

SAFETY DATA SHEET

HAYNES

International

Welding Products and Thermal Spray Wire

SAFETY DEPARTMENT
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EMERGENCY PHONE NUMBERS

HAYNES: 1-765-456-6894

CHEMTREC: 800-424-9300

(24-hour contact for Health & Transportation Emergencies)

This Safety Data Sheet (SDS) 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 those jurisdictions that have adopted the Globally Harmonized System (GHS) of Classification and Labeling of Chemicals.

1. PRODUCT IDENTIFICATION

CHEMICAL NAME: See Section 3 for Alloy Designations

CHEMICAL FAMILY: Alloy

TRADE NAME: See Alloys listed in Section 3

PRODUCT USE: Wire and Rod Welding Products.

2. HAZARDS IDENTIFICATION

Welding rods and wire as shipped are nonflammable and non-explosive and involve minimal hazards during handling and storage. Many of the thermal spray and welding products covered by this SDS, and the fumes produced during thermal spray and welding, contain compounds of chromium, cobalt, and nickel. The following hazard classifications and precautionary statements apply only to the metal fume and dust created during welding and thermal spray operations.

GHS Hazard Classification – Signal Word, Classification, and Category
 (separate classifications are provided for each Haynes product or product groups)

All products in Table 1: **Danger:** Carcinogenicity (Category 1A)All products in Table 1: **Warning:** Skin sensitization, (Category 1)All products in Table 1: **Warning,** Skin irritation (Category 2)All products in Table 1: **Warning:** Acute toxicity, inhalation (Category 4)All products except those listed below: **Warning,** Acute toxicity, oral (Category 4)

HASTELLOY® HYBRID-BC1®, G-35®, Haynes® 182, HAYNES® 242®, HAYNES® 625,

HAYNES® 718, HAYNES® X-750, HAYNES® 112, 601, I-36, M-400,

M-413,N- 61, NFE 258, NIT 32, NIT 50, NIT 60, 17/7 PH, 20CB3 52, 72,

80/20, 80/20 Cb, 95/5, 200 alloy, and all alloys listed on page 10.

Precautionary Statements and Symptoms; All products in Table 1:

P 201 Obtain special instructions before use

P 202 Do not handle until all safety precautions have been read and understood

P261 + P270 Do not eat, drink or smoke when using this product. Avoid breathing dust or fume

P271 Use only outdoors or in a well-ventilated area

P 272 Contaminated work clothing should not be allowed out of the workplace

P 280 Wear protective gloves, clothing, eye and/or face protection

P 284 In case of inadequate ventilation, wear respiratory protection

Hazard Codes and Hazard Statements

H 350 May cause cancer

H 317 May cause an allergic skin reaction

H315 Causes skin irritation

H 332 Harmful if inhaled

H 302 Harmful if swallowed

**DANGER****WARNING**

2. HAZARDS IDENTIFICATION (Continued)

Hazards not otherwise classified or not covered by GHS

Respiratory disease with symptoms ranging from shortness of breath and cough to permanent disability due to loss of lung function; sensitization or hypersensitivity and fibrosis or subsequent effects on the heart may be caused by excessive exposure to dust or fumes containing cobalt, nickel, titanium, and tungsten. Central nervous system depression has been identified with excessive manganese exposure. Insoluble nickel compounds and hexavalent chromium compounds have been linked to nasal, bronchial, and lung cancers. Aluminum and iron have been indicated to cause gastro-intestinal disorders and non-significant changes in the lung. Chronic health effects specific to an element(s) may be difficult to detect due to the numerous elemental constituents in these alloys.

Notice: This product and fumes generated from the normal use of this product contain Manganese. The inhalation of welding rod fumes containing Manganese has been associated with the development of serious Parkinson's Disease-like symptoms, Parkinsonism, Manganism, and other central nervous system conditions. Such symptoms may include impaired speech, balance and movement. Avoid breathing fumes generated in the welding process by utilizing appropriate environmental controls, including but not limited to ventilation, exhaust, and respirators.

WELDING HAZARDS: Welding hazards are complex. Available accident and health records show that the great majority of injuries result from physical accidents; such as from electric shock or restricted visibility/mobility, physical strains, radiation burns (such as "eye flash"), heat burns due to hot metal or spatter, or metal fume fever.

THERMAL SPRAY HAZARDS: In addition to hazards associated with welding, thermal spray operations may create high noise levels, which require hearing protection.

INGESTION: Amounts ingested incidental to industrial handling are not likely to cause illness. Avoid hand, clothing, food, and drink contact with metal fume, or powder which can cause ingestion of particulate during hand to mouth activities such as drinking, smoking, nail biting, etc. Ingestion of large doses may cause nausea, vomiting, and diarrhea.

Warning,

SKIN: Skin contact with welding fume or metal powder residue may cause irritation and in some sensitive individuals an allergic dermatitis. See Table 5 for additional information.

EYES: Welding fume may cause eye irritation. Welding arc rays (ultraviolet light) can injure eyes.

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This SDS is available in the English, French, German, Spanish, Italian, Czech, and Chinese, languages.

3. COMPOSITION / INFORMATION ON INGREDIENTS

The term "hazardous" in "hazardous ingredients" should be interpreted as a term defined in the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard and does not necessarily imply the existence of a welding hazard.

The chemical ingredients of these SDS products are shown in TABLE 1: Thermal Spray Wire, Bare Wire Welding Products for Gas Metal Arc Welding (GMAW), Gas Tungsten Arc Welding (GTAW), Plasma Arc Welding (PAW), Submerged Arc Welding (SAW) and other similar welding processes; and TABLE 3: Shielded Metal Arc Welding (SMAW) Electrode Products. Ingredients reportable per Section 313 of SARA are marked with an (▲); see Section 15 for an explanation. Standard chemical abbreviations and terminology are used in the tables relating to this section.

HEALTH HAZARD TABLES: TABLE 2 shows the HMIS hazard rating for each product. TABLE 4 and TABLE 5 show the compounds which may be encountered during the normal use of Haynes International, Inc. welding products. Complete chemical names, abbreviations, and Chemical Abstracts Service (CAS) numbers and exposure limits are given in TABLE 4. The exposure limits listed in TABLE 4 include OSHA Permissible Exposure Limits (PELs) and ACGIH TLV®-TWA values for potentially hazardous decomposition products of all welding products listed in TABLE 1. The ACGIH cautions "These limits are not fine lines between safe and dangerous concentration and should not be used by anyone untrained in the discipline of industrial hygiene.

4. FIRST AID PROCEDURES

INHALATION	P304 + P340 Breathing difficulty caused by inhalation of dust or fume requires removal to fresh air, and keep the victim comfortable. P321 If breathing has stopped, perform artificial respiration. P308 + P313 obtain medical assistance if exposed or concerned.
INGESTION	P301 + P330 If swallowed, rinse mouth but never give anything by mouth to an unconscious person. P340 Contact a poison control center. P321 Unless the poison control center advises otherwise, have that conscious person slowly drink 1 to 2 glasses of water to dilute, inducement of vomiting is not necessary. P312 Obtain medical assistance if you feel unwell..
SKIN	P362 + P364 Quickly remove contaminated clothing. Do not shake clothing. Wash clothing before re-use. P321 + P352 Skin contamination with dust or fume can be removed by washing with soap and water. P302+P311+P313 + P332 + P333 If skin irritation or rash occurs, call a poison center, get medical advice/attention.
EYES	Do not allow victim to rub or keep eyes tightly shut. Dust or fume should be flushed from the eyes with copious amounts of clean water, until transported to an emergency medical facility. Consult a physician at once.

