

## **SAFETY DATA SHEET**

### **1. PRODUCT AND COMPANY IDENTIFICATION**

#### **Trade designation**

DW-50

#### **Recommended use**

For welding

#### **Restrictions on use**

Do not use except for welding.

#### **Manufacturer**

**Manufacturer's Name:** KOBE STEEL, LTD.

**Address:** 5-9-12 Kitashinagawa Shinagawa-Ku Tokyo JAPAN

**Phone number:** +81-3-5739-6331

**Fax number:** +81-3-5739-6960

**Emergency phone number:** +81-3-5739-6331

#### **Distributor**

**Distributor's Name:** KOBELCO WELDING OF AMERICA INC.

**Address:** 4755 Alpine Rd. Ste 250 Stafford, Texas

**Phone number:** 281-240-5600

**Fax number:** 281-240-5625

**Emergency phone number:** 281-240-5600

### **2. HAZARDS IDENTIFICATION**

Classification according to OSHA Hazard Communication Standard (29 CFR 1910.1200) and the Canadian Controlled Products Regulations.

#### **Hazard classification**

Classification not possible as hazardous according to GHS classification.

#### **Label elements**

**Symbol:** Not applicable

**Signal word:** Not applicable

**Hazard statement:** Not applicable

**Precautionary statement:** Not applicable

#### **Other hazards which do not classified in GHS classification**

**General:** When this product is used in a welding process the hazards are electric shock, fumes, gases, radiation, spatter, slag and heat. Read and understand this Safety Data Sheets and the manufacturer's instructions and the precautionary labels before using this product.

**Shock:** Electrical Shock can kill.

**Radiation:** Arc rays can injure eyes and burn skin.

**Fumes:** Overexposure to welding fumes result in symptoms like dizziness, nausea, dryness or irritation of the nose, throat or eyes. Chronic overexposure to welding fumes may affect respiratory system and nervous system.

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

The welding fumes produced from this welding electrode may contain the listed constituent(s) of Sec.3 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 Sec.3. **The welding fumes may contain Mn, Ni, Cr(VI) and their compounds.** Refer to Sec.8 and 10.

**Gases:** Gases may cause gas poisoning. Under conditions of use, gases may contain carbon oxides, nitrogen oxides, ozone etc. Refer to Sec.8 and 10.

**Spatter, slag:** Spatter, slag can damage eyes.

**Heat:** Spatter, slag, melting metal, hot welds, arc rays and sparks can cause burn injuries and ignite combustibles and flammable materials

### 3. COMPOSITION / INFORMATION ON INGREDIENTS

#### Substance/Mixture

Mixture

| Chemical name    | CAS No.    | Concentration range (%) |
|------------------|------------|-------------------------|
| Iron             | 7439-89-6  | Balance                 |
| Titanium dioxide | 13463-67-7 | < 10                    |
| Manganese        | 7439-96-5  | < 3                     |
| Silicon          | 7440-21-3  | < 1                     |
| Silicon dioxide  | 7631-86-9  | < 1                     |
| Magnesium        | 7439-95-4  | < 1                     |
| Aluminum oxide   | 1344-28-1  | < 1                     |
| Zirconium oxide  | 1314-23-4  | < 1                     |

### 4. FIRST AID MEASURES

#### Description of first aid measures

- Inhalation:** Remove person to fresh air and keep comfortable for breathing and get medical advice/attention. If breathing has stopped, perform artificial respiration and get immediate medical advice/attention.
- Skin contact:** Take off contaminated clothing and rinse skin with soap and water [or shower]. If skin irritation occurs, get medical advice/attention. For reddened or blistered skin, or thermal burns, get medical advice/attention.
- Eye contact:** Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical advice/attention.  
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. If symptoms persist, get medical advice/attention.
- Electric shock:** Disconnect and turn off power. If the victim is semi- or unconscious, open the airway. If the victim cannot breathe, give artificial respiration. If there is no pulse, massage the chest and apply artificial respiration.
- Ingestion:** Unlikely due to form of product, except for granular materials. If ingested, Rinse mouth. Do NOT induce vomiting. Immediately call a POISON CENTER/doctor.

