	SAFETY DATA SHEET	
	In accordance with the criteria of Regulation No 1907/2006 (REACH) as amended	
CADMIUM REFINED		
Date: 29.02.2012	Revision: 13.05.2021	Page/pages: 1/69

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Cadmium refined.

Chemical name: Cadmium (nonpyrophoric) [CAS: 7440-43-9; EC: 231-152-8]

Registration number: 01-2119489023-40-0018.

1.2. Relevant identified uses of the substance or mixture and uses advised against

Relevant identified uses: Cadmium metal production RLE. Cadmium metal production by pyrometallurgy. Storage of ingots-slabs in warehouses. Production of chemicals (pyro). Production of chemicals (hydro). Additive for production of inorganic catalysts. Melting, alloying and casting. Production of "targets" by (EB) PVD. Cadmium casting and rolling. Wire and rods manufacturing. Component for brazing products. Component for soldering products. Downstream use of Cadmium based brazing products. Downstream use of cadmium-based soldering products. Cadmium (alloyed) powder manufacturing. Powders for contact materials. Use of active powders for batteries. Use of fine powders for mechanical plating. Manufacturing of Cadmium containing-alloys. Use of cadmium containing Ag alloys. Electroplating. PVD/coating.

Uses advised against: All other uses than above mentioned.

1.3. Details of the supplier of the safety data sheet

Producer/Distributor: HUTA CYNKU „Miasteczko Śląskie” S.A.

Address: Poland; PL 42-610 Miasteczko Śląskie; Hutniacza 17 street

Telephone/Fax: +48 32 2888 444 (dir.) / +48 32 2888 687/885

E-mail address of the person responsible for the SDS: hcm@hcm.com.pl

1.4. Emergency telephone number

112 (emergency call), 998 (fire brigade), 999 (ambulance)

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

Classification according to Regulation 1272/2008/EC:

Acute Tox. 2; H330

Muta. 2; H341

Carc. 1B; H350

Repr. 2; H361fd

STOT RE 1; H372

Aquatic Acute 1; H400

Aquatic Chronic 1; H410

Hazards to man: Causes damage to organs through prolonged or repeated exposure. May cause cancer. Suspected of causing genetic defects. Suspected of damaging fertility or the unborn child. Fatal if inhaled.

Hazards to environment: Very toxic to aquatic life with long lasting effects.

Hazard from physical and chemical properties: Does not meet the criteria of classification.

In section 16 stated the meaning of H-phrases and symbols.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 2/69

2.2. Label elements
Classification according to Regulation 1272/2008/EC:
Hazard pictograms, signal words:

Danger
Hazard statements:

H330 - Fatal if inhaled.

H341 - Suspected of causing genetic defects.

H350 - May cause cancer.

H361fd - Suspected of damaging fertility. Suspected of damaging the unborn child.

H372 - Causes damage to organs through prolonged or repeated exposure.

H410 - Very toxic to aquatic life with long lasting effects.

Precautionary statements:

P202 - Do not handle until all safety precautions have been read and understood.

P270 - Do not eat, drink or smoke when using this product.

P273 - Avoid release to the environment.

P280 - Wear protective gloves/protective clothing/eye protection/face protection.

P308+P313 - IF exposed or concerned: Get medical advice/attention.

P314 - Get medical advice/attention if you feel unwell.

P405 - Store locked up.

The names of hazardous ingredients on the label: Cadmium (non-pyrophoric)
 (Labelling EC: 231-152-8)


Label elements are permitted to be removed in accordance with Section 1.3.4. of 1272/2008 Regulation (CLP), account of its form in which it is placed on the market.

2.3. Other hazards

No information on meeting the criteria for PBT or vPvB in accordance with Annex XIII of Regulation 1907/2006 (REACH). Tests have not been carried out.

SECTION 3: Composition/information on ingredients
3.1. Substances

Substance name:	Cadmium (non-pyrophoric)*
Concentration [%]:	>99.95
CAS Number:	7440-43-9
EC Number:	231-152-8
Index Number:	048-002-00-0
Classification 1272/2008/EC:	Carc. 1B; H350 Muta. 2; H341 Repr. 2; H361fd Acute Tox. 2; H330 STOT RE 1; H372

	SAFETY DATA SHEET	
	In accordance with the criteria of Regulation No 1907/2006 (REACH) as amended	
CADMIUM REFINED		
Date: 29.02.2012	Revision: 13.05.2021	Page/pages: 3/69

	Aquatic Acute 1; H400 Aquatic Chronic 1; H410
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The content of other pollutants do not exceed 0.03 % by weight. These metals in such amounts do not constitute a basis for the product classification.

*Cadmium is produced during purification of zinc obtained by pyrometallurgical technology by ISP (Imperial Smelting Processes) in the shaft furnace. The process of refining (purification) of zinc in Huta Cynku Miasteczko Śląskie S.A. is carried out by rectification. Cadmium refined obtained from the distillation column „Baby”.

In section 16 stated the meaning of H-phrases and symbols.

3.2. Mixtures

Not applicable.

SECTION 4: First aid measures

4.1. Description of first aid measures

Described below, the recommendations apply to work in exposure to vapours, fumes and dust generating during machining and heat-refined cadmium.

Inhalation: Immediately move person from the danger area to fresh air. Keep warm and quiet. Apply artificial respiration if breathing has stopped. In the event of respiratory distress, give oxygen (oxygen should be administered by a trained person). Immediately seek medical attention, especially in the case of exposure to dust, smoke and fumes of cadmium.


Skin contact: Immediately remove contaminated clothing, shoes. Wash contaminated skin with plenty of water and thoroughly rinse with water. Consult your doctor, especially if any symptoms persist, such as the characteristics of skin irritation, etc. Wash contaminated clothing before reuse.

Eye contact: Remove any contact lenses. When rolled hems eyelids as soon as possible, wash eyes with plenty of clean running water or other sterile fluid for flushing the eyes (wash for at least 10-15 minutes). Avoid strong stream of water so as not to damage the eyes. Consult a doctor - an ophthalmologist in case of continuation of any symptoms.

Ingestion: Rinse mouth with water. If conscious, give plenty of water to drink 2-4 glasses of water. If unconscious do not give any of mouth. Do not induce vomiting unless advised by your doctor. Seek medical advice immediately - show this data sheet. Taking into account the form of the product (block) the exposure of the oral route is unlikely. Cadmium intake via food may be a consequence of not following basic hygiene when handling the product, such as not washing hands after handling the product, exposure to high concentrations of dust and smoke of the product.

4.2. Most important symptoms and effects, both acute and delayed

Inhalation: Fatal if inhaled. May cause respiratory tract cancer. Repeated inhalation may cause chronic bronchitis. Chronic inhalation may cause nasal septum ulceration and perforation. Cadmium and compounds may cause lung, liver and kidney damage and lung and prostate cancer in humans. May cause loss of smell, emphysema, anaemia, bone demineralization, and lung fibrosis. The primary target organ for chronic cadmium disease is clearly the kidney. May cause death after inhalation exposure to fumes and dusts. Inhalation of fumes may cause metal fume fever, which is characterized by flu-like symptoms with metallic taste, fever, chills, cough, weakness, chest pain, muscle pain and increased white blood cell count. Damage may be delayed. May cause nausea, vomiting,

	SAFETY DATA SHEET In accordance with the criteria of Regulation No 1907/2006 (REACH) as amended	
CADMIUM REFINED		
Date: 29.02.2012	Revision: 13.05.2021	Page/pages: 4/69

abdominal pain, diarrhoea, chest tightness, weakness, and delayed pulmonary edema. In humans inhalation causes proteinuria, an excess of protein in the urine.

Skin contact: May cause skin irritation.

Eye contact: May cause eye irritation after contact with fumes and dusts.

Ingestion: May cause gastrointestinal irritation with nausea, vomiting and diarrhoea. Ingestion may produce fluid loss, acute renal failure, and cardiopulmonary depression.

4.3. Indication of any immediate medical attention and special treatment needed

At room temperature, apart from mechanical hazards conditional on the mass of cadmium blocks (about 700 kg), cadmium in metallic form does not pose a direct threat to their health. Remove affected person from the environment contaminated by the product. In the event of health problems, consult your doctor or the centre of toxicological concern. Provide the information contained in the SDS. If unconscious, do not give anything by mouth. In case of acute poisoning, a trained person with the medical staff can provide EDTA (calcium and sodium salts). It should however be taken of the fact that the administration of this substance for people with kidney disease, chronic respiratory disorders, liver or skin can be harmful.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media: Use sand, dust, graphite, dry powder based on sodium chloride.

Unsuitable extinguishing media: Depending on the environment.

5.2. Special hazards arising from the substance or mixture

Product not flammable. In case of a fire, at more than 313°C (melting point of cadmium), hazardous products may be formed: dangerous fumes that contain toxic and irritating fumes and vapours of cadmium, cadmium oxide. Do not inhale fumes and gases to produce a fire. Cadmium dust explosion in a threatening presence of open flames or high temperatures. Under the influence of high temperature cadmium may be ignited rapidly and re-ignite the fire extinguished. Depending on the situation to determine the need to evacuate or isolate the area threatened by fire.

5.3. Advice for firefighters

Wear full protective equipment and self-contained breathing apparatus with independent air circulation. Protect drains, surface waters and soil from pollution. Water from fire treated as hazardous pollution and accumulate in separate containers.

SECTION 6: Accidental release measures


6.1. Personal precautions, protective equipment and emergency procedures

For non-emergency personnel: Access of non-emergency personnel to the area of accident should be restricted until the completion of the disposal of the product. Wear appropriate personal protective equipment.

For emergency responders: Wear appropriate personal protective equipment.

6.2. Environmental precautions

Secure the gullies. Prevent contamination of surface water and ground. In the event of any serious pollution of the environment, notify the appropriate administrative authority, control and rescue services. The used containers should be disposed by delivering to eligible organizations.

	SAFETY DATA SHEET In accordance with the criteria of Regulation No 1907/2006 (REACH) as amended	
CADMIUM REFINED		
Date: 29.02.2012	Revision: 13.05.2021	Page/pages: 5/69

6.3. Methods and material for containment and cleaning up

Collect mechanically. Re-use the collected product.

6.4. Reference to other sections

Disposal - see Section 13. Personal protective equipment - see Section 8.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

When you have all the activities carried out with the product: do not eat, drink, smoke or take drugs. At room temperature, apart from mechanical hazards conditional on the mass of cadmium blocks cadmium in metallic form does not pose a direct threat to their health. Do not breathe dust and smoke-producing product during heat treatment or mechanical. Provide adequate ventilation. Avoid contact with eyes, skin and clothing. Do not breathe dusts and fumes. Wear appropriate personal protective equipment. Wash your hands before break and after working with the product.

7.2. Conditions for safe storage, including any incompatibilities

Do not exceed the allowable unit load warehouse. Internal transport using a forklift or crane. Do not store with foods, drinks and feeds. Avoid strong oxidizers, acids, sulphur, zinc, selenium, tellurium.

7.3. Specific end use(s)

Cadmium metal production RLE. Cadmium metal production by pyrometallurgy. Storage of ingots-slabs in warehouses. Production of chemicals (pyro). Production of chemicals (hydro). Additive for production of inorganic catalysts. Melting, alloying and casting. Production of "targets" by (EB) PVD. Cadmium casting and rolling. Wire and rods manufacturing. Component for brazing products. Component for soldering products. Downstream use of Cadmium based brazing products. Downstream use of cadmium-based soldering products. Cadmium (alloyed) powder manufacturing. Powders for contact materials. Use of active powders for batteries. Use of fine powders for mechanical plating. Manufacturing of Cadmium containing-alloys. Use of cadmium containing Ag alloys. Electroplating. PVD/coating.

SECTION 8: Exposure controls/personal protection

General information: The protection of workers in the Cd-related industry is achieved by the systematic implementation of a carefully designed stepwise risk management system, outlining measures to control worker exposure and combining measurements of both exposure and effect. The system is aimed at prevention of exposure and protection against early manifestation of (subclinical) effect at the level of the critical organ, the kidney. The system is described in detail in the industry guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" (ICdA 2006). It involves essentially 2 phases of action:

1) Controlling the Cd-concentration in the workplace air

Firstly, technical measures are taken to comply with the indicative EU (i-)OEL of 4 µg respirable Cd/m³ proposed by SCOEL in compliance with art. 3 of directive 98/24/EC (2009). This i-OEL is taken forward as a DNEL; compliance with the i-OEL is mandatory if no other measurements of Cd-exposure and effect (as described below) are performed. The OEL of 4µg Cd/m³ is applicable to Cd and Cd-compounds in general, unless the limited solubility of a given Cd-compound is documented. The total/inhalable fraction corresponding to the respirable fraction is function of the particle size of the inhaled particles.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 6/69

2) Individual medical follow up of parameters of exposure and effect In general when working with cadmium, and, notably, if compliance with the i-OEL cannot be ensured in a consistent way, protection of the worker is ensured by complementary risk reduction measures and compliance with biological indicator limit values at the individual level. These measures include:

- Personal respiratory protection and hygiene measures if appropriate in combination with:
- Medical follow-up of the worker involving regular measurement of biological indicators of both exposure and effect:

exposure: measurement of Cd in urine ($\mu\text{g Cd/g Creatinine}$) and/or Cd in blood ($\mu\text{g Cd/l}$) to assess integrated systemic exposure of the individual effect: measurement of early (subclinical) indicators of tubular (kidney) dysfunction. Well established biological indicators (BI) for Cd-effect are e.g. β -microglobuline (β 2-MG) and retinol binding protein (RBP).

The specific medical supervision (for details see ICdA 2006 – part II, section 4) is complementary to the technical and hygiene measures taken. It integrates exposure through all possible routes by assessing the Cd-body burden and assesses early biological indicators (BI's) of (subclinical) renal effect. It ensures as such that the risk to Cd-exposed workers is fully controlled.

8.1. Control parameters

Substance name	TWA	STEL	BLV
<u>Cadmium and cadmium compounds except cadmium oxide fume, cadmium sulphide and cadmium sulphide pigments (as Cd)</u>	<u>0.025 mg/m³</u>	-	-

Legal basis: Ordinance on maximum permissible concentration and intensity of harmful factors in the work environment in accordance with national limit values.

[EH40/2005 Workplace exposure limits, fourth edition, published 2020, ISBN 978 0 7176 6733 8.](#)

Monitoring procedures: Use methods described in European Standards.

DNEL substances – components of the product under conditions of acute and chronic exposure

Workers:

4 $\mu\text{g Cd/m}^3$

General population:

1.0 $\mu\text{g Cd/kg b.w./day}$ (app. 2 $\mu\text{g/g creatinine}$)

PNEC - Predicted No-Effect Concentration

Cadmium [CAS: 7440-43-9]

PNEC aqua (freshwater): 0.19 $\mu\text{g/l}$

PNEC aqua (marine water): 1.14 $\mu\text{g/l}$


PNEC sediment (freshwater): 1.8 $\text{mg/kg sediment d.w.}$

PNEC sediment (marine water): 0.64 $\text{mg/kg sediment d.w.}$

PNEC soil: 0.9 mg/kg soil d.w.

PNEC_{STP} in sewage treatment systems: 20 $\mu\text{g Cd/l}$

PNEC oral: 0.16 mg/kg food (secondary poisoning – birds and mammals)

	SAFETY DATA SHEET In accordance with the criteria of Regulation No 1907/2006 (REACH) as amended	
CADMIUM REFINED		
Date: 29.02.2012	Revision: 13.05.2021	Page/pages: 7/69

8.2. Exposure controls

Mandatory general regulations on occupational health. Do not allow to exceed the normative concentrations of hazardous constituents in the workplace. Ensure adequate ventilation, especially in confined spaces, general and local exhaust. In conditions of insufficient ventilation, wear suitable respiratory equipment. Process enclosures or semi-enclosures where appropriate. Local exhaust ventilation on furnaces and other work areas with potential dust generation, dust capturing and removal techniques. After work, wash and clean the surface of the body and clothing. Do not eat, drink, smoke or take drugs at work. Avoid skin and eyes contamination. Do not inhale dusts and fumes. Keep away from food.

Eye/face protection: When dusts, fumes and vapours are generated wear suitable protective glasses (in accordance with EN 166).

Skin Protection: Wear suitable gloves (in accordance with EN 374). Gloves, protective properties depend not only on the material from which they are made. The time of the protective effect may be different for different glove manufacturers. In the case of many substances cannot accurately estimate the time of the protective gloves. Taking into account the parameters specified by the manufacturer of gloves should pay attention while taking the gloves still retain their protective properties. Suitable protective clothing with long sleeves and trousers.

Respiratory protection: In terms of exposure to concentrations exceeding the limit values of TWA, in terms of exposure to dust, fumes and vapours of the product wear appropriate respiratory protection, for example in terms of short-term exposure - a mask filter or a canister with a suitable breathing apparatus with independent air supply in the exposure to high concentration.

Thermal Hazards: Usually is not required. During work with hot (molten) product wear long-sleeved clothing, aprons, gloves heat-resistant.

Used personal protective equipment should meet the requirements of local/regional/national laws. The employer must provide personal protective equipment appropriate to the type of work and in accordance with all requirements, including maintenance and cleaning.

Concentrations of hazardous substances in the workplace should be monitored in accordance with acknowledged test methods. Mode, method, type and frequency of testing and measurement of harmful factors in the working environment should meet the requirements of local/regional/national laws.

Environmental exposure controls: The large amount of product should not be allowed to penetrate through the ground water, sewage, waste water or soil.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state:	<u>Solid (blocks weighing 700 kg)</u>
Colour:	<u>Shiny silver colour</u>
Odour:	<u>Odourless</u>
Melting point/freezing point:	<u>313 °C</u>
Boiling point or initial boiling point and boiling range:	<u>Not relevant; the product decomposes before boiling</u>
Flammability:	<u>Not applicable</u>
Lower and upper explosion limit:	<u>Not applicable</u>

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 8/69

Flash point:	<u>Not applicable</u>
Auto-ignition temperature:	<u>Not applicable</u>
Decomposition temperature:	<u>Not specified</u>
pH:	<u>Not applicable</u>
Kinematic viscosity:	<u>Not applicable</u>
Solubility:	<u>Soluble in water 2.3 mg/l</u>
Partition coefficient n-octanol/water (log value):	<u>Not applicable</u>
Vapour pressure:	<u>Not applicable</u>
Density and/or relative density:	<u>8.6 g/cm³ at 20 °C</u>
Relative vapour density:	<u>Not applicable</u>
Particle characteristics:	<u>Not specified</u>

9.2. Other information

9.2.1. Information with regard to physical hazard classes
Not specified.

9.2.2. Other safety characteristics
Reaction with acids liberates extremely flammable hydrogen.

SECTION 10: Stability and reactivity**10.1. Reactivity**

In contact with air is oxidized. Tarnishes easily from contact with moist air.

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

Reaction with acids liberates extremely flammable hydrogen (H₂).

10.4. Conditions to avoid

Avoid excessive heat, humidity, contact with moisture and excessive contact with air.

10.5. Incompatible materials

Avoid contact with strong oxidizers, acids, sulphur, zinc, selenium, tellurium.

10.6. Hazardous decomposition products

None under normal conditions of use and storage.

SECTION 11: Toxicological information**11.1. Information on hazard classes as defined in Regulation (EC) No 1272/2008**

Acute toxicity: Fatal if inhaled.

ATE (inhalation, dust) ≤0.5 mg Cd/dm³


Ingestion: Toxic if swallowed. May cause gastrointestinal irritation with nausea, vomiting and diarrhoea. Ingestion may produce fluid loss, acute renal failure, and cardiopulmonary depression.

LD₅₀ (oral, mice, cadmium powder) 890 mg/kg b.w.

LD₅₀ (oral, rats, cadmium powder) 2330 mg/kg b.w.

Inhalation: May be fatal if inhaled. Inhalation of fumes may cause metal fume fever, which is characterized by flu-like symptoms with metallic taste, fever, chills, cough, weakness, chest pain, muscle pain and increased white blood cell count. Damage may be delayed. May cause nausea, vomiting, abdominal pain, diarrhoea, chest tightness, weakness, and delayed pulmonary edema. In humans inhalation causes proteinuria, an excess of protein in the urine.

Substance is classified as hazardous in this class: Acute Tox. 2; H330.

	SAFETY DATA SHEET In accordance with the criteria of Regulation No 1907/2006 (REACH) as amended	
CADMIUM REFINED		
Date: 29.02.2012	Revision: 13.05.2021	Page/pages: 9/69

Skin corrosion/irritation: Based on available data, the classification criteria are not met. May causes skin irritation.

Serious eye damage/irritation: Based on available data, the classification criteria are not met. May causes eye irritation after exposure to fumes and dusts.

Respiratory or skin sensitization: Based on available data, the classification criteria are not met.

