

# SAFETY DATA SHEET

## 1. PRODUCT AND COMPANY IDENTIFICATION

**Product Name:** PRIMALLOY® JS-312

**Product Size:** 5.0 mm

**Other means of identification**

**SDS number:** 200000015236

**Recommended use and restriction on use**

**Recommended use:** SMAW (Shielded Metal Arc Welding)

**Restrictions on use:** Not known. Read this SDS before using this product.

**Manufacturer/Importer/Supplier/Distributor Information**

**Company Name:** The Shanghai Lincoln Electric Co., Ltd.

**Address:** No. 195, Lane 5008, Hu Tai Road

Shanghai 201907

China

**Telephone:** +86 21 6673 4530

**Contact Person:** Safety Data Sheet Questions: [www.lincolnelectric.com/sds](http://www.lincolnelectric.com/sds)

Arc Welding Safety Information: [www.lincolnelectric.com/safety](http://www.lincolnelectric.com/safety)

**Emergency telephone number:**

USA/Canada/Mexico +1 (888) 609-1762

Americas/Europe +1 (216) 383-8962

Asia Pacific +1 (216) 383-8966

Middle East/Africa +1 (216) 383-8969

**3E Company Access Code:** 333988

## 2. HAZARDS IDENTIFICATION

Classified according to the criteria of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS), The United States Occupational Safety and Health Administration's Hazard Communication Standard (29 CFR 1910.1200), Canada's Hazardous Product Regulations and Mexico's Harmonized System for the Identification and Communication of Hazards and Risks from Hazardous Chemicals in the Workplace.

**Hazard Classification** Not classified as hazardous according to applicable GHS hazard classification criteria.

**Label Elements**

**Hazard Symbol:** No symbol

**Signal Word:** No signal word.

**Hazard Statement:** Not applicable

**Precautionary Statements:** Not applicable

**Other hazards which do not result in GHS classification:**

Electrical Shock can kill. If welding must be performed in damp locations or with wet clothing, on metal structures or when in cramped positions such as sitting, kneeling or lying, or if there is a high risk of unavoidable or accidental contact with work piece, use the following equipment: Semiautomatic DC Welder, DC Manual (Stick) Welder, or AC Welder with Reduced Voltage Control.

Arc rays can injure eyes and burn skin. Welding arc and sparks can ignite combustibles and flammable materials. Overexposure to welding fumes and gases can be hazardous. Read and understand the manufacturer's instructions, Safety Data Sheets and the precautionary labels before using this product. Refer to Section 8.

**Substance(s) formed under the conditions of use:**

The welding fume produced from this welding electrode may contain the following constituent(s) and/or their complex metallic oxides as well as solid particles or other constituents from the consumables, base metal, or base metal coating not listed below.

| Chemical Identity | CAS-No.    |
|-------------------|------------|
| Carbon dioxide    | 124-38-9   |
| Carbon monoxide   | 630-08-0   |
| Nitrogen dioxide  | 10102-44-0 |
| Ozone             | 10028-15-6 |
| Manganese         | 7439-96-5  |
| Chromium (VI)     | 18540-29-9 |
| Nickel            | 7440-02-0  |
| Chromium oxide    | 1308-38-9  |
| Fluorides (as F)  | 16984-48-8 |

**3. COMPOSITION / INFORMATION ON INGREDIENTS**
**Reportable Hazardous Ingredients  
Mixtures**

| Chemical Identity                                 | CAS number | Content in percent (%)* |
|---|------------|-------------------------|
| Iron  | 7439-89-6  | 20 - <50%               |
| Chromium and chromium alloys or compounds (as Cr) | 7440-47-3  | 20 - <50%               |
| Titanium dioxide                                  | 13463-67-7 | 10 - <20%               |
| Nickel  | 7440-02-0  | 5 - <10%                |
| Limestone   | 1317-65-3  | 5 - <10%                |
| Manganese   | 7439-96-5  | 1 - <5%                 |
| Calcium fluoride                                  | 7789-75-5  | 1 - <5%                 |
| Feldspar  | 68476-25-5 | 1 - <5%                 |
| Sodium silicate                                   | 1344-09-8  | 1 - <5%                 |
| Potassium hydroxide                               | 1310-58-3  | 0.1 - <1%               |
| Silicon   | 7440-21-3  | 0.1 - <1%               |
| Bentonite   | 1302-78-9  | 0.1 - <1%               |
| Titanium  | 7440-32-6  | 0.1 - <1%               |
| Potassium oxide                                   | 12136-45-7 | 0.1 - <1%               |
| Quartz  | 14808-60-7 | 0.1 - <1%               |

|   |           |           |
|---|-----------|-----------|
| Aluminum and/or aluminum alloys (as Al)           | 7429-90-5 | 0.1 - <1% |
| Molybdenum  | 7439-98-7 | 0.1 - <1% |
| Vanadium alloys (as V)                            | 7440-62-2 | 0.1 - <1% |
| Silicon dioxide (amorphous)                       | 7631-86-9 | 0.1 - <1% |
| Niobium   | 7440-03-1 | 0.1 - <1% |
| Tantalum  | 7440-25-7 | 0.1 - <1% |
| Copper and/or copper alloys and compounds (as Cu) | 7440-50-8 | 0.1 - <1% |
| Magnesite   | 546-93-0  | 0.1 - <1% |
| Potassium carbonate                               | 584-08-7  | 0.1 - <1% |
| Iron oxide  | 1309-37-1 | 0.1 - <1% |
| Aluminum oxide                                    | 1344-28-1 | 0.1 - <1% |
| Sodium alginate                                   | 9005-38-3 | 0.1 - <1% |
| Zirconium oxide                                   | 1314-23-4 | 0.1 - <1% |
| Cobalt and compounds (as Co)                      | 7440-48-4 | 0.1 - <1% |

\* All concentrations are percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.

**Composition Comments:**

The term "Hazardous Ingredients" should be interpreted as a term defined in Hazard Communication standards and does not necessarily imply the existence of a welding hazard. The product may contain additional non-hazardous ingredients or may form additional compounds under the condition of use. Refer to Sections 2 and 8 for more information.

**4. FIRST AID MEASURES**
**Ingestion:**

Avoid hand, clothing, food, and drink contact with fluxes, metal fume or powder which can cause ingestion of particulate during hand to mouth activities such as drinking, eating, smoking, etc. If ingested, do not induce vomiting. Contact a poison control center. Unless the poison control center advises otherwise, wash out mouth thoroughly with water. If symptoms develop, seek medical attention at once.

**Inhalation:**

Move to fresh air if breathing is difficult. If breathing has stopped, perform artificial respiration and obtain medical assistance at once.

**Skin Contact:**

Remove contaminated clothing and wash the skin thoroughly with soap and water. For reddened or blistered skin, or thermal burns, obtain medical assistance at once.

**Eye contact:**

Dust or fume from this product should be flushed from the eyes with copious amounts of clean, tepid water until transported to an emergency medical facility. Do not allow victim to rub or keep eyes tightly closed. Obtain medical assistance at once.

Arc rays can injure eyes. If exposed to arc rays, move victim to dark room, remove contact lenses as necessary for treatment, cover eyes with a padded dressing and rest. Obtain medical assistance if symptoms persist.

**Most important symptoms/effects, acute and delayed**
**Symptoms:**

Short-term (acute) overexposure to fumes and gases from welding and allied processes may result in discomfort such as metal fume fever, dizziness, nausea, or dryness or irritation of nose, throat, or eyes. May aggravate pre-existing respiratory problems (e.g. asthma, emphysema). Long-term (chronic) overexposure to fumes and gases from welding and

allied processes can lead to siderosis (iron deposits in lung), central nervous system effects, bronchitis and other pulmonary effects. Refer to Section 11 for more information.

**Hazards:**

The hazards associated with welding and its allied processes such as soldering and brazing are complex and may include physical and health hazards such as but not limited to electric shock, physical strains, radiation burns (eye flash), thermal burns due to hot metal or spatter and potential health effects of overexposure to fumes, gases or dusts potentially generated during the use of this product. Refer to Section 11 for more information.

**Indication of immediate medical attention and special treatment needed**

**Treatment:** Treat symptomatically.

**5. FIRE-FIGHTING MEASURES**
**General Fire Hazards:**

As shipped, this product is nonflammable. However, welding arc and sparks as well as open flames and hot surfaces associated with brazing and soldering can ignite combustible and flammable materials. Read and understand American National Standard Z49.1, "Safety in Welding, Cutting and Allied Processes" and National Fire Protection Association NFPA 51B, "Standard for Fire Prevention during Welding, Cutting and Other Hot Work" before using this product.

**Suitable (and unsuitable) extinguishing media**

**Suitable extinguishing media:** As shipped, the product will not burn. In case of fire in the surroundings: use appropriate extinguishing agent.

**Unsuitable extinguishing media:** Do not use water jet as an extinguisher, as this will spread the fire.

**Specific hazards arising from the chemical:** Welding arc and sparks can ignite combustibles and flammable products.

**Special protective equipment and precautions for firefighters**

**Special fire fighting procedures:** Use standard firefighting procedures and consider the hazards of other involved materials.

**Special protective equipment for fire-fighters:** Selection of respiratory protection for fire fighting: follow the general fire precautions indicated in the workplace. Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

**6. ACCIDENTAL RELEASE MEASURES**

**Personal precautions, protective equipment and emergency procedures:** If airborne dust and/or fume is present, use adequate engineering controls and, if needed, personal protection to prevent overexposure. Refer to recommendations in Section 8.

**Methods and material for containment and cleaning up:** Absorb with sand or other inert absorbent. Stop the flow of material, if this is without risk. Clean up spills immediately, observing precautions in the personal protective equipment in Section 8. Avoid generating dust. Prevent product from entering any drains, sewers or water sources. Refer to Section 13 for proper disposal.

