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

1.1 Product identifier:

Commercial name: Nickel sulphate

UN-No.: 3260

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

Identified uses: Production of pure nickel (II) sulphate (VI)

Uses advised against: product cannot be publically available

1.3 Details of the supplier of the material safety data sheet:

KGHM Polska Miedź S.A.
"GŁOGÓW" Copper Smelter
ul. Żukowicka 1, 67-200 Głogów

Person responsible for preparing the MSDS: Agnieszka Piechota, phone no.: (+48 76) 747 7176, e-mail: a.piechota@kghm.pl

1.4 Emergency telephone numbers:

Manufacturer (Poland): (+48 76) 747 65 01 – available 24/7.
Fire Dept. (Poland): 998 – available 24/7.
General Emergency (Poland): 112 – available 24/7.
Marine transport (Foreign countries):
Emergency Telephone Responce Number,
Emergency CONTACT (24-Hour-Number),
GBK/Infotrac ID 105036: (USA domestic): 1 800 535 5053 or international (001) 352 323 3500

SECTION 2. Hazards identification

2.1. Classification of the substance or mixture:

Classification according to the Regulation No. 1272/2008 (CLP):

Carc. 1A; H350 – may cause cancer;
Muta. 2; H341 – suspected of causing genetic defects.
Repr. 1 B; H360D – may damage the unborn child.
STOT RE 1; H372 – causes damage to organs through prolonged or repeated exposure.
Acute Tox. 4; H302 – harmful if swallowed;
Acute Tox. 4; H332 – harmful if inhaled;
Skin Corr. 1; H314 – causes severe skin burns and eye damage;
Resp. Sens. 1; H334 – may cause allergy or asthma symptoms or breathing difficulties if inhaled;
Skin Sens. 1; H317 – may cause an allergic skin reaction;
Met. Corr 1; H290 – may be corrosive to metals;
Aquatic Acute 1; H400 – very toxic to aquatic life;
Aquatic Chronic 1; H410 – very toxic to aquatic life with long lasting effects.

Classification according to Directive 1999/45/EC:

Carc. cat. 1; R45 – may cause cancer;
Repro. cat. 2; R61 – may cause harm to the unborn child
Xn; R20/22 – harmful by inhalation and if swallowed;
C; R 34 – causes burns;
R42/43 – may cause sensitization by inhalation and skin contact;
T; R48/23 – toxic: danger of serious damage to health by prolonged exposure through inhalation
Muta. cat. 3; R68 – possible risk of irreversible effects;
N; R50/53 – very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

2.2. Label elements:

Restricted to professional users

GHS05 GHS 07 GHS 08 GHS 09

Signal Word: "DANGER"

Hazard statements (H):

H350 – May cause cancer.
H341 – Suspected of causing genetic defects.
H360D – May damage the unborn child.
H372 – Causes damage to organs through prolonged or repeated exposure.
H302 – Harmful if swallowed.
H332 – Harmful if inhaled.
H314 – Causes severe skin burns and eye damage.
H334 – May cause allergy or asthma symptoms or breathing difficulties if inhaled.
H317 – May cause an allergic skin reaction.
H290 – May be corrosive to metals.
H410 – Very toxic to aquatic life with long lasting effects.

Precautionary Statement (P):

P202 – Do not handle until all safety precautions have been read and understood.
P314 – Get medical advice/attention if you feel unwell.
P405 – Store locked up.
P501 – Dispose of contents/container to producer of product.
P273 – Avoid release to the environment.
P406 – Store in corrosive resistant/… container with a resistant inner liner.

2.3 Other hazards:

After heating up to higher temperatures, toxic products of decomposition are released, such as As_2O_3, SO_2, SO_3. At temperature higher than 840°C, nickel (II) oxide is released. The substance reacts with most of metals and releases flammable hydrogen.

Product does not meet classification criteria of PBT and vPvB.