Germ cell mutagenicity: Suspected of causing genetic defects. There are reports of cadmium mutagenicity. Substance is classified as hazardous in this class: Muta. Cat. 2; H341. The mutagenic properties were demonstrated in mouse mice and cytogenetic analysis in hamsters.

Carcinogenicity: May cause cancer. Substance is classified as hazardous in this class: Carc 1B; H350.

Occupational exposure to cadmium has been associated with a significant increase in prostate and respiratory tract cancer. There is evidence of a significant excess of respiratory cancer deaths among a cohort of cadmium production workers, and concluded that cadmium and its compounds are potential carcinogens. ACGIH classified cadmium as suspected human carcinogen – group A2. IARC classified cadmium as group 1 carcinogen - carcinogenic to humans; and NTP as a known carcinogen.

Reproductive toxicity: Suspected of damaging fertility. Suspected of damaging the unborn child. Teratogenicity - Oral, rat: TDL_0 – 155 mg/kg (male 13 week (s) pre-mating and female 13 week (s) pre-mating) – 3 week (s) after conception – effects in new-born – growth statistics (e.g. % reduced weight gain) and behavioural changes. Oral, rat: TDL_0 – 23 mg/kg (female 1-22 days after conception) – specific developmental abnormalities – blood and lymphatic systems, including spleen and marrow. Oral, mouse: TDL_0 – 1700 mg/kg (female 8-12 days after conception) – effects on new-born - growth statistics and reduced viability index. Reproductive effects: Oral, rat: TDL_0 = 21.5 mg/kg (multigenerations) Fertility – preimplantation mortality (reduction in number of implants per female; total number of implants per corpora lutea). Intraperitoneal, rat: TDL_0 = 1 124 µg/kg (male 1 day pre-mating) paternal effects – spermatogenesis – including genetic material, sperm morphology, motility, and count. The lowest NOAELs correspond to 1 mg Cd/kg b.w./day via the oral route and ca. 0.23 mg Cd/m³ after inhalation. Substance is classified as hazardous in this class: Repr. 2; H361.

STOT - single exposure: Based on available data, the classification criteria are not met.

STOT - repeated exposure: Causes damage to organs through prolonged or repeated exposure. Results from studies in animals and observations in humans indicate that the sensitive targets of cadmium toxicity are kidney and bone following oral exposure and kidney and lungs following inhalation exposure (ATSDR, 2008). Available NOAELs from repeated dose oral and inhalation studies range between 0.12 - 3 mg/kg b.w./day and 0.013×10^{-3} - 0.022×10^{-3} mg/L, respectively. This data supports a classification as STOT RE 1; H372. Substance is classified as hazardous in this class.

Aspiration hazard: Based on available data, the classification criteria are not met.

11.2. Information on other hazards

11.2.1. Endocrine disrupting properties

Not specified.

11.2.2. Other information

Delayed and immediate and chronic effects of short-and long-term exposure

Effects of acute exposure:

Eye contact: May cause eye irritation after contact with fumes and dusts.

Skin contact: May cause skin irritation.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 10/69

Inhalation: Fatal if inhaled. May cause death after inhalation exposure to fumes and dusts. Inhalation of fumes may cause metal fume fever, which is characterized by flu-like symptoms with metallic taste, fever, chills, cough, weakness, chest pain, muscle pain and increased white blood cell count. Damage may be delayed. May cause nausea, vomiting, abdominal pain, diarrhoea, chest tightness, weakness, and delayed pulmonary edema. In humans inhalation causes proteinuria, an excess of protein in the urine.

Ingestion: May cause gastrointestinal irritation with nausea, vomiting and diarrhoea. Ingestion may produce fluid loss, acute renal failure, and cardiopulmonary depression.

Effects of chronic exposure:

Inhalation: May cause cancer. Repeated inhalation may cause chronic bronchitis. Chronic inhalation may cause nasal septum ulceration and perforation. Cadmium and compounds may cause lung, liver and kidney damage and lung and prostate cancer in humans. May cause loss of smell, emphysema, anemia, bone demineralization, and lung fibrosis. The primary target organ for chronic cadmium disease is clearly the kidney.

Target organs: Blood, kidneys, liver, lungs, skeletal structures, prostate.

SECTION 12: Ecological information**12.1. Toxicity**

Very toxic to aquatic life with long lasting effects.

According to section 1.3.4 of Regulation 1272/2008, does not meet this threat, account of its form in which it is placed on the market.

Acute toxicity to aquatic environment:

Fish: Rainbow trout (*Oncorhynchus mykiss*): TL_m = 30 ppm, 24 Hr.

Hard waterfish: Stripped bass (*Lepomis gibbosus*): CL₅₀ = 0.001 ppm, 24-48 Hr.

Static bioassay fish: Fathead minnow (*Pimephales promelas*): TL₅₀ = 7.2 ppm, 96 Hr.

The lowest short-term EC₅₀ is observed on invertebrates (*Daphnia pulex*): 42 µg Cd/l (single measured value). The EC₅₀ values ranged between 38 and 1900 µg Cd/l. Species geomean for *Daphnia* is 130 µg Cd/l.

Substance is classified as hazardous in this class.

Chronic toxicity to aquatic environment

Freshwater: Data on 12 fish species: NOECs range between 0.47 and 13.5 µg/l Cd (dissolved concentrations).

Marine waters: Data on 6 fish species belonging to 6 different families are available. Species NOECs range between 10 and 794 µg Cd/L (dissolved concentrations). The lowest chronic NOEC for use as reference value in classification is 0.21 µg Cd/l (*Daphnia magna*).

Toxicity to microorganisms:

EC₁₀/LC₁₀ or NOEC for aquatic micro-organisms: 0.2 mg/l

Toxicity to organisms in the terrestrial environment:

PNEC oral: 0.16 mg/kg food (secondary poisoning – birds and mammals)

12.2. Persistence and degradability

Biodegradation is not applicable to metals/inorganic substances.

12.3. Bioaccumulative potential

The available evidence makes it difficult to decide whether or not Cd is to be considered as a bioaccumulative substance in the environment. Evidence related to biomagnification in the aquatic food chain consistently shows that Cd is not biomagnifying.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 11/69

12.4. Mobility in soil

Cadmium can enter the air from natural sources.

12.5. Results of PBT and vPvB assessment

Cadmium is an element and as such, the criterion persistence is not applicable to Cd. The case on PBT and vPvB properties of cadmium and its compounds is inconclusive.

12.6. Endocrine disrupting properties

Not specified.

12.7. Other adverse effects

It does not affect global warming and ozone depletion.

SECTION 13: Disposal considerations
13.1. Waste treatment methods

During removal of waste comply with the regional / national laws.

Community legislation:

- Directive **2008/98/EC** of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives as amended.
- European Parliament and Council Directive **94/62/EC** of 20 December 1994 on packaging and packaging waste as amended.

Disposal methods for the product: Do not introduce into the environment. Disposal in accordance with the local/national legislation.


Disposal methods for used packing: Empty containers give for appropriate rubbish dump or for disposal in accordance with the local/national legislation.

SECTION 14: Transport information

	ADR	RID	AND	IMDG	ICAO TI
14.1. UN number or ID number			None		
14.2. UN proper shipping name			None		
14.3. Transport hazard class(es)			None		
14.4. Packing group			None		
14.5. Environmental hazards			Very toxic to aquatic life with long lasting effects		
14.6. Special precautions for user			During cargo handling use personal protective equipment - see Section 8.		
14.7. Maritime transport in bulk according to IMO instruments			Not specified		

SECTION 15: Regulatory information
15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation

	SAFETY DATA SHEET	
	In accordance with the criteria of Regulation No 1907/2006 (REACH) as amended	
CADMIUM REFINED		
Date: 29.02.2012	Revision: 13.05.2021	Page/pages: 12/69

(EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC as amended.

Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 as amended.

Commission Regulation (EU) 2020/878 of 18 June 2020 amending Annex II to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives as amended.

European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste as amended.

Commission Regulation (EU) 2017/542 of 22 March 2017 amending Regulation (EC) No 1272/2008 of the European Parliament and of the Council on classification, labelling and packaging of substances and mixtures by adding an Annex on harmonised information relating to emergency health response.

Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC.

Comply with national health and safety regulations during using this substance.

15.2. Chemical safety assessment

There is a chemical safety report for substance.

SECTION 16: Other information

The full text of statements H under Sections 3:

H350 - May cause cancer.

H341 - Suspected of causing genetic defects.

H361fd - Suspected of damaging fertility or the unborn child.

H330 - Fatal if inhaled.

H372 - Causes damage to organs through prolonged or repeated exposure.

H400 - Very toxic to aquatic life.

H410 - Very toxic to aquatic life with long lasting effects.

Key to abbreviations and acronyms:

Acute Tox. 2 - Acute toxicity (inhal.), Hazard Category 2.

Aquatic Acute 1 - Hazardous to the aquatic environment - Acute Hazard, Category 1.

Aquatic Chronic 1 - Hazardous to the aquatic environment - Chronic Hazard, Category 1.

BLV - Biological limit values.

Carc. 1B - Carcinogenicity, Hazard Category 1B.

DNEL - Derived no-effect level.

EC₅₀ - An exposure concentration associated with a 50% effect.

LC₅₀ - An exposure concentration associated with a 50% lethal effect.

LD₅₀ - The dose that is lethal to 50% of the exposed population.

Muta. 2 - Germ cell mutagenicity, Hazard Category 2.


PNEC - Predicted no-effect concentration.

Repr. 2 - Reproductive toxicity, Hazard Category 2.

STEL - Short-term exposure limit.

STOT RE 1 - Specific target organ toxicity - Repeated exposure, Hazard Category 1.

TWA - 8 hours' time-weighted average.

	SAFETY DATA SHEET	
	In accordance with the criteria of Regulation No 1907/2006 (REACH) as amended	
CADMIUM REFINED		
Date: 29.02.2012	Revision: 13.05.2021	Page/pages: 13/69

Training advice: Before use read the SDS.

Sources of key data:

Manufacturer SDS from 29 February 2012 (in Polish).

Classification according to Regulation (EC) Nr. 1272/2008:

Acute Tox. 2; H330

Muta. 2; H341

Carc. 1B; H350

Repr. 2; H361fd

STOT RE 1; H372

Aquatic Acute 1; H400

Aquatic Chronic 1; H410

Classification procedure:

Calculation method

Calculation method

Calculation method

Calculation method

Calculation method

Calculation method

Calculation method

The information above is based on a current available data concerning the product, but also on the experience and knowledge in this field of the producer. They are neither a quality description of the product nor a guarantee of particular features. They are also treated as aid to safety in transport, storage and usage of the product. This does not free the user from the responsibility of improper usage of the information above also of improper compliance with the law norms in the field.

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SDS from 13.10.2017 (Version 3) has been revised in sections 2.1, 3.1, 5.2, 5.3, 6.1, 6.2, 6.3, 8.1, 8.2, 9.1, 9.2, 11.1, 11.2, 12.6, 12.7, 13.1, 14.1, 14.2, 14.3, 14.4, 14.5, 14.6, 14.7, 15.1 and 16. Changes have been underlined.

This SDS replaces and annuls all the previous versions.

Adequate exposure scenarios are the annexes to the safety data sheet.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 14/69

Exposure scenario 1, annex to the SDS
Section 1. Title of the exposure scenario

Title	Industrial use of Cd-bearing materials, primary and secondary, to produce pure cadmium metal in several process steps – hydrometallurgical and pyrometallurgical, with occasional controlled exposure.
Sector of use	<ul style="list-style-type: none"> ▪ SU3: Industrial uses; ▪ SU8: Manufacture of bulk, large scale chemicals (including petroleum products); ▪ SU14: Manufacture of basic metals, including alloys; ▪ SU0: Other.
Product category	<ul style="list-style-type: none"> ▪ PC7: Base metals and alloys.
Process category	<ul style="list-style-type: none"> ▪ PROC1: Chemical production or refinery in closed process without likelihood of exposure or processes with equivalent containment conditions; ▪ PROC2: Chemical production or refinery in closed continuous process with occasional controlled exposure or processes with equivalent containment conditions; ▪ PROC3: Manufacture or formulation in the chemical industry in closed batch processes with occasional controlled exposure or processes with equivalent containment condition; ▪ PROC4: Chemical production where opportunity for exposure arises; ▪ PROC5: Mixing or blending in batch processes; ▪ PROC8b: Transfer of substance or mixture (charging and discharging) at dedicated facilities; ▪ PROC9: Transfer of substance or mixture into small containers (dedicated filling line, including weighing); ▪ PROC22: Manufacturing and processing of minerals and/or metals at substantially elevated temperature; ▪ PROC25: Other hot work operations with metals; ▪ PROC26: Handling of solid inorganic substances at ambient temperature.
Categories of the release to the environment	<ul style="list-style-type: none"> ▪ ERC1: Manufacture of the substance; ▪ ERC2: Formulation into mixture.

Section 2. Exposure Scenario
Section 2.1. Contributing scenario (1) controlling environmental exposure for the industrial use of Cd-bearing materials, primary and secondary, to produce pure cadmium metal in several process steps – hydrometallurgical and pyrometallurgical, with occasional controlled exposure.
Further specification

Description of activities/process(es) covered in the Exposure Scenario

- Electro-winning
 - The Cadmium sulphate solution is circulating continuously between the electrolytic-cells in the cell-house and the atmospheric coolers outside the building;
 - The temperature is kept around ~30°C and current is applied between the series of Pb-anodes and Al-cathodes;

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 15/69

- Cadmium deposits at the cathode and O₂ is evolved at the anode;
 - A foaming agent is added in order to have a blanket of foam at the solution surface in the cells, and occasionally a cover on the cells, i.o.t. prevent aerosols emissions
 - The Cadmium deposit is removed mechanically from the cathodes every ~24h, is washed and melted in automated furnaces;
 - The anodes need also to be cleaned from occasional deposits (PbO₂/MnO₂) every 2-3 weeks and replaced by new anodes every ~18 months;
 - The cells need to be cleaned up regularly from accumulating cellmud.
- Distillation process
 - Cadmium sulphate solution is treated in successive leaching tanks and Cadmium metal is precipitated by addition of strong reducing agents (i.e. Zinc powder);
 - The solution is filtered and returned to the process; the resulting cake is further bricketted in a press in order to remove residual entrained solution;
 - The Cadmium bricketts are molten and fed to a distillation chamber;
 - Under vacuum, the cadmium is distilled and further cooled in the condenser zone; the liquid; Cadmium stream is kept under a molten salt layer;
 - Cd-sticks are then cast and packed.
 - Maintenance activities

Product characteristics

Product related conditions, e.g. the concentration of the substance in a mixture; viscosity of product; package design affecting exposure.

Cd is produced in its pure form e.g.: >99%.

Amounts used

Daily and annual amount per site (for uses in industrial setting) or daily and annual amount for wide disperse uses.

Up to 700 T/y.

Frequency and duration of use

Intermittent (used < 12 times per year for not more than 24 h) or continuous use/release.

Continuous use.

Environment factors not influenced by risk management

Flow rate of receiving surface water (m³/d, usually 18 000 m³/d for the standard town by default; please note: the default flow rate will be rarely changeable for downstream uses.

Default is used unless specified otherwise.

Other given operational conditions affecting environmental exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process (via air and waste water); dry or water based processes; conditions related to temperature and pressure; indoor or outdoor use of products; work in confined area or open air.

- Air on the working place is filtered before release outside the building;
- All processes are performed indoor in a confined area. All residues containing cadmium are recycled;
- Even when no process waters (e.g. when dry process throughout), some non-process water can be generated containing Cd (e.g. from cleaning).

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 16/69

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure to the environment; this includes in particular conditions ensuring rigorous containment; performance of the containment to be specified (e.g. by quantification of a release factor in section 9.x.2 of the CSR).

- Careful use of sulphuric acid and corrosive solutions, if used;
- Sump containment is provided under the tanks and the filters i.e. to collect any accidental spillage;
- When applicable, process waters need to be specifically treated before release;
- Dosing and packaging operations occur under a special ventilation hood;
- Process air is filtered before release outside the building.

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

Technical measures, e.g. on-site waste water and waste treatment techniques, scrubbers, filters and other technical measures aiming at reducing releases to air, sewage system, surface water or soil; this includes strictly controlled conditions (procedural and control technology) to minimise emissions; specify effectiveness of measures; specify the size of industrial sewage treatment plant (m^3/d), degradation effectiveness and sludge treatment (if applicable).

- On-site waste water treatment techniques are (if applicable) e.g.: chemical precipitation, sedimentation, filtration (efficiency 90-99.98 %);
- Containment of liquid volumes in sumps to collect/prevent accidental spillage;
- Air emissions are controlled by use of bag-house filters and/or other air emission abatement devices e.g. fabric (or bag) filters (up to 99 % efficiency), wet scrubbers (50-99 % efficiency). This may create a general negative pressure in the building. Air emissions are continuously monitored.

Organizational measures to prevent/limit release from site

Specific organisational measures or measures needed to support the functioning of particular technical measures. Those measures need to be reported in particular for demonstrating strictly controlled conditions.

- In general emissions are controlled and prevented by implementing an integrated management system e.g. ISO 9000, ISO 1400X series, or alike, and, when applicable, by being IPPC-compliant
 - Such management system should include general industrial hygiene practice e.g.:
 - information and training of workers;
 - regular cleaning of equipment and floors;
 - procedures for process control and maintenance,
- Treatment and monitoring of releases to outside air, and exhaust gas streams (process & hygiene), according to national regulation;
- SEVESO 2 compliance, if applicable.

Conditions and measures related to municipal sewage treatment plant

Size of municipal sewage system/treatment plant (m^3/d); specify degradation effectiveness; sludge treatment technique (disposal or recovery); measures to limit air emissions from sewage treatment (if applicable); please note: the default size of the municipal STP (2000 m^3/d) will be rarely changeable for downstream uses.

W In cases where applicable: default size, unless specified otherwise.

Conditions and measures related to external treatment of waste for disposal

Fraction of used amount transferred to external waste treatment for disposal; type of suitable treatment for waste generated by workers uses, e.g. hazardous waste incineration, chemical-physical treatment for emulsions, chemical oxidation of aqueous waste; specify effectiveness of

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 17/69

treatment.

- If any, all hazardous wastes are treated by certified contractors according to EU and national legislation;
- Users of Cd and Cd-compounds have to favour the recycling channels of the end-of-life products e.g.; the industrial Ni-Cd rechargeable battery -by far the most important application in Europe -is to be collected, treated and recycled;
- Users of Cd and Cd-compounds have to minimize Cd-containing waste, promote recycling routes and, for the remaining, dispose the waste streams according the Waste regulation.

Conditions and measures related to external recovery of waste

Fraction of used amount transferred to external waste treatment for recovery: specify type of suitable recovery operations for waste generated by workers uses, e.g. re-distillation of solvents, refinery process for lubricant waste, recovery of slags, heat recovery out-side waste incinerators; specify effectiveness of measure.

By-products formed during the process are either recycled, internally or externally, or handled further as waste , according the waste legislation.

Section 2.2. Contributing scenario (2) controlling worker exposure for the industrial use of Cd-bearing materials, primary and secondary, to produce pure cadmium metal in several process steps –hydrometallurgical and pyrometallurgical, with occasional controlled exposure.

Product characteristic

Product related conditions, e.g. the concentration of the substance in a mixture, the physical state of that mixture (solid, liquid; if solid: level of dustiness), package design affecting exposure).

- Pure Cd is cast as massive metal: sticks or balls;
- Cd-finished product is stored in enclosed buildings.

Amounts used

Amounts used at a workplace (per task or per shift); note: sometimes this information is not needed for assessment of worker's exposure.

Up to maximum 1 T/shift.

Frequency and duration of use/exposure

Duration per task/activity (e.g. hours per shift) and frequency (e.g. single events or repeated) of exposure.

8hrs shift (worst case), continuous exposure is assumed as default. Occasional use of personal protection equipment (see below).

Human factors not influenced by risk management

Particular conditions of use, e.g. body parts potentially exposed as a result of the nature of the activity.

Uncovered body parts: (potentially) face.

Other given operational conditions affecting workers exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process into workers environment; room volume, whether the work is carried out outdoors/indoors, process conditions related to temperature and pressure.

All processes are carried out indoor in confined areas.

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure of workers; this in particular includes

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 18/69

conditions ensuring rigorous containment; performance of containment to be specified (e.g. by quantification of residual losses or exposure).

- Process enclosures or semi-enclosures where appropriate;
- Local exhaust ventilation on furnaces and other work areas with potential dust generation, dust capturing and removal techniques;
- Containment of liquid volumes in sumps to collect/prevent accidental spillage.

Technical conditions and measures to control dispersion from source towards the worker

Engineering controls, e.g. exhaust ventilation, general ventilation; specify effectiveness of measure.