5. FIRE FIGHTING MEASURES

As shipped, these products are nonflammable and non-explosive. However, welding arcs and sparks can ignite combustibles, and can initiate fires and explosions. Be sure you read and understand American National Standard Institute standard ANSI Z49.1 "Safety in Welding and Cutting" and National Fire Protection Association standard 51B for fire prevention in "Cutting and Welding Processes" before using these products.

Extinguishing Media	Flash Point (Method Used)	Unusual Fire and Explosive Hazards
N/A	N/A	N/A
Flammable Limit		Special Fire Fighting Procedures
N/A		N/A

6. ACCIDENTAL RELEASE OR SPILL CONTROL MEASURES

In solid form this material poses no special clean-up problems. If this material is in powder or dust form, notify safety personnel, isolate the area and deny entry. Do not sweep. 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. Cleanup personnel should protect against exposure. Properly label all materials collected in waste container. Follow applicable emergency response regulations, such as the OSHA emergency response standard (29 CFR 1910.120).

7. HANDLING AND STORAGE	
HANDLING PRECAUTIONS	Dust and welding fume should be moved or transported to minimize spill or release potential. P405 Store dust and welding fume containers locked up.
STORAGE PRECAUTIONS	In solid form this material poses no special problems. To ensure performance of the product, store in a warm, dry environment away from incompatibles (Section 10).
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 welding) below the exposure limits cited in Table 4. VENTILATION: Use enough ventilation (local exhaust at the arc) to keep fumes and gases from the worker's breathing zone and the general area. Train welders to keep their heads out of the welding plume. If the fumes are removed by filtration or some other means and the air/gas stream is put back into the room, gases and fumes may build up to toxic or asphyxiation levels. Gas build-up should be monitored and if excessive should be removed or reduced to safe levels by some supplementary system and/or reduced by general ventilation.
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 general ventilation does not keep exposure below the exposure limits for air contamination. Remember - the shielding gases used with the GMAW and GTAW processes can displace breathing air and cause asphyxiation in confined work spaces or unventilated areas.
SKIN PROTECTION	Wear hand, head, and body protection which help to prevent injury from radiation, sparks, and electric shock. Refer to ANSI Z49.1 for more information. At a minimum this includes dry welder's gloves and a protective face shield and may include arm protectors, aprons, hats, and shoulder protectors as well as dark, substantial clothing.
EYE PROTECTION	Welding arcs produce ultraviolet and infrared radiation. Use a welder's helmet or a face shield and wear safety glasses under the welder's helmet or face shield. Start with a lens shade that is too dark to see the weld zone. Then go to a lighter shade (a lower number shade) which gives sufficient view of the weld zone. Do not go below the minimum recommended in ANSI standard Z49.1.
ELECTRIC SHOCK	Welders should be trained to avoid electric shock by maintaining a dry work area, insulating themselves from the workpiece and ground, and not touching live electrical parts.
RECOMMENDED MONITORING PROCEDURES	The welding fumes of most of these welding products contain certain ingredients which either may, or will, reach their PEL TLV [®] , or other occupational exposure limit before reaching the TLV [®] -TWA of 5 mg/m ³ for respirable particulate not otherwise specified (NOS). Monitoring the welding fume for these ingredients is recommended. Monitoring for respirable particulate (NOC) is also recommended for all products. Seek professional advice from an industrial hygienist or qualified safety professional for recommended monitoring procedures.
9. PHYSICAL AND CHEMICAL PROPERTIES	
MELTING POINT: >2100°F	<2600°F
SUBLIMES @: Not Applicable	
BOILING POINT: Not Applicable	
EVAPORATION RATE: Not Applicable	
VAPOR PRESSURE (mmHg): Not Applicable	
APPEARANCE AND COLOR: The bare wire welding and thermal spray products are produced as straight lengths and coiled wires. The SMAW electrodes are produced as metal core rods coated with a flux.	

10. STABILITY AND REACTIVITY	
GENERAL REACTIVITY	Stability - As shipped, these wire products are stable and nonreactive and they are not chemically hazardous. For those processes that create a fume or dust form of these products, Haynes recommends a dust sample be tested to determine if the dust is explosible according to the National Fire Protection Association (NFPA) Standard 654.
INCOMPATIBILITY (MATERIALS TO AVOID)	Avoid contact with acids and bases.
HAZARDOUS DECOMPOSITION PRODUCTS	The composition and form of the decomposition products are different from the ingredients listed in Table 1. The decomposition products reasonably expected for the thermal spray wire and welding fumes of these products when used in a variety of processes are provided in Table 6. Gaseous reaction products from thermal spray operations and welding may be expected to include carbon monoxide and carbon dioxide. Ozone and the oxides of nitrogen may be formed by radiation from the arc.
11. TOXICOLOGICAL INFORMATION	
TOXICITY DATA CHRONIC/ CARCINOGENICITY (See Table 5)	Eye: Rabbit (cobalt) unknown amount produced severe reaction with abscess involving lens, ciliary body, vitreous humor, and retina.
	Skin: No data.
	Ingestion: Rat and Guinea Pig (nickel): LD _{Lo} : 5 mg/kg Rat (cobalt) LD ₅₀ : 6171 mg/kg Rabbit (cobalt): LD ₅₀ : 750 mg/kg Rat (chromium VI): LD ₅₀ : 80 mg/kg Human (copper): TD _{Lo} : 120 µg/Kg affects the gastrointestinal tract (nausea or vomiting) Human (chromium): LD _{Lo} : 71 mg/kg Rat (manganese) LD ₅₀ : 9,000 mg/kg Rat (Titanium): LD ₅₀ : >5,000 mg/kg
	Inhalation: Rabbit (nickel): TC _{Lo} : 130 µg/m ³ 35 weeks (intermittent-6 hours) Pig (cobalt) TC _{Lo} : 100 µg/m ³ /6 hours for 13 weeks - (intermittent) Rat (cobalt) LC ₅₀ : >10 mg/liter (1 hour) Human (chromium VI): TC _{Lo} : 110 µg/m ³ 3 years (continuous) tumorigenic (carcinogenic per RTECS) Human (manganese): TC _{Lo} : 2,300 µg/m ³ Rat (titanium): LC ₅₀ : >6,820 mg/ m ³
	Subchronic: Rat (molybdenum) inhalation: 12-16 g/m ³ /1 hour/30 days, resulted in slight growth depression, and thickening of the intraaveolar septa, which contained connective tissue fibers.
	Other: Intravenous; Dog (nickel) LD _{Lo} : 10 mg/kg Implant; Rat (chromium) TD _{Lo} : 1200 µg/kg intermittent over 6 weeks. Rat (cobalt) intramuscular: 126 mg/kg, tumorigenic at site of application.
	Teratology: Rat (molybdenum) oral: 5800 µg/kg given to female 30 weeks prior to mating and during days 1-20 of pregnancy caused specific musculoskeletal system development abnormalities.
	Reproduction: Rat (cobalt) unspecified exposure route, 0.05 mg/kg continuous, administered throughout gestation to female was embryotoxic.
	Mutagenicity: Hamster (chromium III) lung cell: 34 mg/L caused sister chromatid exchange. Human (cobalt) DNA damage: Human Leukocyte 3 mg/L. Human (Chromium VI) DNA damage: Human Leukocyte 50 µmol/L.

12. ECOLOGICAL INFORMATION

In solid form this material poses no special environmental problems. Metal powders, fumes, 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.

Ecotoxicity: Few plants accumulate cobalt at greater than 100 ppm, the level at which severe phytotoxicity would occur. There is little tendency for chromium III bioaccumulation along the food chain. Terrestrial plants can contain enough molybdenum to be toxic to animals but still grow normally.

Environmental Fate: In water, cobalt is adsorbed greatly to hydrolysate or oxidate sediments. It may be taken into solution in small amounts through bacteriological activity. 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. Manganese undergoes complex geochemical cycling, and can accumulate in the top layer of sediment in lakes. In water, molybdenum will precipitate out with natural calcium. Soil levels should not exceed 50 ppm to avoid problems with livestock.

13. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL: Contact an Environmental Engineer or your supplier for recovery and recycling welding rod stubs and scrap wire. P501 Dispose of fume, flux and weld grinding residues from the work area, or from filters, in accordance with local, state and federal regulations. Refer to this SDS for information on the possible contents of the collected fumes and other materials.

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

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

SHIPPING NAME	Welding fume and metal overspray particulate residue 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, Copper, Nickel. 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 Reauthorization Act of 1986 (SARA Title III):
	Immediate Hazard: X Delayed Hazard: X Fire Hazard: - Pressure Hazard: - Reactivity Hazard: -

15. REGULATORY INFORMATION (continued)	
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, Copper, Nickel. 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 Reauthorization Act of 1986 (SARA Title III):
	Immediate Hazard: X Delayed Hazard: X Fire Hazard: - Pressure Hazard: - Reactivity Hazard: -
U.S. FEDERAL REGULATIONS	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), cobalt, chromium, copper, manganese, nickel (as a powder or dust).
STATE REGULATIONS	California's "Safe Drinking Water and Toxic Enforcement Act of 1986" (Proposition 65) During welding, these products may produce cobalt oxide, nickel compounds, and hexavalent chromium compounds which are known to the State of California to cause cancer and birth defects. 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, Cobalt, Copper, Chromium, Manganese, Nickel, and Vanadium (fume or dust) are designated environmental hazards on the Hazardous Substance List. Title 34, Part XIII, Chapter 323.
INTERNATIONAL REGULATIONS	<p>Labeling in Accordance with the GHS</p> <p>The following hazard classification and risk phrases required by the GHS apply to welding fumes and thermal spray particulate created by these products.</p> <p>All products in Table 1 in the form of welding fume: Danger, May cause cancer by inhalation, Category 1A.</p> <p>All products in Table 1 in the form of welding fume: Warning, May cause an allergic skin reaction, Category 1.</p> <p>All metal fume created by melting, welding, and thermal spraying; Warning: causes skin irritation, Category 2.</p> <p>All metal fume created by melting, welding, and thermal spraying; Warning: Harmful if inhaled, Category 4.</p> <p>All products except: HASTELLOY®, HYBRID-BC1® G-35®, HAYNES® 182, HAYNES® 242®, HAYNES® 625-, HAYNES® 718-, HAYNES® X-750-, HAYNES® 112-, 601-, I-36-, M-400-, M-413-, N- 61-, NFE 258- NIT 32-, NIT 50-, NIT 60-, 17/7 PH-, 20CB3- 52-, 72-, 80/20-, 80/20 Cb-, 95/5-, 200 alloy, and all alloys listed on page 9: Warning, Harmful if swallowed, acute toxicity Category 4.</p> <p>Canada WHIMS These products have been classified in accordance with the hazard criteria of the CPR, and the SDS contains all of the information required by the CPR.</p>

16. OTHER INFORMATION

SDS STATUS

This SDS replaces the January 30, 2013 revision for steel wire & rod. Sections 1, 2, 4, 7, 11, 13, and 15 have been changed.

Read and understand the manufacturer's instructions and precautionary labels on the products. See American National Standard Institute standard Z49.1 "SAFETY IN WELDING AND CUTTING" published by the American Welding Society, PO Box 351040, Miami, FL 33135, and the OSHA publication 2206 (29 CFR 1910) available from the U.S. Government Printing Office, Washington DC 20402.

The above information has been prepared by CB&I, 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.

Table 1 Thermal Spray Wire and Bare Wire Welding Products

UNS		Normal Composition, Weight Percent												
ALLOY	Alloy No.	Ni▲	Co▲	Cr▲	Mo	W	Fe	Si	Mn▲	Al▲	Ti	Cu▲	B	Others (V▲)
HASTELLOY® HYBRID-BC1® alloy	N10362	62	--	15	22	--	2*	0.08*	0.25	0.5*	--	--	--	
HASTELLOY® B-3® alloy	N10675	65	3	<3	30	3	<3	0.1	<3	<1	<1	<1	--	
HASTELLOY® C-4 alloy	N06455	65	2*	16	16	0.5*	3*	0.08*	<1	--	0.7*	0.5*	--	--
HASTELLOY® C-22® alloy	N06022	56	2.5*	22	13	3	3	0.02	0.5*	--	--	0.5*	--	V-0.35*
HASTELLOY® C-22HS® alloy	N07022	61	1*	21	17	1*	2*	0.08*	0.8*	0.5*	--	0.5*	0.006*	----
HASTELLOY® C-86 alloy	N06686	55	--	21	16	3.7	2*	0.08*	0.75*	0.5*	0.14	--	--	
HASTELLOY® C-276 alloy	N10276	57	2.5*	16	16	3	5	0.08*	<1	--	--	0.5*	--	V-0.35*
HASTELLOY® C-2000® alloy	N06200	59	2*	23	16	--	3*	0.08*	0.5*	0.5*	--	1.6	--	--
HASTELLOY® G-30® alloy	N06030	43	5*	30	5.5	2.5	15	0.8*	1.5*	--	--	2	--	Cb-0.8
HASTELLOY® N alloy	N10003	71	<1	7	17	<1	<5	<1	<1	--	--	<1	--	V-<1
HASTELLOY® G-35® alloy	N06035	58	<1	33.2	8.1	0.6*	2*	0.6*	0.5*	0.4*	--	0.3*	--	--
HASTELLOY® S alloy	N06635	67	2*	16	15	<1	3*	0.4	0.5	0.25	--	0.35*	0.015*	La-0.02
HASTELLOY® W alloy	N10004	63	2.5*	5	24	<1	6	<1	<1	--	--	0.5*	--	V- 0.6*
HASTELLOY® X alloy	N06002	47	1.5	22	9	0.6	18	<1	<1	<0.5	0.15*	0.5*	0.008*	Cb-0.5*
HAYNES® C-263 alloy	N07263	52	20	20	6	--	0.7*	0.2	0.4	0.6*	2.4*	0.2*	0.005*	Zr-0.04*, (Al+Ti)-2.6
HAYNES® GTD222 alloy	2220**	50	19	22.5	<1	2	<1	0.25*	0.1*	1.3	2.3	0.1*	0.004	Cb-0.8, Ta-1
HAYNES® HR-120® alloy	N08120	37	3.0	25	<1	<0.5	33	0.6	0.7	0.1	0.2*	<0.5	<0.1	Cb-0.7
HAYNES® HR-160® alloy	N12160	37	29	28	<1	<1	3.5*	2.75	1*	0.4	0.5	0.5*	-	Cb+Ta-0.3*
HAYNES® HR-224® alloy	2224**	47	2*	20	0.5*	0.5*	27.5	0.3	0.5*	3.8	0.3	--	0.004*	Cb-0.15*, La-0.01*, Zr-0.025*
HAYNES® HR-235™ alloy	2431	57	1.1*	31	5.6	-	1.5*	0.4	0.5	0.3	-	3.8	-	--
HAYNES® NS-163® alloy	1630**	8	40	28	--	--	21	0.5*	0.5*	0.5*	1.3	--	0.015*	Cb-1
HAYNES® Waspaloy	N07001	58	13.5	19	4.3	--	2*	0.1*	0.1*	1.5	3	0.1*	0.006	Zr-0.04*
HAYNES® X-750 alloy	N07750	70 ^b	1*	16	--	--	8*	0.35*	0.35*	0.8	2.5*	0.5*	--	Cb+Ta-1
HAYNES® 25 alloy	R30605	10	51	20	<1	15	3*	0.4*	1.5	--	--	--	--	--

Table 1 Thermal Spray Wire and Bare Wire Welding Products (continued)

