

MATERIAL SAFETY DATA SHEET

TITANIUM ALLOYS

SECTION 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: Titanium Alloys

Note: Titanium alloys in their usual solid form and under normal conditions do not present an inhalation, ingestion, or contact health hazard or fire or explosion hazard. Operations such as welding, sawing, brazing, burning, grinding, cutting, abrasive blasting, heat treating, pickling, machining, or similar operations may generate dust, fumes, chips, or machine turnings that may create a health or fire or explosion hazard. This MSDS does not apply to titanium alloys in powdered forms.

Manufacturer's Name:

Wyman-Gordon Company
244 Worcester Street
North Grafton, MA 01536-8001

Emergency Phone Number:

(508) 839-4441

Telephone Number for Information

(508) 839-4441

SECTION 2: COMPOSITION AND INFORMATION ON INGREDIENTS: The chemical composition of Titanium Alloys will vary by the alloy grade. Approximate weight percent (WT. %) ranges are shown below. Refer to product specification for exact composition.

Contains the following alloys:

30	Ti 38-644	Ti 6-2-4-2	Ti 8-1-1
CP + Pd	Ti 40	Ti 6-2-4-2 Si	Ti 829
CP Ti	Ti 425	Ti 6-2-4-6	Ti 834
Stryker	Ti 48-53	Ti 6-2s	Ti CP-1
Ti 10-2-3	Ti 5-2.5	Ti 6-4	Ti CP-2
Ti 1100	Ti 55	Ti 6-4 ELI	Ti CP-3
Ti 15-11-3	Ti 550	Ti 6-6-2	Ti CP-4
Ti 15-3	Ti 551	Ti 6-7	Ti Grade 12
Ti 15-3-3-3	Ti 5-5-2-2	Ti 679	Ti Grade 7
Ti 15Mo	Ti 5-5-5-3	Ti 685	Ti XT
Ti 17	Ti 5-6-2-1	Ti 70	TiOstalloy
Ti 2.5	Ti 6-2-1-1	Ti 7-4	TiOsteum
Ti 3-2.5	Ti 6-2-2-2-2	Ti 8	TMZF

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Titanium (Ti)	Aluminum (Al)	Vanadium (V)	Iron (Fe)	Tin (Sn)	Zirconium (Zr)	Molybdenum (Mo)	Chromium (Cr)
76-99.7	0-10	0-16	0-5	0-11	0-10	0-15	0-11
Copper (Cu)	Manganese (Mn)	Nickel (Ni)	Tantalum (Ta)	Cobalt (Co)	Tungsten (W)	Palladium (Pd)	
0-5	0-5	0-0.8	0-1	0-Trace	0-Trace	0-0.2	

OCCUPATIONAL EXPOSURE LIMITS

Ingredient	CAS Number	Classified as Carcinogen	PEL (2008) (8-Hour TWA)	TLV (2007) (8-Hour TWA)
Aluminum (as Al)	7429-90-5	None Found	Total Dust 15 mg/m ³ Respirable Dust 5 mg/m ³	Metal Dust 10 mg/m ³ Welding Fume 5 mg/m ³
Chromium (as Cr metal) (as Cr III) (as Cr VI)	7440-47-3	IARC Class 3 IARC Class 3 IARC Class 1, Yes NTP	1.0 mg/m ³ 0.5 mg/m ³ 5.0 µg/m ³ Action Level = 2.5 µg/m ³	0.5 mg/m ³ 0.5 mg/m ³ 0.01 mg/m ³ (Insoluble) 0.05 mg/m ³ Water Soluble
Iron (as Fe) (as Fe ₂ O ₃)	7439-89-6 1309-37-1	None Found	PEL Vacated 1989 Oxide Fume 10 mg/m ³	Dust & Fume 5 mg/m ³
Molybdenum (as Mo)	7439-98-7	None Found	Total Dust 15 mg/m ³ (Insoluble)	Insoluble 10 mg/m ³
Tin	7440-31-5	None Found	2 mg/m ³ (Inorganic except oxides)	2 mg/m ³ Metal oxide & inorganic compounds except tin hydride
Titanium (as Ti) (as TiO ₂)	7440-32-6 13463-67-7	None Found IARC Group 3	None Listed Total Dust 15 mg/m ³	None Listed 10 mg/m ³
Vanadium (as V) (as V ₂ O ₅)	7440-62-2 1314-62-1	None Found	None Listed Respirable Dust 0.5 mg/m ³ (Ceiling) Fume 0.1 mg/m ³ (Ceiling)	None Listed Fume & Dust 0.05 mg/m ³
Zirconium	7440-67-7	None Found	5 mg/m ³	5 mg/m ³ 10 mg/m ³ STEL
Copper (as Cu)	7440-50-8	None Found	Dust & Mist 1.0 mg/m ³ Fume 0.1 mg/m ³	Dust & Mist 1.0 mg/m ³ Fume 0.2 mg/m ³
Manganese (as Mn)	7439-96-5	RTECS Contains Tumorigenic and/or carcinogenic and/or neoplastic data for components in this product	Fume 5.0 mg/m ³ (Ceiling)	0.2 mg/m ³ Manganese and inorganic compounds as Mn
Nickel (as Ni)	7440-02-0	IARC Group 2	1.0 mg/m ³	1.5 mg/m ³
Tantalum (as Ta)	7440-25-7	None Found	5 mg/m ³	5 mg/m ³
Cobalt (as Co)	7440-48-4	IARC Group 2	0.1 mg/m ³ (Metal, dust & fume)	0.02 mg/m ³ Cobalt and inorganic compounds as Co
Tungsten (as W)	7440-33-7	None Found	None Listed	Insoluble 5 mg/m ³
Palladium	7440-05-3	None Found	None Listed	None Listed