SECTION 3. Composition/information on ingredients

3.1. Substances:

n/a

3.2. Mixtures:

a) according to the Regulation No. 1272/2008 (CLP):

No.	Name of substance	CAS No.	EC No.	Index No.	Content [mass fraction in %]	Symbols	H phrases	REACH registration number
1.	Nickel (II) sulphate (VI) $NiSO_4$ x n H20 (n = 1, 3, 4)	7786-81-4	232-104-9	028-009-00-5	88 ≤ c ≤ 96	Carc. 1A Muta. 2 Repr. 1B STOT RE 1 Acute tox. 4 Acute tox. 4 Skin. Irrit. 2 Resp. Sens. 1 Skin. Sens. 1 Aquatic Acute 1 Aquatic Chronic 1	H350i H341 H360D H372 H302 H332 H315 H334 H317 H400 H410	01-2119439361-44-0003
2.	Sulphuric acid (VI) H_2SO_4	7664-93-9	231-639-5	016-020-00-8	c ≤ 10	Skin. Corr. 1A	H314	01-2119458838-20-0041
3.	Arsenic acid As_2O_3	7778-39-4	231-901-9	033-005-00-1	≤ 0,5	Carc. 1A Acute Tox. 2 Skin. Corr 1B Aquatic Acute 1 Aquatic Chronic 1	H350 H300 H314 H400 H410	Impurity included in nickel sulfate registration dossier

b) acc. to Directive 1999/45/EC:

No.	Name of substance	CAS No.	EC No.	Index No.	Content [mass fraction in %]	Symbols	R phrases	REACH registration number
1.	Nickel (II) sulphate (VI) $NiSO_4$ x n H_2O (n = 1, 3, 4)	7786-81-4	232-104-9	028-009-00-5	88 ≤ c ≤ 96	Carc., cat. 1 Repro. cat. 2; Muta. cat.3; T; Xn, Xi; N	49-61-20/22-38-42/43-48/23-68-50/53	01-2119439361-44-0003
2.	Sulphuric acid (VI) H_2SO_4	7664-93-9	231-639-5	016-020-00-8	c ≤ 10	C	35	01-2119458838-20-0041
3.	Arsenic acid As_2O_3	7778-39-4	231-901-9	033-005-00-1	≤ 0,5	Carc. cat.1, T+; C; N	45-28-34-50/53	Impurity included in nickel sulfate registration dossier

Full text of H and R phrases not expanded in Section 2 can be found Section 16.

SECTION 4. First Aid measures

4.1 Description of first aid measures:

Respiratory ways: Take the victim out of the place of exposure. Provide calmness in semi-sitting or sitting position. Protect against loss of body heat. **Immediate medical help necessary**.

Contact with eyes: Immediately rinse with a lot of cool, running water, for about 15 minutes, with eyelid open. Avoid intensive water jet because conjunctiva may become mechanically damaged. **Immediate medical help necessary**.

Skin contact: Remove contaminated clothing. Immediately clean contaminated skin with a lot of running water at room temperature. In case of skin changes, seek dermatologist attention.

Alimentary way: Rinse mouth with water. Have the victim drink 2 glasses of water. If the vomiting is self-induced, rinse mouth with water and drink water again. **Immediate medical help necessary**.

General guidelines: Persons endangered to eye intoxication should be instructed about the necessity and method of immediate eye-rinsing.

Note: aqueous solutions have acid reaction, pH of 10% of aqueous solution is about 1.

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

Ways of exposure: alimentary way, respiratory ways, skin, eyes.

- respiratory ways: vapour/dust is toxic, pose serious threat to health after long-term exposure, may cause cancer, cause burning of mucosa, dyspnoea, may case sensitization;
- alimentary system: ingestion causes acute pain, nausea, vomiting, diarrhoea, burning of stomach cavity, throat, gullet;
- skin contact: causes burns, ulceration, may cause sensitization;
- contact with eyes: vapour/dust causes burning of eyelids and eyeballs.