#### Most important symptoms/effects, acute and delayed

- Symptoms:** Short-term (acute) overexposure to welding fumes 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 welding fumes 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:** Welding hazards 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 welding fume or dust. 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 can ignite combustibles and flammable products. Read and understand American National Standard Z49.1, "Safety In Welding, Cutting and Allied Processes" 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 CO<sub>2</sub>, powder or water spray.

**Unsuitable extinguishing media:** None known

#### Specific hazards arising from the chemical

None known

**Special protective equipment and precautions for fire-fighters**

**Special protective equipment:** 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.

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

**6. ACCIDENTAL RELEASE MEASURES**

**General**

Unlikely due to form of product, except for granular materials. The welding fumes and slags may be released.

**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**

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.

**7. HANDLING AND STORAGE**

**Precautions for safe handling**

**Reduction of fumes and dusts:** Keep formation of airborne dusts to a minimum. Provide appropriate exhaust ventilation at places where dust is formed. Read and understand the manufacturer's instruction and the precautionary label on the product. See American National Standard Z49.1, "Safety In Welding, Cutting and Allied Processes"

**Prevention of electric shock:** Do not touch live electrical parts such as the welding wire and welding machine terminals. Wear insulated gloves and safety boots. 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 workpiece, use the following equipment: Semiautomatic DC Welder, DC Manual (Stick) Welder, or AC Welder with Reduced Voltage Control.

**Prevention of fire and explosion:** Remove flammable and combustible materials and liquids.

**Prevention of harm when handling welding consumables:** Handle with care to avoid stings and cuts. Hold the welding wire manually when loosening the wire.

**Conditions for safe storage, including any incompatibilities**

Store welding consumables inside a room without humidity. Do not store welding consumables directly on the ground or beside a wall. Keep welding consumables away from chemical substances like acids which could cause chemical reactions. Store in accordance with local/regional/national regulations.

**8. EXPOSURE CONTROLS / PERSONAL PROTECTION**

**Control parameters**

For substances may be included in welding fumes, gases and flux, occupational exposure values are shown in Annex. **Keep exposure below exposure limits.** Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) are values published by the American Conference of Government Industrial Hygienists (ACGIH). ACGIH Statement of Positions Regarding the TLVs and BEIs 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 potential fume constituents of health interest.

**Appropriate engineering controls**

**Ventilation:** Use enough ventilation, local exhaust at the arc, or both to keep the fumes and gases below the exposure limits in the worker's breathing zone and the general area. Keep exposure as low as possible.

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).

#### **Individual protection measures**

- Eye protection:** Wear helmet or use face shield with filter lens. As a rule of thumb, start with a shade which is too dark to see the weld zone. Then go to the next lighter shade which gives sufficient view of the weld zone. Provide protective screens and flash goggles, if necessary, to shield others.
- Hand protection:** Wear protective gloves. Suitable gloves can be recommended by the glove supplier.
- Protective Clothing:** Wear hand, head, and body protection which help to prevent injury from radiation, sparks and electrical shock. See Z49.1. At a minimum this includes welder's gloves and a protective face shield, and may include arm protectors, aprons, hats, shoulder protection, as well as dark substantial clothing. Wear dry gloves free of holes or split seams. Train the welder not to permit electrically live parts or electrodes to contact 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. Use respirable fume respirator or air supplied respirator when welding in confined space or where local exhaust or ventilation does not keep exposure below exposure limits.
- Ear protection:** Wear earplugs or earmuffs when using engine driven arc welding machine or pulsed arc welding machine that generates high-level noise.
- 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.

### **9. PHYSICAL AND CHEMICAL PROPERTIES**

|  |   |
|--|---|
| <b>Physical state:</b>                               | Solid                                     |
| <b>Color:</b>  | Silver or Copper                          |
| <b>Odor:</b>   | Odorless                                  |
| <b>Odor threshold:</b>                               | No further relevant information available |
| <b>pH:</b>   | Not applicable                            |
| <b>Melting point/freezing point:</b>                 | No further relevant information available |
| <b>Initial boiling point and boiling range:</b>      | No further relevant information available |
| <b>Flash point:</b>                                  | Not applicable                            |
| <b>Evaporation rate:</b>                             | Not applicable                            |
| <b>Flammability:</b>                                 | No further relevant information available |
| <b>Upper/lower flammability or explosive limits:</b> | No further relevant information available |
| <b>Vapor pressure:</b>                               | Not applicable                            |
| <b>Vapor density:</b>                                | Not applicable                            |
| <b>Solubility(ies)</b>                               | No further relevant information available |
| <b>Partition coefficient (n-octanol/water):</b>      | No further relevant information available |
| <b>Auto-ignition temperature:</b>                    | No further relevant information available |
| <b>Decomposition temperature:</b>                    | No further relevant information available |
| <b>Viscosity:</b>                                    | Not applicable                            |

### **10. STABILITY AND REACTIVITY**

#### **Reactivity**

Non-reactive under normal conditions of storage and transport.