**Environmental Precautions:** Avoid release to the environment. Prevent further leakage or spillage if safe to do so. Do not contaminate water sources or sewer. Environmental manager must be informed of all major spillages.

## 7. HANDLING AND STORAGE

**Precautions for safe handling:** Prevent formation of dust. Provide appropriate exhaust ventilation at places where dust is formed.

Read and understand the manufacturer's instruction and the precautionary label on the product. Refer to Lincoln Safety Publications at [www.lincolnelectric.com/safety](http://www.lincolnelectric.com/safety). See American National Standard Z49.1, "Safety In Welding, Cutting and Allied Processes" published by the American Welding Society, <http://pubs.aws.org> and OSHA Publication 2206 (29CFR1910), U.S. Government Printing Office, [www.gpo.gov](http://www.gpo.gov).

**Conditions for safe storage, including any incompatibilities:** Store in closed original container in a dry place. Store in accordance with local/regional/national regulations. Store away from incompatible materials.

## 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

### Control Parameters

#### Occupational Exposure Limits: US

| Chemical Identity  | Type    | Exposure Limit Values | Source  |
|--|---------|-----------------------|---|
| Chromium and chromium alloys or compounds (as Cr) - as Cr                          | PEL     | 1 mg/m3               | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
|  | REL     | 0.5 mg/m3             | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
| Chromium and chromium alloys or compounds (as Cr) - Inhalable fraction. - as Cr(0) | TWA     | 0.5 mg/m3             | US. ACGIH Threshold Limit Values, as amended (03 2018)                      |
| Chromium and chromium alloys or compounds (as Cr)                                  | IDLH    | 250 mg/m3             | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Titanium dioxide   | TWA     | 10 mg/m3              | US. ACGIH Threshold Limit Values, as amended (12 2010)                      |
| Titanium dioxide - Total dust.   | PEL     | 15 mg/m3              | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Titanium dioxide   | IDLH    | 5,000 mg/m3           | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Nickel - Inhalable fraction.   | TWA     | 1.5 mg/m3             | US. ACGIH Threshold Limit Values, as amended (12 2010)                      |
| Nickel - as Ni   | REL     | 0.015 mg/m3           | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
| Nickel   | IDLH    | 10 mg/m3              | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Nickel - as Ni   | PEL     | 1 mg/m3               | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Limestone - Total dust.  | PEL     | 15 mg/m3              | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Limestone - Respirable fraction.   | PEL     | 5 mg/m3               | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Limestone - Respirable.  | REL     | 5 mg/m3               | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
| Limestone - Total  | REL     | 10 mg/m3              | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
| Manganese - Fume. - as Mn  | Ceiling | 5 mg/m3               | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
|  | REL     | 1 mg/m3               | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
|  | STEL    | 3 mg/m3               | US. NIOSH: Pocket Guide to Chemical   |

|  |           |   | Hazards, as amended (2005)   |
|--|-----------|---|--|
| Manganese - Inhalable fraction. - as Mn  | TWA       | 0.1 mg/m3                                       | US. ACGIH Threshold Limit Values, as amended (03 2014)                       |
| Manganese - Respirable fraction. - as Mn   | TWA       | 0.02 mg/m3                                      | US. ACGIH Threshold Limit Values, as amended (03 2014)                       |
| Manganese  | IDLH      | 500 mg/m3                                       | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
| Calcium fluoride - as F  | TWA       | 2.5 mg/m3                                       | US. ACGIH Threshold Limit Values, as amended (12 2010)                       |
| Calcium fluoride   | IDLH      | 250 mg/m3                                       | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
|  | IDLH      | 250 mg/m3                                       | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
| Calcium fluoride - as F  | PEL       | 2.5 mg/m3                                       | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006)  |
| Calcium fluoride - Dust.   | TWA       | 2.5 mg/m3                                       | US. OSHA Table Z-2 (29 CFR 1910.1000) (02 2006)                              |
| Potassium hydroxide  | Ceiling   | 2 mg/m3   | US. ACGIH Threshold Limit Values, as amended (12 2010)                       |
|  | Ceil_Time | 2 mg/m3   | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2016)               |
| Silicon - Total dust.  | PEL       | 15 mg/m3  | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006)  |
| Silicon - Respirable fraction.   | PEL       | 5 mg/m3   | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006)  |
| Silicon - Respirable.  | REL       | 5 mg/m3   | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
| Silicon - Total  | REL       | 10 mg/m3  | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
| Quartz - Respirable fraction.  | TWA       | 0.025 mg/m3                                     | US. ACGIH Threshold Limit Values, as amended (12 2010)                       |
| Quartz - Respirable.   | TWA       | 2.4 millions of particles per cubic foot of air | US. OSHA Table Z-3 (29 CFR 1910.1000) (2000)                                 |
|  | TWA       | 0.1 mg/m3                                       | US. OSHA Table Z-3 (29 CFR 1910.1000) (2000)                                 |
| Quartz - Respirable dust.  | REL       | 0.05 mg/m3                                      | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
| Quartz - Respirable dust.  | TWA       | 0.05 mg/m3                                      | US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050) (03 2016) |
|  | OSHA_ACT  | 0.025 mg/m3                                     | US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050) (03 2016) |
| Quartz - Respirable dust.  | PEL       | 0.05 mg/m3                                      | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (03 2016)  |
| Quartz   | IDLH      | 50 mg/m3  | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
| Aluminum and/or aluminum alloys (as Al) - Respirable fraction.                       | TWA       | 1 mg/m3   | US. ACGIH Threshold Limit Values, as amended (12 2010)                       |
| Aluminum and/or aluminum alloys (as Al) - Total dust. - as Al                        | PEL       | 15 mg/m3  | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006)  |
| Aluminum and/or aluminum alloys (as Al) - Welding fume or pyrophoric powder. - as Al | REL       | 5 mg/m3   | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
| Aluminum and/or aluminum alloys (as Al) - Respirable.                                | REL       | 5 mg/m3   | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
| Aluminum and/or aluminum alloys (as Al) - Total                                      | REL       | 10 mg/m3  | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
| Aluminum and/or aluminum alloys (as Al) - Respirable fraction. - as Al               | PEL       | 5 mg/m3   | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (03 2016)  |
| Molybdenum - Total dust. - as Mo   | PEL       | 15 mg/m3  | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02        |

|  |      |  |   |
|--|------|--|---|
|  |      |  | 2006)   |
| Molybdenum - Inhalable fraction. - as Mo                                   | TWA  | 10 mg/m3                                       | US. ACGIH Threshold Limit Values, as amended (03 2014)                      |
| Molybdenum - Respirable fraction. - as Mo                                  | TWA  | 3 mg/m3  | US. ACGIH Threshold Limit Values, as amended (03 2014)                      |
| Molybdenum   | IDLH | 5,000 mg/m3                                    | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Silicon dioxide (amorphous)  | TWA  | 20 millions of particles per cubic foot of air | US. OSHA Table Z-3 (29 CFR 1910.1000) (2000)                                |
|  | TWA  | 0.8 mg/m3                                      | US. OSHA Table Z-3 (29 CFR 1910.1000) (2000)                                |
|  | REL  | 6 mg/m3  | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
|  | IDLH | 3,000 mg/m3                                    | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Tantalum - Dust.   | PEL  | 5 mg/m3  | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Tantalum - Dust. - as Ta   | REL  | 5 mg/m3  | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
|  | STEL | 10 mg/m3                                       | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
| Tantalum   | IDLH | 2,500 mg/m3                                    | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Copper and/or copper alloys and compounds (as Cu) - Dust and mist. - as Cu | TWA  | 1 mg/m3  | US. ACGIH Threshold Limit Values, as amended (03 2014)                      |
| Copper and/or copper alloys and compounds (as Cu) - Fume. - as Cu          | TWA  | 0.2 mg/m3                                      | US. ACGIH Threshold Limit Values, as amended (03 2014)                      |
|  | REL  | 0.1 mg/m3                                      | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2016)              |
| Copper and/or copper alloys and compounds (as Cu) - Dust and mist. - as Cu | REL  | 1 mg/m3  | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2016)              |
| Copper and/or copper alloys and compounds (as Cu) - Fume. - as Cu          | PEL  | 0.1 mg/m3                                      | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Copper and/or copper alloys and compounds (as Cu) - Dust and mist. - as Cu | PEL  | 1 mg/m3  | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Copper and/or copper alloys and compounds (as Cu)                          | IDLH | 100 mg/m3                                      | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Magnesite - Total  | REL  | 10 mg/m3                                       | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
| Magnesite - Respirable.  | REL  | 5 mg/m3  | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
| Magnesite - Total dust.  | PEL  | 15 mg/m3                                       | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Magnesite - Respirable fraction.   | PEL  | 5 mg/m3  | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Iron oxide - Respirable fraction.  | TWA  | 5 mg/m3  | US. ACGIH Threshold Limit Values, as amended (12 2010)                      |
| Iron oxide - Fume.   | PEL  | 10 mg/m3                                       | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Iron oxide - Dust and fume. - as Fe  | REL  | 5 mg/m3  | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
| Iron oxide   | IDLH | 2,500 mg/m3                                    | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Aluminum oxide - Respirable fraction.                                      | TWA  | 1 mg/m3  | US. ACGIH Threshold Limit Values, as amended (12 2010)                      |
|  | PEL  | 5 mg/m3  | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Aluminum oxide - Total dust.   | PEL  | 15 mg/m3                                       | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |



|   |      |  |   |
|---|------|--|---|
|   |      |  | 2006)   |
| Aluminum oxide - Respirable fraction.                 | TWA  | 15 millions of particles per cubic foot of air | US. OSHA Table Z-3 (29 CFR 1910.1000) (03 2016)                             |
|   | TWA  | 5 mg/m3  | US. OSHA Table Z-3 (29 CFR 1910.1000) (03 2016)                             |
| Aluminum oxide - Total dust.                          | TWA  | 15 mg/m3                                       | US. OSHA Table Z-3 (29 CFR 1910.1000) (03 2016)                             |
|   | TWA  | 50 millions of particles per cubic foot of air | US. OSHA Table Z-3 (29 CFR 1910.1000) (03 2016)                             |
| Zirconium oxide - as Zr                               | STEL | 10 mg/m3                                       | US. ACGIH Threshold Limit Values, as amended (12 2010)                      |
|   | TWA  | 5 mg/m3  | US. ACGIH Threshold Limit Values, as amended (12 2010)                      |
|   | REL  | 5 mg/m3  | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
|   | STEL | 10 mg/m3                                       | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
|   | PEL  | 5 mg/m3  | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Zirconium oxide                                       | IDLH | 25 mg/m3                                       | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Cobalt and compounds (as Co) - as Co                  | TWA  | 0.02 mg/m3                                     | US. ACGIH Threshold Limit Values, as amended (12 2010)                      |
| Cobalt and compounds (as Co) - Dust and fume. - as Co | REL  | 0.05 mg/m3                                     | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
|   | PEL  | 0.1 mg/m3                                      | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Cobalt and compounds (as Co)                          | IDLH | 20 mg/m3                                       | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |

### Occupational Exposure Limits: Canada

| Chemical Identity  | Type       | Exposure Limit Values | Source  |
|--|------------|-----------------------|---|
| Chromium and chromium alloys or compounds (as Cr) - as Cr                          | TWA        | 0.5 mg/m3             | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|  | TWA        | 0.5 mg/m3             | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|  | 8 HR ACL   | 0.5 mg/m3             | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | 15 MIN ACL | 1.5 mg/m3             | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Chromium and chromium alloys or compounds (as Cr)                                  | TWA        | 0.5 mg/m3             | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Chromium and chromium alloys or compounds (as Cr) - Inhalable fraction. - as Cr(0) | TWA        | 0.5 mg/m3             | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2018)  |
| Chromium and chromium alloys or compounds (as Cr) - Total                          | TWA        | 0.5 mg/m3             | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018) |
| Titanium dioxide   | TWA        | 10 mg/m3              | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Titanium dioxide - Total dust.   | TWA        | 10 mg/m3              | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |



|   |            |            |   |
|---|------------|------------|---|
| Titanium dioxide - Respirable fraction. | TWA        | 3 mg/m3    | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Titanium dioxide                        | TWA        | 10 mg/m3   | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|   | TWA        | 10 mg/m3   | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|   | 8 HR ACL   | 10 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | 15 MIN ACL | 20 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Titanium dioxide - Total dust.          | TWA        | 10 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Nickel                                  | TWA        | 1.5 mg/m3  | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Nickel - as Ni                          | TWA        | 0.05 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018) |
| Nickel - Inhalable fraction.            | TWA        | 1.5 mg/m3  | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
| Nickel - Inhalable fraction. - as Ni    | TWA        | 1 mg/m3    | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (06 2015)  |
|   | 8 HR ACL   | 1.5 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | 15 MIN ACL | 3 mg/m3    | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Nickel                                  | TWA        | 1 mg/m3    | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Limestone                               | TWA        | 10 mg/m3   | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Limestone - Total dust.                 | STEL       | 20 mg/m3   | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|   | TWA        | 10 mg/m3   | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Limestone - Respirable fraction.        | TWA        | 3 mg/m3    | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Limestone                               | 8 HR ACL   | 10 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | 15 MIN ACL | 20 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as  |

|  |            |            |   |
|--|------------|------------|---|
|  |            |            | amended (05 2009)   |
| Limestone - Total dust.                  | TWA        | 10 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Manganese - as Mn                        | TWA        | 0.2 mg/m3  | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|  | 8 HR ACL   | 0.2 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | 15 MIN ACL | 0.6 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Manganese - Respirable fraction. - as Mn | TWA        | 0.02 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
| Manganese - Inhalable fraction. - as Mn  | TWA        | 0.1 mg/m3  | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
| Manganese - as Mn                        | TWA        | 0.2 mg/m3  | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (06 2015)  |
| Manganese - Fume, total dust. - as Mn    | TWA        | 0.2 mg/m3  | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Manganese - Respirable. - as Mn          | TWA        | 0.02 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018) |
| Manganese - Total - as Mn                | TWA        | 0.2 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018) |
| Calcium fluoride - as F                  | TWA        | 2.5 mg/m3  | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|  | TWA        | 2.5 mg/m3  | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|  | TWA        | 2.5 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|  | TWA        | 2.5 mg/m3  | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|  | TWA        | 2.5 mg/m3  | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|  | 8 HR ACL   | 2.5 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | 15 MIN ACL | 5 mg/m3    | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | TWA        | 2.5 mg/m3  | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Potassium hydroxide                      | CEILING    | 2 mg/m3    | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|  | CEILING    | 2 mg/m3    | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational  |

|  |            |             |   |
|--|------------|-------------|---|
|  |            |             | Health and Safety Regulation 296/97, as amended) (07 2007)  |
|  | CEILING    | 2 mg/m3     | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|  | CEV        | 2 mg/m3     | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (07 2010)  |
|  | Ceiling    | 2 mg/m3     | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | CEILING    | 2 mg/m3     | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Silicon - Total dust.  | TWA        | 10 mg/m3    | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (07 2010)  |
| Silicon  | 8 HR ACL   | 10 mg/m3    | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | 15 MIN ACL | 20 mg/m3    | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Silicon - Total dust.  | TWA        | 10 mg/m3    | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Quartz - Respirable particles.                                       | TWA        | 0.025 mg/m3 | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Quartz - Respirable fraction.  | TWA        | 0.025 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|  | TWA        | 0.025 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|  | 8 HR ACL   | 0.05 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | TWA        | 0.10 mg/m3  | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (06 2015)  |
| Quartz - Respirable dust.  | TWA        | 0.1 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Aluminum and/or aluminum alloys (as Al) - Pyrophoric powder. - as Al | TWA        | 5 mg/m3     | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Aluminum and/or aluminum alloys (as Al) - Dust.                      | TWA        | 10 mg/m3    | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Aluminum and/or aluminum alloys (as Al) - Respirable.                | TWA        | 1 mg/m3     | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Aluminum and/or aluminum alloys (as Al) - Respirable fraction.       | TWA        | 1 mg/m3     | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|  | TWA        | 1 mg/m3     | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
| Aluminum and/or aluminum alloys (as Al) - Pyrophoric powder. - as Al | 8 HR ACL   | 5 mg/m3     | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |

|  |            |          |   |
|--|------------|----------|---|
| Aluminum and/or aluminum alloys (as Al) - Dust. - as Al              | 8 HR ACL   | 10 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Aluminum and/or aluminum alloys (as Al) - Pyrophoric powder. - as Al | 15 MIN ACL | 10 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Aluminum and/or aluminum alloys (as Al) - Dust. - as Al              | 15 MIN ACL | 20 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Aluminum and/or aluminum alloys (as Al)                              | TWA        | 10 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Aluminum and/or aluminum alloys (as Al) - as Al                      | TWA        | 5 mg/m3  | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Aluminum and/or aluminum alloys (as Al) - Welding fume. - as Al      | TWA        | 5 mg/m3  | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Molybdenum - Inhalable   | TWA        | 10 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Molybdenum - Respirable.   | TWA        | 3 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Molybdenum - Inhalable fraction. - as Mo                             | TWA        | 10 mg/m3 | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|  | 8 HR ACL   | 10 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Molybdenum - Respirable fraction. - as Mo                            | 8 HR ACL   | 3 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Molybdenum - Inhalable fraction. - as Mo                             | 15 MIN ACL | 20 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Molybdenum - Respirable fraction. - as Mo                            | 15 MIN ACL | 6 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | TWA        | 3 mg/m3  | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
| Molybdenum - Inhalable fraction. - as Mo                             | TWA        | 10 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
| Molybdenum - Respirable fraction. - as Mo                            | TWA        | 3 mg/m3  | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (06 2015)  |
| Molybdenum - as Mo   | TWA        | 10 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Silicon dioxide (amorphous)  | TWA        | 10 mg/m3 | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (07 2010)  |
| Tantalum - Dust. - as Ta   | TWA        | 5 mg/m3  | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Tantalum   | TWA        | 5 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as                    |

|  |               |           |   |
|--|---------------|-----------|---|
|  |               |           | amended) (07 2007)  |
| Tantalum - as Ta   | 15 MIN<br>ACL | 10 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | 8 HR ACL      | 5 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Tantalum - Dust. - as Ta   | TWA           | 5 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Copper and/or copper alloys and compounds (as Cu) - Fume.                  | TWA           | 0.2 mg/m3 | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Copper and/or copper alloys and compounds (as Cu) - Dust and mist. - as Cu | TWA           | 1 mg/m3   | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Copper and/or copper alloys and compounds (as Cu) - Fume. - as Cu          | TWA           | 0.2 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Copper and/or copper alloys and compounds (as Cu) - Dust and mist. - as Cu | TWA           | 1 mg/m3   | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|  | TWA           | 1 mg/m3   | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
| Copper and/or copper alloys and compounds (as Cu) - Fume. - as Cu          | TWA           | 0.2 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
| Copper and/or copper alloys and compounds (as Cu) - Dust and fume. - as Cu | TWA           | 1 mg/m3   | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (06 2015)  |
| Copper and/or copper alloys and compounds (as Cu) - Dust and mist. - as Cu | 8 HR ACL      | 1 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Copper and/or copper alloys and compounds (as Cu) - Fume. - as Cu          | 15 MIN<br>ACL | 0.6 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Copper and/or copper alloys and compounds (as Cu) - Dust and mist. - as Cu | 15 MIN<br>ACL | 3 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Copper and/or copper alloys and compounds (as Cu) - Fume. - as Cu          | 8 HR ACL      | 0.2 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Copper and/or copper alloys and compounds (as Cu) - Dust and mist. - as Cu | TWA           | 1 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Copper and/or copper alloys and compounds (as Cu) - Fume. - as Cu          | TWA           | 0.2 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
|  | TWA           | 0.2 mg/m3 | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (08 2017)  |
| Magnesite - Total dust.  | TWA           | 10 mg/m3  | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (07 2010)  |
| Magnesite  | 8 HR ACL      | 10 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|  | 15 MIN<br>ACL | 20 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety   |