- Local exhaust ventilation system (high efficiency 90-95 %);
- Cyclones/filters (for minimizing dust emissions): efficiency: 70-90 % (cyclones), 50-80 % (dust filters), 85-95 % (double stage, cassette filters);
- Process enclosure, especially in potentially dusty units;
- Dust control: dust and Cd in dust needs to be measured in the workplace air (static or individual) according to national regulations;
- Special care for the general establishment and maintenance of a clean working environment by e.g.:
 - Cleaning of process equipment and workshop;
 - Storage of packaged Cd finished product in enclosed buildings.

(see also Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 1 (ICdA 2006)).

Organisational measures to prevent /limit releases, dispersion and exposure

Specific organisational measures or measures needed to support the functioning of particular technical measures (e.g. training and supervision). Those measures need to be reported in particular for demonstrating strictly controlled conditions (to justify exposure based waiving).

The protection of workers in the Cd-related industry is achieved by the systematic implementation of a carefully designed stepwise risk management system, outlining measures to control worker exposure and combining measurements of both exposure and effect. The system is aimed at prevention of exposure and protection against early manifestation of (subclinical) effect at the level of the critical organ, the kidney. The system is described in detail in the industry guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" (ICdA 2006). It involves essentially 2 phases of action:

1) Controlling the Cd-concentration in the workplace air

Firstly, technical measures are taken to comply with the indicative EU (i-)OEL of 4 µg respirable Cd/m³ proposed by SCOEL in compliance with art. 3 of directive 98/24/EC (2009). This i-OEL is taken forward as a DNEL; compliance with the i-OEL is mandatory if no other measurements of Cd-exposure and effect (as described below) are performed. The OEL of 4µg Cd/m³ is applicable to Cd and Cd-compounds in general, unless the limited solubility of a given Cd-compound is documented. The total/inhalable fraction corresponding to the respirable fraction is function of the particle size of the inhaled particles.

2) Individual medical follow up of parameters of exposure and effect

In general when working with cadmium, and, notably, if compliance with the i-OEL cannot be ensured in a consistent way, protection of the worker is ensured by complementary risk reduction measures and compliance with biological indicator limit values at the

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 19/69

individual level. These measures include:

- Personal respiratory protection and hygiene measures if appropriate (see below, section "Conditions and measures related to personal protection, hygiene and health evaluation" for detail), in combination with
- Medical follow-up of the worker involving regular measurement of biological indicators of both exposure and effect:
 - exposure: measurement of Cd in urine ($\mu\text{g Cd/g creatinine}$) and/or Cd in blood ($\mu\text{g Cd/l}$) to assess integrated systemic exposure of the individual;
 - effect: measurement of early (subclinical) indicators of tubular (kidney) dysfunction. Well-established biological indicators (BI) for Cd-effect are e.g. β -microglobuline (β 2-MG) and retinol binding protein (RBP).

The specific medical supervision (for details see ICdA 2006 – part II, section 4) is complementary to the technical and hygiene measures taken. It integrates exposure through all possible routes by assessing the Cd-body burden and assesses early biological indicators (BI's) of (subclinical) renal effect. It ensures as such that the risk to Cd-exposed workers is fully controlled.

The results of the medical supervision are applied as follows (see also Figure below):

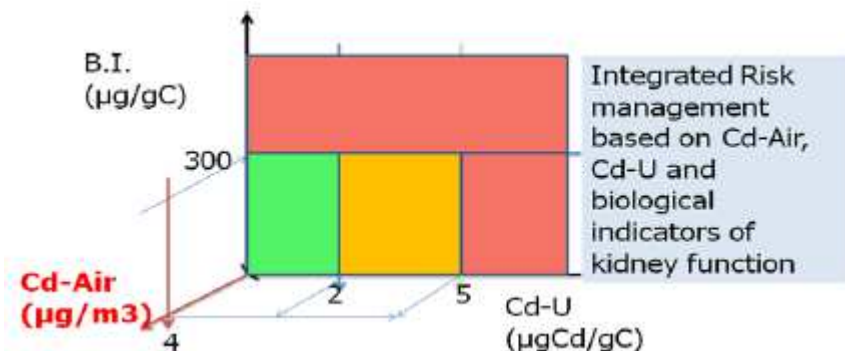


Figure: Illustration of Eurometaux/ICdA medical supervision guidance (2006) (BI: *biological indicators*; C: *creatinine*).

General medical follow-up level:

$\text{Cd-U} \leq 2 \mu\text{g Cd/g creatinine (C)}$. This is a conservative threshold based on general population studies, as described in Section 5.6.2. In this situation, the worker is followed by general medical follow-up (complementary indicator: $\text{Cd-B} \leq 5 \mu\text{g Cd/L}$). No further special action is required beyond proper implementation of the general hygiene procedures and medical surveillance.

Action level:

$2 < \text{Cd-U} \leq 5 \mu\text{g Cd/g creatinine}$: Action level zone. This zone is defined by the threshold based on studies at the workplace, as described in Section 5.6.2. Observation of Cd-U (or Cd-B) values in this "action" zone triggers (complementary trigger: $5 \mu\text{g Cd/l} < \text{Cd-B} \leq 8 \mu\text{g Cd/l}$) an individual follow up of the worker characterized by:

- Systematic and frequent follow up of exposure by measuring Cd-U (complementary analysis: Cd-B), combined with individual analysis and follow-up of hygiene behaviour
- Measurement of biological indicators (BI's) of early renal dysfunction (e.g. beta-2 microglobuline (B2-M) or retinol-binding protein (RBP) on a regular basis;

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 20/69

When the worker moves into this action level zone, the occupational doctor and plant hygiene team will check for the reason for the increased exposure (analysis of the workplace, with a view to identify possible substance releases, analysis of compliance with hygienic procedures, and interview with the worker to assess possible other causes, e.g. due to current or previous exposure, due to personal hygiene behaviour?).

Based on the results of the individual medical surveillance programme, the following management decisions are taken:

- The worker remains in the action zone: If the Cd-U (Cd-B) values do not progress further towards the threshold and the BI's remain stable and below the reference value (e.g. 300 µg/g creatinine for β2-MG and RBP), the worker is kept at the workplace. Additional hygiene measures are taken as appropriate, and medical follow-up is strictly continued.
- The worker is removed from exposure:
 - If Cd-U > 5 µg Cd/g creatinine (or Cd-B > 8 µg/l) and/or
 - o If the BI's are exceeding the reference values or showing a consistent pattern of increase which may lead to approaching the reference values.

The management scheme as outlined above is applicable to workers that entered the Cd industry rather recently. Workers that have been working in the Cd-industry for long may have been historically exposed to elevated Cd -levels, and may show e.g. Cd-U levels exceeding 5 µg/gC due to historical exposure. The supervising medical doctor will evaluate these individuals carefully, focusing on the BI's. In any case, when BI values exceed the BI-reference values or approach them, the worker will be removed from Cd-exposure.

In addition to the above, general industrial hygiene programmes are to be implemented, as required by EU Directive 98/24/EC on protection of workers from chemical agents and other referenced systems on best practice: IPPC-BREF notes, BIMSCH or equivalent, ICH-Q7, FAMI-QS, ISO9000, ISO 13.100 or alike:

- General industrial hygiene practice;
- Collective protection measures and use of warning & safety signs;
- Minimizing the number of workers exposed or likely to be exposed;
- Workplace cleanliness : ensure procedures are designed, written and implemented so as to make sure cleanliness is obtained at workstations, work sections, traffic and storage areas, upper areas, building structures and various horizontal surfaces, air suction ducts;
- Procedures for process control.

Conditions and measures related to personal protection, hygiene and health evaluation

Personal protection, e.g. wearing of gloves, face protection, full body dermal protection, goggles, respirator; specify effectiveness of measure; specify the suitable material for the PPE (where relevant) and advise how long the protective equipment can be used before replacement (if relevant).

The implementation of the risk management system as described above is strictly followed up.

Individual protection measures are used as described in detail in the Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 2, 3, 4 (ICdA 2006), and consist of e.g.:

- Wearing of gloves and protective clothing is compulsory (efficiency ≥90%);
- With normal handling, no respiratory personal protection (breathing apparatus) is

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 21/69

necessary. If risk for exceedance of OEL/DNEL, use e.g.:

- dust filter-half mask P1 (efficiency 75 %)
- dust filter-half mask P2 (efficiency 90 %)
- dust filter-half mask P3 (efficiency 95 %)
- dust filter-full mask P1 (efficiency 75 %)
- dust filter-full mask P2 (efficiency 90 %)
- dust filter-full mask P3 (efficiency 97.5 %)
- Eyes: safety glasses are optional;
- Implement best practice in collective and individual hygiene procedures in compliance with articles 5 and 8 of 98/24/EC: Information-training of the workers and their staff and line managers focused on careful hygiene behaviour. Industry practice has shown that at low levels of industrial exposure to Cd, such as at the level of the i-OEL, installation and maintaining of careful industrial hygiene practice is important for ensuring full control of exposure. Such hygiene practice must cover all aspects of the workday and involves e.g.:
 - Provide training on the risks resulting with substance exposure at the time of hire and on a periodic basis;
 - Provide work clothes with appropriate change frequency (weekly to daily) and ensure they are used accordingly;
 - Structure adequate changing rooms (three compartments: city side, shower and workplace side with 2 locker rooms);
 - Ensure snacks and drinks are provided and consumed in proper areas separated from the main work area;
 - Develop adequate procedures to ensure meals are not a source of substance intake (hand washing, partial removal of work clothes before taking meals);
 - strict separation of workplace and other working environments at the plant, including changing clothes;
 - Ensure showers are taken at end of shifts;
 - No smoking on the workplace;
 - No-bearing of beards, no moustaches

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 22/69

Exposure scenario 2, annex to the SDS
Section 1. Title of the exposure scenario

Title	industrial use of Cd-cathodes, slabs, balls, sticks, primary or secondary, by melting, possibly alloying, and casting/transformation in required massive formats, and possibly stored as slabs, ingot, anodes, sheet, bar, rod, wire.
Sector of use	<ul style="list-style-type: none"> ▪ SU3: Industrial uses; ▪ SU10: Formulation; ▪ SU14: Manufacture of basic metals, including alloys; ▪ SU15: Manufacture of fabricated metal products, except machinery and equipment; ▪ SU17: General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment; ▪ SU0: Other.
Product category	<ul style="list-style-type: none"> ▪ PC7: Base metals and alloys; ▪ PC14: Metal surface treatment products; ▪ PC38: Welding and soldering products, flux products.
Process category	<ul style="list-style-type: none"> ▪ PROC2: Chemical production or refinery in closed continuous process with occasional controlled exposure or processes with equivalent containment conditions; ▪ PROC3: Manufacture or formulation in the chemical industry in closed batch processes with occasional controlled exposure or processes with equivalent containment condition; ▪ PROC5: Mixing or blending in batch processes; ▪ PROC6: Calendering operations; ▪ PROC8b: Transfer of substance or mixture (charging and discharging) at dedicated facilities; ▪ PROC9: Transfer of substance or mixture into small containers (dedicated filling line, including weighing); ▪ PROC13: Treatment of articles by dipping and pouring; ▪ PROC15: Use as laboratory reagent; ▪ PROC21: Low energy manipulation and handling of substances bound in/on materials or articles; ▪ PROC22: Manufacturing and processing of minerals and/or metals at substantially elevated temperature; ▪ PROC23: Open processing and transfer operations at substantially elevated temperature; ▪ PROC24: High (mechanical) energy work-up of substances bound in /on materials and/or articles; ▪ PROC26: Handling of solid inorganic substances at ambient temperature.
Categories of complex articles	<ul style="list-style-type: none"> ▪ AC1: Vehicles; ▪ AC2: Machinery, mechanical appliances, electrical/electronic articles; ▪ AC3: Electrical batteries and accumulators; ▪ AC7: Metal articles.
Categories of the release to the environment	<ul style="list-style-type: none"> ▪ ERC1: Manufacture of the substance; ▪ ERC2: Formulation into mixture;

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 23/69

- ERC4: Use of non-reactive processing aid at industrial site (no inclusion into or onto article);
- ERC5: Use at industrial site leading to inclusion into/onto article;
- ERC10a: Widespread use of articles with low release (outdoor);
- ERC11a: Widespread use of articles with low release (indoor).

Section 2. Exposure Scenario
Section 2.1. Contributing scenario (1) controlling environmental exposure for the industrial use of Cd-cathodes, slabs, balls, sticks, primary or secondary, by melting, possibly alloying, and casting/transformation in required massive formats, and possibly stored as slabs, ingot, anodes, sheet, bar, rod, wire.
Further specification

Description of activities/process(es) covered in the Exposure Scenario

- Delivering and stockpiling of the metallic cadmium and other alloying metals (e.g. Cu, Ag, Sn, Bi);
- The ingots are fed into the melting/alloying furnace;
- The alloying metals and cadmium are mixed and molten at 300°C or just above the melting point of the resulting alloy;
- The melt is transferred to the casting ladle, cast into ingots, or directly into a (continuous) casting machine;
- The Cd-containing sticks are then cast and packed;
- Maintenance activities.

Product characteristics
Product related conditions, e.g. the concentration of the substance in a mixture; viscosity of product; package design affecting exposure.

The resulting Cd-alloy contains up to 85 w/w % Cd.

Amounts used
Daily and annual amount per site (for uses in industrial setting) or daily and annual amount for wide disperse uses.

Up to 700 T/y.

Frequency and duration of use
Intermittent (used <12 times per year for not more than 24 h) or continuous use/release.

Both continuous or intermittent use apply.

Environment factors not influenced by risk management
Flow rate of receiving surface water (m³/d, usually 18 000 m³/d for the standard town by default; please note: the default flow rate will be rarely changeable for downstream uses.

Default is used unless specified otherwise.

Other given operational conditions affecting environmental exposure
Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process (via air and waste water); dry or water based processes; conditions related to temperature and pressure; indoor or outdoor use of products; work in confined area or open air.

- Air on the working place is filtered before release outside the building;
- All processes are performed indoor in a confined area. All residues containing

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 24/69

cadmium are recycled;

- Even when no process waters (e.g. when dry process throughout), some non-process water can be generated containing Cd (e.g. from cleaning).

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure to the environment; this includes in particular conditions ensuring rigorous containment; performance of the containment to be specified (e.g. by quantification of a release factor in section 9.x.2 of the CSR).

- Sump containment is provided under the tanks and the filters i.e. to collect any accidental spillage;
- When applicable, process waters need to be specifically treated before release;
- Dosing and packaging operations occur under a special ventilation hood;
- Process air is filtered before release outside the building.

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

Technical measures, e.g. on-site waste water and waste treatment techniques, scrubbers, filters and other technical measures aiming at reducing releases to air, sewage system, surface water or soil; this includes strictly controlled conditions (procedural and control technology) to minimise emissions; specify effectiveness of measures; specify the size of industrial sewage treatment plant (m^3/d), degradation effectiveness and sludge treatment (if applicable).

- On-site waste water treatment techniques are (if applicable) e.g.: chemical precipitation, sedimentation, filtration (efficiency 90-99.98 %);
- Containment of liquid volumes in sumps to collect/prevent accidental spillage;
- Air emissions are controlled by use of bag-house filters and/or other air emission abatement devices e.g. fabric (or bag) filters (up to 99 % efficiency), wet scrubbers (50-99 % efficiency). This may create a general negative pressure in the building. Air emissions are continuously monitored.

Organizational measures to prevent/limit release from site

Specific organisational measures or measures needed to support the functioning of particular technical measures. Those measures need to be reported in particular for demonstrating strictly controlled conditions.

- In general emissions are controlled and prevented by implementing an integrated management system e.g. ISO 9000, ISO 1400X series, or alike, and, when applicable, by being IPPC-compliant
 - Such management system should include general industrial hygiene practice e.g.:
 - information and training of workers;
 - regular cleaning of equipment and floors;
 - procedures for process control and maintenance
- Treatment and monitoring of releases to outside air, and exhaust gas streams (process & hygiene), according to national regulation;
- SEVESO 2 compliance, if applicable.

Conditions and measures related to municipal sewage treatment plant

Size of municipal sewage system/treatment plant (m^3/d); specify degradation effectiveness; sludge treatment technique (disposal or recovery); measures to limit air emissions from sewage treatment (if applicable); please note: the default size of the municipal STP (2000 m^3/d) will be rarely changeable for downstream uses.

W In cases where applicable: default size, unless specified otherwise.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 25/69

Conditions and measures related to external treatment of waste for disposal

Fraction of used amount transferred to external waste treatment for disposal; type of suitable treatment for waste generated by workers uses, e.g. hazardous waste incineration, chemical-physical treatment for emulsions, chemical oxidation of aqueous waste; specify effectiveness of treatment.

- If any, all hazardous wastes are treated by certified contractors according to EU and national legislation;
- Users of Cd and Cd-compounds have to favour the recycling channels of the end-of-life products e.g.; the industrial Ni-Cd rechargeable battery -by far the most important application in Europe -is to be collected, treated and recycled;
- Users of Cd and Cd-compounds have to minimize Cd-containing waste, promote recycling routes and, for the remaining, dispose the waste streams according the Waste regulation.

Conditions and measures related to external recovery of waste

Fraction of used amount transferred to external waste treatment for recovery: specify type of suitable recovery operations for waste generated by workers uses, e.g. re-distillation of solvents, refinery process for lubricant waste, recovery of slags, heat recovery out-side waste incinerators; specify effectiveness of measure.

By-products formed during the process are either recycled, internally or externally, or handled further as waste , according the waste legislation.

Section 2.2. Contributing scenario (2) controlling worker exposure for the industrial use of Cd-cathodes, slabs, balls, sticks, primary or secondary, by melting, possibly alloying, and casting/transformation in required massive formats, and possibly stored as slabs, ingot, anodes, sheet, bar, rod, wire.

Product characteristic

Product related conditions, e.g. the concentration of the substance in a mixture, the physical state of that mixture (solid, liquid; if solid: level of dustiness), package design affecting exposure).

- Metallic Cd or Cd alloy is cast in massive form: slabs, ingot, anodes, sheet, bar, rod, wire;
- Cd-containing finished product is stored in enclosed buildings.

Amounts used

Amounts used at a workplace (per task or per shift); note: sometimes this information is not needed for assessment of worker's exposure.

Up to maximum 1 T/shift.

Frequency and duration of use/exposure

Duration per task/activity (e.g. hours per shift) and frequency (e.g. single events or repeated) of exposure.

8hrs shift (worst case), continuous exposure is assumed as default. Occasional use of personal protection equipment (see below).

Human factors not influenced by risk management

Particular conditions of use, e.g. body parts potentially exposed as a result of the nature of the activity.

Uncovered body parts: (potentially) face.

Other given operational conditions affecting workers exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process into workers environment; room volume, whether the work is

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 26/69

carried out outdoors/indoors, process conditions related to temperature and pressure.

All processes are carried out indoor in confined areas.

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure of workers; this in particular includes conditions ensuring rigorous containment; performance of containment to be specified (e.g. by quantification of residual losses or exposure).

- Process enclosures or semi-enclosures where appropriate;
- Local exhaust ventilation on furnaces and other work areas with potential dust generation, dust capturing and removal techniques;
- Containment of liquid volumes in sumps to collect/prevent accidental spillage.

Technical conditions and measures to control dispersion from source towards the worker

Engineering controls, e.g. exhaust ventilation, general ventilation; specify effectiveness of measure.

- Local exhaust ventilation system (high efficiency 90-95 %);
- Cyclones/filters (for minimizing dust emissions): efficiency: 70-90 % (cyclones), 50-80 % (dust filters), 85-95 % (double stage, cassette filters);
- Process enclosure, especially in potentially dusty units;
- Dust control: dust and Cd in dust needs to be measured in the workplace air (static or individual) according to national regulations;
- Special care for the general establishment and maintenance of a clean working environment by e.g.:

- Cleaning of process equipment and workshop;
- Storage of packaged Cd finished product in enclosed buildings.

(see also Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 1 (ICdA 2006)).

Organisational measures to prevent /limit releases, dispersion and exposure

Specific organisational measures or measures needed to support the functioning of particular technical measures (e.g. training and supervision). Those measures need to be reported in particular for demonstrating strictly controlled conditions (to justify exposure based waiving).