#### **Chemical stability**

Stable under normal conditions of storage and transport.

#### **Possibility of hazardous reactions**

Contact with acids, alkalis and oxidizing agents could cause reaction and generation of gas.

#### **Conditions to avoid**

Avoid heat or contamination of acids, alkalis and oxidizing agents.

### **Incompatible materials**

Avoid contact with acids, alkalis and oxidizing agents.

### **Hazardous decomposition products**

Welding fumes and gases are generated as byproducts during the welding. The composition and quantity of fumes and gases cannot be recognized simply. The composition and quantity of the fumes and gases are dependent upon the base metal being welded (included coating such as solvent, paint, plating), the welding process, welding procedure, welding parameter and electrodes used. Other conditions which also influence the quantity of the fumes and gases to which workers may be exposed include the number of welding spots, the volume of the worker area, the quality and amount of ventilation, the position of the welder'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.)

The fumes and gases are different in percent and form from the ingredients listed in Section 3. The fumes and gases 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 include ***the oxides of iron, manganese and other metals*** present in the welding consumable or base metal. And, it is known that these metal oxides are complex oxides, not single compounds. ***Hexavalent chromium compounds*** may be in the welding fume of consumables or base metals which contain chromium. ***Nickel compounds*** may be in the welding fume of consumables or base metals which contain Nickel. Gaseous and particulate fluoride may be in the welding fume of consumables 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.

## **11. TOXICOLOGICAL INFORMATION**

### **General**

Classification not possible as product. Refer to Sec.2. Inhalation of welding fumes and gases can be dangerous to your health. The composition and quantity of both are dependent upon the material being worked, the process, procedures, and consumables used. Refer to Sec.10.

### **Acute toxicity**

Short-term (acute) overexposure to welding fumes 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).

**Cr:** The presence of chromium/chromate in welding fumes can cause irritation of nasal membranes and skin.

**Ni:** The presence of nickel compounds in fume can cause metallic taste, nausea, tightness of chest, fever.

**F:** Exposure to the fluoride ion in welding fumes may cause hypocalcemia-calcium deficiency in the blood that can result in muscle cramps and inflammation and necrosis of mucous membranes.

**Gases:** Some toxic gases associated with welding may cause pulmonary edema, asphyxiation, and death.

### **Chronic toxicity**

Long-term (chronic) overexposure to welding fumes can lead to siderosis (iron deposits in lung), central nervous system effects, bronchitis, pneumoconiosis and other pulmonary effects. The severity of the change is proportional to the length of the exposure. The changes may be caused by non-work factors such as smoking, etc.

**Ni:** Long term overexposure to nickel fumes may also cause pulmonary fibrosis and edema.

**Cr:** Chromates may cause ulceration, perforation of the nasal septum, and severe irritation of the bronchial tubes and lungs. Liver damage have also been reported. Chromates contain the hexavalent form of chromium.

**Mn:** Overexposure to manganese compounds may affect the central nervous system, symptoms of which are languor, sleepiness, muscular weakness, emotional disturbances and spastic gait. The effect of manganese on the nervous system is irreversible.

**Cu:** Overexposure to copper fumes may lead to copper poisoning, resulting in hemolytic anemia and liver, kidney and spleen damage.

**Fe:** Inhalation of too much iron oxide fume over a long time can cause siderosis, sometimes called "iron pigmentation" of the lung, which can be seen on a chest x-ray but causes little or no disability. Chronic overexposure to iron (>50-100mg Fe per day) can result in pathological deposition of iron in body tissues, symptoms of which are fibrosis of the pancreas, diabetes mellitus, and liver cirrhosis.

**SiO<sub>2</sub>:** 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.

**F:** Chronic fluoride absorption can result in osseous fluorosis, increased radiographic density of the bones and mottling of the teeth.