ALLOY	UNS Alloy No.	Normal Composition, Weight Percent												
		<u>Ni</u> ▲	<u>Co</u> ▲	<u>Cr</u> ▲	<u>Mo</u>	<u>W</u>	<u>Fe</u>	<u>Si</u>	<u>Mn</u> ▲	<u>Al</u> ▲	<u>Ti</u>	<u>Cu</u> ▲	<u>B</u>	<u>Others (V▲)</u>
HAYNES® 82 alloy	N06082	73	<0.1	20	--	--	0.9	0.1	3	<0.1	0.3*	<0.1	--	Cb-2.4, Ta-<0.1
HAYNES® 92 alloy	N07092	>67	--	16	--	--	<8	<1	2	--	--	<1	--	
HAYNES® 188 alloy	R30188	22	39	22	--	14	3*	0.35	1.25*	--	--	--	0.015*	La-0.03
HAYNES® 214® alloy	N07214	75	2*	16	0.5*	0.5*	3	0.2*	0.5*	4.5	0.5*	--	0.01*	Y-0.01, Zr-0.1*, Cb-0.15*
HAYNES® 230-W® alloy	N06231	57	5*	22	2	14	3*	0.4	0.5	0.3	0.1*	0.5*	0.003*	La-0.02
HAYNES® 242® alloy	N10242	65	<1	8	25	--	2*	0.8*	0.8*	0.5*	--	0.5*	0.006*	--
HAYNES® 244™ alloy	2444	60	1*	8	25	6	2*	0.1*	0.8*	0.5*	-	0.5*	0.006*	--
HAYNES® M418 alloy	N04060	69*	--	--	--	--	2.5*	1.3*	4*	1.3*	<3	<19	--	
HAYNES® 282® alloy	N07208	57	10	20	8.5	--	1.5*	0.15*	0.3*	1.5	2.1	--	0.005	--
HAYNES® 556® alloy	R30556	20	18	22	3	2.5	31	0.4	1	0.2	--	--	0.02*	Zr-0.02,La-0.02,Ta-0.6, Cb-0.3*
HAYNES® 617	N06617	54	12.5	22	9	--	2*	0.2*	0.2*	1.2	0.4	0.5*	0.006*	
HAYNES® 625 alloy	N06625	62	1*	22	0.9*	--	5*	0.5*	0.5*	0.4*	0.4*	0.5*	--	Cb & Ta-3.7
HAYNES® 625 (Low Iron)	N06625	62	<1	21	9	-	0.75*	0.5*	0.5*	0.4*	0.4*	0.5*	-	Cb + Ta- 3.7
HAYNES® 718 alloy	N07718	52	<1	18	3	--	19	0.35*	0.35*	0.5	0.9	0.1*	0.0004	Cb+Ta-5
I-36 alloy	K93601	36	<0.1	<0.1	--	--	63	0.14	0.3	0	--	<0.1	--	
L605 alloy	R30605	10	51	20	<1	15	3*	0.4*	1.5	--	--	--	--	--
M-400 alloy	N04400	67*	0.2*	--	--	--	1.4*	0.2*	1*	<0.1	--	33*	--	
M-413 alloy	C71581	31	<0.1	-	-	-	0.6	<0.1	0.7	<0.1	0.3	68	-	
MULTIMET® alloy	R30155	20	20	21	3	2.5	30	<1	1.5	--	--	0.5*	--	Cb-1, N 0.15, Ta-0.05*
N 61 alloy	N02061	96	<0.1	<0.1	<0.1	--	<0.1	0.4*	0.4	0.4*	3	<0.1	--	Cb-<0.1, Ta-<0.1
NFE 258 alloy	W82002	56*	<0.1	<0.1	<0.1	--	43	0.1*	0.7	<0.1	<0.1	<0.1	--	
NIT 32 alloy	S24100	1.5	<0.1	18	0.2	<0.1	69	0.4	12	--	<0.1	0.2	--	Cb-<0.1 V-<0.1
NIT 50 alloy	S20910	12	0.3*	21	2	--	59	0.5*	5	--	--	0.4	--	Cb-.016, V-0.15
NIT 60 alloy	S21800	8	<0.1	16	0.2	<0.1	63	4	8	<0.1	<0.1	0.2	--	V-<0.1
MP35N alloy	R30035	37*	34*	20*	10*	<0.1	0.3*	0.1*	0.1*	<0.1	0.7*	<0.1	<0.1	
ULTIMET® alloy	R31233	9	54	26	5	2	3	0.3	0.8	--	--	--	--	N-0.08
17/7 PH alloy	S17700	8*	0.1*	16	0.5*	--	73	0.5*	1*	1*	<0.1	0.4*	--	

Table 1 Thermal Spray Wire and Bare Wire Welding Products (continued)

ALLOY	UNS	Normal Composition, Weight Percent												
	Alloy No.	Ni▲	Co▲	Cr▲	Mo	W	Fe	Si	Mn▲	Al▲	Ti	Cu▲	B	Others (V▲)
20CB3 alloy	N08020	33	<0.1	20	3*	--	71	0.4*	2*	<0.1	<0.1	3.4	<0.1	Cb-.06*, V-<0.1, Ta-<0.1
52 alloy	N14052	50	<0.1	<0.1	--	--	49	0.1	0.5*	<0.1	<0.1	<0.1	--	
72 alloy	N06072	55	<0.1	44	<0.1	--	0.3	<0.1	<0.1	0.2*	0.5	<0.1	<0.1	
80/20 alloy	N06003	78	<0.1	20	--	--	0.7	1.3	<0.1	0.2	--	<0.1	--	
80/20 CB alloy	N06009	77	--	19	--	--	0.7	1.3	0.3	--	--	--	--	Cb-0.8
95/5 alloy	N03301	94	<0.1	--	--	--	<0.1	0.5*	0.3	5	0.7*	0.1*	--	Cb-<0.1, Ta-<0.1
200 alloy	N02200	99.4	--	<0.1	<0.1	--	0.2	<0.1	<0.1	--	<0.1	<0.1	--	
214W alloy	N07214	<70	2*	<17	0.5*	0.5*	<4	0.2*	0.5*	<5	0.5*	--	0.004*	Cb 0.15*; Y<0.04; Zir 0.02*
202 alloy	S20200	5*	--	18*	--	--	69*	0.6*	8	--	--	--	--	
302 alloy	S30200	8	--	18	0.3*	--	72	0.6*	1.8*	--	--	0.4*	--	
302 MO alloy	S30200	9	0.1	17	1.3	--	71	0.5	1.2	<0.1	--	0.1	--	
302 N alloy	S30200	9	--	18	--	--	70	0.6*	1.9	--	--	0.4	--	
302 NC alloy	S30200	8	--	17	<0.1	<0.1	74	0.4	0.3	<0.1	<0.1	<0.1	<0.1	V-0.1, Ta-<0.1
302 V alloy	S30200	8	<0.1	18	0.4	--	72	0.4	1	<0.1	--	0.2	--	
304 alloy	S30400	9	--	18	0.3*	--	71	0.5*	1.8*	--	--	0.3*	--	
304 L alloy	S30403	9	0.2*	18	0.4*	--	70	0.7*	1.8*	<0.1	--	0.5*	--	Y-<0.1
304 V alloy	S30400	8	0.15	18	0.2*	--	72	0.6*	0.7*	--	--	0.3*	--	
305 alloy	S30500	12*	--	18	0.3*	--	68	0.5*	1.4*	--	--	0.4*	--	
308 L alloy	S30800	10	--	21	--	--	66	0.8	1.9	--	--	--	--	
316 alloy	S31600	10	--	17*	2	--	69	0.5*	1.5*	--	--	0.5*	--	
316 L alloy	S31603	10	--	16	2	--	70	0.5*	1.5*	--	--	<0.1	--	
347 alloy	S34700	9	<0.1	17	0.3	--	70	0.6	1.5	<0.1	<0.1	0.2	<0.1	Cb-0.6, V-<0.1, Ta-<0.1
416 alloy	S41600	0.3*	--	13	<0.1	--	85	0.5*	0.9*	<0.1	--	0.1	--	
420H alloy	S42080	0.5*	--	<14	0.75*	--	82	0.5*	<0.6	--	--	0.75*	--	
420 alloy	S42000	0.1	--	13	--	--	86	0.2	0.5*	<0.1	--	0.1	--	
430 alloy	S43000	0.2*	--	17	<0.1	--	82	0.5*	0.5*	<0.1	--	0.1	--	
455 alloy	S45500	8	--	11	<0.1	--	77	<0.1	<0.1	--	1.2	2.2	--	Cb-0.2
600 alloy	N06600	74	0.05*	16	0.3	<0.1	9	0.4*	0.8	0.2	0.3*	0.02*	--	
601 alloy	N06601	60	--	23	--	--	16	0.3*	0.6	1.5	0.3	<0.1	0.003	
622 alloy	N06022	52	2.5*	<23	14	<3.5	<3	0.08*	0.05*	--	--	0.5*	--	V 0.35*;