The protection of workers in the Cd-related industry is achieved by the systematic implementation of a carefully designed stepwise risk management system, outlining measures to control worker exposure and combining measurements of both exposure and effect. The system is aimed at prevention of exposure and protection against early manifestation of (subclinical) effect at the level of the critical organ, the kidney. The system is described in detail in the industry guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" (ICdA 2006). It involves essentially 2 phases of action:

1) Controlling the Cd-concentration in the workplace air

Firstly, technical measures are taken to comply with the indicative EU (i-)OEL of 4 µg respirable Cd/m³ proposed by SCOEL in compliance with art. 3 of directive 98/24/EC (2009). This i-OEL is taken forward as a DNEL; compliance with the i-OEL is mandatory if no other measurements of Cd-exposure and effect (as described below) are performed. The OEL of 4µg Cd/m³ is applicable to Cd and Cd-compounds in general, unless the limited solubility of a given Cd-compound is documented. The total/inhalable fraction corresponding to the respirable fraction is function of the particle size of the inhaled particles.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 27/69

2) Individual medical follow up of parameters of exposure and effect

In general when working with cadmium, and, notably, if compliance with the i-OEL cannot be ensured in a consistent way, protection of the worker is ensured by complementary risk reduction measures and compliance with biological indicator limit values at the individual level. These measures include:

- Personal respiratory protection and hygiene measures if appropriate (see below, section "Conditions and measures related to personal protection, hygiene and health evaluation" for detail), in combination with
- Medical follow-up of the worker involving regular measurement of biological indicators of both exposure and effect:
 - exposure: measurement of Cd in urine ($\mu\text{g Cd/g Creatinine}$) and/or Cd in blood ($\mu\text{g Cd/l}$) to assess integrated systemic exposure of the individual;
 - effect: measurement of early (subclinical) indicators of tubular (kidney) dysfunction. Well-established biological indicators (BI) for Cd-effect are e.g. β -microglobuline (β 2-MG) and retinol binding protein (RPB).

The specific medical supervision (for details see ICdA 2006 – part II, section 4) is complementary to the technical and hygiene measures taken. It integrates exposure through all possible routes by assessing the Cd-body burden and assesses early biological indicators (BI's) of (subclinical) renal effect. It ensures as such that the risk to Cd-exposed workers is fully controlled.

The results of the medical supervision are applied as follows (see also Figure below):

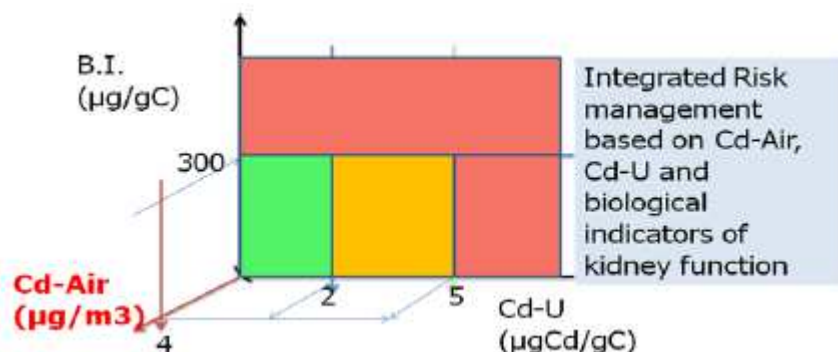


Figure: Illustration of Eurometaux/ICdA medical supervision guidance (2006) (BI: *biological indicators*; C: *creatinine*).

General medical follow-up level:

$\text{Cd-U} \leq 2 \mu\text{g Cd/g creatinine (C)}$. This is a conservative threshold based on general population studies, as described in Section 5.6.2. In this situation, the worker is followed by general medical follow-up (complementary indicator: $\text{Cd-B} \leq 5 \mu\text{g Cd/L}$). No further special action is required beyond proper implementation of the general hygiene procedures and medical surveillance.

Action level:

$2 < \text{Cd-U} \leq 5 \mu\text{g Cd/g creatinine}$: Action level zone. This zone is defined by the threshold based on studies at the workplace, as described in Section 5.6.2. Observation of Cd-U (or Cd-B) values in this "action" zone triggers (complementary trigger: $5 \mu\text{g Cd/l} < \text{Cd-B} \leq 8 \mu\text{g Cd/l}$) an individual follow up of the worker characterized by:

- Systematic and frequent follow up of exposure by measuring Cd-U (complementary analysis: Cd-B), combined with individual analysis and follow-up

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 28/69

of hygiene behaviour

- Measurement of biological indicators (BI's) of early renal dysfunction (e.g. beta-2 microglobuline (B2-M) or retinol-binding protein (RBP) on a regular basis;

When the worker moves into this action level zone, the occupational doctor and plant hygiene team will check for the reason for the increased exposure (analysis of the workplace, with a view to identify possible substance releases, analysis of compliance with hygienic procedures, and interview with the worker to assess possible other causes, e.g. due to current or previous exposure, due to personal hygiene behaviour?).

Based on the results of the individual medical surveillance programme, the following management decisions are taken:

- The worker remains in the action zone: If the Cd-U (Cd-B) values do not progress further towards the threshold and the BI's remain stable and below the reference value (e.g. 300 µg/g creatinine for β2-MG and RBP), the worker is kept at the workplace. Additional hygiene measures are taken as appropriate, and medical follow-up is strictly continued.
- The worker is removed from exposure:
 - If Cd-U > 5 µg Cd/g creatinine (or Cd-B > 8 µg/l) and/or
 - o If the BI's are exceeding the reference values or showing a consistent pattern of increase which may lead to approaching the reference values.

The management scheme as outlined above is applicable to workers that entered the Cd industry rather recently. Workers that have been working in the Cd-industry for long may have been historically exposed to elevated Cd -levels, and may show e.g. Cd-U levels exceeding 5 µg/gC due to historical exposure. The supervising medical doctor will evaluate these individuals carefully, focusing on the BI's. In any case, when BI values exceed the BI-reference values or approach them, the worker will be removed from Cd-exposure.

In addition to the above, general industrial hygiene programmes are to be implemented, as required by EU Directive 98/24/EC on protection of workers from chemical agents and other referenced systems on best practice: IPPC-BREF notes, BIMSCH or equivalent, ICH-Q7, FAMI-QS, ISO9000, ISO 13.100 or alike:

- General industrial hygiene practice;
- Collective protection measures and use of warning & safety signs;
- Minimizing the number of workers exposed or likely to be exposed;
- Workplace cleanliness : ensure procedures are designed, written and implemented so as to make sure cleanliness is obtained at workstations, work sections, traffic and storage areas, upper areas, building structures and various horizontal surfaces, air suction ducts;
- Procedures for process control.

Conditions and measures related to personal protection, hygiene and health evaluation

Personal protection, e.g. wearing of gloves, face protection, full body dermal protection, goggles, respirator; specify effectiveness of measure; specify the suitable material for the PPE (where relevant) and advise how long the protective equipment can be used before replacement (if relevant).

The implementation of the risk management system as described above is strictly followed up.

Individual protection measures are used as described in detail in the Guidance document

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 29/69

"Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 2, 3, 4 (ICdA 2006), and consist of e.g.:

- Wearing of gloves and protective clothing is compulsory (efficiency $\geq 90\%$);
- With normal handling, no respiratory personal protection (breathing apparatus) is necessary. If risk for exceedance of OEL/DNEL, use e.g.:
 - dust filter-half mask P1 (efficiency 75 %)
 - dust filter-half mask P2 (efficiency 90 %)
 - dust filter-half mask P3 (efficiency 95 %)
 - dust filter-full mask P1 (efficiency 75 %)
 - dust filter-full mask P2 (efficiency 90 %)
 - dust filter-full mask P3 (efficiency 97.5 %)
- Eyes: safety glasses are optional;
- Implement best practice in collective and individual hygiene procedures in compliance with articles 5 and 8 of 98/24/EC: Information-training of the workers and their staff and line managers focused on careful hygiene behaviour. Industry practice has shown that at low levels of industrial exposure to Cd, such as at the level of the i-OEL, installation and maintaining of careful industrial hygiene practice is important for ensuring full control of exposure. Such hygiene practice must cover all aspects of the workday and involves e.g.:
 - Provide training on the risks resulting with substance exposure at the time of hire and on a periodic basis;
 - Provide work clothes with appropriate change frequency (weekly to daily) and ensure they are used accordingly;
 - Structure adequate changing rooms (three compartments: city side, shower and workplace side with 2 locker rooms);
 - Ensure snacks and drinks are provided and consumed in proper areas separated from the main work area;
 - Develop adequate procedures to ensure meals are not a source of substance intake (hand washing, partial removal of work clothes before taking meals);
 - strict separation of workplace and other working environments at the plant, including changing clothes;
 - Ensure showers are taken at end of shifts;
 - No smoking on the workplace;
 - No-bearing of beards, no moustaches

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 30/69

Exposure scenario 3, annex to the SDS
Section 1. Title of the exposure scenario

Title	Industrial use of cadmium, pure or alloyed, in the production of Cd powder /dust by different sputtering techniques. Main application of the product are batteries, chemical industry and corrosion protection.
Sector of use	<ul style="list-style-type: none"> ▪ SU3: Industrial uses; ▪ SU8: Manufacture of bulk, large scale chemicals (including petroleum products); ▪ SU9: Manufacture of fine chemicals; ▪ SU10: Formulation; ▪ SU14: Manufacture of basic metals, including alloys; ▪ SU16: Manufacture of computer, electronic and optical products, electrical equipment; ▪ SU0: Other.
Product category	<ul style="list-style-type: none"> ▪ PC2: Adsorbents; ▪ PC7: Base metals and alloys; ▪ PC9b: Fillers, putties, plasters, modelling clay; ▪ PC14: Metal surface treatment products; ▪ PC20: Processing aids such as pH-regulators, flocculants, precipitants, neutralization agents; ▪ PC40: Extraction agents.
Process category	<ul style="list-style-type: none"> ▪ PROC2: Chemical production or refinery in closed continuous process with occasional controlled exposure or processes with equivalent containment conditions; ▪ PROC3: Manufacture or formulation in the chemical industry in closed batch processes with occasional controlled exposure or processes with equivalent containment condition; ▪ PROC5: Mixing or blending in batch processes; ▪ PROC8b: Transfer of substance or mixture (charging and discharging) at dedicated facilities; ▪ PROC9: Transfer of substance or mixture into small containers (dedicated filling line, including weighing); ▪ PROC14: Tableting, compression, extrusion, pelletisation, granulation; ▪ PROC26: Handling of solid inorganic substances at ambient temperature; ▪ PROC27a: Production of metal powders (hot processes); ▪ PROC27b: Production of metal powders (wet processes).
Categories of the release to the environment	<ul style="list-style-type: none"> ▪ ERC1: Manufacture of the substance; ▪ ERC2: Formulation into mixture; ▪ ERC4: Use of non-reactive processing aid at industrial site (no inclusion into or onto article); ▪ ERC5: Use at industrial site leading to inclusion into/onto article; ▪ ERC6a: Use of intermediate; ▪ ERC6b: Use of reactive processing aid at industrial site (no inclusion into or onto article).

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 31/69

Section 2. Exposure Scenario
Section 2.1. Contributing scenario (1) controlling environmental exposure for the Industrial use of cadmium, pure or alloyed, in the production of Cd powder/dust by different sputtering techniques. Main application of the product are batteries, chemical industry and corrosion protection.
Further specification

Description of activities/process(es) covered in the Exposure Scenario

- Manual deposition of cadmium metal ingots or sticks into a melting furnace (just above the melting point at ~350 °C), under an exhaust hood. The bath surface is covered by a solid layer of ashes reducing the generation of fumes;
- Closed transfer of molten cadmium –communicating vessels- into the induction heated zone and vaporisation of the liquid cadmium into the reaction chamber (>700 °C);
- Under closed and re-circulated inert gas stream (O₂-free nitrogen), the injected Cadmium gas stream is allowed to cool down and to solidify to small Cd-particles;
- Further cooling, filtration and packaging of produced Cadmium dust/ powder. Workers have to place and adjust the bag or drum under the discharge pipe and to set the process in motion. Filled bags or drums are subsequently closed and carried to the storage area;
- Maintenance activities.

Product characteristics
Product related conditions, e.g. the concentration of the substance in a mixture; viscosity of product; package design affecting exposure.

Cd powders are produced alloyed or in their pure form e.g.: up to >99 %.

Amounts used
Daily and annual amount per site (for uses in industrial setting) or daily and annual amount for wide disperse uses.

Up to 160 T/y.

Frequency and duration of use
Intermittent (used <12 times per year for not more than 24 h) or continuous use/release.

Both continuous or intermittent use apply.

Environment factors not influenced by risk management
Flow rate of receiving surface water (m³/d, usually 18 000 m³/d for the standard town by default; please note: the default flow rate will be rarely changeable for downstream uses.

Default is used unless specified otherwise.

Other given operational conditions affecting environmental exposure
Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process (via air and waste water); dry or water based processes; conditions related to temperature and pressure; indoor or outdoor use of products; work in confined area or open air.

- Air on the working place is filtered before release outside the building;
- All processes are performed indoor in a confined area. All residues containing cadmium are recycled;
- Even when no process waters (e.g. when dry process throughout), some non-process water can be generated containing Cd (e.g. from cleaning).

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 32/69

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure to the environment; this includes in particular conditions ensuring rigorous containment; performance of the containment to be specified (e.g. by quantification of a release factor in section 9.x.2 of the CSR).

- Dosing and packaging operations occur under a special ventilation hood;
- Process air is filtered before release outside the building.

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

Technical measures, e.g. on-site waste water and waste treatment techniques, scrubbers, filters and other technical measures aiming at reducing releases to air, sewage system, surface water or soil; this includes strictly controlled conditions (procedural and control technology) to minimise emissions; specify effectiveness of measures; specify the size of industrial sewage treatment plant (m^3/d), degradation effectiveness and sludge treatment (if applicable).

- On-site waste water treatment techniques are (if applicable) e.g.: chemical precipitation, sedimentation, filtration (efficiency 90-99.98 %);
- Containment of liquid volumes in sumps to collect/prevent accidental spillage;
- Air emissions are controlled by use of bag-house filters and/or other air emission abatement devices e.g. fabric (or bag) filters (up to 99 % efficiency), wet scrubbers (50-99 % efficiency). This may create a general negative pressure in the building. Air emissions are continuously monitored.

Organizational measures to prevent/limit release from site

Specific organisational measures or measures needed to support the functioning of particular technical measures. Those measures need to be reported in particular for demonstrating strictly controlled conditions.

- In general emissions are controlled and prevented by implementing an integrated management system e.g. ISO 9000, ISO 1400X series, or alike, and, when applicable, by being IPPC-compliant
 - Such management system should include general industrial hygiene practice e.g.:
 - information and training of workers;
 - regular cleaning of equipment and floors;
 - procedures for process control and maintenance
- Treatment and monitoring of releases to outside air, and exhaust gas streams (process & hygiene), according to national regulation;
- SEVESO 2 compliance, if applicable.

Conditions and measures related to municipal sewage treatment plant

Size of municipal sewage system/treatment plant (m^3/d); specify degradation effectiveness; sludge treatment technique (disposal or recovery); measures to limit air emissions from sewage treatment (if applicable); please note: the default size of the municipal STP ($2000 m^3/d$) will be rarely changeable for downstream uses.

In cases where applicable: default size, unless specified otherwise.

Conditions and measures related to external treatment of waste for disposal

Fraction of used amount transferred to external waste treatment for disposal; type of suitable treatment for waste generated by workers uses, e.g. hazardous waste incineration, chemical-physical treatment for emulsions, chemical oxidation of aqueous waste; specify effectiveness of treatment.

- If any, all hazardous wastes are treated by certified contractors according to EU and national legislation;

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 33/69

- Users of Cd and Cd-compounds have to favour the recycling channels of the end-of-life products e.g.; the industrial Ni-Cd rechargeable battery -by far the most important application in Europe -is to be collected, treated and recycled;
- Users of Cd and Cd-compounds have to minimize Cd-containing waste, promote recycling routes and, for the remaining, dispose the waste streams according the Waste regulation.

Conditions and measures related to external recovery of waste

Fraction of used amount transferred to external waste treatment for recovery: specify type of suitable recovery operations for waste generated by workers uses, e.g. re-distillation of solvents, refinery process for lubricant waste, recovery of slags, heat recovery out-side waste incinerators; specify effectiveness of measure.

By-products formed during the process are either recycled, internally or externally, or handled further as waste , according the waste legislation.

Section 2.2. Contributing scenario (2) controlling worker exposure for the Industrial use of cadmium, pure or alloyed, in the production of Cd powder /dust by different sputtering techniques. Main application of the product are batteries, chemical industry and corrosion protection.

Product characteristic

Product related conditions, e.g. the concentration of the substance in a mixture, the physical state of that mixture (solid, liquid; if solid: level of dustiness), package design affecting exposure).

- Pure Cd powder is formed with possibly high dustiness (5-15µm (Outotec 2010));
- Special safety ("easy use") packaging is used to prevent exposure while packaging;
- Cd-finished product is stored in sealed packaging, in enclosed buildings.

Amounts used

Amounts used at a workplace (per task or per shift); note: sometimes this information is not needed for assessment of worker's exposure.

Up to maximum 1 T/day.

Frequency and duration of use/exposure

Duration per task/activity (e.g. hours per shift) and frequency (e.g. single events or repeated) of exposure.

8hrs shift (worst case), continuous exposure is assumed as default. Occasional use of personal protection equipment (see below).

Human factors not influenced by risk management

Particular conditions of use, e.g. body parts potentially exposed as a result of the nature of the activity.

Uncovered body parts: (potentially) face.

Other given operational conditions affecting workers exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process into workers environment; room volume, whether the work is carried out outdoors/indoors, process conditions related to temperature and pressure.

All processes are carried out indoor in confined areas.

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure of workers; this in particular includes conditions ensuring rigorous containment; performance of containment to be specified (e.g. by quantification of residual losses or exposure).

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 34/69

- Process enclosures or semi-enclosures where appropriate;
- Local exhaust ventilation on furnaces and other work areas with potential dust generation, dust capturing and removal techniques;
- Containment of liquid volumes in sumps to collect/prevent accidental spillage.

Technical conditions and measures to control dispersion from source towards the worker

Engineering controls, e.g. exhaust ventilation, general ventilation; specify effectiveness of measure.

- Local exhaust ventilation system (high efficiency 90-95 %);
- Cyclones/filters (for minimizing dust emissions): efficiency: 70-90 % (cyclones), 50-80 % (dust filters), 85-95 % (double stage, cassette filters);
- Process enclosure, especially in potentially dusty units;
- Dust control: dust and Cd in dust needs to be measured in the workplace air (static or individual) according to national regulations;
- Special care for the general establishment and maintenance of a clean working environment by e.g.:
 - Cleaning of process equipment and workshop;
 - Storage of packaged Cd finished product in enclosed buildings.

(see also Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 1 (ICdA 2006)).

Organisational measures to prevent /limit releases, dispersion and exposure

Specific organisational measures or measures needed to support the functioning of particular technical measures (e.g. training and supervision). Those measures need to be reported in particular for demonstrating strictly controlled conditions (to justify exposure based waiving).

The protection of workers in the Cd-related industry is achieved by the systematic implementation of a carefully designed stepwise risk management system, outlining measures to control worker exposure and combining measurements of both exposure and effect. The system is aimed at prevention of exposure and protection against early manifestation of (subclinical) effect at the level of the critical organ, the kidney. The system is described in detail in the industry guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" (ICdA 2006). It involves essentially 2 phases of action:

1) Controlling the Cd-concentration in the workplace air

Firstly, technical measures are taken to comply with the indicative EU (i-)OEL of 4 µg respirable Cd/m³ proposed by SCOEL in compliance with art. 3 of directive 98/24/EC (2009). This i-OEL is taken forward as a DNEL; compliance with the i-OEL is mandatory if no other measurements of Cd-exposure and effect (as described below) are performed. The OEL of 4µg Cd/m³ is applicable to Cd and Cd-compounds in general, unless the limited solubility of a given Cd-compound is documented. The total/inhalable fraction corresponding to the respirable fraction is function of the particle size of the inhaled particles.

2) Individual medical follow up of parameters of exposure and effect

In general when working with cadmium, and, notably, if compliance with the i-OEL cannot be ensured in a consistent way, protection of the worker is ensured by complementary risk reduction measures and compliance with biological indicator limit values at the individual level. These measures include:

- Personal respiratory protection and hygiene measures if appropriate (see below, section "Conditions and measures related to personal protection, hygiene and

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 35/69

- health evaluation" for detail), in combination with
- Medical follow-up of the worker involving regular measurement of biological indicators of both exposure and effect:
 - exposure: measurement of Cd in urine ($\mu\text{g Cd/g Creatinine}$) and/or Cd in blood ($\mu\text{g Cd/l}$) to assess integrated systemic exposure of the individual;
 - effect: measurement of early (subclinical) indicators of tubular (kidney) dysfunction. Well-established biological indicators (BI) for Cd-effect are e.g. β -microglobuline (β 2-MG) and retinol binding protein (RBP).

The specific medical supervision (for details see ICdA 2006 – part II, section 4) is complementary to the technical and hygiene measures taken. It integrates exposure through all possible routes by assessing the Cd body burden and assesses early biological indicators (BI's) of (subclinical) renal effect. It ensures as such that the risk to Cd-exposed workers is fully controlled.