**Carcinogenicity**

Welding fumes (not otherwise specified) are possibly carcinogenic to humans. Welding fumes is on the IARC lists as posing a cancer risk.

**SiO<sub>2</sub>:** 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.

**Ni:** Nickel and its compounds are on the IARC and NTP lists as posing respiratory cancer risk.

**Cr:** Hexavalent chromium and its compounds are on the IARC and NTP lists as posing a cancer risk to humans.

**Arc** Skin cancer has been reported.

**rays:**

**Respiratory or Skin Sensitization**

**Ni:** Nickel and its compounds are skin sensitizers with symptoms ranging from slight itch to severe dermatitis.

**Cr:** Chromates may cause allergic reactions, including skin rash. Asthma has been reported in some sensitized individuals. Skin contact may result in irritation, ulceration, sensitization, and contact dermatitis.

**Others**

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.

**12. ECOLOGICAL INFORMATION**

**Ecotoxicity**

Product: No further relevant information available

**Persistence and degradability**

Product: No further relevant information available

**Bioaccumulative potential**

Product: No further relevant information available

**Mobility in soil**

Product: No further relevant information available

**13. DISPOSAL CONSIDERATIONS**

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 National, State, and Local requirements. Discharge, treatment, or disposal may be subject to National, State, or Local laws.

**14. TRANSPORT INFORMATION**

|   |                |
|---|----------------|
| <b>UN number:</b>   | Not applicable |
| <b>UN proper shipping name:</b>   | Not applicable |
| <b>Transport hazard class(es):</b>  | Not applicable |
| <b>Packing group:</b>   | Not applicable |
| <b>Environmental hazards:</b>   | Not applicable |
| <b>Transport in bulk (according to Annex II of MARPOL73/78 and the IBC Code):</b> | Not applicable |
| <b>Special precautions for user:</b>  | Not applicable |

**15. REGULATORY INFORMATION**

Regulations of each country are applied to substance/mixtures.

**16. OTHER INFORMATION**

**Reference**

American National Standard (ANSI) Z49.1 "Safety in Welding, Cutting, and Allied Processes"

**Date of issue**

2015-05-20

**Disclaimer**

The information given in this SDS is based on the present level of our knowledge and experience. This information is believed to be accurate as of the revision date shown above. However, no warranty, expressed or implied, is given. Because the conditions or methods of use are beyond KOBE STEEL, LTD.'s control, we assume no liability resulting from the use of this product. Regulatory requirements are subject to change and may differ between various locations. Compliance with all applicable Federal, State, Provincial, and local laws and regulations remain the responsibility of the user. If necessary, consult an industrial hygienist or other expert to understand this information and safeguard the environment and protect workers from potential hazards associated with the handling or use of this product.

## Annex

OCCUPATIONAL EXPOSURE VALUES <sup>1)</sup> TWA <sup>11)</sup> (mg/m<sup>3</sup>)