SECTION 3: HAZARDS IDENTIFICATION (See Note in Section 1)

Carcinogenicity: IARC, NTP, and OSHA do not list titanium alloy as a carcinogen. Chromium metal contained in some titanium alloys is classified as carcinogenic by IARC. Hexavalent chromium though not present in the alloy may be formed during welding or other thermal processes.

Routes of Entry/Exposure: Titanium alloys in their usual solid form and under normal conditions do not present an inhalation, ingestion, or contact health hazard. Inhalation may occur if dust or fumes are generated. Skin absorption is not likely to occur, but irritation may occur when in contact with skin. Ingestion is not likely to occur.

Target Organs: Lungs, eyes and skin.

Short-Term (Acute) Effects of Overexposure:

Eyes: Dusts or fumes can cause irritation with burning and tearing.

Inhalation: Dusts or fumes can cause irritation and dryness of the nose and throat, coughing, bronchitis, pneumonia, chest pain, and pulmonary edema.

Skin: Dusts or fumes can cause irritation with itching. Dermatitis may occur.

Ingestion: Diarrhea, black stool, and cramping may occur.

Long-Term (Chronic) Effects of Overexposure: No significant adverse health effects found in literature search specific to titanium alloys. Chronic exposure to certain metals in titanium alloys may cause non-progressive pulmonary fibrosis or chronic bronchitis when overexposed to elevated dust or fume concentrations. Other symptoms include shortness of breath, cough, chest tightness, and wheezing without impairment. Dermatitis and allergic sensitization have been reported.

Conditions Aggravated By Exposure: Persons with sensitive skin or allergies to metals may be aggravated by exposure. Persons with respiratory problems may also be aggravated by exposure.

Also See TOXICOLOGICAL INFORMATION (Section 11)

SECTION 4: FIRST AID MEASURES

Eyes: Immediately flush eyes with plenty of water for at least 15 minutes holding eyelids apart to ensure flushing of entire eye surface. Seek medical attention after flushing eyes with water.

Inhalation: Get person out of contaminated area to fresh air. If breathing has stopped, give artificial respiration and seek medical attention immediately.

Skin: Wash contaminated areas with plenty of soap and water for at least 15 minutes. Remove contaminated clothing and wash before reuse. Seek medical attention if any irritation or redness occurs.

Ingestion: Seek medical attention immediately. Never give anything by mouth to an unconscious person.

Get appropriate in-plant, paramedic, or community medical support after first aid is given.

Note to Physicians: Treat Symptomatically.