|                                       |            |          |   |
|---------------------------------------|------------|----------|---|
|                                       |            |          | Regulations, 1996, Table 21), as amended (05 2009)  |
| Magnesite - Total dust.               | TWA        | 10 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Iron oxide - Respirable.              | TWA        | 5 mg/m3  | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Iron oxide - Total dust.              | TWA        | 10 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Iron oxide - Dust. - as Fe            | TWA        | 5 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Iron oxide - Fume. - as Fe            | STEL       | 10 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Iron oxide - Respirable fraction.     | TWA        | 3 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Iron oxide - Fume. - as Fe            | TWA        | 5 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Iron oxide - Respirable fraction.     | TWA        | 5 mg/m3  | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|                                       | TWA        | 5 mg/m3  | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
| Iron oxide                            | 8 HR ACL   | 10 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                                       | 15 MIN ACL | 20 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Iron oxide - Dust and fume. - as Fe   | 15 MIN ACL | 10 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                                       | 8 HR ACL   | 5 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Iron oxide - Total dust.              | TWA        | 10 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Iron oxide - Dust and fume. - as Fe   | TWA        | 5 mg/m3  | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Aluminum oxide                        | TWA        | 10 mg/m3 | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Aluminum oxide - Respirable.          | TWA        | 1 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
| Aluminum oxide - Respirable fraction. | TWA        | 3 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational  |



|                                       |            |          |   |
|---------------------------------------|------------|----------|---|
|                                       |            |          | Health and Safety Regulation 296/97, as amended) (05 2013)  |
| Aluminum oxide - Total dust.          | TWA        | 10 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (05 2013) |
| Aluminum oxide - Respirable fraction. | TWA        | 1 mg/m3  | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|                                       | TWA        | 3 mg/m3  | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (06 2015)  |
|                                       | TWA        | 1 mg/m3  | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
| Aluminum oxide - Inhalable fraction.  | TWA        | 10 mg/m3 | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (06 2015)  |
| Aluminum oxide                        | 8 HR ACL   | 10 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                                       | 15 MIN ACL | 20 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Aluminum oxide - Total dust. - as Al  | TWA        | 10 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Zirconium oxide - as Zr               | TWA        | 5 mg/m3  | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                                       | STEL       | 10 mg/m3 | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                                       | STEL       | 10 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                                       | TWA        | 5 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                                       | STEL       | 10 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|                                       | TWA        | 5 mg/m3  | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|                                       | TWA        | 5 mg/m3  | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|                                       | STEL       | 10 mg/m3 | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|                                       | 8 HR ACL   | 5 mg/m3  | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                                       | 15 MIN ACL | 10 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                                       | TWA        | 5 mg/m3  | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
|                                       | STEL       | 10 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational  |



|                                      |            |            |   |
|--------------------------------------|------------|------------|---|
|                                      |            |            | health and safety), as amended (09 2017)  |
| Cobalt and compounds (as Co) - as Co | TWA        | 0.02 mg/m3 | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                                      | TWA        | 0.02 mg/m3 | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                                      | TWA        | 0.02 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|                                      | TWA        | 0.02 mg/m3 | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|                                      | 8 HR ACL   | 0.02 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                                      | 15 MIN ACL | 0.06 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                                      | TWA        | 0.02 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |

#### Occupational Exposure Limits: Mexico

| Chemical Identity                                 | Type    | Exposure Limit Values | Source   |
|---|---------|-----------------------|--|
| Iron - as Fe                                      | VLE-PPT | 1 mg/m3               | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Chromium and chromium alloys or compounds (as Cr) | VLE-PPT | 0.5 mg/m3             | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
|   | VLE-PPT | 0.05 mg/m3            | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
|   | VLE-PPT | 0.01 mg/m3            | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Titanium dioxide                                  | VLE-PPT | 10 mg/m3              | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Nickel - Inhalable fraction. - as Ni              | VLE-PPT | 1.5 mg/m3             | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Manganese - as Mn                                 | VLE-PPT | 0.2 mg/m3             | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Calcium fluoride - as F                           | VLE-PPT | 2.5 mg/m3             | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Potassium hydroxide                               | VLE-P   | 2 mg/m3               | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Quartz - Respirable fraction.                     | VLE-PPT | 0.025 mg/m3           | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |

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| Aluminum and/or aluminum alloys (as Al) - Respirable fraction.             | VLE-PPT | 1 mg/m3    | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Molybdenum - Respirable fraction. - as Mo                                  | VLE-PPT | 0.5 mg/m3  | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Copper and/or copper alloys and compounds (as Cu) - Fume. - as Cu          | VLE-PPT | 0.2 mg/m3  | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Copper and/or copper alloys and compounds (as Cu) - Dust and mist. - as Cu | VLE-PPT | 1 mg/m3    | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Iron oxide - Respirable fraction.  | VLE-PPT | 5 mg/m3    | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Aluminum oxide   | VLE-PPT | 10 mg/m3   | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Zirconium oxide - as Zr  | VLE-PPT | 5 mg/m3    | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
|  | VLE-CT  | 10 mg/m3   | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Cobalt and compounds (as Co) - as Co                                       | VLE-PPT | 0.02 mg/m3 | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |

**Biological Limit Values: US**

| Chemical Identity   | Exposure Limit Values | Source              |
|---|-----------------------|---------------------|
| Calcium fluoride (Fluoride: Sampling time: Prior to shift.)                             | 2 mg/l (Urine)        | ACGIH BEI (03 2013) |
| Calcium fluoride (Fluoride: Sampling time: End of shift.)                               | 3 mg/l (Urine)        | ACGIH BEI (03 2013) |
| Cobalt and compounds (as Co) (Cobalt: Sampling time: End of shift at end of work week.) | 15 µg/l (Urine)       | ACGIH BEI (03 2015) |

**Biological Limit Values: Mexico**

| Chemical Identity   | Exposure Limit Values         | Source           |
|---|-------------------------------|------------------|
| Calcium fluoride (fluorides: Sampling time: Prior to shift.)                            | 3 mg/g (Creatinine in urine)  | MX IBE (06 2012) |
| Calcium fluoride (fluorides: Sampling time: End of shift.)                              | 10 mg/g (Creatinine in urine) | MX IBE (06 2012) |
| Cobalt and compounds (as Co) (Cobalt: Sampling time: End of shift at end of work week.) | 15 µg/l (Urine)               | MX IBE (06 2012) |
|   | 1 µg/l (Blood)                | MX IBE (06 2012) |

**Additional exposure limits under the conditions of use: US**

| Chemical Identity | Type | Exposure Limit Values | Source   |
|-------------------|------|-----------------------|--|
| Carbon dioxide    | TWA  | 5,000 ppm             | US. ACGIH Threshold Limit Values, as amended (12 2010) |
|                   | STEL | 30,000 ppm            | US. ACGIH Threshold Limit Values, as                   |

|  |           |                         |  |
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|  |           |                         | amended (12 2010)  |
|  | PEL       | 5,000 ppm 9,000 mg/m3   | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006)  |
|  | STEL      | 30,000 ppm 54,000 mg/m3 | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
|  | REL       | 5,000 ppm 9,000 mg/m3   | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
|  | IDLH      | 40,000 ppm              | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
| Carbon monoxide                          | TWA       | 25 ppm                  | US. ACGIH Threshold Limit Values, as amended (12 2010)                       |
|  | PEL       | 50 ppm 55 mg/m3         | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006)  |
|  | REL       | 35 ppm 40 mg/m3         | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
|  | Ceil_Time | 200 ppm 229 mg/m3       | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
|  | IDLH      | 1,200 ppm               | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
| Nitrogen dioxide                         | TWA       | 0.2 ppm                 | US. ACGIH Threshold Limit Values, as amended (02 2012)                       |
|  | Ceiling   | 5 ppm 9 mg/m3           | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006)  |
|  | STEL      | 1 ppm 1.8 mg/m3         | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
|  | IDLH      | 20 ppm                  | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
|  | IDLH      | 13 ppm                  | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
| Ozone                                    | PEL       | 0.1 ppm 0.2 mg/m3       | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006)  |
|  | Ceil_Time | 0.1 ppm 0.2 mg/m3       | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
|  | TWA       | 0.05 ppm                | US. ACGIH Threshold Limit Values, as amended (03 2014)                       |
|  | TWA       | 0.20 ppm                | US. ACGIH Threshold Limit Values, as amended (03 2014)                       |
|  | TWA       | 0.10 ppm                | US. ACGIH Threshold Limit Values, as amended (03 2014)                       |
|  | TWA       | 0.08 ppm                | US. ACGIH Threshold Limit Values, as amended (03 2014)                       |
|  | IDLH      | 5 ppm                   | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
| Manganese - Fume. - as Mn                | Ceiling   | 5 mg/m3                 | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006)  |
|  | REL       | 1 mg/m3                 | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
|  | STEL      | 3 mg/m3                 | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)               |
| Manganese - Inhalable fraction. - as Mn  | TWA       | 0.1 mg/m3               | US. ACGIH Threshold Limit Values, as amended (03 2014)                       |
| Manganese - Respirable fraction. - as Mn | TWA       | 0.02 mg/m3              | US. ACGIH Threshold Limit Values, as amended (03 2014)                       |
| Manganese                                | IDLH      | 500 mg/m3               | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)   |
| Chromium (VI)                            | TWA       | 0.005 mg/m3             | US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050) (02 2006) |
|  | OSHA_ACT  | 0.0025 mg/m3            | US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050) (02 2006) |
|  | Ceiling   | 0.1 mg/m3               | US. OSHA Table Z-2 (29 CFR 1910.1000) (02 2006)                              |
| Chromium (VI) - as Cr(VI)                | REL       | 0.0002 mg/m3            | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2016)               |