| SUBSTANCE [CAS No.] <sup>2)</sup>   | ACGIH <sup>3)</sup> TLVs <sup>4)</sup>                 | OSHA <sup>5)</sup> PELs <sup>6)</sup> | NIOSH <sup>7)</sup> RELs <sup>8)</sup> | DFG <sup>9)</sup> MAKs <sup>10)</sup>       |
|---|--|---------------------------------------|--|---|
| Aluminum [7429-90-5] metal and insoluble compounds  | 1 <sup>12)</sup>                                       | 5 <sup>12)</sup>                      | 5 <sup>12)</sup>                       | 4 <sup>13)</sup> , [1,5 <sup>12)</sup> ]    |
| Aluminum [7429-90-5] metal and insoluble compounds, total dust                            | ---  | 15                                    | 10                                     | ---   |
| Aluminum [7429-90-5] welding fumes, as Al   | ---  | ---                                   | 5                                      | ---   |
| Aluminum oxide [1344-28-1]  | ---  | 5 <sup>12)</sup>                      | ---                                    | 4 <sup>13)</sup> , [1,5 <sup>12)</sup> ]    |
| Aluminum oxide [1344-28-1], total dust  | ---  | 15                                    | ---                                    | ---   |
| Boron oxide [1303-86-2]   | 10   | ---                                   | 10                                     | ---   |
| Boron oxide [1303-86-2], total dust   | ---  | 15                                    | ---                                    | ---   |
| Barium [7440-39-3] and soluble compounds, as Ba   | 0.5  | 0.5                                   | 0.5                                    | ---   |
| Barium compounds, soluble, as Ba  | ---  | ---                                   | ---                                    | 0.5 <sup>13)</sup>                          |
| Calcium oxide [1305-78-8]   | 2  | 5                                     | 2                                      | 1 <sup>13)</sup>                            |
| Calcium carbonate [1317-65-3] (NIOSH : includes [471-34-1])                               | ---  | 5 <sup>12)</sup>                      | 5 <sup>12)</sup>                       | ---   |
| Calcium carbonate [1317-65-3], total dust   | ---  | 15                                    | 10                                     | ---   |
| Cobalt [7440-48-4] and inorganic compounds, as Co   | 0.02   | ---                                   | ---                                    | ---   |
| Cobalt [7440-48-4] and inorganic compounds, metal dust and fume, as Co                    | ---  | 0.1                                   | 0.05                                   | ---   |
| Chromium [7440-47-3] metal  | 0.5  | 1                                     | 0.5                                    | ---   |
| Chromium [7440-47-3] (II) inorganic compounds, as Cr                                      | ---  | 0.5                                   | 0.5                                    | ---   |
| Chromium [7440-47-3] (VI) compounds, as Cr (VI)   | ---  | 0.005                                 | ---                                    | ---   |
| Chromium [7440-47-3] (III) inorganic compounds, as Cr                                     | 0.5  | 0.5                                   | 0.5                                    | ---   |
| Chromium [7440-47-3] (VI) inorganic compounds, water-soluble, as Cr                       | 0.05   | ---                                   | 0.0002                                 | ---   |
| Chromium [7440-47-3] (VI) inorganic compounds, water-insoluble, as Cr                     | 0.01   | ---                                   | 0.0002                                 | ---   |
| Chromium [7440-47-3] (VI) inorganic compounds, water-soluble, as Cr (VI)                  | ---  | 0.005                                 | ---                                    | ---   |
| Chromium [7440-47-3] (VI) inorganic compounds, water-insoluble, as Cr (VI)                | ---  | 0.005                                 | ---                                    | ---   |
| Copper [7440-50-8], fume, as Cu   | 0.2  | 0.1                                   | 0.1                                    | ---   |
| Copper [7440-50-8], dusts and mists, as Cu  | 1  | 1                                     | 1                                      | ---   |
| Copper [7440-50-8] and its inorganic compounds  | ---  | ---                                   | ---                                    | 0.01 <sup>12)</sup>                         |
| Fluorides, as F   | 2.5  | 2.5                                   | 2.5                                    | 1 <sup>13)</sup>                            |
| Iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) [1309-37-1]                                  | 5 <sup>12)</sup>                                       | ---                                   | ---                                    | ---   |
| Iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) [1309-37-1], fume                            | ---  | 10                                    | ---                                    | ---   |
| Iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) [1309-37-1], dust and fume, as Fe            | ---  | ---                                   | 5                                      | ---   |
| Magnesium oxide [1309-48-4]   | 10 <sup>13)</sup>                                      | ---                                   | ---                                    | 4 <sup>13)</sup> , [1,5 <sup>12)</sup> ]    |
| Magnesium oxide [1309-48-4], fume, total particulate                                      | ---  | 15                                    | ---                                    | ---   |
| Manganese [7439-96-5] and inorganic compounds, as Mn                                      | 0.1 <sup>13)</sup> , [0.02 <sup>12)</sup> ]            | ---                                   | 1, [3 <sup>14)</sup> ]                 | 0.2 <sup>13)</sup> , [0.02 <sup>12)</sup> ] |
| Manganese [7439-96-5], fume, as Mn  | 0.1 <sup>13)</sup> , [0.02 <sup>12)</sup> ]            | ---                                   | 1, [3 <sup>14)</sup> ]                 | 0.2 <sup>13)</sup> , [0.02 <sup>12)</sup> ] |