Table 1 Thermal Spray Wire and Bare Wire Welding Products (continued)

ALLOY	UNS	Normal Composition, Weight Percent												
	Alloy No.	<u>Ni</u> ▲	<u>Co</u> ▲	<u>Cr</u> ▲	<u>Mo</u>	<u>W</u>	<u>Fe</u>	<u>Si</u>	<u>Mn</u> ▲	<u>Al</u> ▲	<u>Ti</u>	<u>Cu</u> ▲	<u>B</u>	<u>Others (V</u> ▲)
800 alloy	N08800	32	0.2*	19.5	0.2*	--	46*	0.8*	1.0	0.6*	0.5	0.2*	--	
825 alloy	N08825	41*	0.06*	23*	3*	--	31*	0.3*	0.6*	0.1	1*	2.5*	--	

(▲) Reportable ingredients per Section 313 of SARA - See Section 15 for additional information. XX* - indicates maximum value. XX^b - indicates minimum value. XX** - Haynes metal No.

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Table 2 Product Hazard Rating - Hazardous Materials Identification System (HMIS)

H = Health Rating F = Flammability Rating R = Reactivity Rating

ALLOY	Alloy No.	H	F	R	ALLOY	Alloy No.	H	F	R
HASTELLOY® HYBRID-BC1® alloy	N10362	3*	0	0	M-400 alloy	N04400	2*	0	0
HASTELLOY® B-3® alloy	N10675	3*	0	0	M-413 alloy	C71581	2*	0	0
HASTELLOY® C-4 alloy	N06455	3*	0	0	N 61 alloy	N02061	2*	0	0
HASTELLOY® C-22® alloy	N06022	3*	0	0	NFE 258 alloy	W82002	2*	0	0
HASTELLOY® C-22HS® alloy	N07022	3*	0	0	NIT 32 alloy	S20000	3*	0	0
HASTELLOY® C-86 alloy	N06686	3*	0	0	NIT 50 alloy	S20000	3*	0	0
HASTELLOY® C-276 alloy	N10276	3*	0	0	NIT 60 alloy	S21800	3*	0	0
HASTELLOY® C-2000® alloy	N06200	3*	0	0	MP35N alloy	R30035	3*	2	0
HASTELLOY® G-30® alloy	N06030	3*	2	0	ULTIMET® alloy	R31233	2*	2	0
HASTELLOY® G-35® alloy	N06035	3*	0	0	17/7 PH alloy	S17700	3*	0	0
HASTELLOY® N alloy	N10003	3*	0	0	20CB3 alloy	N08021	3*	0	0
HASTELLOY® S alloy	N06635	3*	0	0	52 alloy	N14052	2*	0	0
HASTELLOY® W alloy	N10004	3*	0	0	72 alloy	N06072	3*	0	0
HASTELLOY® X alloy	N06002	3*	0	0	80/20 alloy	N06003	3*	0	0
HAYNES® C-263 alloy	N07263	3*	2	0	80/20 CB alloy	N06003	3*	0	0
HAYNES® GTD222 alloy	2220**	3*	2	0	95/5 alloy	N03301	2*	0	0
HAYNES® HR-120® alloy	N08120	3*	0	0	200 alloy	N02200	2*	0	0
HAYNES® HR-160® alloy	N12160	3*	2	0	202 alloy	S20200	3*	0	0
HAYNES® HR224® alloy	2224**	3*	0	0	214 W	N07214	3*	0	0
HAYNES® HR235™ alloy	2431	3*	0	0	302 alloy	S30200	3*	0	0
HAYNES® Waspaloy alloy	N07001	3*	2	0	302 MO alloy	S30200	3*	0	0
HAYNES® NS-163® alloy	1630**	3*	2	0	302 N alloy	S30200	3*	0	0
HAYNES® X-750 alloy	N07750	3*	0	0	302 NC alloy	S30200	3*	0	0
HAYNES® 25 alloy	R30605	2*	2	0	302 V alloy	S30200	3*	0	0
HAYNES® 82	N06082	3*	0	0	304 alloy	S30400	3*	0	0
HAYNES® 92 alloy	N07092	3*	0	0	304 L alloy	S30403	3*	0	0
HAYNES® 188 alloy	R30188	3*	2	0	304 V alloy	S30400	3*	0	0
HAYNES® 214® alloy	N07214	3*	0	0	305 alloy	S30500	3*	0	0

Table 2 Product Hazard Rating – Hazardous Materials Identification System (HMIS)
H = Health Rating F = Flammability Rating R = Reactivity Rating

ALLOY	Alloy No.	H	F	R	ALLOY	Alloy No.	H	F	R
HAYNES® 230-W® alloy	N06231	3*	0	0	308 L alloy	S30800	3*	0	0
HAYNES® 242® alloy	N10242	3*	0	0	316 alloy	S31600	3*	0	0
HAYNES® 244™ alloy	2444	3*	0	0	316 L alloy	S31603	3*	0	0
HAYNES® 282® alloy	N07208	3*	2	0	347 alloy	S34700	3*	0	0
HAYNES® M418 alloy	N04060	2*	0	0	416 alloy	S41600	3*	0	0
HAYNES® 556® alloy	R30556	3*	0	0	420 alloy	S42000	3*	0	0
HAYNES® 617 CE's	N06617	3*	0	0	420H alloy	S42080	3*	0	0
HAYNES® 625 alloy	N06625	3*	0	0	430 alloy	S43000	3*	0	0
HAYNES® 625 (low iron) alloy	N06625	3*	0	0	455 alloy	S45500	3*	0	0
HAYNES® 718 alloy	N07718	3*	0	0	600 alloy	N06600	3*	0	0
I-35 alloy	K93601	2*	0	0	601 alloy	N06601	3*	0	0
MULTIMET® alloy	R30155	3*	0	0	622 alloy	N06022	3*	0	0
					800 alloy	N08800	3*	0	0
					825 alloy	N08825	3*	0	0

Note: Ratings applicable for the metal oxide components of each product. Metal oxides are typically found in welding fume. The flammability and reactivity hazard ratings are appropriate for large, concentrated quantities of welding fume, such as found in a dust collector.
* = Chronic health effects, see Table 5.
XX** - Haynes metal No. HAYNES and HASTELLOY are trademarks of Haynes International, Inc.