SECTION 5: FIRE FIGHTING MEASURES (See Note in Section 1)

Autoignition Temperature: Autoignition will not occur for solid metal alloy. Dust cloud can ignite at 330° to 590°C (NFPA 481, Appendix A)

Flammable Limits: 0.045 oz/ft³ (NFPA 481, Appendix A)

Extinguishing Media: **Do Not** Use Water or Carbon Dioxide Extinguishers! Dry sodium chloride is most effective for containing particulate fires. Flux (KCl, MgCl₂, CaF₂) is effective in reducing the oxygen supply of the fire. See NFPA Code No. 481 for more information.

Special Fire Fighting Procedures: Wear self-contained breathing apparatus with full facepiece operated in positive pressure mode and full turn-out gear.

Unusual Fire and Explosion Hazards: No fire or explosion hazard with solid metal alloys. A severe fire hazard may exist when fine turnings or chips are produced and during disposal of scrap containing chips or fines. Dry titanium alloy powder under 48 mesh (NFPA 481, Appendix B) can be ignited by a match or small spark. Toxic metal fumes of titanium, aluminum, vanadium, iron, tin, zirconium, molybdenum, and chromium may be emitted.

SECTION 6: ACCIDENTAL RELEASE MEASURES (See Note in Section 1)

Should spills of dust occur, use vacuum cleaner rated to clean up explosive dust and equipped with High Efficiency Particulate (HEPA) filters to clean minor spills. Do not sweep or use compressed air to clean up spills. Dispose of spilled material in accordance with local, state, and federal regulations.

SECTION 7: HANDLING AND STORAGE

Handling Precautions: Avoid generation of dust. Use good housekeeping practices if dusts are formed to prevent accumulation. Use appropriate personal protection. Contact qualified safety and health specialists to review usage and possible exposures.

Storage Requirements: Store in cool, dry, and well ventilated area away from incompatibles. Protect from physical damage and contact with water.

Regulatory Requirements: Follow OSHA, EPA, and DOT requirements.

SECTION 8: EXPOSURE CONTROLS, PERSONAL PROTECTION (See Note in Section 1)

Air Monitoring: Air monitoring should be performed by a professional industrial hygienist to determine the level of exposure. Results from monitoring will help to determine the appropriate personal protective clothing, and equipment required.

Respiratory Protection: Air monitoring will help determine if and what level of respiratory protection is required. A respiratory protection program must be implemented if respirators are required (29 CFR 1910.134). Half face air purifying respirators with high efficiency particulate (HEPA) filters can be used when airborne concentrations do not exceed ten (10) times the Equivalent Exposure for PELs or TLVs.

Protective Clothing: Normal work clothes may be worn when airborne exposures are within allowable limits and contact with dust is not likely to occur. Use a qualified safety and health specialists to perform a hazard assessment (29 CFR 1910.133).

Engineering Controls: Local exhaust ventilation should be used whenever feasible to capture dust or fumes before reaching workers' breathing zone. Local exhaust should meet criteria in NFPA 481. Use vacuum cleaners rated to clean up explosive dust and equipped with High Efficiency Particulate (HEPA) filters to clean work surfaces and protective clothing before removal. Use non-sparking metal equipment.

Work Practices: Food and beverages should not be consumed, tobacco products should not be present or used, and cosmetics should not be applied in areas where dust or fumes are present. Workers should wash their hands and face prior to eating, drinking, smoking, or applying cosmetics and at the end of the work shift. Adequate washing facilities should be available and used by workers. Keep work areas free of waste.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Titanium alloys are solid at room temperatures with a silver or gray color. No odor.

Melting Point: 1675°C (for titanium)

Specific Gravity: 4.35 – 4.4

Vapor Pressure: NA

Evaporation Rate: NA

Vapor Density: NA

Solubility in Water: Insoluble

Percent Volatile: Nil

pH: NA

SECTION 10: STABILITY AND REACTIVITY (See Note in Section 1)

Stability: Titanium alloys are stable at room temperature under normal storage and handling conditions.

Conditions Contributing to Instability: Avoid creating dusty airborne conditions. Violent explosion can occur when water comes in contact with molten metal (reference NFPA 481).

Incompatibility: Avoid contact with red fuming nitric acid (NFPA 481). Reacts violently with cupric or lead oxide when heated (NFPA 491M). Reacts with fluorine, dry chlorine, potassium chlorate, potassium nitrate, and potassium permanganate (NFPA 481 and 491M).

Hazardous Decomposition Products: Toxic metal oxide fumes.