|   |      |              |   |
|---|------|--------------|---|
| Chromium (VI) - Inhalable fraction. - as Cr(VI)   | TWA  | 0.0002 mg/m3 | US. ACGIH Threshold Limit Values, as amended (03 2018)                      |
|   | TWA  | 0.0002 mg/m3 | US. ACGIH Threshold Limit Values, as amended (03 2018)                      |
|   | STEL | 0.0005 mg/m3 | US. ACGIH Threshold Limit Values, as amended (03 2018)                      |
|   | STEL | 0.0005 mg/m3 | US. ACGIH Threshold Limit Values, as amended (03 2018)                      |
| Chromium (VI)                                     | IDLH | 15 mg/m3     | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (2018)     |
| Nickel - Inhalable fraction.                      | TWA  | 1.5 mg/m3    | US. ACGIH Threshold Limit Values, as amended (12 2010)                      |
| Nickel - as Ni                                    | REL  | 0.015 mg/m3  | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2005)              |
| Nickel  | IDLH | 10 mg/m3     | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Nickel - as Ni                                    | PEL  | 1 mg/m3      | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Chromium oxide - as Cr                            | PEL  | 0.5 mg/m3    | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Chromium oxide - Inhalable fraction. - as Cr(III) | TWA  | 0.003 mg/m3  | US. ACGIH Threshold Limit Values, as amended (03 2018)                      |
| Chromium oxide - as Cr(III)                       | REL  | 0.5 mg/m3    | US. NIOSH: Pocket Guide to Chemical Hazards, as amended (2016)              |
| Chromium oxide                                    | IDLH | 25 mg/m3     | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |
| Fluorides (as F) - as F                           | TWA  | 2.5 mg/m3    | US. ACGIH Threshold Limit Values, as amended (12 2010)                      |
|   | PEL  | 2.5 mg/m3    | US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000) (02 2006) |
| Fluorides (as F) - Dust.                          | TWA  | 2.5 mg/m3    | US. OSHA Table Z-2 (29 CFR 1910.1000) (02 2006)                             |
| Fluorides (as F)                                  | IDLH | 250 mg/m3    | US. NIOSH. Immediately Dangerous to Life or Health (IDLH) Values (10 2017)  |

**Additional exposure limits under the conditions of use: Canada**

| Chemical Identity | Type     | Exposure Limit Values   | Source  |
|-------------------|----------|-------------------------|---|
| Carbon dioxide    | STEL     | 30,000 ppm 54,000 mg/m3 | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                   | TWA      | 5,000 ppm 9,000 mg/m3   | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                   | TWA      | 5,000 ppm               | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                   | STEL     | 15,000 ppm              | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                   | TWA      | 5,000 ppm               | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|                   | STEL     | 30,000 ppm              | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|                   | STEL     | 30,000 ppm              | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|                   | TWA      | 5,000 ppm               | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|                   | 8 HR ACL | 5,000 ppm               | Canada. Saskatchewan OELs   |

|                  |               |                              |   |
|------------------|---------------|------------------------------|---|
|                  |               |                              | (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                  | 15 MIN<br>ACL | 30,000 ppm                   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                  | TWA           | 5,000 ppm      9,000 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
|                  | STEL          | 30,000 ppm      54,000 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Carbon monoxide  | TWA           | 25 ppm      29 mg/m3         | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                  | TWA           | 25 ppm                       | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                  | STEL          | 100 ppm                      | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                  | TWA           | 25 ppm                       | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|                  | TWA           | 25 ppm                       | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (07 2010)  |
|                  | 8 HR ACL      | 25 ppm                       | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                  | 15 MIN<br>ACL | 190 ppm                      | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                  | TWA           | 35 ppm      40 mg/m3         | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
|                  | STEL          | 200 ppm      230 mg/m3       | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Nitrogen dioxide | STEL          | 5 ppm      9.4 mg/m3         | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                  | TWA           | 3 ppm      5.6 mg/m3         | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                  | CEILING       | 1 ppm                        | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                  | TWA           | 0.2 ppm                      | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2012)  |
|                  | STEL          | 5 ppm                        | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|                  | TWA           | 3 ppm                        | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|                  | 8 HR ACL      | 3 ppm                        | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                  | 15 MIN        | 5 ppm                        | Canada. Saskatchewan OELs   |

|                   |            |                   |   |
|-------------------|------------|-------------------|---|
|                   | ACL        |                   | (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                   | TWA        | 3 ppm 5.6 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Ozone             | STEL       | 0.3 ppm 0.6 mg/m3 | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                   | TWA        | 0.1 ppm 0.2 mg/m3 | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                   | TWA        | 0.05 ppm          | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                   | TWA        | 0.1 ppm           | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                   | TWA        | 0.08 ppm          | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                   | TWA        | 0.2 ppm           | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|                   | TWA        | 0.1 ppm 0.2 mg/m3 | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (07 2010)  |
|                   | STEL       | 0.3 ppm 0.6 mg/m3 | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (07 2010)  |
|                   | 15 MIN ACL | 0.15 ppm          | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                   | 8 HR ACL   | 0.05 ppm          | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                   | CEILING    | 0.1 ppm 0.2 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (12 2008)   |
|                   | TWA        | 0.20 ppm          | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
|                   | TWA        | 0.05 ppm          | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
|                   | TWA        | 0.08 ppm          | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
|                   | TWA        | 0.10 ppm          | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
| Manganese - as Mn | TWA        | 0.2 mg/m3         | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|                   | 8 HR ACL   | 0.2 mg/m3         | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|                   | 15 MIN ACL | 0.6 mg/m3         | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |



|   |            |              |   |
|---|------------|--------------|---|
| Manganese - Respirable fraction. - as Mn        | TWA        | 0.02 mg/m3   | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
| Manganese - Inhalable fraction. - as Mn         | TWA        | 0.1 mg/m3    | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2014)  |
| Manganese - as Mn                               | TWA        | 0.2 mg/m3    | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (06 2015)  |
| Manganese - Fume, total dust. - as Mn           | TWA        | 0.2 mg/m3    | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Manganese - Respirable. - as Mn                 | TWA        | 0.02 mg/m3   | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018) |
| Manganese - Total - as Mn                       | TWA        | 0.2 mg/m3    | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018) |
| Chromium (VI) - as Cr                           | TWA        | 0.01 mg/m3   | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|   | TWA        | 0.05 mg/m3   | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|   | TWA        | 0.05 mg/m3   | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|   | 15 MIN ACL | 0.03 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | 15 MIN ACL | 0.15 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | 8 HR ACL   | 0.01 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | 8 HR ACL   | 0.05 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | TWA        | 0.05 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
|   | TWA        | 0.01 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Chromium (VI) - Inhalable fraction. - as Cr(VI) | STEL       | 0.0005 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2018)  |
|   | STEL       | 0.0005 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2018)  |
|   | TWA        | 0.0002 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2018)  |
|   | TWA        | 0.0002 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2018)  |
| Chromium (VI) - Total - as Cr                   | TWA        | 0.025 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018) |
|   | CEILING    | 0.1 mg/m3    | Canada. British Columbia OELs.  |



|   |            |             |   |
|---|------------|-------------|---|
|   |            |             | (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018)                                |
| Nickel  | TWA        | 1.5 mg/m3   | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
| Nickel - as Ni                                    | TWA        | 0.05 mg/m3  | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018) |
| Nickel - Inhalable fraction.                      | TWA        | 1.5 mg/m3   | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
| Nickel - Inhalable fraction. - as Ni              | TWA        | 1 mg/m3     | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (06 2015)  |
|   | 8 HR ACL   | 1.5 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | 15 MIN ACL | 3 mg/m3     | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
| Nickel  | TWA        | 1 mg/m3     | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Chromium oxide - as Cr                            | TWA        | 0.5 mg/m3   | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|   | TWA        | 0.5 mg/m3   | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |
|   | 8 HR ACL   | 0.5 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | 15 MIN ACL | 1.5 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)  |
|   | TWA        | 0.5 mg/m3   | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017)   |
| Chromium oxide - Inhalable fraction. - as Cr(III) | TWA        | 0.003 mg/m3 | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2018)  |
| Chromium oxide - Total - as Cr                    | TWA        | 0.5 mg/m3   | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2018) |
| Fluorides (as F) - as F                           | TWA        | 2.5 mg/m3   | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|   | TWA        | 2.5 mg/m3   | Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2), as amended (07 2009)   |
|   | TWA        | 2.5 mg/m3   | Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) (07 2007) |
|   | TWA        | 2.5 mg/m3   | Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act), as amended (03 2011)  |
|   | TWA        | 2.5 mg/m3   | Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents), as amended (11 2010)  |

|  |            |           |   |
|--|------------|-----------|---|
|  | 8 HR ACL   | 2.5 mg/m3 | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)          |
|  | 15 MIN ACL | 5 mg/m3   | Canada. Saskatchewan OELs (Occupational Health and Safety Regulations, 1996, Table 21), as amended (05 2009)          |
|  | TWA        | 2.5 mg/m3 | Canada. Quebec OELs. (Ministry of Labor - Regulation respecting occupational health and safety), as amended (09 2017) |