| Molybdenum [7439-98-7] and soluble compounds, as Mo                                       | 0.5 <sup>12)</sup>                                     | 5                                     | ---                                    | ---   |
| Molybdenum [7439-98-7] and insoluble compounds, as Mo                                     | 10 <sup>13)</sup> , [3 <sup>12)</sup> ]                | ---                                   | ---                                    | ---   |
| Molybdenum [7439-98-7] and insoluble compounds, total dust, as Mo                         | ---  | 15                                    | ---                                    | ---   |
| Nickel [7440-02-0], elemental   | 1.5 <sup>13)</sup>                                     | 1                                     | 0.015                                  | ---   |
| Nickel [7440-02-0] soluble compounds, as Ni (ACGIH : inorganic only)                      | 0.1 <sup>13)</sup>                                     | 1                                     | 0.015                                  | ---   |
| Nickel [7440-02-0] insoluble compounds, as Ni (ACGIH : inorganic only)                    | 0.2 <sup>13)</sup>                                     | 1                                     | 0.015                                  | ---   |
| Nickel [7440-02-0] compounds  | ---  | ---                                   | 0.015                                  | ---   |
| Silica, amorphous, fused (DFG : includes [7699-41-4])                                     | ---  | ---                                   | 0.3 <sup>12)</sup>                     | ---   |
| Silica, amorphous, fused, dust  | ---  | A <sup>13)</sup> [ <sup>15)</sup>     | ---                                    | ---   |
| Silica, amorphous, fused, total dust  | ---  | B <sup>16)</sup>                      | ---                                    | ---   |
| Silica, crystalline, α-quartz   | 0.025 <sup>12)</sup>                                   | ---                                   | ---                                    | ---   |
| Silica, crystalline, α-quartz, dust   | ---  | A <sup>13)</sup> [ <sup>15)</sup>     | 0.05 <sup>12)</sup>                    | ---   |
| Silica, crystalline, α-quartz, total dust   | ---  | B <sup>16)</sup>                      | ---                                    | ---   |
| Silicon [7440-21-3]   | ---  | 5 <sup>12)</sup>                      | 5 <sup>12)</sup>                       | ---   |
| Silicon [7440-21-3], total dust   | ---  | 15                                    | 10                                     | ---   |
| Tin [7440-31-5], metal  | 2  | 2                                     | 2                                      | ---   |
| Tin [7440-31-5], oxide, as Sn   | 2  | ---                                   | 2                                      | ---   |
| Tin [7440-31-5], oxide and inorganic compounds, except SnH <sub>4</sub> , as Sn           | 2  | ---                                   | 2                                      | ---   |
| Tin [7440-31-5], oxide and inorganic compounds, except oxide and SnH <sub>4</sub> , as Sn | ---  | 2                                     | ---                                    | ---   |
| Tin [7440-31-5], organic compounds, as Sn   | 0.1, [0.2 <sup>14)</sup> ]                             | 0.1                                   | 0.1                                    | 0.1 <sup>13)</sup>                          |
| Tantalum [7440-25-7], metal   | ---  | 5                                     | 5, [10 <sup>14)</sup> ]                | 4 <sup>13)</sup> , [1,5 <sup>12)</sup> ]    |
| Tantalum [7440-25-7] oxide, dust, as Ta   | ---  | 5                                     | 5, [10 <sup>14)</sup> ]                | ---   |
| Titanium dioxide [13463-67-7]   | 10   | ---                                   | ---                                    | ---   |
| Titanium dioxide [13463-67-7], total dust   | ---  | 15                                    | ---                                    | ---   |
| Vanadium pentoxide [1314-62-1], as V  | 0.05 <sup>12)</sup>                                    | ---                                   | ---                                    | ---   |
| Ferrovandium [12604-58-9] dust  | 1, [3 <sup>14)</sup> ]                                 | 1                                     | 1, [3 <sup>14)</sup> ]                 | ---   |
| Tungsten [7440-33-7] and insoluble compounds, as W  | 5, [10 <sup>14)</sup> ]                                | ---                                   | 5, [10 <sup>14)</sup> ]                | ---   |
| Tungsten [7440-33-7], soluble compounds, as W   | 1, [3 <sup>14)</sup> ]                                 | ---                                   | 1, [3 <sup>14)</sup> ]                 | ---   |
| Zinc oxide [1314-13-2]  | 2 <sup>12)</sup> , [10 <sup>12)</sup> ] <sup>14)</sup> | 5 <sup>12)</sup>                      | ---                                    | 0.1 <sup>12)</sup> , [2 <sup>13)</sup> ]    |
| Zinc oxide [1314-13-2], total dust  | ---  | 15                                    | ---                                    | ---   |
| Zinc oxide [1314-13-2], dust only   | ---  | ---                                   | 5                                      | ---   |
| Zinc oxide [1314-13-2], fume  | ---  | 5                                     | 5, [10 <sup>14)</sup> ]                | 0.1 <sup>12)</sup> , [2 <sup>13)</sup> ]    |
| Zirconium [7440-67-7]   | 5, [10 <sup>14)</sup> ]                                | ---                                   | ---                                    | ---   |
| Zirconium [7440-67-7] compounds, as Zr  | 5, [10 <sup>14)</sup> ]                                | 5                                     | 5, [10 <sup>14)</sup> ]                | ---   |
| Zirconium [7440-67-7] insoluble compounds   | ---  | ---                                   | 5, [10 <sup>14)</sup> ]                | 1 <sup>13)</sup>                            |
| Zirconium [7440-67-7] soluble compounds   | ---  | ---                                   | 5, [10 <sup>14)</sup> ]                | ---   |