Summary of HMIS rating numbers: H = Health Hazard rating; 0 = minimal hazard; 1 = slight hazard; 2 = moderate hazard; 3 = serious hazard; 4 = severe hazard
F = Flammability hazard rating: 0 = minimal hazard; 1 = slight hazard; 2 = moderate hazard; 3 = serious hazard; 4 = severe hazard
R = Reactivity hazard rating: 0 = minimal hazard; 1 = slight hazard; 2 = moderate hazard; 3 = serious hazard; 4 = severe hazard

Table 3

Shielded Metal Arc Welding (SMAW) Electrode Products			
Alloy	AWS/UNS Alloy No.	Core Wire composition ⁽¹⁾ (~80% by Wt.)	Other Coating Ingredients ⁽²⁾ (~20% by Wt.)
HASTELLOY® B-3® alloy	W80675	N10675	Oxides and/or Fluorides of Aluminum (Al) ▲ Barium (Ba) Calcium (Ca) Magnesium (Mg) Potassium (K) Sodium (Na) Strontium (Sr) and Titanium (Ti)
HASTELLOY® C-4 alloy	W86455	N06445	
HASTELLOY® C-22® alloy	W86022	N06022	
HASTELLOY® C-276 alloy	W80276	N10276	
HASTELLOY® C-2000® alloy	W86200	N06200	
HASTELLOY® G-30® alloy	W86030	N06030	
HASTELLOY® G-35® alloy	W86035	N06035	
HASTELLOY® X alloy	W86002	N06002	
HAYNES® 230-W® alloy	W86231	N06231	
HAYNES® 182 alloy	W86182	N07092	
HAYNES® 117 alloy	W86117	N06617	
HAYNES® 112 alloy	W86112	N06625	
MULTIMET® alloy	W73155	R30155	
ULTIMET® alloy	R31233	R31233	
HAYNES® 25 alloy	W73605	R30605	

(1) Corresponding core wire composition of grade is provided in Table 1 as identified by UNS Number or alloy metal number.

(2) Chemical Abstracts Service (CAS) numbers, PEL and TLV®-TWA information are provided in Table 4.

(▲) Reportable ingredients per Section 313 of SARA - See Section 15 for additional information.

Table 4 Exposure Limits for Potentially Hazardous Constituents in Thermal Spray Wire and Welding Fumes

Metal or Chemical, Symbol	CAS Number	Exposure Limits as 8-hour TWA (as mg/m ³)	
		OSHA - Permissible Exposure Limit (PEL) ⁽¹⁾	ACGIH - Threshold Limit Value (TLV [®]) ⁽¹⁾
Aluminum (Al/Al ₂ O ₃)	7429-90-5/ 1344-28-1	Aluminum Oxide as Al: 15, total Aluminum Oxide as Al: 5, Respirable	Welding Fume as Al: 10
Argon ⁽²⁾ (A)	7440-37-1	Regarded as simple asphyxiant. Inert gases which may replace air and deprive the body of oxygen.	
Carbon Dioxide ⁽²⁾ (CO ₂)	124-38-9	Regarded as simple asphyxiant. Inert gases which may replace air and deprive the body of oxygen.	
Helium ⁽²⁾ (He)	7440-59-7	Regarded as simple asphyxiant. Inert gases which may replace air and deprive the body of oxygen.	
Nitrogen ⁽²⁾ (N)	7727-37-9	Regarded as simple asphyxiant. Inert gases which may replace air and deprive the body of oxygen.	
Barium compounds (Ba X)	7440-39-3	Soluble compounds as Ba: 0.5	Soluble compounds as Ba: 0.5
Boron Oxide (B ₂ O ₃)	1303-86-2	Oxide Dust Total: 15	Oxide Dust Total: 10
Calcium (Ca)	7440-70-2	None	None
Calcium Oxide (CaO)	1305-78-8	5	2
Carbon Monoxide ⁽²⁾ (CO)	630-08-0	55 (50 ppm)	29 (25 ppm)
Chromium VI Soluble Compounds	(3)	0.005	0.05 (as Cr)
Chromium VI Insoluble Compounds	(3)	0.005	0.01(as Cr)
Chromium oxide Cr III (Cr ₂ O ₃)	1308-38-9	0.5 (as Cr)	0.5 (as Cr)
Chromium oxide Cr II (CrO)	12018-00-7	0.5 (as Cr)	-
Chromium metal (Cr)	7440-47-3	1 (as Cr)	0.5 (as Cr)
Cobalt (Co) and inorganic compounds	7440-48-4	0.1 metal dust and fume (as Co)	0.02 (as Co)
Columbium (Niobium) (Cb/Cb ₂ O ₈ , Nb/Nb ₂ O ₈)	7440-03-1/ 1313-96-8	None	None
Copper oxide fume (CuO)	1317-38-0	0.1 (as Cu)	0.2 (as Cu)
Copper (Cu)	7440-50-8	1 (as Cu)	1 (as Cu)
Fluorides	(3)	2.5 (as fluorine)	2.5 (as fluorine)
Calcium Fluoride (CaF ₂)	7789-75-5	None	None
Sodium Fluoride (NAF)	7681-49-4	None	None
Potassium Fluoride (KF)	7789-23-3	None	None
Aluminum Fluoride (AlF ₃)	7784-18-1	None	None
Lithium Fluoride (LiF)	7789-24-4	None	None
Hydrogen Fluoride (HF)	7664-39-3	3 ppm	0.41; 1.64 (ceiling) ⁽⁴⁾

Table 4 Exposure Limits for Potentially Hazardous Constituents in Thermal Spray Wire and Welding Fumes (continued)

Metal or Chemical, Symbol	CAS Number	Exposure Limits as 8-hour TWA (as mg/m ³)	
		OSHA - Permissible Exposure Limit (PEL) ⁽¹⁾	ACGIH - Threshold Limit Value (TLV [®]) ⁽¹⁾
Iron oxide (dust and fume) (Fe ₂ O ₃)	1309-37-1	10 (as Fe)	5 ⁽⁵⁾ (as Fe)
Lanthanum (La)	7439-91-0	None	None
Lithium (Li/Li ₂ O)	7439-92-2/ 12057-24-8	None	1 (as Li ₂ O) (ceiling) ^{(4), (6)}
Magnesium (Mg)	7439-95-4	None	None
Magnesium Oxide (MgO)	1309-48-4	Fume as MgO: 15	Fume as MgO: 10 ⁽⁷⁾
Manganese (Mn, MnO)	7439-96-5	5 (ceiling) ⁽⁴⁾ (as Mn)	0.02 (as Mn)
Molybdenum compounds (Mo X)	7439-98-7	Soluble Compounds as Mo: 5	Soluble Compounds as Mo: 0.5 ⁽⁵⁾ Insoluble Compounds as Mo: 3 ⁽⁵⁾ ; 10 ⁽⁷⁾
Nickel (Ni, NiX)	7440-02-0	1 (elemental, soluble and insoluble compounds) (as Ni)	1.5 ⁽⁷⁾ elemental, 0.1 ⁽⁷⁾ soluble, 0.2 ⁽⁷⁾ insoluble compounds as Ni
Nitric Oxide ⁽²⁾ (NO)	10102-43-2	30	31
Nitrogen Dioxide ⁽²⁾ (NO ₂)	10102-44-2	9 (ceiling)	5.6; 9.4 (STEL) ⁽⁸⁾
Ozone ⁽²⁾ (O ₃)	10028-15-6	0.2 (0.1 ppm)	0.1 (0.05 ppm), Heavy workload ⁽⁹⁾
Potassium (K/K ₂ O)	7440-09-7/ 12136-47-7	None	None
Silica fume (amorp) (SiO ₂)	69012-64-2	None	None
Silicon (Si)	7440-21-3	Total Dust: 15, Respirable Dust: 5	None
Sodium (Na/Na ₂ O)	7440-23-5/ 1313-59-3	None	None
Strontium (Sr/SrO)	7440-24-6/ 1314-11-0	None	None
Tantalum (Ta)	7440-25-7	Metal and Oxide Dust: 5	Metal and Oxide Dust as Ta: 5
Titanium Dioxide (TiO ₂)	13463-67-7	15	10
Titanium (Ti)	7440-32-6	None	None
Tungsten (W) compounds	7440-33-7	None	Insoluble compounds as W: 5; 10 (STEL) ⁽⁸⁾ Soluble compounds as W: 1; 3 (STEL) ⁽⁸⁾
Vanadium Pentoxide (V ₂ O ₅)	1314-62-1	0.5 ceiling - respirable dust 0.1 ceiling - fume	0.05 Respirable Dust or Fume ⁽⁵⁾
Yttrium (Y) HW-7031-5	7440-65-5	1	Metal and Compounds as Y: 1