**Additional exposure limits under the conditions of use: Mexico**

| Chemical Identity                    | Type    | Exposure Limit Values | Source   |
|--------------------------------------|---------|-----------------------|--|
| Carbon dioxide                       | VLE-CT  | 30,000 ppm            | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
|                                      | VLE-PPT | 5,000 ppm             | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Carbon monoxide                      | VLE-PPT | 25 ppm                | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Nitrogen dioxide                     | VLE-PPT | 0.2 ppm               | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Ozone                                | VLE-P   | 0.1 ppm               | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Manganese - as Mn                    | VLE-PPT | 0.2 mg/m3             | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Chromium (VI)                        | VLE-PPT | 0.05 mg/m3            | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Nickel - Inhalable fraction. - as Ni | VLE-PPT | 1.5 mg/m3             | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Chromium oxide                       | VLE-PPT | 0.5 mg/m3             | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |
| Fluorides (as F) - as F              | VLE-PPT | 2.5 mg/m3             | Mexico. OELs. (NOM-010-STPS-2014 Chemical Pollutants at the Workplace; Assessment and Control), as amended (04 2014) |

**Appropriate Engineering Controls**

**Ventilation:** Use enough ventilation and local exhaust at the arc, flame or heat source to keep the fumes and gases from the worker's breathing zone and the general area. Train the operator to keep their head out of the fumes. **Keep exposure as low as possible.**

**Individual protection measures, such as personal protective equipment**
**General information:**

**Exposure Guidelines:** To reduce the potential for overexposure, use controls such as adequate ventilation and personal protective equipment (PPE). Overexposure refers to exceeding applicable local limits, the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) or the Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limits (PELs). Workplace

exposure levels should be established by competent industrial hygiene assessments. Unless exposure levels are confirmed to be below the applicable local limit, TLV or PEL, whichever is lower, respirator use is required. Absent these controls, overexposure to one or more compound constituents, including those in the fume or airborne particles, may occur resulting in potential health hazards. According to the ACGIH, TLVs and Biological Exposure Indices (BEIs) “represent conditions under which ACGIH believes that nearly all workers may be repeatedly exposed without adverse health effects.” The ACGIH further states that the TLV-TWA should be used as a guide in the control of health hazards and should not be used to indicate a fine line between safe and dangerous exposures. See Section 10 for information on constituents which have some potential to present health hazards. Welding consumables and materials being joined may contain chromium as an unintended trace element. Materials that contain chromium may produce some amount of hexavalent chromium (CrVI) and other chromium compounds as a byproduct in the fume. In 2018, the American Conference of Governmental Industrial Hygienists (ACGIH) lowered the Threshold Limit Value (TLV) for hexavalent chromium from 50 micrograms per cubic meter of air (50 µg/m³) to 0.2 µg/m³. At these new limits, CrVI exposures at or above the TLV may be possible in cases where adequate ventilation is not provided. CrVI compounds are on the IARC and NTP lists as posing a lung cancer and sinus cancer risk. Workplace conditions are unique and welding fume exposures levels vary. Workplace exposure assessments must be conducted by a qualified professional, such as an industrial hygienist, to determine if exposures are below applicable limits and to make recommendations when necessary for preventing overexposures.

**Eye/face protection:**

Wear helmet or use face shield with filter lens shade number 12 or darker for open arc processes – or follow the recommendations as specified in ANSI Z49.1, Section 4, based on your process and settings. No specific lens shade recommendation for submerged arc or electroslag processes. Shield others by providing appropriate screens and flash goggles.

**Skin Protection****Hand Protection:**

Wear protective gloves. Suitable gloves can be recommended by the glove supplier.

**Other:**

**Protective Clothing:** Wear hand, head, and body protection which help to prevent injury from radiation, open flames, hot surfaces, sparks and electrical shock. See Z49.1. At a minimum, this includes welder's gloves and a protective face shield when welding, and may include arm protectors, aprons, hats, shoulder protection, as well as dark substantial clothing when welding, brazing and soldering. Wear dry gloves free of holes or split seams. Train the operator not to permit electrically live parts or electrodes from contacting the skin . . . or clothing or gloves if they are wet. Insulate yourself from the work piece and ground using dry plywood, rubber mats or other dry insulation.

**Respiratory Protection:**

Keep your head out of fumes. Use enough ventilation and local exhaust to keep fumes and gases from your breathing zone and the general area. An approved respirator should be used unless exposure assessments are below applicable exposure limits.

**Hygiene measures:**

Do not eat, drink or smoke when using the product. Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants. Determine the composition and quantity of fumes and gases to which workers are

exposed by taking an air sample from inside the welder's helmet if worn or in the worker's breathing zone. Improve ventilation if exposures are not below limits. See ANSI/AWS F1.1, F1.2, F1.3 and F1.5, available from the American Welding Society, [www.aws.org](http://www.aws.org).

## 9. PHYSICAL AND CHEMICAL PROPERTIES

|  |                                       |
|--|---------------------------------------|
| <b>Appearance:</b>   | Steel rod with extruded flux coating. |
| <b>Physical state:</b>                                       | Solid                                 |
| <b>Form:</b>   | Solid                                 |
| <b>Color:</b>  | No data available.                    |
| <b>Odor:</b>   | No data available.                    |
| <b>Odor threshold:</b>                                       | No data available.                    |
| <b>pH:</b>   | No data available.                    |
| <b>Melting point/freezing point:</b>                         | No data available.                    |
| <b>Initial boiling point and boiling range:</b>              | No data available.                    |
| <b>Flash Point:</b>  | No data available.                    |
| <b>Evaporation rate:</b>                                     | No data available.                    |
| <b>Flammability (solid, gas):</b>                            | No data available.                    |
| <b>Upper/lower limit on flammability or explosive limits</b> |                                       |
| <b>Flammability limit - upper (%):</b>                       | No data available.                    |
| <b>Flammability limit - lower (%):</b>                       | No data available.                    |
| <b>Explosive limit - upper:</b>                              | No data available.                    |
| <b>Explosive limit - lower:</b>                              | No data available.                    |
| <b>Vapor pressure:</b>                                       | No data available.                    |
| <b>Vapor density:</b>  | No data available.                    |
| <b>Density:</b>  | No data available.                    |
| <b>Relative density:</b>                                     | No data available.                    |
| <b>Solubility(ies)</b>                                       |                                       |
| <b>Solubility in water:</b>                                  | No data available.                    |
| <b>Solubility (other):</b>                                   | No data available.                    |
| <b>Partition coefficient (n-octanol/water):</b>              | No data available.                    |
| <b>Auto-ignition temperature:</b>                            | No data available.                    |
| <b>Decomposition temperature:</b>                            | No data available.                    |
| <b>Viscosity:</b>  | No data available.                    |

## 10. STABILITY AND REACTIVITY

|  |  |
|--|--|
| <b>Reactivity:</b>                         | The product is non-reactive under normal conditions of use, storage and transport. |
| <b>Chemical Stability:</b>                 | Material is stable under normal conditions.  |
| <b>Possibility of hazardous reactions:</b> | None under normal conditions.  |
| <b>Conditions to avoid:</b>                | Avoid heat or contamination.   |
| <b>Incompatible Materials:</b>             | Strong acids. Strong oxidizing substances. Strong bases.                           |

**Hazardous Decomposition Products:**

Fumes and gases from welding and its allied processes such as brazing and soldering cannot be classified simply. The composition and quantity of both are dependent upon the metal to which the joining or hot work is applied, the process, procedure - and where applicable - the electrode or consumable used. Other conditions which also influence the composition and quantity of the fumes and gases to which workers may be exposed include: coatings on the metal being welded or worked (such as paint, plating, or galvanizing), the number of operators and the volume of the work area, the quality and amount of ventilation, the position of the operator's head with respect to the fume plume, as well as the presence of contaminants in the atmosphere (such as chlorinated hydrocarbon vapors from cleaning and degreasing activities.)

In cases where an electrode or other applied material is consumed, the fume and gas decomposition products generated are different in percent and form from the ingredients listed in Section 3. Decomposition products of normal operation include those originating from the volatilization, reaction, or oxidation of the materials shown in Section 3, plus those from the base metal and coating, etc., as noted above. Reasonably expected fume constituents produced during arc welding and brazing include the oxides of iron, manganese and other metals present in the welding consumable or base metal. Hexavalent chromium compounds may be in the welding or brazing fume of consumables or base metals which contain chromium. Gaseous and particulate fluoride may be in the fume of consumables or flux materials which contain fluoride. Gaseous reaction products may include carbon monoxide and carbon dioxide. Ozone and nitrogen oxides may be formed by the radiation from the arc associated with welding.

**11. TOXICOLOGICAL INFORMATION****General information:**

The International Agency for Research on Cancer (IARC) has determined welding fumes and ultraviolet radiation from welding are carcinogenic to humans (Group 1). According to IARC, welding fumes cause cancer of the lung and positive associations have been observed with cancer of the kidney. Also according to IARC, ultraviolet radiation from welding causes ocular melanoma. IARC identifies gouging, brazing, carbon arc or plasma arc cutting, and soldering as processes closely related to welding. Read and understand the manufacturer's instructions, Safety Data Sheets and the precautionary labels before using this product.

**Information on likely routes of exposure****Inhalation:**

Potential chronic health hazards related to the use of welding consumables are most applicable to the inhalation route of exposure. Refer to Inhalation statements in Section 11.

**Skin Contact:**

Arc rays can burn skin. Skin cancer has been reported.

**Eye contact:**

Arc rays can injure eyes.

**Ingestion:**

Health injuries from ingestion are not known or expected under normal use.

**Symptoms related to the physical, chemical and toxicological characteristics**

**Inhalation:**

Respiratory exposure to the crystalline silica present in this welding electrode is not anticipated during normal use. Respiratory overexposure to airborne crystalline silica is known to cause silicosis, a form of disabling pulmonary fibrosis which can be progressive and may lead to death. Crystalline silica is on the IARC (International Agency for Research on Cancer) and NTP (National Toxicology Program) lists as posing a cancer risk to humans. Note: All regional authorities do not use the same criteria for assigning carcinogenic classifications to chemicals. For example, the European Union (EU) CLP does not require classifying crystalline silica as a carcinogenic compound. Short-term (acute) overexposure to fumes and gases from welding and allied processes may result in discomfort such as metal fume fever, dizziness, nausea, or dryness or irritation of nose, throat, or eyes. May aggravate pre-existing respiratory problems (e.g. asthma, emphysema). Long-term (chronic) overexposure to fumes and gases from welding and allied processes can lead to siderosis (iron deposits in lung), central nervous system effects, bronchitis and other pulmonary effects.