Conditions Contributing to Hazard Polymerization: None Known

SECTION 11: TOXICOLOGICAL INFORMATION (See Note in Section 1)

Eye Effects: No known human testing.

Skin Effects: Mild irritation (TiO₂)

Acute Inhalation Effects: Human, inhalation, TC_{Lo}: 1 mg/m³/8 hr (V₂O₃);
Rat, unreported, LD₅₀: 27500 µg/kg (Cr)

Chronic Effects: Rat, inhalation, TD₅₀: 158 mg/kg (TiO₂)

Carcinogenicity: Inadequate human evidence, IARC Group 3 (TiO₂);
Known to be carcinogenic by NTP (as Cr)

Teratogenicity: No references found.

Mutagenicity: Mouse, interperitoneal, Micronucleus Test: 3 gm/kg/3 Days (TiO₂)

See NIOSH, RTECS YW1355000 (vanadium), GB4200000 (chromium), and XR2275000 (titanium oxide) for additional toxicity data.

SECTION 12: ECOLOGICAL INFORMATION

Ecotoxicity: There is little tendency for bioaccumulation along food chain.

Environmental Degradation: In water, Titanium alloys will eventually precipitate in sediments.
Titanium alloys will not rust in salt water.

SECTION 13: DISPOSAL CONSIDERATIONS

Dispose of spilled material in accordance with local, state, and federal regulations.

SECTION 14: TRANSPORTATION INFORMATION

DOT Transportation Data: Titanium alloys are not listed in 49 CFR 172.101

SECTION 15: REGULATORY INFORMATION

The OSHA PELs are included in Section 2. The titanium alloys contain toxic chemicals subject to the reporting requirements of SARA Title III Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (40 CFR 372). This law requires certain manufacturers to report annual emissions of specific toxic chemical and chemical categories. Aluminum as a fume or dust, vanadium, molybdenum trioxide, and chromium are listed as Section 313 toxic chemicals. The titanium alloys may also require notification under SARA Title III Section 311/312 if inventories exceed the Threshold Planning Quantity. Your State Emergency Planning Committee should be contacted to determine if the Threshold Planning Quantity reporting requirements for your state are lower than EPA reporting requirements. The table below represents current EPA requirements.

	Aluminum (Al)	Vanadium (V)	Molybdenum (Mo)	Chromium (Cr)	Copper (Cu)	Manganese (Mn)	Nickel (Ni)
CAS Numbers	7429-90-5 (as Al) 1344-28-1 (as Al ₂ O ₃)	7440-62-2 (as V)	7439-98-7 (as Mo) 1313-27-5 (as MoO ₃)	7440-47-3 (as Cr) 1308-38-9 (as Cr ₂ O ₃)	7440-50-8 (as Cu)	7439-96-5 (as Mn)	7440-02-0 (as Ni)
SARA 313	Y (only as fume or dust)	Y (only as fume or dust)	Y (only as MoO ₃)	Y	Y	Y	Y
SARA 302 EHS TPQ (lbs)	NA	10,000 as part of alloy	NA	NA	NA	NA	NA
RCRA Hazardous Waste No.	NA	NA	NA	D007	NA	NA	NA
RCRA Hazardous Waste Code	NA	NA	NA	E	NA	NA	NA
CERCLA RQ (lbs)	NA	NA	NA	5,000 * (as Cr)	5,000 *	NA	100 *

	Iron (Fe)	Tantalum (Ta)	Tungsten (W)	Titanium (Ti)	Tin (Sn)	Zirconium (Zr)	Cobalt (Co)	Palladium (Pd)
CAS Numbers	1309-37-1 (as FE)	7440-25-7 (as Ta)	7440-33-7 (as W)	7440-32-6 (as Ti)	7440-31-5 (as Sn)	7440-67-7 (as Zr)	7440-48-4 (as Co)	7440-05-3 (as Pd)
SARA 313	NA	NA	NA	NA	NA	NA	Y	NA
SARA 302 EHS TPQ (lbs)	NA	NA	NA	NA	NA	NA	NA	NA
RCRA Hazardous Waste No.	NA	NA	NA	NA	NA	NA	NA	NA
RCRA Hazardous Waste Code	NA	NA	NA	NA	NA	NA	NA	NA
CERCLA RQ (lbs)	NA	NA	NA	NA	NA	NA	NA	NA

* = CERCLA reporting required only if diameter of particles released is less than 100 micrometers.