Table 4 Exposure Limits for Potentially Hazardous Constituents in Thermal Spray Wire and Welding Fumes (continued)

Exposure Limits as 8-hour TWA (as mg/m ³)			
Metal or Chemical, Symbol	CAS Number	OSHA - Permissible Exposure Limit (PEL) ⁽¹⁾	ACGIH - Threshold Limit Value (TLV [®]) ⁽¹⁾
Zirconium compounds (Zr X)	7440-67-7	Compounds as Zr: 5	Zr Metal and Compounds as Zr: 5; 10 (STEL) ⁽⁸⁾

(1) All limits are Total Dust unless indicated otherwise.

(2) Gases generated by arc welding processes.

(3) Varies with compound.

(4) Ceiling limit - shall not be exceeded instantaneously.

(5) Respirable fraction of particulate - refer to the ACGIH-TLV[®] booklet for a definition.

(6) Workplace Environmental Exposure Levels (WEEL), published by the American Industrial Hygiene Association.

(7) Inhalable fraction of particulate - refer to the ACGIH-TLV[®] booklet for a definition.

(8) STEL = Short-term exposure limit - A 15-minute TWA exposure limit.

(9) See additional TLV[®] listings for moderate or light workloads.

(10) National Institute For Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL).

Table 5 Health Hazards

The following table shows the compounds and gases which have been discussed previously, and which may be encountered, their names and formulas, their CAS number, and briefly describes possible known short term and long term health effects which may result from excessive exposure.

Name of Compound, Formula and CAS Number	On Any Carcinogens List? If So, Which Ones?	Health Effects Resulting From Excessive Exposure	
		Acute (Short Term)	Chronic (Long Term)
Welding Fumes and Components of Welding Fumes			
Welding Fumes (not otherwise classified) CAS No. - none	Yes IARC	May include metallic taste, nausea, tightness of chest, fever, dizziness, dryness or irritation of eyes, nose or throat	Excessive levels may cause bronchial asthma, lung fibrosis, pneumoconiosis or siderosis.
Hexavalent Chromium (Cr VI) Sodium Chromate Na ₂ CrO ₃ (soluble) CAS No. 7775-11-3 Potassium Chromate K ₂ CrO ₃ (soluble) CAS No. 7789-00-6	Yes IARC group 1 NTP-K OSHA	Inhalation and Skin Contact: Irritation of mucous membranes	Inhalation: Perforation of the nasal septum. Increased incidence of lung cancer. Skin Contact: Skin ulceration, dermatitis.
Chromium Metal-Cr CAS No. 7740-47-3 Chromium oxide (Cr II) CrO CAS No. 12018-00-7 Chromium oxide (Cr III) Cr ₂ O ₃	Yes IARC group 3	Skin Contact: Allergic reactions (dermatitis) in some people.	None known.
Nickel-Ni CAS No. 7440-02-0 Nickel oxide-NiO CAS No. 1313-99-1	Yes IARC group 1 NTP-K	Inhalation: Respiratory irritation. Allergic reactions in some people. Metallic taste, nausea, tightness in chest, metal fume fever. Skin Contact: Contact dermatitis with permanent sensitization.	Inhalation: Chronic pulmonary irritation. Perforation of nasal septum. Increased incidence of lung and larynx cancer.
Cobalt-Co CAS No. 7440-48-4 Cobalt Oxide - CoO CAS no. 1307-96-6	No	Inhalation: Pulmonary irritant, sensitization, cough. Eye Contact: Irritation, conjunctivitis Skin: Mild irritation sensitization, allergic dermatitis. Ingestion: Pain, nausea, vomiting, hypotension (low blood pressure).	Chronic exposure to cobalt is more dangerous than isolated exposures. Possible lung fibrosis and respiratory hypersensitivity. Heart disease, elevated red blood cell counts, chest pain and edema.
Copper-Cu CAS No. 7440-50-8 Copper oxide-CuO CAS No. 1317-38-0	No	Inhalation: Metal fume fever, muscle ache, respiratory irritant. Skin: Irritation, Ingestion: Nausea, vomiting, abdominal pain; large doses may cause stomach and intestine ulceration, and kidney and liver damage.	Mild dermatitis and degeneration of mucous membranes. Repeated inhalation can cause chrome respiratory disease.

Table 5 Health Hazards (continued)

Name of Compound, Formula and CAS Number	On Any Carcinogens List? If So, Which Ones?	Health Effects Resulting From Excessive Exposure	
		Acute (Short Term)	Chronic (Long Term)
Manganese-Mn CAS No. 7439-96-5 Manganese dioxide-as Mn for fume MnO ₂ CAS No. 1313-13-9	No	Can include metal fume fever, dry throat, coughing, tight chest, low back pain, vomiting, fatigue, headache	"Manganism." SENSITIVITY VARIES. Affects central nervous system. Muscular weakness, tremors, symptoms similar to Parkinson=s disease. Exposed employees should get quarterly medical examinations for manganism.
Vanadium Pentoxide (V ₂ O ₅)	No	Irritant to mucous membranes. Metallic taste, cough, throat and eye irritation, eczema.	Nasal catarrh, nose bleeds, chronic respiratory problems.
Iron-Fe CAS No. 7439-89-6 Iron Oxide-FeO CAS No. 1345-25-1 Iron Oxide-Fe ₂ O ₃ CAS No. 1309-37-1 Iron Oxide-Fe ₃ O ₄ CAS No. 1309-38-2	No	Probably none, except as nuisance dust.	Possible siderosis if exposures are excessive and long term. Regarded as benign. Lungs clear gradually after exposure is ended.
Calcium Fluoride CaF ₂ (Insoluble) CAS No. 7789-75-5 Sodium fluoride NaF fume (Soluble) CAS No. 7681-49-4 Potassium fluoride KF (Soluble) CAS No. 7789-23-3 Aluminum Fluoride AlF ₃ (Insoluble) CAS No. 7784-18-1 Lithium Fluoride LiF (Slightly soluble) CAS No. 7789-24-4	No	CaF ₂ probably inert. Soluble fluorides may be irritants and corrosive to mucous membranes.	Soluble portions may cause osteoporosis and mottling of teeth, but effects seem reduced in the presence of iron as found in welding electrode fumes.
Gases Generated by Arc Welding processes			
Fluorides: i.e., Silicon Tetrafluoride SiF ₄ CAS No. 7783-61-1 Hydrogen fluoride HF CAS No. 7664-39-3		See soluble fluorides portion under Welding Fumes	
Nitric oxide-NO CAS No. 10102-43-2	No	Irritant to mucous membranes, drowsiness.	Chronic respiratory disease.
Nitrogen dioxide-NO ₂ CAS No. 10102-44-2	No	Irritant to mucous membranes, coughing, chest pain, pulmonary edema.	Chronic respiratory disease.