**Information on toxicological effects****Acute toxicity (list all possible routes of exposure)****Oral**

|   |                          |
|---|--------------------------|
| <b>Product:</b>                                   | Not classified           |
| <b>Specified substance(s):</b>                    |                          |
| Iron  | LD 50 (Rat): 98.6 g/kg   |
| Limestone   | LD 50 (Rat): 6,450 mg/kg |
| Calcium fluoride                                  | LD 50 (Rat): 4,250 mg/kg |
| Sodium silicate                                   | LD 50 (Rat): 1.1 g/kg    |
| Potassium hydroxide                               | LD 50 (Rat): 333 mg/kg   |
| Copper and/or copper alloys and compounds (as Cu) | LD 50 (Rat): 481 mg/kg   |
| Potassium carbonate                               | LD 50 (Rat): 1,870 mg/kg |
| Cobalt and compounds (as Co)                      | LD 50 (Rat): 550 mg/kg   |

**Dermal**

|                                |                               |
|--------------------------------|-------------------------------|
| <b>Product:</b>                | Not classified                |
| <b>Specified substance(s):</b> |                               |
| Potassium carbonate            | LD 50 (Rabbit): > 2,000 mg/kg |

**Inhalation**

|   |                               |
|---|-------------------------------|
| <b>Product:</b>                         | Not classified                |
| <b>Specified substance(s):</b>          |                               |
| Aluminum and/or aluminum alloys (as Al) | LC 50 (Rat, 1 h): 7.6 mg/l    |
| Aluminum oxide                          | LC 50 (Rat, 4 h): > 2.3 mg/l  |
| Cobalt and compounds (as Co)            | LC 50 (Rat, 4 h): ≤ 0.05 mg/l |

**Repeated dose toxicity**

|                 |                |
|-----------------|----------------|
| <b>Product:</b> | Not classified |
|-----------------|----------------|

**Skin Corrosion/Irritation**

|                 |                |
|-----------------|----------------|
| <b>Product:</b> | Not classified |
|-----------------|----------------|

**Serious Eye Damage/Eye Irritation**

|                 |                |
|-----------------|----------------|
| <b>Product:</b> | Not classified |
|-----------------|----------------|

**Respiratory or Skin Sensitization**

|                 |                |
|-----------------|----------------|
| <b>Product:</b> | Not classified |
|-----------------|----------------|

**Carcinogenicity**

**Product:** Arc rays: Skin cancer has been reported.

**IARC Monographs on the Evaluation of Carcinogenic Risks to Humans:**

|                              |  |
|------------------------------|--|
| Titanium dioxide             | Overall evaluation: 2B. Possibly carcinogenic to humans. |
| Nickel                       | Overall evaluation: 2B. Possibly carcinogenic to humans. |
| Quartz                       | Overall evaluation: 1. Carcinogenic to humans.           |
| Cobalt and compounds (as Co) | Overall evaluation: 2B. Possibly carcinogenic to humans. |

**US. National Toxicology Program (NTP) Report on Carcinogens:**

|                              |  |
|------------------------------|--|
| Nickel                       | Reasonably Anticipated to be a Human Carcinogen. |
| Quartz                       | Known To Be Human Carcinogen.                    |
| Cobalt and compounds (as Co) | Reasonably Anticipated to be a Human Carcinogen. |

**US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050), as amended:**

|        |        |
|--------|--------|
| Quartz | Cancer |
|--------|--------|

**Germ Cell Mutagenicity**
**In vitro**

**Product:** Not classified

**In vivo**

**Product:** Not classified

**Reproductive toxicity**

**Product:** Not classified

**Specific Target Organ Toxicity - Single Exposure**

**Product:** Not classified

**Specific Target Organ Toxicity - Repeated Exposure**

**Product:** Not classified

**Aspiration Hazard**
**Product:**

Not classified

**Other effects:**

Organic polymers may be used in the manufacture of various welding consumables. Overexposure to their decomposition byproducts may result in a condition known as polymer fume fever. Polymer fume fever usually occurs within 4 to 8 hours of exposure with the presentation of flu like symptoms, including mild pulmonary irritation with or without an increase in body temperature. Signs of exposure can include an increase in white blood cell count. Resolution of symptoms typically occurs quickly, usually not lasting longer than 48 hours.

**Symptoms related to the physical, chemical and toxicological characteristics under the condition of use**
**Inhalation:**
**Specified substance(s):**

Manganese

Overexposure to manganese fumes may affect the brain and central nervous system, resulting in poor coordination, difficulty speaking, and arm or leg tremor. This condition can be irreversible.



|               |   |
|---------------|---|
| Chromium (VI) | Chromates may cause ulceration, perforation of the nasal septum, and severe irritation of the bronchial tubes and lungs. Liver damage and allergic reactions, including skin rash, have been reported. Asthma has been reported in some sensitized individuals. Skin contact may result in irritation, ulceration, sensitization, and contact dermatitis. Chromates contain the hexavalent form of chromium. Hexavalent chromium and its compounds are on the IARC (International Agency for Research on Cancer) and NTP (National Toxicology Program) lists as posing a cancer risk to humans. |
| Nickel        | Nickel and its compounds are on the IARC and NTP lists as posing respiratory cancer risk, and are skin sensitizers with symptoms ranging from slight itch to severe dermatitis.   |

#### Additional toxicological Information under the conditions of use:

##### Acute toxicity

###### Oral

###### Specified substance(s):

|                  |                            |
|------------------|----------------------------|
| Chromium (VI)    | LD 50 (Rat): 27 - 59 mg/kg |
| Fluorides (as F) | LD 50 (Rat): 4,250 mg/kg   |

###### Inhalation

###### Specified substance(s):

|                  |                                 |
|------------------|---------------------------------|
| Carbon dioxide   | LC Lo (Human, 5 min): 90000 ppm |
| Carbon monoxide  | LC 50 (Rat, 4 h): 1300 ppm      |
| Nitrogen dioxide | LC 50 (Rat, 4 h): 88 ppm        |
| Ozone            | LC Lo (Human, 30 min): 50 ppm   |
| Chromium (VI)    | LC 50 (Rat, 4 h): 33 - 70 mg/m3 |

#### IARC Monographs on the Evaluation of Carcinogenic Risks to Humans:

###### Specified substance(s):

|                |  |
|----------------|--|
| Chromium (VI)  | Overall evaluation: 1. Carcinogenic to humans.                           |
| Nickel         | Overall evaluation: 2B. Possibly carcinogenic to humans.                 |
| Chromium oxide | Overall evaluation: 3. Not classifiable as to carcinogenicity to humans. |

#### US. National Toxicology Program (NTP) Report on Carcinogens:

###### Specified substance(s):

|               |  |
|---------------|--|
| Chromium (VI) | Known To Be Human Carcinogen.                    |
| Nickel        | Reasonably Anticipated to be a Human Carcinogen. |

#### US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050), as amended:

###### Specified substance(s):

|               |        |
|---------------|--------|
| Chromium (VI) | Cancer |
|---------------|--------|

###### Other effects:

###### Specified substance(s):

|                  |                                    |
|------------------|------------------------------------|
| Carbon dioxide   | Asphyxia                           |
| Carbon monoxide  | Carboxyhemoglobinemia              |
| Nitrogen dioxide | Lower respiratory tract irritation |
| Nickel           | Dermatitis Pneumoconiosis          |

## 12. ECOLOGICAL INFORMATION

### Ecotoxicity

#### Acute hazards to the aquatic environment:

##### Fish

**Product:** Not classified.

##### Specified substance(s):

|   |  |
|---|--|
| Nickel  | LC 50 (Fathead minnow ( <i>Pimephales promelas</i> ), 96 h): 2.916 mg/l  |
| Calcium fluoride                                  | LC 50 (48 h): 299 mg/l LC 50 (96 h): 108 mg/l LC 100 ( <i>Tinca vulgaris</i> , 48 h): > 3,000 mg/l LC 50 (96 h): 340 mg/l LC 50 (96 h): 165 mg/l |
| Sodium silicate                                   | LC 50 (Western mosquitofish ( <i>Gambusia affinis</i> ), 96 h): 1,800 mg/l   |
| Potassium hydroxide                               | LC 50 ( <i>Gambusia affinis</i> , 96 h): 80 mg/l   |
| Bentonite   | LC 50 (Rainbow trout, donaldson trout ( <i>Oncorhynchus mykiss</i> ), 96 h): 19,000 mg/l   |
| Aluminum and/or aluminum alloys (as Al)           | LC 50 (Grass carp, white amur ( <i>Ctenopharyngodon idella</i> ), 96 h): 0.21 - 0.31 mg/l  |
| Molybdenum  | LC 50 (Rainbow trout, donaldson trout ( <i>Oncorhynchus mykiss</i> ), 96 h): 800 mg/l  |
| Copper and/or copper alloys and compounds (as Cu) | LC 50 (Fathead minnow ( <i>Pimephales promelas</i> ), 96 h): 1.6 mg/l  |
| Potassium carbonate                               | LC 50 (Fathead minnow ( <i>Pimephales promelas</i> ), 96 h): < 750 mg/l  |
| Cobalt and compounds (as Co)                      | LC 50 (Rainbow trout, donaldson trout ( <i>Oncorhynchus mykiss</i> ), 28 d): > 0.17 - < 15.61 mg/l   |

#### Aquatic Invertebrates

##### Product:

Not classified.