The results of the medical supervision are applied as follows (see also Figure below):

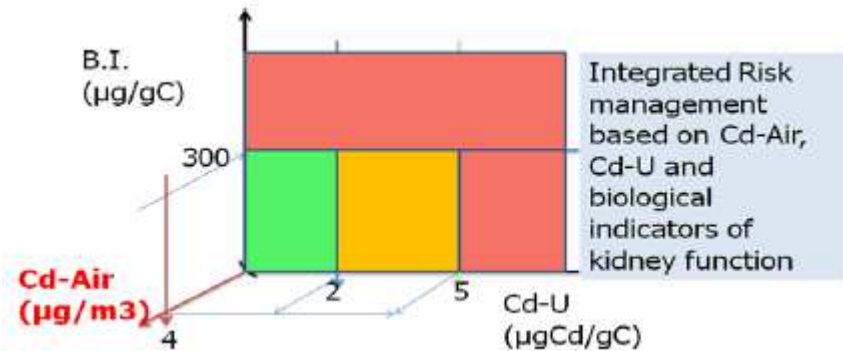


Figure: Illustration of Eurometaux/ICdA medical supervision guidance (2006) (BI: *biological indicators*; C: *creatinine*).

General medical follow-up level:

$\text{Cd-U} \leq 2 \mu\text{g Cd/g creatinine (C)}$. This is a conservative threshold based on general population studies, as described in Section 5.6.2. In this situation, the worker is followed by general medical follow-up (complementary indicator: $\text{Cd-B} \leq 5 \mu\text{g Cd/l}$). No further special action is required beyond proper implementation of the general hygiene procedures and medical surveillance.

Action level:

$2 < \text{Cd-U} \leq 5 \mu\text{g Cd/g creatinine}$: Action level zone. This zone is defined by the threshold based on studies at the workplace, as described in Section 5.6.2. Observation of Cd-U (or Cd-B) values in this "action" zone triggers (complementary trigger: $5 \mu\text{g Cd/l} < \text{Cd-B} \leq 8 \mu\text{g Cd/l}$) an individual follow up of the worker characterized by:

- Systematic and frequent follow up of exposure by measuring Cd-U (complementary analysis: Cd-B), combined with individual analysis and follow-up of hygiene behaviour
- Measurement of biological indicators (BI's) of early renal dysfunction (e.g. beta-2 microglobuline (B2-M) or retinol-binding protein (RBP) on a regular basis;

When the worker moves into this action level zone, the occupational doctor and plant hygiene team will check for the reason for the increased exposure (analysis of the workplace, with a view to identify possible substance releases, analysis of compliance with

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 36/69

hygienic procedures, and interview with the worker to assess possible other causes, e.g. due to current or previous exposure, due to personal hygiene behaviour?).

Based on the results of the individual medical surveillance programme, the following management decisions are taken:

- The worker remains in the action zone: If the Cd-U (Cd-B) values do not progress further towards the threshold and the BI's remain stable and below the reference value (e.g. 300 µg/g creatinine for β2-MG and RBP), the worker is kept at the workplace. Additional hygiene measures are taken as appropriate, and medical follow-up is strictly continued.
- The worker is removed from exposure:
 - If Cd-U > 5 µg Cd/g creatinine (or Cd-B > 8 µg/l) and/or
 - o If the BI's are exceeding the reference values or showing a consistent pattern of increase which may lead to approaching the reference values.

The management scheme as outlined above is applicable to workers that entered the Cd industry rather recently. Workers that have been working in the Cd-industry for long may have been historically exposed to elevated Cd -levels, and may show e.g. Cd-U levels exceeding 5 µg/gC due to historical exposure. The supervising medical doctor will evaluate these individuals carefully, focusing on the BI's. In any case, when BI values exceed the BI-reference values or approach them, the worker will be removed from Cd-exposure.

In addition to the above, general industrial hygiene programmes are to be implemented, as required by EU Directive 98/24/EC on protection of workers from chemical agents and other referenced systems on best practice: IPPC-BREF notes, BIMSCH or equivalent, ICH-Q7, FAMI-QS, ISO9000, ISO 13.100 or alike:

- General industrial hygiene practice;
- Collective protection measures and use of warning & safety signs;
- Minimizing the number of workers exposed or likely to be exposed;
- Workplace cleanliness : ensure procedures are designed, written and implemented so as to make sure cleanliness is obtained at workstations, work sections, traffic and storage areas, upper areas, building structures and various horizontal surfaces, air suction ducts;
- Procedures for process control.

Conditions and measures related to personal protection, hygiene and health evaluation

Personal protection, e.g. wearing of gloves, face protection, full body dermal protection, goggles, respirator; specify effectiveness of measure; specify the suitable material for the PPE (where relevant) and advise how long the protective equipment can be used before replacement (if relevant).

The implementation of the risk management system as described above is strictly followed up.

Individual protection measures are used as described in detail in the Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 2, 3, 4 (ICdA 2006), and consist of e.g.:

- Wearing of gloves and protective clothing is compulsory (efficiency ≥ 90 %);
- With normal handling, no respiratory personal protection (breathing apparatus) is necessary. If risk for exceedance of OEL/DNEL, use e.g.:
 - dust filter-half mask P1 (efficiency 75 %)
 - dust filter-half mask P2 (efficiency 90 %)

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 37/69

- dust filter-half mask P3 (efficiency 95 %)
- dust filter-full mask P1 (efficiency 75 %)
- dust filter-full mask P2 (efficiency 90 %)
- dust filter-full mask P3 (efficiency 97.5 %)
- Eyes: safety glasses are optional;
- Implement best practice in collective and individual hygiene procedures in compliance with articles 5 and 8 of 98/24/EC: Information-training of the workers and their staff and line managers focused on careful hygiene behaviour. Industry practice has shown that at low levels of industrial exposure to Cd, such as at the level of the i-OEL, installation and maintaining of careful industrial hygiene practice is important for ensuring full control of exposure. Such hygiene practice must cover all aspects of the workday and involves e.g.:
 - Provide training on the risks resulting with substance exposure at the time of hire and on a periodic basis;
 - Provide work clothes with appropriate change frequency (weekly to daily) and ensure they are used accordingly;
 - Structure adequate changing rooms (three compartments: city side, shower and workplace side with 2 locker rooms);
 - Ensure snacks and drinks are provided and consumed in proper areas separated from the main work area;
 - Develop adequate procedures to ensure meals are not a source of substance intake (hand washing, partial removal of work clothes before taking meals);
 - strict separation of workplace and other working environments at the plant, including changing clothes;
 - Ensure showers are taken at end of shifts;
 - No smoking on the workplace;
 - No-bearing of beards, no moustaches

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 38/69

Exposure scenario 4, annex to the SDS
Section 1. Title of the exposure scenario

Title	Industrial use of Cd-ingots or -powder in the manufacture of other Cd-substances through different process routes, hydro-, pyro-, electrolytic process.
Sector of use	<ul style="list-style-type: none"> ▪ SU3: Industrial uses; ▪ SU8: Manufacture of bulk, large scale chemicals (including petroleum products); ▪ SU9: Manufacture of fine chemicals; ▪ SU10: Formulation; ▪ SU0: Other.
Product category	<ul style="list-style-type: none"> ▪ PC7: Base metals and alloys; ▪ PC20: Processing aids such as pH-regulators, flocculants, precipitants, neutralization agents; ▪ PC21: Laboratory chemicals.
Process category	<ul style="list-style-type: none"> ▪ PROC2: Chemical production or refinery in closed continuous process with occasional controlled exposure or processes with equivalent containment conditions; ▪ PROC3: Manufacture or formulation in the chemical industry in closed batch processes with occasional controlled exposure or processes with equivalent containment condition; ▪ PROC8b: Transfer of substance or mixture (charging and discharging) at dedicated facilities; ▪ PROC9: Transfer of substance or mixture into small containers (dedicated filling line, including weighing); ▪ PROC13: Treatment of articles by dipping and pouring; ▪ PROC15: Use as laboratory reagent; ▪ PROC22: Manufacturing and processing of minerals and/or metals at substantially elevated temperature; ▪ PROC26: Handling of solid inorganic substances at ambient temperature.
Categories of the release to the environment	<ul style="list-style-type: none"> ▪ ERC1: Manufacture of the substance.

Section 2. Exposure Scenario
Section 2.1. Contributing scenario (1) controlling environmental exposure for the Industrial use of Cd-ingots or -powder in the manufacture of other Cd-substances through different process routes, hydro-, pyro-, electrolytic process.
Further specification

- a) pyro-process(es) for Cd0 production
- Feeding of the primary materials (Cd-metal pieces) into the melting furnace (just above the melting point at ~350 °C), under an exhaust hood. The bath surface is covered by a solid layer of ashes reducing the generation of fumes;
 - Closed transfer of molten cadmium –communicating vessels- into the induction heated zone and vaporisation of the liquid cadmium into the reaction chamber (>700 °C);
 - Under closed and re-circulated air gas stream, the injected Cadmium gas stream is oxidised and allowed to cool down and to solidify to small CdO-particles;

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 39/69

- Further cooling , filtration and packaging of produced CdO dust/ powder.
- b) Local oxydation process of (alloyed) Cd-coatings
- Metallic Cd-coatings, alloyed or not, are superficially oxidised under controlled conditions;
 - Articles, i.e. contact materials are further assembled and stored.
- c) Hydrometallurgical processes for production of Cd-O
- Although not applied very often, from a purified cadmium salt solution (predominantly sulphate or chloride);
 - Cadmium hydroxide and/or carbonate can be precipitated by the addition of alkalines and filtered from the solutions;
 - Finally, Cadmium oxide can be generated by calcination (dehydration, decarboxylation) of the Cadmium hydroxide or Cadmium carbonate or a mixture of both.
- d) Hydrometallurgical processes for production of other Cd-compounds:
- Reception of Cd-bearing materials, if applicable, and transfer to the reaction tank (with reaction media);
 - Reception of the Intermediate cadmium bearing solution in the reaction tank, if applicable;
 - Sequential addition of reagents for purification steps and filtration on press filter, when needed;
 - Ventilation is adapted;
 - Possibly concentration by water evaporation, under exhaust hood;
 - Discharge and packaging of produced Cd-compound crystals;
 - Filled bags or drums are subsequently closed and carried to the storage area;
 - Exposure to dust can occur during packing of the powdery forms. Solutions are packed in intermediate bulk containers (ca. 1 m³ capacity); solids are packed in bags or drums;
 - Maintenance activities.

Product characteristics

Product related conditions, e.g. the concentration of the substance in a mixture; viscosity of product; package design affecting exposure.

Cd compounds are produced in their pure form e.g.: >99 %.

Amounts used

Daily and annual amount per site (for uses in industrial setting) or daily and annual amount for wide disperse uses.

CdO: Up to 4000 T/y; most other Cd-compounds up to 10 T/y.

Frequency and duration of use

Intermittent (used < 12 times per year for not more than 24 h) or continuous use/release.

Continuous use assumed.

Environment factors not influenced by risk management

Flow rate of receiving surface water (m³/d, usually 18 000 m³/d for the standard town by default; please note: the default flow rate will be rarely changeable for downstream uses.

Default is used unless specified otherwise.

Other given operational conditions affecting environmental exposure

Other given operational conditions: e.g. technology or process techniques determining the initial

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 40/69

release of substance from process (via air and waste water); dry or water based processes; conditions related to temperature and pressure; indoor or outdoor use of products; work in confined area or open air.

- Air on the working place is filtered before release outside the building;
- All processes are performed indoor in a confined area. All residues containing cadmium are recycled;
- Even when no process waters (e.g. when dry process throughout), some non-process water can be generated containing Cd (e.g. from cleaning).

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure to the environment; this includes in particular conditions ensuring rigorous containment; performance of the containment to be specified (e.g. by quantification of a release factor in section 9.x.2 of the CSR).

- Process enclosures and closed circuits where relevant and possible;
- Local exhaust ventilation on furnaces and other work areas with potential dust generation, dust capturing and removal techniques. Process air is filtered before release outside the building;
- When applicable, resulting process waters need to be specifically treated before release;
- Dosing and packaging operations occur under a special ventilation hood;
- Containment of liquid volumes in sumps to collect/prevent accidental spillage, acid solutions are treated with alkali. There is high temperature in the surroundings of the calcinations furnaces.

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

Technical measures, e.g. on-site waste water and waste treatment techniques, scrubbers, filters and other technical measures aiming at reducing releases to air, sewage system, surface water or soil; this includes strictly controlled conditions (procedural and control technology) to minimise emissions; specify effectiveness of measures; specify the size of industrial sewage treatment plant (m^3/d), degradation effectiveness and sludge treatment (if applicable).

- On-site waste water treatment techniques are (if applicable) e.g.: chemical precipitation, sedimentation, filtration (efficiency 90-99.98 %);
- Containment of liquid volumes in sumps to collect/prevent accidental spillage;
- Air emissions are controlled by use of bag-house filters and/or other air emission abatement devices e.g. fabric (or bag) filters (up to 99 % efficiency), wet scrubbers (50-99 % efficiency). This may create a general negative pressure in the building. Air emissions are continuously monitored.

Organizational measures to prevent/limit release from site

Specific organisational measures or measures needed to support the functioning of particular technical measures. Those measures need to be reported in particular for demonstrating strictly controlled conditions.

- In general emissions are controlled and prevented by implementing an integrated management system e.g. ISO 9000, ISO 1400X series, or alike, and, when applicable, by being IPPC-compliant
 - Such management system should include general industrial hygiene practice e.g.:
 - information and training of workers;
 - regular cleaning of equipment and floors;
 - procedures for process control and maintenance
- Treatment and monitoring of releases to outside air, and exhaust gas streams

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 41/69

(process & hygiene), according to national regulation;

- SEVESO 2 compliance, if applicable.

Conditions and measures related to municipal sewage treatment plant

Size of municipal sewage system/treatment plant (m³/d); specify degradation effectiveness; sludge treatment technique (disposal or recovery); measures to limit air emissions from sewage treatment (if applicable); please note: the default size of the municipal STP (2000 m³/d) will be rarely changeable for downstream uses.

In cases where applicable: default size, unless specified otherwise.

Conditions and measures related to external treatment of waste for disposal

Fraction of used amount transferred to external waste treatment for disposal; type of suitable treatment for waste generated by workers uses, e.g. hazardous waste incineration, chemical-physical treatment for emulsions, chemical oxidation of aqueous waste; specify effectiveness of treatment.

- If any, all hazardous wastes are treated by certified contractors according to EU and national legislation;
- Users of Cd and Cd-compounds have to favour the recycling channels of the end-of-life products e.g.; the industrial Ni-Cd rechargeable battery -by far the most important application in Europe -is to be collected, treated and recycled;
- Users of Cd and Cd-compounds have to minimize Cd-containing waste, promote recycling routes and, for the remaining, dispose the waste streams according the Waste regulation.

Conditions and measures related to external recovery of waste

Fraction of used amount transferred to external waste treatment for recovery: specify type of suitable recovery operations for waste generated by workers uses, e.g. re-distillation of solvents, refinery process for lubricant waste, recovery of slags, heat recovery out-side waste incinerators; specify effectiveness of measure.

By-products formed during the process are either recycled, internally or externally, or handled further as waste, according the waste legislation.

Section 2.2. Contributing scenario (2) controlling worker exposure for the Industrial use of cadmium, pure or alloyed, in the production of Cd powder /dust by different sputtering techniques. Main application of the product are batteries, chemical industry and corrosion protection.
Product characteristic

Product related conditions, e.g. the concentration of the substance in a mixture, the physical state of that mixture (solid, liquid; if solid: level of dustiness), package design affecting exposure).

- Pure Cd powder is formed with possibly high dustiness (5-15µm (Outotec 2010));
- Special safety ("easy use") packaging is used to prevent exposure while packaging;
- Cd-finished product is stored in sealed packaging, in enclosed buildings.

Amounts used

Amounts used at a workplace (per task or per shift); note: sometimes this information is not needed for assessment of worker's exposure.

Up to maximum 6T/shift (CdO), 0.02T/shift (most other compounds).

Frequency and duration of use/exposure

Duration per task/activity (e.g. hours per shift) and frequency (e.g. single events or repeated) of exposure.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 42/69

8hrs shift (worst case), continuous exposure is assumed as default. Occasional use of personal protection equipment (see below).

Human factors not influenced by risk management

Particular conditions of use, e.g. body parts potentially exposed as a result of the nature of the activity.

Uncovered body parts: (potentially) face.

Other given operational conditions affecting workers exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process into workers environment; room volume, whether the work is carried out outdoors/indoors, process conditions related to temperature and pressure.

All processes are carried out indoor in confined areas.

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure of workers; this in particular includes conditions ensuring rigorous containment; performance of containment to be specified (e.g. by quantification of residual losses or exposure).

- Process enclosures or semi-enclosures where appropriate;
- Local exhaust ventilation on furnaces and other work areas with potential dust generation, dust capturing and removal techniques;
- Containment of liquid volumes in sumps to collect/prevent accidental spillage.

Technical conditions and measures to control dispersion from source towards the worker

Engineering controls, e.g. exhaust ventilation, general ventilation; specify effectiveness of measure.

- Local exhaust ventilation system (high efficiency 90-95 %);
- Cyclones/filters (for minimizing dust emissions): efficiency: 70-90 % (cyclones), 50-80 % (dust filters), 85-95 % (double stage, cassette filters);
- Process enclosure, especially in potentially dusty units;
- Dust control: dust and Cd in dust needs to be measured in the workplace air (static or individual) according to national regulations;
- Special care for the general establishment and maintenance of a clean working environment by e.g.:

- Cleaning of process equipment and workshop;
- Implementation of "easy use" packaging;
- Storage of packaged Cd finished product in enclosed buildings.

(see also Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 1 (ICdA 2006)).

Organisational measures to prevent /limit releases, dispersion and exposure

Specific organisational measures or measures needed to support the functioning of particular technical measures (e.g. training and supervision). Those measures need to be reported in particular for demonstrating strictly controlled conditions (to justify exposure based waiving).

The protection of workers in the Cd-related industry is achieved by the systematic implementation of a carefully designed stepwise risk management system, outlining measures to control worker exposure and combining measurements of both exposure and effect. The system is aimed at prevention of exposure and protection against early manifestation of (subclinical) effect at the level of the critical organ, the kidney. The system is described in detail in the industry guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" (ICdA

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 43/69

2006). It involves essentially 2 phases of action:

1) Controlling the Cd-concentration in the workplace air

Firstly, technical measures are taken to comply with the indicative EU (i-)OEL of 4 µg respirable Cd/m³ proposed by SCOEL in compliance with art. 3 of directive 98/24/EC (2009). This i-OEL is taken forward as a DNEL; compliance with the i-OEL is mandatory if no other measurements of Cd-exposure and effect (as described below) are performed. The OEL of 4µg Cd/m³ is applicable to Cd and Cd-compounds in general, unless the limited solubility of a given Cd-compound is documented. The total/inhalable fraction corresponding to the respirable fraction is function of the particle size of the inhaled particles.

2) Individual medical follow up of parameters of exposure and effect

In general when working with cadmium, and, notably, if compliance with the i-OEL cannot be ensured in a consistent way, protection of the worker is ensured by complementary risk reduction measures and compliance with biological indicator limit values at the individual level. These measures include:

- Personal respiratory protection and hygiene measures if appropriate (see below, section "Conditions and measures related to personal protection, hygiene and health evaluation" for detail), in combination with
- Medical follow-up of the worker involving regular measurement of biological indicators of both exposure and effect:
 - exposure: measurement of Cd in urine (µg Cd/g Creatinine) and/or Cd in blood (µg Cd/l) to assess integrated systemic exposure of the individual;
 - effect: measurement of early (subclinical) indicators of tubular (kidney) dysfunction. Well-established biological indicators (BI) for Cd-effect are e.g. β-microglobuline (β2-MG) and retinol binding protein (RBP).

The specific medical supervision (for details see ICdA 2006 – part II, section 4) is complementary to the technical and hygiene measures taken. It integrates exposure through all possible routes by assessing the Cd body burden and assesses early biological indicators (BI's) of (subclinical) renal effect. It ensures as such that the risk to Cd-exposed workers is fully controlled.

The results of the medical supervision are applied as follows (see also Figure below):

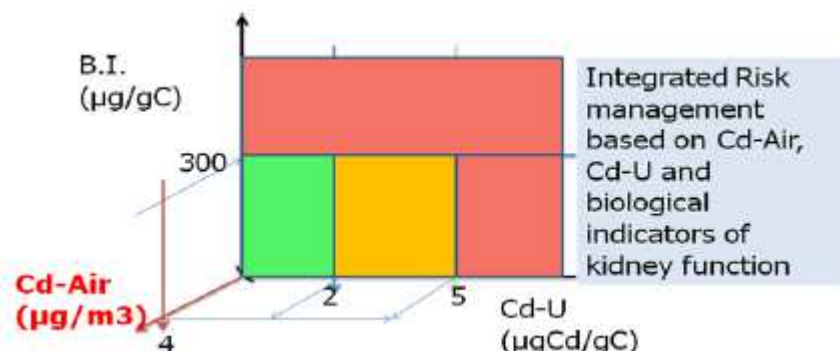


Figure: Illustration of Eurometaux/ICdA medical supervision guidance (2006) (BI: *biological indicators*; C: *creatinine*).