SARA Categories: Immediate (acute) health hazard and Delayed (Chronic) health hazard.

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IN ACCORDANCE WITH 40 CFR 372.45 SUPPLIER NOTIFICATION, WYMAN-GORDON COMPANY IS NOTIFYING YOU THAT METAL ALLOYS YOU RECEIVE FROM US MAY CONTAIN TOXIC CHEMICALS WHICH ARE SUBJECT TO THE REPORTING REQUIREMENTS OF SARA 313 OF THE EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT OF 1986. POTENTIAL REPORTABLE TOXIC CHEMICALS AND CAS NUMBERS INCLUDE: ALUMINUM (FUME OR DUST) (7429-90-5), CHROMIUM (7440-47-3), COBALT (7440-48-4), COPPER (7440-50-8), MANGANESE (7439-96-5), MOLYBDENUM (7439-98-7), NICKEL (7440-02-0) AND VANADIUM (FUME OR DUST) (7440-62-2).

SECTION 16: OTHER INFORMATION

Abbreviations:

PEL = Permissible Exposure Limit	TLV = Threshold Limit Value
STEL = Short Term Exposure Limit	oz = ounce
ft ³ = cubic foot	mg = milligram (1/1,000 of a gram) (454 grams in one pound)
m ³ = cubic meter	NA = Not Applicable
NT = Not Tested	Nil = Negligible
C = Ceiling	TWA = Time Weighted Average
CAS = Chemical Abstract Service	RCRA = Resource Conservation and Recovery Act (40 CFR 261)
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act (40 CFR 302)	SARA = Superfund Amendments and Reauthorization Act (40 CFR 372)
TPQ = Threshold Planning Quantity	RQ = Reportable Quantities
H = Acute Hazardous Waste	Y = Yes
E = Toxicity Characteristic Waste	I = Ignitable Waste
LD50 = Lethal Dose for 50% of species tested	R = High Risk Potential (HRP)
LDLo = Lowest published lethal dose	TD50 = Toxic Dose for 50% of species tested
IARC = International Agency for Research on Cancer	TDLo = Lowest Published Toxic Dose
Group 1 - Human Sufficient Evidence	NTP = National Toxicology Program
Group 2B - Human Limited Evidence	NFPA = National Fire Protection Association
Group 3 - Human Inadequate Evidence	NIOSH = National Institute of Occupational Safety and Health
BEI = Biological Exposure Index	RTECS = Registry of Toxic Effects of Chemical Substances

References:

The information contained on this Material Safety Data Sheet (MSDS) is believed to be correct as it was obtained from sources which we believe are reliable, including:

OSHA Regulations, Title 29 Part 1910	American Conference of Government Industrial Hygienists TLV and
BEI's, 1991	
ACGIH Documentation of TLV's and BEI's, 1991, 2007	NIOSH <i>Occupational Diseases—A Guide to Their Recognition</i>
NIOSH RTECS	NIOSH Pocket Guide 4/99
NIOSH Criteria Documents Plus CD-ROM, 12/96	NIOSH Health Hazard Evaluations, CD-ROM 7/97
NIOSH TIC	SAX's <i>Dangerous Properties of Industrial Materials</i> , CD-ROM
Patty's Industrial Hygiene and Toxicology, CD-ROM	Hawley's <i>Condensed Chemical Dictionary</i> , CD-ROM
Handbook of Environmental Data on Organic Chemicals	EPA Regulations, Title 40, Parts 261, 304, 368, 372
Hazardous Materials Handbook	Toxicology Profiles, Agency for Toxic Substances and Disease Registry, PHS
IARC 7th Annual Report on Carcinogens	NTP Annual Report on Carcinogens, National Technical Information
Service	
American Industrial Hygiene Association Journal	<i>Chemical Protective Clothing Performance Index Book</i> , J. Wiley and Sons
<i>Toxicology, The Basic Science of Poisons</i> , McGraw-Hill	<i>Industrial Toxicology, Safety, & Health Applications in the Workplace</i> , Van Nostrand
	Occupational Health Guidelines for Chemical Hazards, NIOSH/OSHA

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Date Revised: October, 2009