##### Specified substance(s):

|   |  |
|---|--|
| Nickel  | EC 50 (Water flea ( <i>Daphnia magna</i> ), 48 h): 1 mg/l  |
| Manganese   | EC 50 (Water flea ( <i>Daphnia magna</i> ), 48 h): 40 mg/l   |
| Calcium fluoride                                  | EC 50 ( <i>Daphnia magna</i> ; <i>Daphnia</i> sp., 120 h): 20 - 39 mg/l EC 50 ( <i>Daphnia magna</i> ; <i>Daphnia</i> sp., 24 h): 352 mg/l EC 50 ( <i>Daphnia magna</i> ; <i>Daphnia</i> sp., 96 h): 26 - 48 mg/l EC 50 ( <i>Daphnia magna</i> ; <i>Daphnia</i> sp., 48 h): 97 mg/l EC 50 ( <i>Daphnia magna</i> ; <i>Daphnia</i> sp., 48 h): 153 mg/l |
| Sodium silicate                                   | EC 50 (Water flea ( <i>Ceriodaphnia dubia</i> ), 48 h): 22.94 - 49.01 mg/l   |
| Copper and/or copper alloys and compounds (as Cu) | EC 50 (Water flea ( <i>Daphnia magna</i> ), 48 h): 0.102 mg/l  |
| Potassium carbonate                               | LC 50 (Water flea ( <i>Ceriodaphnia dubia</i> ), 48 h): 580 - 670 mg/l   |

#### Chronic hazards to the aquatic environment:

##### Fish

##### Product:

Not classified.

#### Aquatic Invertebrates

##### Product:

Not classified.

#### Toxicity to Aquatic Plants

##### Product:

Not classified.

##### Specified substance(s):

|   |  |
|---|--|
| Copper and/or copper alloys and compounds (as Cu) | LC 50 (Green algae ( <i>Scenedesmus dimorphus</i> ), 3 d): 0.0623 mg/l |
|---|--|

#### Persistence and Degradability

##### Biodegradation

##### Product:

No data available.

#### Bioaccumulative potential

##### Bioconcentration Factor (BCF)

##### Product:

No data available.

##### Specified substance(s):

|        |   |
|--------|---|
| Nickel | Zebra mussel ( <i>Dreissena polymorpha</i> ), Bioconcentration Factor (BCF): 5,000 - 10,000 (Lotic) Bioconcentration factor calculated using dry weight tissue conc |
|--------|---|

Copper and/or copper  
alloys and compounds  
(as Cu)

Cobalt and compounds  
(as Co)

Blue-green algae (*Anacystis nidulans*), Bioconcentration Factor (BCF):  
36.01 (Static)

Brown shrimp (*Penaeus aztecus*), Bioconcentration Factor (BCF): > 2,250 -  
< 2,500 (Static)

**Mobility in soil:**

No data available.

**13. Disposal considerations****General information:**

The generation of waste should be avoided or minimized whenever possible. When practical, recycle in an environmentally acceptable, regulatory compliant manner. Dispose of non-recyclable products in accordance with all applicable Federal, State, Provincial, and Local requirements.

**Disposal instructions:**

Disposal of this product may be regulated as a Hazardous Waste. The welding consumable and/or by-product from the welding process (including, but not limited to slag, dust, etc.) may contain levels of leachable heavy metals such as Barium or Chromium. Prior to disposal, a representative sample must be analyzed in accordance with US EPA's Toxicity Characteristic Leaching Procedure (TCLP) to determine if any constituents exist above regulated threshold levels. Discard any product, residue, disposable container, or liner in an environmentally acceptable manner according to Federal, State and Local Regulations.

**Contaminated Packaging:**

Dispose of contents/container to an appropriate treatment and disposal facility in accordance with applicable laws and regulations, and product characteristics at time of disposal.

**14. TRANSPORT INFORMATION****DOT**

UN Number:

UN Proper Shipping Name:

NOT DG REGULATED

Transport Hazard Class(es)

Class:

NR

Label(s):

—

Packing Group:

—

Marine Pollutant:

No

**IMDG**

UN Number:

UN Proper Shipping Name:

NOT DG REGULATED

Transport Hazard Class(es)

Class:

NR

Label(s):

—

EmS No.:

Packing Group:

—

Marine Pollutant:

No

**IATA**

UN Number:

Proper Shipping Name:

NOT DG REGULATED

Transport Hazard Class(es):

Class:

NR

Label(s): —  
Packing Group: —  
Marine Pollutant: No  
Cargo aircraft only: Allowed.

**TDG**

UN Number:  
UN Proper Shipping Name: NOT DG REGULATED  
Transport Hazard Class(es)  
Class: NR  
Label(s): —  
Packing Group: —  
Marine Pollutant: No

**15. REGULATORY INFORMATION****US Federal Regulations****TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)**

None present or none present in regulated quantities.

**US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050), as amended****Chemical Identity**

Quartz

**OSHA hazard(s)**

kidney effects  
lung effects  
immune system effects  
Cancer

**CERCLA Hazardous Substance List (40 CFR 302.4):****Chemical Identity**

Chromium and chromium alloys or  
compounds (as Cr)

Nickel

Manganese

Potassium hydroxide

Copper and/or copper alloys and  
compounds (as Cu)

Cobalt and compounds (as Co)

**Reportable quantity**

5000lbs.

100lbs.

Included in the regulation but with no data values. See  
regulation for further details.

1000lbs.

5000lbs.

Included in the regulation but with no data values. See  
regulation for further details.

**Superfund Amendments and Reauthorization Act of 1986 (SARA)****Hazard categories**

Not classified

Not classified

**SARA 302 Extremely Hazardous Substance**

None present or none present in regulated quantities.

**SARA 304 Emergency Release Notification**

None present or none present in regulated quantities.

**SARA 311/312 Hazardous Chemical****Chemical Identity****Threshold Planning Quantity****SARA 313 (TRI Reporting)****Chemical Identity****Reporting threshold****Reporting threshold for**

|   | <u>for other users</u> | <u>manufacturing and processing</u> |
|---|------------------------|-------------------------------------|
| Chromium and chromium alloys or compounds (as Cr) | 10000 lbs              | 25000 lbs.                          |
| Nickel  | 10000 lbs              | 25000 lbs.                          |
| Manganese   | 10000 lbs              | 25000 lbs.                          |
| Cobalt and compounds (as Co)                      | 10000 lbs              | 25000 lbs.                          |

**Clean Water Act Section 311 Hazardous Substances (40 CFR 117.3)****Chemical Identity**

Potassium hydroxide

**Reportable quantity**

Reportable quantity: 1000 lbs.

**Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130):**

None present or none present in regulated quantities.

**US State Regulations****US. California Proposition 65****WARNING**Cancer - [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov)

**WARNING:** 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.)

**WARNING:** Cancer and Reproductive Harm – [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov)

**US. New Jersey Worker and Community Right-to-Know Act****Chemical Identity**

Chromium and chromium alloys or compounds (as Cr)

Titanium dioxide

Nickel

Limestone

Manganese

Calcium fluoride

Quartz

Cobalt and compounds (as Co)

**US. Massachusetts RTK - Substance List****Chemical Identity**

Chromium and chromium alloys or compounds (as Cr)

Nickel

Quartz

**US. Pennsylvania RTK - Hazardous Substances****Chemical Identity**

Chromium and chromium alloys or compounds (as Cr)

Titanium dioxide

Nickel

Limestone

Manganese

Calcium fluoride

**US. Rhode Island RTK**

No ingredient regulated by RI Right-to-Know Law present.

**Canada Federal Regulations****List of Toxic Substances (CEPA, Schedule 1)****Chemical Identity**

Titanium dioxide  
Aluminum and/or  
aluminum alloys (as Al)  
Tantalum  
Iron oxide  
Aluminum oxide

**Export Control List (CEPA 1999, Schedule 3)**

Not Regulated

**National Pollutant Release Inventory (NPRI)**

**Canada. National Pollutant Release Inventory (NPRI) Substances, Part 5, VOCs with Additional Reporting Requirements**

NPRI PT5 Not Regulated

**Canada. National Pollutant Release Inventory (NPRI) (Schedule 1, Parts 1-4)**

NPRI Not Regulated

**Greenhouse Gases**

Not Regulated

**Controlled Drugs and Substances Act**

CA CDSI Not Regulated

CA CDSII Not Regulated

CA CDSIII Not Regulated

CA CDSIV Not Regulated

CA CDSV Not Regulated

CA CDSVII Not Regulated

CA CDSVIII Not Regulated

**Precursor Control Regulations**

Not Regulated

**Mexico. Substances subject to reporting for the pollutant release and transfer registry (PRTR):** Not applicable

**Inventory Status:**

|  |   |
|--|---|
| Australia AICS:                          | On or in compliance with the inventory                            |
| Canada DSL Inventory List:               | One or more components are not listed or are exempt from listing. |
| Canada NDSL Inventory:                   | One or more components are not listed or are exempt from listing. |
| Ontario Inventory:                       | On or in compliance with the inventory                            |
| China Inv. Existing Chemical Substances: | One or more components are not listed or are exempt from listing. |
| Japan (ENCS) List:                       | One or more components are not listed or are exempt from listing. |
| Japan ISHL Listing:                      | One or more components are not listed or are exempt from listing. |
| Japan Pharmacopoeia Listing:             | One or more components are not listed or are exempt from listing. |
| Korea Existing Chemicals Inv. (KECI):    | On or in compliance with the inventory                            |
| Mexico INSQ:                             | One or more components are not listed or are exempt from listing. |
| New Zealand Inventory of Chemicals:      | On or in compliance with the inventory                            |
| Philippines PICCS:                       | One or more components are not listed or are exempt from listing. |
| Taiwan Chemical Substance Inventory:     | On or in compliance with the inventory                            |
| US TSCA Inventory:                       | On or in compliance with the inventory                            |
| EINECS, ELINCS or NLP:                   | One or more components are not listed or are exempt from listing. |

**16. OTHER INFORMATION**

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**Definitions:**

**Revision Date:** 05/18/2020

**Further Information:** Additional information is available by request.

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