General medical follow-up level:

Cd-U ≤ 2 µg Cd/g creatinine (C). This is a conservative threshold based on general population studies, as described in Section 5.6.2. In this situation, the worker is followed

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 44/69

by general medical follow-up (complementary indicator: $Cd-B \leq 5 \mu g Cd/L$). No further special action is required beyond proper implementation of the general hygiene procedures and medical surveillance.

Action level:

$2 < Cd-U \leq 5 \mu g Cd/g$ creatinine: Action level zone. This zone is defined by the threshold based on studies at the workplace, as described in Section 5.6.2. Observation of Cd-U (or Cd-B) values in this "action" zone triggers (complementary trigger: $5 \mu g Cd/l < Cd-B \leq 8 \mu g Cd/l$) an individual follow up of the worker characterized by:

- Systematic and frequent follow up of exposure by measuring Cd-U (complementary analysis: Cd-B), combined with individual analysis and follow-up of hygiene behaviour
- Measurement of biological indicators (BI's) of early renal dysfunction (e.g. beta-2 microglobuline (B2-M) or retinol-binding protein (RBP) on a regular basis;

When the worker moves into this action level zone, the occupational doctor and plant hygiene team will check for the reason for the increased exposure (analysis of the workplace, with a view to identify possible substance releases, analysis of compliance with hygienic procedures, and interview with the worker to assess possible other causes, e.g. due to current or previous exposure, due to personal hygiene behaviour?).

Based on the results of the individual medical surveillance programme, the following management decisions are taken:

- The worker remains in the action zone: If the Cd-U (Cd-B) values do not progress further towards the threshold and the BI's remain stable and below the reference value (e.g. $300 \mu g/g$ creatinine for $\beta 2$ -MG and RBP), the worker is kept at the workplace. Additional hygiene measures are taken as appropriate, and medical follow-up is strictly continued.
- The worker is removed from exposure:
 - If $Cd-U > 5 \mu g Cd/g$ creatinine (or $Cd-B > 8 \mu g/l$) and/or
 - o If the BI's are exceeding the reference values or showing a consistent pattern of increase which may lead to approaching the reference values.

The management scheme as outlined above is applicable to workers that entered the Cd industry rather recently. Workers that have been working in the Cd-industry for long may have been historically exposed to elevated Cd -levels, and may show e.g. Cd-U levels exceeding $5 \mu g/gC$ due to historical exposure. The supervising medical doctor will evaluate these individuals carefully, focusing on the BI's. In any case, when BI values exceed the BI-reference values or approach them, the worker will be removed from Cd-exposure.

In addition to the above, general industrial hygiene programmes are to be implemented, as required by EU Directive 98/24/EC on protection of workers from chemical agents and other referenced systems on best practice: IPPC-BREF notes, BIMSCH or equivalent, ICH-Q7, FAMI-QS, ISO9000, ISO 13.100 or alike:

- General industrial hygiene practice;
- Collective protection measures and use of warning & safety signs;
- Minimizing the number of workers exposed or likely to be exposed;
- Workplace cleanliness: ensure procedures are designed, written and implemented so as to make sure cleanliness is obtained at workstations, work sections, traffic and storage areas, upper areas, building structures and various horizontal surfaces, air suction ducts;

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 45/69

- Procedures for process control.

Conditions and measures related to personal protection, hygiene and health evaluation

Personal protection, e.g. wearing of gloves, face protection, full body dermal protection, goggles, respirator; specify effectiveness of measure; specify the suitable material for the PPE (where relevant) and advise how long the protective equipment can be used before replacement (if relevant).

The implementation of the risk management system as described above is strictly followed up.

Individual protection measures are used as described in detail in the Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 2, 3, 4 (ICdA 2006), and consist of e.g.:

- Wearing of gloves and protective clothing is compulsory (efficiency $\geq 90\%$);
- With normal handling, no respiratory personal protection (breathing apparatus) is necessary. If risk for exceedance of OEL/DNEL, use e.g.:
 - dust filter-half mask P1 (efficiency 75 %)
 - dust filter-half mask P2 (efficiency 90 %)
 - dust filter-half mask P3 (efficiency 95 %)
 - dust filter-full mask P1 (efficiency 75 %)
 - dust filter-full mask P2 (efficiency 90 %)
 - dust filter-full mask P3 (efficiency 97.5 %)
- Eyes: safety glasses are optional;
- Implement best practice in collective and individual hygiene procedures in compliance with articles 5 and 8 of 98/24/EC: Information-training of the workers and their staff and line managers focused on careful hygiene behaviour. Industry practice has shown that at low levels of industrial exposure to Cd, such as at the level of the i-OEL, installation and maintaining of careful industrial hygiene practice is important for ensuring full control of exposure. Such hygiene practice must cover all aspects of the workday and involves e.g.:
 - Provide training on the risks resulting with substance exposure at the time of hire and on a periodic basis;
 - Provide work clothes with appropriate change frequency (weekly to daily) and ensure they are used accordingly;
 - Structure adequate changing rooms (three compartments: city side, shower and workplace side with 2 locker rooms);
 - Ensure snacks and drinks are provided and consumed in proper areas separated from the main work area;
 - Develop adequate procedures to ensure meals are not a source of substance intake (hand washing, partial removal of work clothes before taking meals);
 - strict separation of workplace and other working environments at the plant, including changing clothes;
 - Ensure showers are taken at end of shifts;
 - No smoking on the workplace;
 - No-bearing of beards, no moustaches.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 46/69

Exposure scenario 5, annex to the SDS
Section 1. Title of the exposure scenario

Title	Industrial use of cadmium massive pieces (i.e. bars, sticks, balls), pure or alloyed, cast and optionally further transformed (rolled, extruded and/or punched) to form semi-finished articles.
Sector of use	<ul style="list-style-type: none"> ▪ SU3: Industrial uses; ▪ SU14: Manufacture of basic metals, including alloys; ▪ SU15: Manufacture of fabricated metal products, except machinery and equipment; ▪ SU16: Manufacture of computer, electronic and optical products, electrical equipment; ▪ SU0: Other.
Product category	<ul style="list-style-type: none"> ▪ PC7: Base metals and alloys; ▪ PC38: Welding and soldering products, flux products.
Process category	<ul style="list-style-type: none"> ▪ PROC5: Mixing or blending in batch processes; ▪ PROC6: Calendaring operations; ▪ PROC8b: Transfer of substance or mixture (charging and discharging) at dedicated facilities; ▪ PROC14: Tableting, compression, extrusion, pelletisation, granulation; ▪ PROC21: Low energy manipulation and handling of substances bound in/on materials or articles; ▪ PROC22: Manufacturing and processing of minerals and/or metals at substantially elevated temperature; ▪ PROC24: High (mechanical) energy work-up of substances bound in /on materials and/or articles; ▪ PROC25: Other hot work operations with metals; ▪ PROC26: Handling of solid inorganic substances at ambient temperature.
Categories of complex articles	<ul style="list-style-type: none"> ▪ AC1: Vehicles; ▪ AC2: Machinery, mechanical appliances, electrical/electronic articles; ▪ AC3: Electrical batteries and accumulators; ▪ AC7: Metal articles.
Categories of the release to the environment	<ul style="list-style-type: none"> ▪ ERC2: Formulation into mixture; ▪ ERC3: Formulation into solid matrix; ▪ ERC5: Use at industrial site leading to inclusion into/onto article.

Section 2. Exposure Scenario
Section 2.1. Contributing scenario (1) controlling environmental exposure for the industrial use of cadmium massive pieces (i.e. bars, sticks, balls,..), pure or alloyed, cast and optionally further transformed (rolled, extruded and/or punched) to form semi-finished articles.
Further specification

Description of activities/process(es) covered in the exposure scenario, e.g. casting for rolling, granules/pellet casting, die casting, brass casting.

- High purity cadmium (alloy) ingot is melted, optionally alloyed, and poured onto

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 47/69

the casting machine or fed to the injection nozzles;

- After casting, the strip, the granules are rapidly cooled down; the remainder of the operations concerns automated operations of the final articles that are in the massive metal form;
- All castings are performed in specially dedicated equipment;
- The fresh scrap is usually returned to the melting furnace for direct recycling;
- The articles are stored before shipping to the final transformer;
- Maintenance activities.

Product characteristics

Product related conditions, e.g. the concentration of the substance in a mixture; viscosity of product; package design affecting exposure.

- Cadmium alloys can be made with Cu, Ag.
- These alloying elements may trigger some specific risk management measures for workers.

Amounts used

Daily and annual amount per site (for uses in industrial setting) or daily and annual amount for wide disperse uses.

Up to 0.25 T Cd/day; 50 T/y.

Frequency and duration of use

Intermittent (used <12 times per year for not more than 24 h) or continuous use/release.

Continuous use.

Environment factors not influenced by risk management

Flow rate of receiving surface water (m³/d, usually 18 000 m³/d for the standard town by default; please note: the default flow rate will be rarely changeable for downstream uses.

Default is used unless specified otherwise.

Other given operational conditions affecting environmental exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process (via air and waste water); dry or water based processes; conditions related to temperature and pressure; indoor or outdoor use of products; work in confined area or open air.

- The molten cadmium in the kettle is at melting point (350 °C);
- Dry manipulations in the whole building: only cooling water is present, whether in closed circuit or reused in another process;
- Air on the working place is filtered before release outside the building;
- All indoor processes, in confined area.

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure to the environment; this includes in particular conditions ensuring rigorous containment; performance of the containment to be specified (e.g. by quantification of a release factor in section 9.x.2 of the CSR).

- When applicable, sump containment is provided under the tanks and the filters i.o. to collect any accidental spillage and process waters need to be specifically treated before release;
- Dusty operations occur under a specific local ventilation hood;
- Process air is filtered before release outside the building.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 48/69

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

Technical measures, e.g. on-site waste water and waste treatment techniques, scrubbers, filters and other technical measures aiming at reducing releases to air, sewage system, surface water or soil; this includes strictly controlled conditions (procedural and control technology) to minimise emissions; specify effectiveness of measures; specify the size of industrial sewage treatment plant (m^3/d), degradation effectiveness and sludge treatment (if applicable).

- On-site waste water treatment techniques are (if applicable) e.g.: chemical precipitation, sedimentation, filtration (efficiency 90-99.98 %);
- Containment of liquid volumes in sumps to collect/prevent accidental spillage;
- Air emissions are controlled by use of bag-house filters and/or other air emission abatement devices e.g. fabric (or bag) filters (up to 99 % efficiency), wet scrubbers (50-99 % efficiency). This may create a general negative pressure in the building. Air emissions are continuously monitored.

Organizational measures to prevent/limit release from site

Specific organisational measures or measures needed to support the functioning of particular technical measures. Those measures need to be reported in particular for demonstrating strictly controlled conditions.

- In general emissions are controlled and prevented by implementing an integrated management system e.g. ISO 9000, ISO 1400X series, or alike, and, when applicable, by being IPPC-compliant
 - Such management system should include general industrial hygiene practice e.g.:
 - information and training of workers;
 - regular cleaning of equipment and floors;
 - procedures for process control and maintenance.
- Treatment and monitoring of releases to outside air, and exhaust gas streams (process & hygiene), according to national regulation;
- SEVESO 2 compliance, if applicable.

Conditions and measures related to municipal sewage treatment plant

Size of municipal sewage system/treatment plant (m^3/d); specify degradation effectiveness; sludge treatment technique (disposal or recovery); measures to limit air emissions from sewage treatment (if applicable); please note: the default size of the municipal STP ($2000 m^3/d$) will be rarely changeable for downstream uses.

In cases where applicable: default size, unless specified otherwise.

Conditions and measures related to external treatment of waste for disposal

Fraction of used amount transferred to external waste treatment for disposal; type of suitable treatment for waste generated by workers uses, e.g. hazardous waste incineration, chemical-physical treatment for emulsions, chemical oxidation of aqueous waste; specify effectiveness of treatment.

- If any, all hazardous wastes are treated by certified contractors according to EU and national legislation;
- Users of Cd and Cd-compounds have to favour the recycling channels of the end-of-life products e.g.; the industrial Ni-Cd rechargeable battery –by far the most important application in Europe –is to be collected, treated and recycled;
- Users of Cd and Cd-compounds have to minimize Cd-containing waste, promote recycling routes and, for the remaining, dispose the waste streams according the Waste regulation.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 49/69

Conditions and measures related to external recovery of waste

Fraction of used amount transferred to external waste treatment for recovery: specify type of suitable recovery operations for waste generated by workers uses, e.g. re-distillation of solvents, refinery process for lubricant waste, recovery of slags, heat recovery out-side waste incinerators; specify effectiveness of measure.

By-products formed during the process are either recycled, internally or externally, or handled further as waste, according to the waste legislation.

Section 2.2. Contributing scenario (2) controlling worker exposure for the industrial use of cadmium massive pieces (i.e. bars, sticks, balls.), pure or alloyed, cast and optionally further transformed (rolled, extruded and/or punched) to form semi-finished articles.**Product characteristic**

Product related conditions, e.g. the concentration of the substance in a mixture, the physical state of that mixture (solid, liquid; if solid: level of dustiness), package design affecting exposure).

- The composition of major Cd alloys can be as high as Cd: >80 %;
- Variable amounts of Cu, Al, Ni, Ag may be added to some alloy products to improve specific properties of the material;
- The final forms are massive metal;
- Cd-containing finished product is stored in dedicated zones.

Amounts used

Amounts used at a workplace (per task or per shift); note: sometimes this information is not needed for assessment of worker's exposure.

Up to 0.25 T/d, 50 T/y.

Frequency and duration of use/exposure

Duration per task/activity (e.g. hours per shift) and frequency (e.g. single events or repeated) of exposure.

8hrs shift (worst case), continuous exposure is assumed as default. Occasional use of personal protection equipment (see below).

Human factors not influenced by risk management

Particular conditions of use, e.g. body parts potentially exposed as a result of the nature of the activity.

Uncovered body parts: (potentially) face.

Other given operational conditions affecting workers exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process into workers environment; room volume, whether the work is carried out outdoors/indoors, process conditions related to temperature and pressure.

- The molten cadmium in the kettle is basically at melting point (350 °C).
- All processes are carried out indoor in confined areas.

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure of workers; this in particular includes conditions ensuring rigorous containment; performance of containment to be specified (e.g. by quantification of residual losses or exposure).

- Process enclosures or semi-enclosures where appropriate;
- Local exhaust ventilation on furnaces and other work areas with potential dust generation, dust capturing and removal techniques;

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 50/69

- Containment of liquid volumes in sumps to collect/prevent accidental spillage.

Technical conditions and measures to control dispersion from source towards the worker

Engineering controls, e.g. exhaust ventilation, general ventilation; specify effectiveness of measure.

- Local exhaust ventilation system (high efficiency 90-95 %);
- Cyclones/filters (for minimizing dust emissions): efficiency: 70-90 % (cyclones), 50-80 % (dust filters), 85-95 % (double stage, cassette filters);
- Process enclosure, especially in potentially dusty units;
- Dust control: dust and Cd in dust needs to be measured in the workplace air (static or individual) according to national regulations;
- Special care for the general establishment and maintenance of a clean working environment by e.g.:
 - Cleaning of process equipment and workshop;
 - Implementation of "easy use" packaging;
 - Storage of packaged Cd finished product in enclosed buildings.

(see also Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 1 (ICdA 2006)).

Organisational measures to prevent /limit releases, dispersion and exposure

Specific organisational measures or measures needed to support the functioning of particular technical measures (e.g. training and supervision). Those measures need to be reported in particular for demonstrating strictly controlled conditions (to justify exposure based waiving).

The protection of workers in the Cd-related industry is achieved by the systematic implementation of a carefully designed stepwise risk management system, outlining measures to control worker exposure and combining measurements of both exposure and effect. The system is aimed at prevention of exposure and protection against early manifestation of (subclinical) effect at the level of the critical organ, the kidney. The system is described in detail in the industry guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" (ICdA 2006). It involves essentially 2 phases of action:

1) Controlling the Cd-concentration in the workplace air

Firstly, technical measures are taken to comply with the indicative EU (i-)OEL of 4 µg respirable Cd/m³ proposed by SCOEL in compliance with art. 3 of directive 98/24/EC (2009). This i-OEL is taken forward as a DNEL; compliance with the i-OEL is mandatory if no other measurements of Cd-exposure and effect (as described below) are performed. The OEL of 4µg Cd/m³ is applicable to Cd and Cd-compounds in general, unless the limited solubility of a given Cd-compound is documented. The total/inhalable fraction corresponding to the respirable fraction is function of the particle size of the inhaled particles.

2) Individual medical follow up of parameters of exposure and effect

In general when working with cadmium, and, notably, if compliance with the i-OEL cannot be ensured in a consistent way, protection of the worker is ensured by complementary risk reduction measures and compliance with biological indicator limit values at the individual level. These measures include:

- Personal respiratory protection and hygiene measures if appropriate (see below, section "Conditions and measures related to personal protection, hygiene and health evaluation" for detail), in combination with

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 51/69

- Medical follow-up of the worker involving regular measurement of biological indicators of both exposure and effect:
 - exposure: measurement of Cd in urine ($\mu\text{g Cd/g Creatinine}$) and/or Cd in blood ($\mu\text{g Cd/l}$) to assess integrated systemic exposure of the individual;
 - effect: measurement of early (subclinical) indicators of tubular (kidney) dysfunction. Well-established biological indicators (BI) for Cd-effect are e.g. β -microglobuline (β 2-MG) and retinol binding protein (RBP).

The specific medical supervision (for details see ICdA 2006 – part II, section 4) is complementary to the technical and hygiene measures taken. It integrates exposure through all possible routes by assessing the Cd body burden and assesses early biological indicators (BI's) of (subclinical) renal effect. It ensures as such that the risk to Cd-exposed workers is fully controlled.

The results of the medical supervision are applied as follows (see also Figure below):

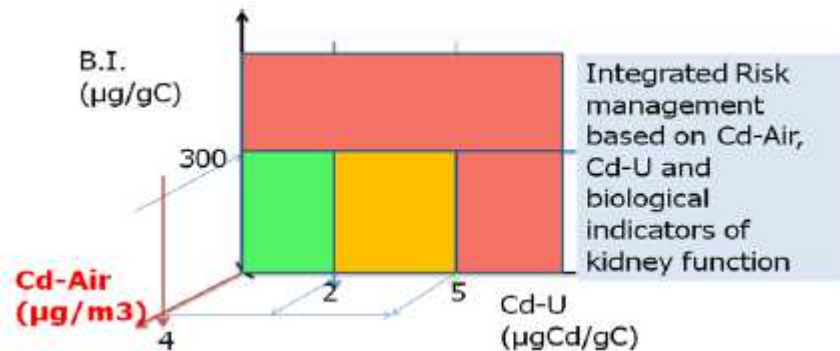


Figure: Illustration of Eurometaux/ICdA medical supervision guidance (2006) (BI: *biological indicators*; C: *creatinine*).

General medical follow-up level:

$\text{Cd-U} \leq 2 \mu\text{g Cd/g creatinine (C)}$. This is a conservative threshold based on general population studies, as described in Section 5.6.2. In this situation, the worker is followed by general medical follow-up (complementary indicator: $\text{Cd-B} \leq 5 \mu\text{g Cd/L}$). No further special action is required beyond proper implementation of the general hygiene procedures and medical surveillance.

Action level:

$2 < \text{Cd-U} \leq 5 \mu\text{g Cd/g creatinine}$: Action level zone. This zone is defined by the threshold based on studies at the workplace, as described in Section 5.6.2. Observation of Cd-U (or Cd-B) values in this "action" zone triggers (complementary trigger: $5 \mu\text{g Cd/l} < \text{Cd-B} \leq 8 \mu\text{g Cd/l}$) an individual follow up of the worker characterized by:

- Systematic and frequent follow up of exposure by measuring Cd-U (complementary analysis: Cd-B), combined with individual analysis and follow-up of hygiene behaviour
- Measurement of biological indicators (BI's) of early renal dysfunction (e.g. beta-2 microglobuline (B2-M) or retinol-binding protein (RBP) on a regular basis;

When the worker moves into this action level zone, the occupational doctor and plant hygiene team will check for the reason for the increased exposure (analysis of the workplace, with a view to identify possible substance releases, analysis of compliance with hygienic procedures, and interview with the worker to assess possible other causes, e.g. due to current or previous exposure, due to personal hygiene behaviour?).

