alloy products identified above may contain, in varying concentrations, the following elemental constituents: aluminum, chromium, iron, tin, titanium, and vanadium.
- Inhalation of metal dust or fume generated by the use of these alloys may cause adverse health effects such as reduced lung function, nasal, and mucous membrane irritation. Exposure to dust or fume generated by the use of these alloys may also cause eye irritation, skin rash, and effects on other organ systems.
- Hexavalent chromium oxides that may be found in welding fume are considered by OSHA as carcinogens because they are so classified by NTP and IARC.
- Avoid breathing dust or fume. If the use of this material produces dust or fume, use appropriate ventilation controls, personal protective equipment or both. For additional information refer to the Material Safety Data Sheet (MSDS H3098) for this product.

DANGER! FINELY DIVIDED TITANIUM POWDER AND DUST ARE POTENTIAL FIRE AND EXPLOSION HAZARDS WHEN EXPOSED TO A HEAT SOURCE OR FLAME. DO NOT USE WATER OR A CO₂ EXTINGUISHER TO CONTROL A TITANIUM FIRE. THE APPLICATION OF WATER OR CO₂ TO BURNING TITANIUM CAN CAUSE AN EXPLOSION. METAL AND DUST FIRES CAN BE EFFECTIVELY CONTROLLED BY:

- 1) SMOTHERING WITH TALC, OR SODIUM CHLORIDE,
- 2) SMOTHERING THE FIRE WITH A SALT FLUX, SUCH AS POTASSIUM CHLORIDE, MAGNESIUM CHLORIDE, OR CALCIUM FLUORIDE OR,
- 3) OTHER SUITABLE CLASS "D" FIRE EXTINGUISHING POWDERS.

¹ NIOSH RTECS Number: The National Institute for Occupational Safety & Health (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECS) Access number for a specific element or compound's toxicological data.

² Mg/m³ = milligrams per cubic meter. Many substances do not have a unique exposure limit. The absence of an exposure limit does not lessen consideration for exposure risk. In the absence of specific information, professional judgment may be required.

³ OSHA PEL: the Occupational Safety & Health Administration (OSHA) Permissible Exposure Limit (PEL) unless noted otherwise is an 8-hour time weighted average (TWA). Ceiling limits are listed for some materials that should not be exceeded at any time.

⁴ ACGIH TLV[®]: The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV[®]) - ACGIH also recommends a short term exposure limit (STEL) for certain substances (which are a 15-minute TWA) during the shift.

⁵ Respirable fraction of particulate - see the ACGIH-TLV[®] booklet for a definition.