(Continued) OCCUPATIONAL EXPOSURE VALUES <sup>1)</sup> TWA<sup>11)</sup> (ppm)

| SUBSTANCE [CAS No.] <sup>2)</sup>                    | ACGIH <sup>3)</sup> TLVs <sup>4)</sup> | OSHA <sup>5)</sup> PELs <sup>6)</sup> | NIOSH <sup>7)</sup> RELs <sup>8)</sup> | DFG <sup>9)</sup> MAKs <sup>10)</sup> |
|--|--|---------------------------------------|--|---------------------------------------|
| Phenol [108-95-2]                                    | 5                                      | 5                                     | 5                                      | ---                                   |
| Carbon monoxide [630-08-0]                           | 25                                     | 50                                    | 35                                     | 30                                    |
| Carbon dioxide [124-38-9]                            | 5000, [30000 <sup>14), 15)</sup>       | 5000                                  | 5000, [30000 <sup>14)</sup>            | 5000                                  |
| Phosgene [75-44-5]                                   | 0.1                                    | 0.1                                   | 0.1                                    | 0.1                                   |
| Hydrogen fluoride [7664-39-3] as F                   | 0.5, [2 <sup>14)</sup>                 | 3                                     | 3                                      | 1                                     |
| Nitric oxide [10102-43-9]                            | 25                                     | 25                                    | 25                                     | ---                                   |
| Nitrogen dioxide [10102-44-0]                        | 0.2                                    | ---                                   | 1 <sup>14)</sup>                       | 0.5                                   |
| Ozone [10028-15-6]                                   | ---                                    | 0.1                                   | 0.1 <sup>14)</sup>                     | ---                                   |
| Heavy work   | 0.05                                   | ---                                   | ---                                    | ---                                   |
| Moderate work  | 0.08                                   | ---                                   | ---                                    | ---                                   |
| Light work   | 0.1                                    | ---                                   | ---                                    | ---                                   |
| Light, moderate, or heavy workload ( $\leq 2$ hours) | 0.2                                    | ---                                   | ---                                    | ---                                   |
| Phosphine [7803-51-2]                                | 0.3, [1 <sup>14)</sup>                 | 0.3                                   | 0.3, [1 <sup>14)</sup>                 | 0.1                                   |

1) 2014 Guide to Occupational Exposure Values, ACGIH

2) Chemical Abstract Service Registry Number

3) American Conference of Governmental Industrial Hygienists

4) ACGIH Threshold Limit Values

5) U.S. Occupational Safety and Health Administration

6) OSHA Permissible Exposure Limits

7) U.S. National Institute for Occupational Safety and Health

8) NIOSH Recommended Exposure Limits

9) Deutsche Forschungsgemeinschaft

10) DFG Maximum Concentrations at the Workplace

11) Time-weighted average exposure concentration for a conventional 8-hour (TLV, PEL) or up to a 10-hour (REL) workday and a 40-hour workweek

12) Measured as respirable fraction of the aerosol.

13) Measured as inhalable fraction of the aerosol.

14) The concentration that shall not be exceeded during any part of the working exposure

15)  $\frac{250\text{mppcf}}{\% \text{SiO}^2+5}$  or  $\frac{10\text{mg}/\text{m}^3}{\% \text{SiO}^2+2}$ 16)  $\frac{30\text{mg}/\text{m}^3}{\% \text{SiO}^2+2}$