Acute intoxication symptoms:

Product in the form of mist and fumes causes pain, weeping, burns of conjunctiva, cornea, throat pains, cough, shallow breathing, accelerated breathing, breathlessness, glottis spasm, larynx oedema, bronchi spasm, lungs oedema. Death may occur as a result of glottis spasm. Skin contamination causes thermal (exothermic reaction with moist skin) and chemical burning. Eyes contamination causes burning of eyelids, eyeball and permanent damage. When ingested, causes burns of oral cavity, throat, gullet; may lead to perforation of gullet, stomach, bleeding of alimentary tract, shock.

Long-term exposure:

Long-term exposure to sulfuric acid may lead to chronic inflammation of conjunctivas, nose bleeding, chronic bronchi inflammation. Repeated exposure of skin may lead to ulceration, changes in nails.

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

If the victim is unconscious, make sure that the respiratory tract is not obstructed and place the victim in a recovery position. Provide medical assistance.

SECTION 5. Firefighting measures

5.1 Extinguishing agents:

Appropriate extinguishing agents: Non-flammable substance. Apply extinguishing agents proper for the surrounding materials: water (if the container is tight) – sprayed jet, carbon dioxide, extinguishing powders, foam extinguishers, sand.

Unsuitable extinguishing agents: Not known.

5.2 Special hazards arising from the substance or mixture:

Substance soluble in water, creating caustic solutions which when in contact with most of metals release extremely flammable hydrogen.

Hazardous decomposition products: at high temperatures, sulphuric acid is distilled off and decomposition takes place releasing toxic sulphur oxides vapours (SO2, SO3), dusts of nickel oxides and arsenic trioxide.

5.3 Advice for fire-fighters:

During fire harmful substances may form. Wear protective, gas-tight clothes and apparatus isolating respiratory ways.

Additional information: Notify those in the surroundings about the fire. Remove all personnel not participating in the breakdown liquidation procedure from the area of hazard. Call fire department or police department. If possible, remove containers from fire hazard area. Do not let the fire water, contaminated with the substance, to penetrate surface or underground water.

SECTION 6. Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures:

6.1.1 For non-emergency personnel: Do not inhale dusts. Avoid direct contact. In case of choosing evacuation route consider the direction of the dust/fume movement.

6.1.2 For emergency responders: Avoid dust generation, do not inhale dusts. Avoid direct contact. Apply clothing protecting against chemicals as well as eye protection. In case of dust formation, wear dust mask.

Additional information:

Notify those in the surroundings about the emergency. Remove all personnel not participating in the breakdown liquidation procedure from the area of hazard. Call fire department and police if necessary. Protect the spilt substance against rain and wind by covering it with canvas cover.

6.2 Environmental precautions:

Do not let the product penetrate the sewage system, underground and surface water and soil. In case of failure, protect the substance against penetration to the environment. Collect maximum quantity to proper containers in order to utilize it.

6.3 Methods and material for containment and cleaning up:

Liquidate the leak (seal the defective package and put it in the protective package). Collect the spilt

substance to container (acid-resistant) and dispose of as hazardous waste. Procedure with waste according to section 13.

6.4 Reference to other sections

Personal protection equipment described in section 8.2.2
Disposal considerations in section 13.

SECTION 7. Handling and storage

7.1 Precautions for safe handling:

Avoid generation of vapour/dust within the work stand. When handling the substance, do not drink, eat, smoke; avoid contact with the substance and its solutions. During work, apply eye and skin protection. Work stand should be equipped with eyewash. Work stand should be equipped with means for collecting spilt substance. After work, thoroughly clean hands and face.

7.2 Conditions for safe storage, including any incompatibilities:

Store in properly identified and tight acid resistant containers. Protect the container against damage. Keep the substance in roofed place with impermeable floor; if there is no roof, the substance must be protected against atmospheric precipitation with foil. Properly identify the storage place with access for authorized, trained personnel only.

Ventilation requirements: Premises must be equipped with proper local exhaust ventilation with housing in the area of vapours/dust emission to aerial environment and with general ventilation of the room. In case of insufficient ventilation, wear suitable individual protection of the respiratory system.