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 52/69

Based on the results of the individual medical surveillance programme, the following management decisions are taken:

- The worker remains in the action zone: If the Cd-U (Cd-B) values do not progress further towards the threshold and the BI's remain stable and below the reference value (e.g. 300 µg/g creatinine for β2-MG and RBP), the worker is kept at the workplace. Additional hygiene measures are taken as appropriate, and medical follow-up is strictly continued.
- The worker is removed from exposure:
 - If Cd-U > 5 µg Cd/g creatinine (or Cd-B > 8 µg/l) and/or
 - o If the BI's are exceeding the reference values or showing a consistent pattern of increase which may lead to approaching the reference values.

The management scheme as outlined above is applicable to workers that entered the Cd industry rather recently. Workers that have been working in the Cd-industry for long may have been historically exposed to elevated Cd -levels, and may show e.g. Cd-U levels exceeding 5 µg/gC due to historical exposure. The supervising medical doctor will evaluate these individuals carefully, focusing on the BI's. In any case, when BI values exceed the BI-reference values or approach them, the worker will be removed from Cd-exposure.

In addition to the above, general industrial hygiene programmes are to be implemented, as required by EU Directive 98/24/EC on protection of workers from chemical agents and other referenced systems on best practice: IPPC-BREF notes, BIMSCH or equivalent, ICH-Q7, FAMI-QS, ISO9000, ISO 13.100 or alike:

- General industrial hygiene practice;
- Collective protection measures and use of warning & safety signs;
- Minimizing the number of workers exposed or likely to be exposed;
- Workplace cleanliness : ensure procedures are designed, written and implemented so as to make sure cleanliness is obtained at workstations, work sections, traffic and storage areas, upper areas, building structures and various horizontal surfaces, air suction ducts;
- Procedures for process control.

Conditions and measures related to personal protection, hygiene and health evaluation

Personal protection, e.g. wearing of gloves, face protection, full body dermal protection, goggles, respirator; specify effectiveness of measure; specify the suitable material for the PPE (where relevant) and advise how long the protective equipment can be used before replacement (if relevant).

The implementation of the risk management system as described above is strictly followed up.

Individual protection measures are used as described in detail in the Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 2, 3, 4 (ICdA 2006), and consist of e.g.:

- Wearing of gloves and protective clothing is compulsory (efficiency ≥ 90 %);
- With normal handling, no respiratory personal protection (breathing apparatus) is necessary. If risk for exceedance of OEL/DNEL, use e.g.:
 - dust filter-half mask P1 (efficiency 75 %)
 - dust filter-half mask P2 (efficiency 90 %)
 - dust filter-half mask P3 (efficiency 95 %)
 - dust filter-full mask P1 (efficiency 75 %)

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 53/69

- dust filter-full mask P2 (efficiency 90 %)
- dust filter-full mask P3 (efficiency 97.5 %)
- Eyes: safety glasses are optional;
- Implement best practice in collective and individual hygiene procedures in compliance with articles 5 and 8 of 98/24/EC: Information-training of the workers and their staff and line managers focused on careful hygiene behaviour. Industry practice has shown that at low levels of industrial exposure to Cd, such as at the level of the i-OEL, installation and maintaining of careful industrial hygiene practice is important for ensuring full control of exposure. Such hygiene practice must cover all aspects of the workday and involves e.g.:
 - Provide training on the risks resulting with substance exposure at the time of hire and on a periodic basis;
 - Provide work clothes with appropriate change frequency (weekly to daily) and ensure they are used accordingly;
 - Structure adequate changing rooms (three compartments: city side, shower and workplace side with 2 locker rooms);
 - Ensure snacks and drinks are provided and consumed in proper areas separated from the main work area;
 - Develop adequate procedures to ensure meals are not a source of substance intake (hand washing, partial removal of work clothes before taking meals);
 - strict separation of workplace and other working environments at the plant, including changing clothes;
 - Ensure showers are taken at end of shifts;
 - No smoking on the workplace;
 - No-bearing of beards, no moustaches.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 54/69

Exposure scenario 6, annex to the SDS
Section 1. Title of the exposure scenario

Title	Industrial and professional use of metallic Cd-powder, alloyed or not, passivated or not, for mechanical plating, or the production of different basic mixtures or dispersions i.e. for batteries, catalysts, paints, inks, contact materials, and other coatings.
Sector of use	<ul style="list-style-type: none"> ▪ SU3: Industrial uses; ▪ SU9: Manufacture of fine chemicals; ▪ SU14: Manufacture of basic metals, including alloys; ▪ SU15: Manufacture of fabricated metal products, except machinery and equipment; ▪ SU16: Manufacture of computer, electronic and optical products, electrical equipment; ▪ SU0: Other.
Product category	<ul style="list-style-type: none"> ▪ PC7: Base metals and alloys; ▪ PC14: Metal surface treatment products.
Process category	<ul style="list-style-type: none"> ▪ PROC3: Manufacture or formulation in the chemical industry in closed batch processes with occasional controlled exposure or processes with equivalent containment condition; ▪ PROC5: Mixing or blending in batch processes; ▪ PROC8b: Transfer of substance or mixture (charging and discharging) at dedicated facilities; ▪ PROC9: Transfer of substance or mixture into small containers (dedicated filling line, including weighing); ▪ PROC24: High (mechanical) energy work-up of substances bound in /on materials and/or articles.
Categories of complex articles	<ul style="list-style-type: none"> ▪ AC1: Vehicles; ▪ AC2: Machinery, mechanical appliances, electrical/electronic articles; ▪ AC3: Electrical batteries and accumulators; ▪ AC7: Metal articles.
Categories of the release to the environment	<ul style="list-style-type: none"> ▪ ERC2: Formulation into mixture; ▪ ERC3: Formulation into solid matrix; ▪ ERC4: Use of non-reactive processing aid at industrial site (no inclusion into or onto article); ▪ ERC5: Use at industrial site leading to inclusion into/onto article.

Section 2. Exposure Scenario

Section 2.1. Contributing scenario (1) controlling environmental exposure for the Industrial and professional use of metallic Cd-powder, alloyed or not, passivated or not, for mechanical plating, or the production of different basic mixtures or dispersions i.e. for batteries, catalysts, paints, inks, contact materials, and other coatings.

Further specification

In the described process, the cadmium powder containing preparation/mixture is:

- unpacked and possibly stored in silos

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 55/69

- Extracted from the silo, and
 - in the making of basic mixtures, dosed and fed with the other reagents and/or solvents to the mixing tank, batch-wise or continuously, according the process receipt. The resulting cadmium containing mixture (dispersion, paste) is directly further processed, or packed, for further treatment/use;
 - in the very specific applications, e.g. mechanical plating, the cadmium powder is applied to the steel surface.

Product characteristics

Product related conditions, e.g. the concentration of the substance in a mixture; viscosity of product; package design affecting exposure.

Cd powder in preparation can be >25 %, usually <5 %.

Amounts used

Daily and annual amount per site (for uses in industrial setting) or daily and annual amount for wide disperse uses.

Maximum 10 T/y.

Frequency and duration of use

Intermittent (used < 12 times per year for not more than 24 h) or continuous use/release.

Continuous production is assumed as a worst case. It is possible that use is not continuous; this has to be considered when estimating exposure.

Environment factors not influenced by risk management

Flow rate of receiving surface water:.

Default for generic scenario: 18 000 m³/d, unless specified otherwise.

Other given operational conditions affecting environmental exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process (via air and waste water); dry or water based processes; conditions related to temperature and pressure; indoor or outdoor use of products; work in confined area or open air.

- Even when no process waters occur, some non-process water can be generated containing Cd (e.g. from cleaning);
- All processes are performed indoor in a confined area;
- All residues containing Cd are recycled.

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure to the environment; this includes in particular conditions ensuring rigorous containment; performance of the containment to be specified (e.g. by quantification of a release factor in section 9.x.2 of the CSR).

- Local exhaust ventilation on mixing tanks and other work areas with potential dust generation;
- Dust capturing and removal techniques are applied;
- Process enclosures where relevant and possible.

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

Technical measures, e.g. on-site waste water and waste treatment techniques, scrubbers, filters and other technical measures aiming at reducing releases to air, sewage system, surface water or soil; this includes strictly controlled conditions (procedural and control technology) to minimise emissions; specify effectiveness of measures; specify the size of industrial sewage treatment plant (m³/d), degradation effectiveness and sludge treatment (if applicable).

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 56/69

- Operations may imply wet or dry process-steps;
- Sump containment is provided under the tanks and the filters i.o. to collect any accidental spillage;
- On-site waste water treatment techniques can be applied to prevent releases to water (if applicable) e.g.: chemical precipitation, sedimentation and filtration (efficiency 90-99.98 %);
- Air emissions are controlled by use of bag-house filters and/or other air emission abatement devices e.g. fabric or bag filters, wet scrubbers. This may create a general negative pressure in the building.

Organizational measures to prevent/limit release from site

Specific organisational measures or measures needed to support the functioning of particular technical measures. Those measures need to be reported in particular for demonstrating strictly controlled conditions.

- In general emissions are controlled and prevented by implementing an integrated management system e.g. ISO 9000, ISO 1400X series, or alike, and, when applicable, by being IPPC-compliant
 - Such management system should include general industrial hygiene practice e.g.:
 - information and training of workers;
 - regular cleaning of equipment and floors;
 - procedures for process control and maintenance.
- Treatment and monitoring of releases to outside air, and exhaust gas streams (process & hygiene), according to national regulation;
- SEVESO 2 compliance, if applicable.

Conditions and measures related to municipal sewage treatment plant

Size of municipal sewage system/treatment plant (m³/d); specify degradation effectiveness; sludge treatment technique (disposal or recovery); measures to limit air emissions from sewage treatment (if applicable); please note: the default size of the municipal STP (2000 m³/d) will be rarely changeable for downstream uses.

In cases where applicable: default size, unless specified otherwise.

Conditions and measures related to external treatment of waste for disposal

Fraction of used amount transferred to external waste treatment for disposal; type of suitable treatment for waste generated by workers uses, e.g. hazardous waste incineration, chemical-physical treatment for emulsions, chemical oxidation of aqueous waste; specify effectiveness of treatment.

- If any, all hazardous wastes are treated by certified contractors according to EU and national legislation;
- Users of Cd and Cd-compounds have to favour the recycling channels of the end-of-life products e.g.; the industrial Ni-Cd rechargeable battery -by far the most important application in Europe -is to be collected, treated and recycled;
- Users of Cd and Cd-compounds have to minimize Cd-containing waste, promote recycling routes and, for the remaining, dispose the waste streams according the Waste regulation.

Conditions and measures related to external recovery of waste

Fraction of used amount transferred to external waste treatment for recovery: specify type of suitable recovery operations for waste generated by workers uses, e.g. re-distillation of solvents, refinery process for lubricant waste, recovery of slags, heat recovery out-side waste incinerators; specify effectiveness of measure.

By-products formed during the process are either recycled, internally or externally, or

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 57/69

handled further as waste , according the waste legislation.

Section 2.2. Contributing scenario (2) controlling worker exposure for the Industrial and professional use of metallic Cd-powder, alloyed or not, passivated or not, for mechanical plating, or the production of different basic mixtures or dispersions i.e. for batteries, catalysts, paints, inks, contact materials, and other coatings.

Product characteristic

Product related conditions, e.g. the concentration of the substance in a mixture, the physical state of that mixture (solid, liquid; if solid: level of dustiness), package design affecting exposure).

- The concentration of Cd in the mixtures can be up to >25 % but is usually of the order of ≤5 %, depending on the application;
- The preparation can be solid, or in the liquid state, as a paste or dispersion or other viscous or polymerized matrix, with a low level of dustiness; however, powder forms can occur, medium dustiness is therefore applied as a worst case.

Amounts used

Amounts used at a workplace (per task or per shift); note: sometimes this information is not needed for assessment of worker's exposure.

Max 10 T/y = 0.05 T/d depending of application.

Frequency and duration of use/exposure

Duration per task/activity (e.g. hours per shift) and frequency (e.g. single events or repeated) of exposure.

8-hour shifts (default worst case) are assumed as starting point; it is emphasised that the real duration of exposure could be less. This has to be considered when estimating exposure.

Human factors not influenced by risk management

Particular conditions of use, e.g. body parts potentially exposed as a result of the nature of the activity.

Uncovered body parts: (potentially) face.

Other given operational conditions affecting workers exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process into workers environment; room volume, whether the work is carried out outdoors/indoors, process conditions related to temperature and pressure.

- Wet or dry processes
- All indoor processes in confined area.

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure of workers; this in particular includes conditions ensuring rigorous containment; performance of containment to be specified (e.g. by quantification of residual losses or exposure).

- Local exhaust ventilation on mixing tanks, furnaces and other work areas with potential dust generation, dust capturing and removal techniques;
- Process enclosures where appropriate.

Technical conditions and measures to control dispersion from source towards the worker

Engineering controls, e.g. exhaust ventilation, general ventilation; specify effectiveness of measure.

- Local exhaust ventilation system (high efficiency 90-95 %);

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 58/69

- Cyclones/filters (for minimizing dust emissions): efficiency: 70-90 % (cyclones), 50-80 % (dust filters), 85-95 % (double stage, cassette filters);
- Process enclosure, especially in potentially dusty units;
- Dust control: dust and Cd in dust needs to be measured in the workplace air (static or individual) according to national regulations;
- Special care for the general establishment and maintenance of a clean working environment by e.g.:
 - Cleaning of process equipment and workshop;
 - Storage of packaged Cd finished product in enclosed buildings.

(see also Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 1 (ICdA 2006)).

Organisational measures to prevent /limit releases, dispersion and exposure

Specific organisational measures or measures needed to support the functioning of particular technical measures (e.g. training and supervision). Those measures need to be reported in particular for demonstrating strictly controlled conditions (to justify exposure based waiving).

The protection of workers in the Cd-related industry is achieved by the systematic implementation of a carefully designed stepwise risk management system, outlining measures to control worker exposure and combining measurements of both exposure and effect. The system is aimed at prevention of exposure and protection against early manifestation of (subclinical) effect at the level of the critical organ, the kidney. The system is described in detail in the industry guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" (ICdA 2006). It involves essentially 2 phases of action:

1) Controlling the Cd-concentration in the workplace air

Firstly, technical measures are taken to comply with the indicative EU (i-)OEL of 4 µg respirable Cd/m³ proposed by SCOEL in compliance with art. 3 of directive 98/24/EC (2009). This i-OEL is taken forward as a DNEL; compliance with the i-OEL is mandatory if no other measurements of Cd-exposure and effect (as described below) are performed. The OEL of 4µg Cd/m³ is applicable to Cd and Cd-compounds in general, unless the limited solubility of a given Cd-compound is documented. The total/inhalable fraction corresponding to the respirable fraction is function of the particle size of the inhaled particles.

2) Individual medical follow up of parameters of exposure and effect

In general when working with cadmium, and, notably, if compliance with the i-OEL cannot be ensured in a consistent way, protection of the worker is ensured by complementary risk reduction measures and compliance with biological indicator limit values at the individual level. These measures include:

- Personal respiratory protection and hygiene measures if appropriate (see below, section "Conditions and measures related to personal protection, hygiene and health evaluation" for detail), in combination with
- Medical follow-up of the worker involving regular measurement of biological indicators of both exposure and effect:
 - exposure: measurement of Cd in urine (µg Cd/g Creatinine) and/or Cd in blood (µg Cd/l) to assess integrated systemic exposure of the individual;
 - effect: measurement of early (subclinical) indicators of tubular (kidney) dysfunction. Well-established biological indicators (BI) for Cd-effect are e.g. β₂-microglobuline (β₂-MG) and retinol binding protein (RPB).

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 59/69

The specific medical supervision (for details see ICdA 2006 – part II, section 4) is complementary to the technical and hygiene measures taken. It integrates exposure through all possible routes by assessing the Cd-body burden and assesses early biological indicators (BI's) of (subclinical) renal effect. It ensures as such that the risk to Cd-exposed workers is fully controlled.

The results of the medical supervision are applied as follows (see also Figure below):

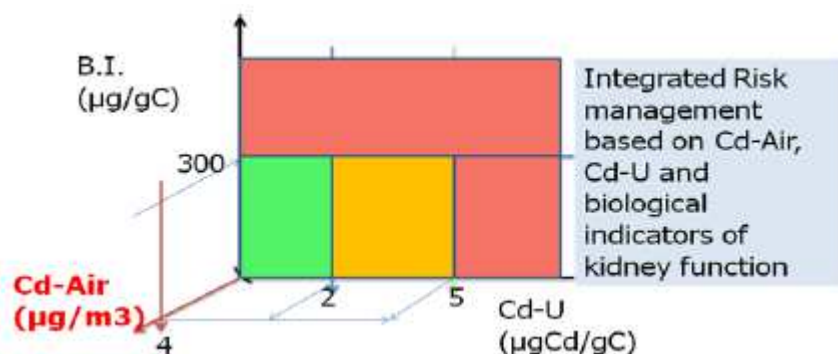


Figure: Illustration of Eurometaux/ICdA medical supervision guidance (2006) (BI: *biological indicators*; C: *creatinine*).

General medical follow-up level:

$Cd-U \leq 2 \mu\text{g Cd/g creatinine (C)}$. This is a conservative threshold based on general population studies, as described in Section 5.6.2. In this situation, the worker is followed by general medical follow-up (complementary indicator: $Cd-B \leq 5 \mu\text{g Cd/L}$). No further special action is required beyond proper implementation of the general hygiene procedures and medical surveillance.

Action level:

$2 < Cd-U \leq 5 \mu\text{g Cd/g creatinine}$: Action level zone. This zone is defined by the threshold based on studies at the workplace, as described in Section 5.6.2. Observation of Cd-U (or Cd-B) values in this "action" zone triggers (complementary trigger: $5 \mu\text{g Cd/l} < Cd-B \leq 8 \mu\text{g Cd/l}$) an individual follow up of the worker characterized by:

- Systematic and frequent follow up of exposure by measuring Cd-U (complementary analysis: Cd-B), combined with individual analysis and follow-up of hygiene behaviour
- Measurement of biological indicators (BI's) of early renal dysfunction (e.g. beta-2 microglobuline (B2-M) or retinol-binding protein (RBP) on a regular basis.

When the worker moves into this action level zone, the occupational doctor and plant hygiene team will check for the reason for the increased exposure (analysis of the workplace, with a view to identify possible substance releases, analysis of compliance with hygienic procedures, and interview with the worker to assess possible other causes, e.g. due to current or previous exposure, due to personal hygiene behaviour?).

Based on the results of the individual medical surveillance programme, the following management decisions are taken:

- The worker remains in the action zone: If the Cd-U (Cd-B) values do not progress further towards the threshold and the BI's remain stable and below the reference value (e.g. $300 \mu\text{g/g creatinine}$ for $\beta 2\text{-MG}$ and RBP), the worker is kept at the workplace. Additional hygiene measures are taken as appropriate, and medical

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 60/69

follow-up is strictly continued.

- The worker is removed from exposure:
 - If Cd-U > 5 µg Cd/g creatinine (or Cd-B > 8 µg/l) and/or
 - o If the BI's are exceeding the reference values or showing a consistent pattern of increase which may lead to approaching the reference values.

The management scheme as outlined above is applicable to workers that entered the Cd industry rather recently. Workers that have been working in the Cd-industry for long may have been historically exposed to elevated Cd -levels, and may show e.g. Cd-U levels exceeding 5 µg/gC due to historical exposure. The supervising medical doctor will evaluate these individuals carefully, focusing on the BI's. In any case, when BI values exceed the BI-reference values or approach them, the worker will be removed from Cd-exposure.

In addition to the above, general industrial hygiene programmes are to be implemented, as required by EU Directive 98/24/EC on protection of workers from chemical agents and other referenced systems on best practice: IPPC-BREF notes, BIMSCH or equivalent, ICH-Q7, FAMI-QS, ISO9000, ISO 13.100 or alike:

- General industrial hygiene practice;
- Collective protection measures and use of warning & safety signs;
- Minimizing the number of workers exposed or likely to be exposed;
- Workplace cleanliness : ensure procedures are designed, written and implemented so as to make sure cleanliness is obtained at workstations, work sections, traffic and storage areas, upper areas, building structures and various horizontal surfaces, air suction ducts;
- Procedures for process control.

Conditions and measures related to personal protection, hygiene and health evaluation

Personal protection, e.g. wearing of gloves, face protection, full body dermal protection, goggles, respirator; specify effectiveness of measure; specify the suitable material for the PPE (where relevant) and advise how long the protective equipment can be used before replacement (if relevant).

The implementation of the risk management system as described above is strictly followed up.