Table 5 Health Hazards (continued)

Name of Compound, Formula and CAS Number	On Any Carcinogens List? If So, Which Ones?	Health Effects Resulting From Excessive Exposure	
		Acute (Short Term)	Chronic (Long Term)
Ozone-O ₃ CAS No. 10028-15-6	No	Irritant to mucous membranes, pulmonary edema.	Chronic respiratory disease.
Carbon monoxide-CO CAS No. 630-08-0	No	Headache, rapid breathing, oxygen deprivation, confusion, dizziness, weakness.	Oxygen deprivation.
Argon-A CAS No. 7440-37-1 Carbon dioxide-CO ₂ CAS No. 124-38-9 Helium-HE CAS No. 7440-59-7 Nitrogen-N	No	Inert gases which may replace air and deprive the body of oxygen. (CO ₂ is not inert but effect is as above).	None known

Table 6

Welding Fumes and Gases Information

PRODUCTS	FUMES EXPECTED	GASES EXPECTED
Bare Wire Products used in Gas Metal Arc Welding (all alloys listed in Table 1)	Complex oxide combinations of all elements present in the welding wire grade listed in Table 1 (including trivalent, and hexavalent chromium) The exposure limit for hazardous constituents in welding fumes is listed in Table 4	Normally low. Ozone and oxides of nitrogen generation possible at welding arc or well away from arc. Inert shielding gases can cause asphyxiation in confined welding spaces and unventilated areas.
Bare Wire Products used in Gas Tungsten Arc Welding, plasma arc welding and other similar processes (all alloys listed in Table 1)	Same as above, however, fume volume is very small under normal GTAW conditions	Same as above
All Shielded Metal Arc Welding electrode alloys listed in Table 3	Complex oxide and fluoride combinations of all electrode ingredients listed in Table 3	Normally low, if any symptoms indicate the need, check for gaseous fluorides and/or oxides of nitrogen See Health Hazard Data given in Table 5 for symptoms.
Bare Wire Products used in Submerged Arc Welding (some alloys listed in Table 1)	Same as above, however, fume volume is very small under normal SAW conditions	Same as above
<p>Other conditions which also influence the composition and quantity of the fume and gases to which employees may be exposed include:</p> <ul style="list-style-type: none"> (1) coatings on the metal being welded (such as paint, plating, galvanizing) (2) the number of welders and volume of the work space (3) the quality and amount of ventilation (4) position of the welder=s head relative to the fume plume, and (5) presence of contamination in the atmosphere (such as chlorinated hydrocarbon vapors from cleaning and degreasing). 		

LABEL INFORMATION

Welding Products and Thermal Spray Wire

Notice: The following hazard statements and precautionary statements apply only to the metal fume and dust created during welding and thermal spray operations.

HAZARD STATEMENTS:

May cause cancer by inhalation.
May cause an allergic skin reaction.
Causes skin irritation.
Harmful if inhaled.
Harmful if swallowed

PRECAUTIONARY STATEMENTS:

Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Avoid breathing dust or fume.
Do not eat, drink or smoke when using this product.
Use only outdoors or in a well-ventilated area.
In case of inadequate ventilation, wear respiratory protection.
Wear protective gloves, protective clothing, eye, and face protection
Contaminated work clothing should not be allowed out of the workplace.
If exposed or concerned, get medical advice/attention.
Refer to special instructions; Safety Data Sheet.



Signal Word: DANGER



NOTICE: PROTECT yourself and others. Be sure this label is read and understood by the welder (end user). FUMES AND GASES can be hazardous to your health. ARC RAYS can injure eyes and burn skin. ELECTRIC SHOCK can KILL.

- o Before use, read and understand the manufacturer's instructions, the Safety Data Sheet and your employer's safety practices.
- o Keep your head out of fumes.
- o Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from breathing zone and the general area.
- o Special care should be taken when welding galvanized, plated, or painted parts to avoid exposure to toxic fumes.
- o Wear correct eye, ear, and body protection. Wear welder's gloves when inserting the electrode into the holder. Do not touch any unprotected part of your body.
- o Do not touch live electric parts.
- o Use of thermal spray wire will create similar hazards described for welding products, and may also create high noise levels.
- o See American National Standard ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*, published by the American Welding Society, 550 Northwest LaJeune Road, Miami, Florida 33126. United States (U.S.) Occupational Safety and Health Administration (OSHA) *Safety and Health Standards* are published by the U.S. Government Printing Office, 732 North Capitol Street, Washington, D.C. 20401.

NOTICE: This product and fumes generated from the normal use of this product contain Manganese. The inhalation of welding rod fumes containing Manganese has been associated with the development of serious Parkinson's Disease-like symptoms, Parkinsonism, Manganism, and other central nervous system conditions. Such symptoms may include impaired speech, balance and movement. Avoid breathing fumes generated in the welding process by utilizing appropriate environmental controls, including but not limited to ventilation, exhaust, and respirators.

NOTICE: Read and understand the warning label, affixed to this package and the Safety Data Sheet for this product before using. The following chemicals and their oxides may be hazardous during welding: manganese, silicon dioxide, iron oxide, cobalt, hexavalent chromium, molybdenum, nickel, vanadium, and tungsten. Lung damage, nervous system damage and allergic skin reaction may result from overexposure. The U.S. OSHA considers hexavalent chromium and nickel compounds as carcinogens.

NOTICE: SPECIAL VENTILATION AND/OR EXHAUST REQUIRED: Use industrial hygiene monitoring to ensure that use of this material will not exceed the applicable OSHA Permissible Exposure Limit (PEL), Threshold Limit Value® (TLV®) and equivalent exposure limits. The TLV® for manganese (0.02 mg/m³), cobalt (0.02 mg/m³), and PEL for hexavalent chromium (0.005 mg/m³) may be exceeded during welding. Use enough ventilation, local exhaust and respirators to keep the worker's breathing zone and general area below the TLV® for exposure to manganese.

LABEL INFORMATION

Welding Products and Thermal Spray Wire

NOTICE: This product contains or produces a chemical known to the State of-California to cause cancer and birth defects (or other reproductive harm). (California Health & Safety Code Section 25249.5 et seq.).

FIRST AID_(The following instructions apply only to welding dust and fume forms of the product)

Inhalation: Breathing difficulty caused by inhalation of dust or fume requires removal to fresh air and keep the person comfortable. If breathing has stopped, perform artificial respiration and obtain medical assistance if exposed or concerned.

Ingestion: If swallowed, rinse mouth, but never give anything by mouth to an unconscious person. Contact a poison control center. Unless the poison control center advises otherwise, have that conscious person slowly drink 1 to 2 glasses of water to dilute, inducement of vomiting is not necessary. Obtain medical assistance if you feel unwell.

Skin: Remove contaminated clothing. Do not shake clothing. Wash clothing before reuse. Skin contamination with dust or fume can be removed by washing with soap and water. If skin irritation or rash occurs, call a poison center. Get medical advice/attention.

Eyes: Do not allow victim to rub or keep eyes tightly shut. Dust or fume should be flushed from the eyes with copious amounts of clean water, until transported to an emergency medical facility. Consult a physician at once.

Typical Welding Fume Constituents:

Sodium Dichromate	Potassium Dichromate	Nickel (Ni)	Cobalt (Co)	Manganese
CAS No. 10588-01-9	CAS No. 7778-50-9	CAS No 7440-02-0.	CAS NO. 7440-48-4	CAS No.7439-96-5

Conditioning Information

All welding electrodes should be stored in a dry rod oven after the canister has been opened. It is recommended that the dry rod oven be maintained at about 250 to 400°F (121 to 204°C). The HASTELLOY B-2 and B-3 alloys coating formulation are considered a low moisture formulation and therefore it is mandatory that those electrodes be carefully controlled. If electrodes are exposed to an uncontrolled atmosphere, they can be reconditioned by heating in a reconditioning oven at 600 to 700°F (316 to 371°C) for 2 to 3 hours.

HAYNES
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