Individual protection measures are used as described in detail in the Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 2, 3, 4 (ICdA 2006), and consist of e.g.:

- Wearing of gloves and protective clothing is compulsory (efficiency ≥ 90 %);
- With normal handling, no respiratory personal protection (breathing apparatus) is necessary. If risk for exceedance of OEL/DNEL, use e.g.:
 - dust filter-half mask P1 (efficiency 75 %)
 - dust filter-half mask P2 (efficiency 90 %)
 - dust filter-half mask P3 (efficiency 95 %)
 - dust filter-full mask P1 (efficiency 75 %)
 - dust filter-full mask P2 (efficiency 90 %)
 - dust filter-full mask P3 (efficiency 97.5 %)
- Eyes: safety glasses are optional;
- Implement best practice in collective and individual hygiene procedures in compliance with articles 5 and 8 of 98/24/EC: Information-training of the workers and their staff and line managers focused on careful hygiene behaviour. Industry practice has shown that at low levels of industrial exposure to Cd, such as at the

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 61/69

level of the i-OEL, installation and maintaining of careful industrial hygiene practice is important for ensuring full control of exposure. Such hygiene practice must cover all aspects of the workday and involves e.g.:

- Provide training on the risks resulting with substance exposure at the time of hire and on a periodic basis;
- Provide work clothes with appropriate change frequency (weekly to daily) and ensure they are used accordingly;
- Structure adequate changing rooms (three compartments: city side, shower and workplace side with 2 locker rooms);
- Ensure snacks and drinks are provided and consumed in proper areas separated from the main work area;
- Develop adequate procedures to ensure meals are not a source of substance intake (hand washing, partial removal of work clothes before taking meals);
- strict separation of workplace and other working environments at the plant, including changing clothes;
- Ensure showers are taken at end of shifts;
- No smoking on the workplace;
- No-bearing of beards, no moustaches.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 62/69

Exposure scenario 7, annex to the SDS

Section 1. Title of the exposure scenario

Title	Industrial and professional use of massive pieces made of – or coated with – cadmium, alloyed or not.
Sector of use	<ul style="list-style-type: none"> ▪ SU3: Industrial uses; ▪ SU14: Manufacture of basic metals, including alloys; ▪ SU15: Manufacture of fabricated metal products, except machinery and equipment; ▪ SU16: Manufacture of computer, electronic and optical products, electrical equipment; ▪ SU17: General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment; ▪ SU18: Manufacture of furniture; ▪ SU19: Building and construction work; ▪ SU22: Professional uses; ▪ SU0: Other.
Product category	<ul style="list-style-type: none"> ▪ PC7: Base metals and alloys; ▪ PC38: Welding and soldering products, flux products.
Process category	<ul style="list-style-type: none"> ▪ PROC1: Chemical production or refinery in closed process without likelihood of exposure or processes with equivalent containment conditions; ▪ PROC2: Chemical production or refinery in closed continuous process with occasional controlled exposure or processes with equivalent containment conditions; ▪ PROC21: Low energy manipulation and handling of substances bound in/on materials or articles; ▪ PROC22: Manufacturing and processing of minerals and/or metals at substantially elevated temperature; ▪ PROC25: Other hot work operations with metals.
Categories of complex articles	<ul style="list-style-type: none"> ▪ AC1: Vehicles; ▪ AC2: Machinery, mechanical appliances, electrical/electronic articles; ▪ AC3: Electrical batteries and accumulators; ▪ AC7: Metal articles.
Categories of the release to the environment	<ul style="list-style-type: none"> ▪ ERC1: Manufacture of the substance; ▪ ERC2: Formulation into mixture; ▪ ERC4: Use of non-reactive processing aid at industrial site (no inclusion into or onto article); ▪ ERC5: Use at industrial site leading to inclusion into/onto article; ▪ ERC10a: Widespread use of articles with low release (outdoor); ▪ ERC11a: Widespread use of articles with low release (indoor).

Section 2. Exposure Scenario

Section 2.1. Contributing scenario (1) controlling environmental exposure for the industrial and professional use of massive pieces made of – or coated with – cadmium, alloyed or not.

Further specification

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 63/69

This scenario covers both the industrial scale processes and professional use. In the described process, the Cd metal containing preparation/mixture is further processed, involving potentially the following steps:

- Reception/unpacking of material;
- Final application, embedding, or shaping to produce the end product or article.

Product characteristics*Product related conditions.*

Cd metal in the article is <25 % when located in the coating, >25 % when located in the mass of the article.

Amounts used*Daily and annual amount per site.*

- The quantities involved in this scenario are 10-50 times smaller than in blending;
- Typical quantities for Industrial use are 1T/y (typical), maximum 10T/y (in industrial setting);
- For professional use: Maximum 1T/y;
- (consumer use is advised against).

Frequency and duration of use*Intermittent (used <12 times per year for not more than 24 h) or continuous use/release.*

Continuous production is assumed as a worst case. Usually, use is not continuous; this has to be considered when estimating exposure.

Environment factors not influenced by risk management*Flow rate of receiving surface water:.*

Default for generic scenario: 18 000 m³/d, unless specified otherwise.

Other given operational conditions affecting environmental exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process (via air and waste water); dry or water based processes; conditions related to temperature and pressure; indoor or outdoor use of products; work in confined area or open air.

- Solid, so in principle all dry processes throughout, no process waters. Even when no process waters occur (with dry process throughout), some non-process water can be generated containing zinc (e.g. from cleaning);
- In industrial and professional setting, processes are performed usually indoor in a confined area;
- Professional use can be outdoors;
- All residues containing zinc are recycled;
- Air on the working place is filtered before release outside the building (industrial setting).

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure to the environment; this includes in particular conditions ensuring rigorous containment; performance of the containment to be specified (e.g. by quantification of a release factor in section 9.x.2 of the CSR).

- In industrial and professional setting indoor, the following applies:
 - Local exhaust ventilation on dusty/high temperature operations and other work areas with potential dust generation;
 - Dust capturing and removal techniques are applied;

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 64/69

- Process enclosures where relevant and possible;
- No outdoor professional use is assumed.

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

Technical measures, e.g. on-site waste water and waste treatment techniques, scrubbers, filters and other technical measures aiming at reducing releases to air, sewage system, surface water or soil; this includes strictly controlled conditions (procedural and control technology) to minimise emissions; specify effectiveness of measures; specify the size of industrial sewage treatment plant (m^3/d), degradation effectiveness and sludge treatment (if applicable).

- In industrial and professional setting indoor, the following applies:
 - No process waters, so possible emissions to water are limited and non-process related.
 - If Cd emissions to water, on-site waste water treatment techniques can be applied to prevent releases to water (if applicable) e.g.: chemical precipitation, sedimentation and filtration (efficiency 90-99.98 %).
 - By exposure modelling it is predicted that at use quantities of ≥ 5 T/y, refinement of the exposure assessment to water and sediment needs to be made (exposure assessment based on real measured data and local parameters). Treatment of the emissions to water may be needed under such conditions (see "exposure estimation and risk characterisation").
 - Air emissions are controlled by use of bag-house filters and/or other air emission abatement devices e.g. fabric or bag filters, wet scrubbers. This may create a general negative pressure in the building.

Organizational measures to prevent/limit release from site

Specific organisational measures or measures needed to support the functioning of particular technical measures. Those measures need to be reported in particular for demonstrating strictly controlled conditions.

In general, emissions are controlled and prevented by implementing an appropriate management system. This would involve:

- information and training of workers;
- regular cleaning of equipment and floors;
- procedures for process control and maintenance.
- Treatment and monitoring of releases to outside air, and exhaust gas streams (process & hygiene), according to national regulation;
- SEVESO 2 compliance, if applicable.

Conditions and measures related to municipal sewage treatment plant

Size of municipal sewage system/treatment plant (m^3/d); specify degradation effectiveness; sludge treatment technique (disposal or recovery); measures to limit air emissions from sewage treatment (if applicable); please note: the default size of the municipal STP ($2000 m^3/d$) will be rarely changeable for downstream uses.

In cases where applicable: default size, unless specified otherwise.

Conditions and measures related to external treatment of waste for disposal

Fraction of used amount transferred to external waste treatment for disposal; type of suitable treatment for waste generated by workers uses, e.g. hazardous waste incineration, chemical-physical treatment for emulsions, chemical oxidation of aqueous waste; specify effectiveness of treatment.

- If any, all hazardous wastes are treated by certified contractors according to EU and national legislation;
- Users of Cd and Cd-compounds have to favour the recycling channels of the end-of-life products e.g.; the industrial Ni-Cd rechargeable battery -by far the most

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 65/69

important application in Europe –is to be collected, treated and recycled;

- Users of Cd and Cd-compounds have to minimize Cd-containing waste, promote recycling routes and, for the remaining, dispose the waste streams according the Waste regulation.

Conditions and measures related to external recovery of waste

Fraction of used amount transferred to external waste treatment for recovery: specify type of suitable recovery operations for waste generated by workers uses, e.g. re-distillation of solvents, refinery process for lubricant waste, recovery of slags, heat recovery out-side waste incinerators; specify effectiveness of measure.

All residues are recycled or handled and conveyed according to waste legislation.

Section 2.2. Contributing scenario (2) controlling worker exposure for the industrial and professional use of massive pieces made of – or coated with – cadmium, alloyed or not.**Product characteristic**

Product related conditions, e.g. the concentration of the substance in a mixture, the physical state of that mixture (solid, liquid; if solid: level of dustiness), package design affecting exposure).

Cd metal in the article is <25 % when located in the coating, >25 % when located in the mass of the article.

- The Cd containing mixture is in the solid state, usually with a low level of dustiness;
- However, for some processes, e.g. brazing (PC 38), Cd-fumes can be generated; for these processes, high dustiness is considered.

Amounts used

Amounts used at a workplace (per task or per shift); note: sometimes this information is not needed for assessment of worker's exposure.

- The quantities involved in this scenario are usually <1T/y in industrial setting, maximum 10T/y;
- Professional use (in non-industrial setting) can amount to 1T/y maximum.

Frequency and duration of use/exposure

Duration per task/activity (e.g. hours per shift) and frequency (e.g. single events or repeated) of exposure.

8-hour shifts (default worst case) are assumed as starting point; it is emphasised that the real duration of exposure could be less. This has to be considered when estimating exposure.

Human factors not influenced by risk management

Particular conditions of use, e.g. body parts potentially exposed as a result of the nature of the activity.

Uncovered body parts: (potentially) face.

Other given operational conditions affecting workers exposure

Other given operational conditions: e.g. technology or process techniques determining the initial release of substance from process into workers environment; room volume, whether the work is carried out outdoors/indoors, process conditions related to temperature and pressure.

- Dry processes: dry operational conditions throughout the process; no process waters;
- All indoor processes (industrial) in confined area;
- High temperature processes can occur (brazing);
- All processes are carried out indoor in confined areas, no outdoor use assumed.

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 66/69

Technical conditions and measures at process level (source) to prevent release

Process design aiming to prevent releases and hence exposure of workers; this in particular includes conditions ensuring rigorous containment; performance of containment to be specified (e.g. by quantification of residual losses or exposure).

- Process enclosures or semi-enclosures where appropriate;
- Local exhaust ventilation on furnaces and other work areas with potential dust and fumes generation, dust capturing and removal techniques.

Technical conditions and measures to control dispersion from source towards the worker

Engineering controls, e.g. exhaust ventilation, general ventilation; specify effectiveness of measure.

- Local exhaust ventilation system (high efficiency 90-95 %);
- Cyclones/filters (for minimizing dust emissions): efficiency: 70-90 % (cyclones), 50-80 % (dust filters), 85-95 % (double stage, cassette filters);
- Process enclosure, especially in potentially dusty units;
- Dust control: dust and Cd in dust needs to be measured in the workplace air (static or individual) according to national regulations;
- Special care for the general establishment and maintenance of a clean working environment by e.g.:
 - Cleaning of process equipment and workshop;
 - Implementation of "easy use" packaging;
 - Storage of packaged Cd finished product in enclosed buildings.

(see also Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 1 (ICdA 2006)).

Organisational measures to prevent /limit releases, dispersion and exposure

Specific organisational measures or measures needed to support the functioning of particular technical measures (e.g. training and supervision). Those measures need to be reported in particular for demonstrating strictly controlled conditions (to justify exposure based waiving).

The protection of workers in the Cd-related industry is achieved by the systematic implementation of a carefully designed stepwise risk management system, outlining measures to control worker exposure and combining measurements of both exposure and effect. The system is aimed at prevention of exposure and protection against early manifestation of (subclinical) effect at the level of the critical organ, the kidney. The system is described in detail in the industry guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" (ICdA 2006). It involves essentially 2 phases of action:

1) Controlling the Cd-concentration in the workplace air

Firstly, technical measures are taken to comply with the indicative EU (i-)OEL of 4 µg respirable Cd/m³ proposed by SCOEL in compliance with art. 3 of directive 98/24/EC (2009). This i-OEL is taken forward as a DNEL; compliance with the i-OEL is mandatory if no other measurements of Cd-exposure and effect (as described below) are performed. The OEL of 4µg Cd/m³ is applicable to Cd and Cd-compounds in general, unless the limited solubility of a given Cd-compound is documented. The total/inhalable fraction corresponding to the respirable fraction is function of the particle size of the inhaled particles.

2) Individual medical follow up of parameters of exposure and effect

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 67/69

In general when working with cadmium, and, notably, if compliance with the i-OEL cannot be ensured in a consistent way, protection of the worker is ensured by complementary risk reduction measures and compliance with biological indicator limit values at the individual level. These measures include:

- Personal respiratory protection and hygiene measures if appropriate (see below, section "Conditions and measures related to personal protection, hygiene and health evaluation" for detail), in combination with
- Medical follow-up of the worker involving regular measurement of biological indicators of both exposure and effect:
 - exposure: measurement of Cd in urine ($\mu\text{g Cd/g Creatinine}$) and/or Cd in blood ($\mu\text{g Cd/l}$) to assess integrated systemic exposure of the individual;
 - effect: measurement of early (subclinical) indicators of tubular (kidney) dysfunction. Well-established biological indicators (BI) for Cd-effect are e.g. β -microglobuline (β 2-MG) and retinol binding protein (RBP).

The specific medical supervision (for details see ICdA 2006 – part II, section 4) is complementary to the technical and hygiene measures taken. It integrates exposure through all possible routes by assessing the Cbody burden and assesses early biological indicators (BI's) of (subclinical) renal effect. It ensures as such that the risk to Cd-exposed workers is fully controlled.

The results of the medical supervision are applied as follows (see also Figure below):

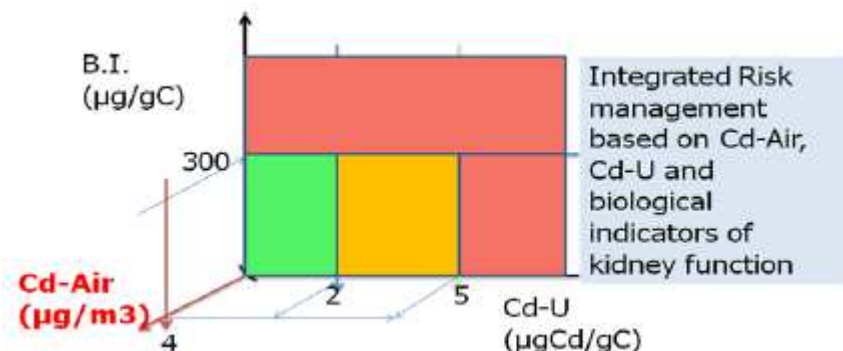


Figure: Illustration of Eurometaux/ICdA medical supervision guidance (2006) (BI: *biological indicators*; C: *creatinine*).

General medical follow-up level:

$\text{Cd-U} \leq 2 \mu\text{g Cd/g creatinine (C)}$. This is a conservative threshold based on general population studies, as described in Section 5.6.2. In this situation, the worker is followed by general medical follow-up (complementary indicator: $\text{Cd-B} \leq 5 \mu\text{g Cd/L}$). No further special action is required beyond proper implementation of the general hygiene procedures and medical surveillance.

Action level:

$2 < \text{Cd-U} \leq 5 \mu\text{g Cd/g creatinine}$: Action level zone. This zone is defined by the threshold based on studies at the workplace, as described in Section 5.6.2. Observation of Cd-U (or Cd-B) values in this "action" zone triggers (complementary trigger: $5 \mu\text{g Cd/l} < \text{Cd-B} \leq 8 \mu\text{g Cd/l}$) an individual follow up of the worker characterized by:

- Systematic and frequent follow up of exposure by measuring Cd-U (complementary analysis: Cd-B), combined with individual analysis and follow-up of hygiene behaviour
- Measurement of biological indicators (BI's) of early renal dysfunction (e.g. beta-2

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 68/69

microglobuline (B2-M) or retinol-binding protein (RBP) on a regular basis; When the worker moves into this action level zone, the occupational doctor and plant hygiene team will check for the reason for the increased exposure (analysis of the workplace, with a view to identify possible substance releases, analysis of compliance with hygienic procedures, and interview with the worker to assess possible other causes, e.g. due to current or previous exposure, due to personal hygiene behaviour?).

Based on the results of the individual medical surveillance programme, the following management decisions are taken:

- The worker remains in the action zone: If the Cd-U (Cd-B) values do not progress further towards the threshold and the BI's remain stable and below the reference value (e.g. 300 µg/g creatinine for β2-MG and RBP), the worker is kept at the workplace. Additional hygiene measures are taken as appropriate, and medical follow-up is strictly continued.
- The worker is removed from exposure:
 - If Cd-U > 5 µg Cd/g creatinine (or Cd-B > 8 µg/l) and/or
 - o If the BI's are exceeding the reference values or showing a consistent pattern of increase which may lead to approaching the reference values.

The management scheme as outlined above is applicable to workers that entered the Cd industry rather recently. Workers that have been working in the Cd-industry for long may have been historically exposed to elevated Cd -levels, and may show e.g. Cd-U levels exceeding 5 µg/gC due to historical exposure. The supervising medical doctor will evaluate these individuals carefully, focusing on the BI's. In any case, when BI values exceed the BI-reference values or approach them, the worker will be removed from Cd-exposure.

In addition to the above, general industrial hygiene programmes are to be implemented , as required by EU Directive 98/24/EC on protection of workers from chemical agents and other referenced systems on best practice: IPPC-BREF notes, BIMSCH or equivalent, ICH-Q7, FAMI-QS, ISO9000, ISO 13.100 or alike:

- General industrial hygiene practice;
- Collective protection measures and use of warning & safety signs;
- Minimizing the number of workers exposed or likely to be exposed;
- Workplace cleanliness : ensure procedures are designed, written and implemented so as to make sure cleanliness is obtained at workstations, work sections, traffic and storage areas, upper areas, building structures and various horizontal surfaces, air suction ducts;
- Procedures for process control.

Conditions and measures related to personal protection, hygiene and health evaluation

Personal protection, e.g. wearing of gloves, face protection, full body dermal protection, goggles, respirator; specify effectiveness of measure; specify the suitable material for the PPE (where relevant) and advise how long the protective equipment can be used before replacement (if relevant).

The implementation of the risk management system as described above is strictly followed up.

Individual protection measures are used as described in detail in the Guidance document "Management of the risk related to the chronic occupational exposure to cadmium and its compounds" part II, section 2, 3, 4 (ICdA 2006), and consist of e.g.:

CADMIUM REFINED

Date: 29.02.2012

Revision: 13.05.2021

Page/pages: 69/69

- Wearing of gloves and protective clothing is compulsory (efficiency $\geq 90\%$);
- With normal handling, no respiratory personal protection (breathing apparatus) is necessary. If risk for exceedance of OEL/DNEL, use e.g.:
 - dust filter-half mask P1 (efficiency 75 %)
 - dust filter-half mask P2 (efficiency 90 %)
 - dust filter-half mask P3 (efficiency 95 %)
 - dust filter-full mask P1 (efficiency 75 %)
 - dust filter-full mask P2 (efficiency 90 %)
 - dust filter-full mask P3 (efficiency 97.5 %)
- Eyes: safety glasses are optional;
- Implement best practice in collective and individual hygiene procedures in compliance with articles 5 and 8 of 98/24/EC: Information-training of the workers and their staff and line managers focused on careful hygiene behaviour. Industry practice has shown that at low levels of industrial exposure to Cd, such as at the level of the i-OEL, installation and maintaining of careful industrial hygiene practice is important for ensuring full control of exposure. Such hygiene practice must cover all aspects of the workday and involves e.g.:
 - Provide training on the risks resulting with substance exposure at the time of hire and on a periodic basis;
 - Provide work clothes with appropriate change frequency (weekly to daily) and ensure they are used accordingly;
 - Structure adequate changing rooms (three compartments: city side, shower and workplace side with 2 locker rooms);
 - Ensure snacks and drinks are provided and consumed in proper areas separated from the main work area;
 - Develop adequate procedures to ensure meals are not a source of substance intake (hand washing, partial removal of work clothes before taking meals);
 - strict separation of workplace and other working environments at the plant, including changing clothes;
 - Ensure showers are taken at end of shifts;
 - No smoking on the workplace;
 - No-bearing of beards, no moustaches.