Other information: Always keep in original containers. Do not use emptied container for other purposes.

7.3 Specific end use(s):

The uses identified in item 1.2.

SECTION 8. Exposure control/personal protection

8.1 Control parameters:

Values of the highest admissible concentrations that should be controlled (Poland):

No.	Name of substance	CAS No.	NDS [mghn^3]	NDSCh [mg/m^3]
1.	Nickel and its compounds, except nickel tetracarbonyl – calculated to Ni	-	0.25	-
2.	Sulphuric acid (VI)	7664-93-9	1	3
3.	Arsenic and its inorganic compounds calculated to As	-	0.01	-

Values of the highest admissible concentrations that should be controlled (consignee):

No.	Name of substance	CAS No.	TIV-TWA (mg/m$^{3)}$	TLV-STEL [mg/m^3]
1.	Soluble nickel compounds, except nickel tetracarbonyl – calculated to Ni Nickel compounds calculated to Ni	-	0.1 (ACGIH-TWA, USA) 1 (OSHA PEL, USA) 0.1 (MEL, Great Britain) 0.1 (TWA, Belgium) 0.1 (HTP, Finland)	- - - - -

	Soluble nickel salts calculated to Ni		0.05 (MAK-Wert, Germany)	-
2.	Sulphuric acid Sulphuric acid (vapours) [1][2]	7664-93-9	0.2 (ACGIH-TWA, USA) 1 (OSHA-PEL, USA) 0.2 (HTP, Finland) 0.1(MAK-Wert, Germany) 0.05 (European Union)	3 (ACGIH-TWA, USA) - 1 (HTP, Finland) 0.1 (MAK-Wert, Germany)
3.	Arsenic and its inorganic compounds calculated to As Arsenic and its compounds, except for arsenic hydride calculated to As		0.01 (ACGIH-TWA, USA) 0.01 (HTP, Finland) 0.1 (TWA, Great Britain)	- - -

[1] When selecting appropriate method of monitoring the exposure, consider potential limitations and disturbances which could be created in the presence of other sulphur compounds.
[2] Vapours are defined as trachea fraction.

Legal basis:

Decree of the Minister of Labour and Social Policy of November 29th, 2002 on the highest allowable concentrations and intensities of agents harmful for health in the work environment (Official Journal 02.217.1833 with subsequent amendments); According to Directive of the Commission 91/322/EWG of May 29th, 1991, on establishing indicative limit values by implementing Council Directive 80/1107/EEC on the protection of workers from the risks related to exposure to chemical, physical and biological agents at work. (Official Journal L 177 of 5.7.1991); According to Directive 2000/39/EC - indicative occupational exposure limit values of 8 June 2000 establishing a first list of indicative occupational exposure limit values in implementation of Council Directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work. (Official Journal L 142 of 16.6.2000 with subsequent amendments); Directive of the Commission 2009/161/EU of December 17th, 2009, establishing the third list of indicative values of occupational exposure in order to execute the Directive 98/241/EC as well as amending the Commission Directive 2000/39/EC (Official Journal L 338 of 19.12.2009);

The **derived no-effect levels** (DNELs) for nickel - workers:

- Acute exposure, inhalation, DNEL = 16mg Ni/m^3
- Chronic exposure, inhalation, DNEL = 0.05 mg Ni/m^3
- Chronic exposure, dermal, DNEL = 0.00044 mg Ni/cm^2

The **derived no-effect levels** (DNELs) for nickel - the general public:

- Acute exposure, inhalation, DNEL = 9.6 mg Ni/m^3
- Acute exposure, oral, DNEL = 0.012 mg Ni / kg / day
- Chronic exposure, inhalation, DNEL = 0.00002 mg Ni/m^3

8.2 Exposure controls:

8.2.1 Appropriate engineering controls:

Information contained in exposure scenarios attached to the Safety Data Sheet.

8.2.2 Personal protection measures same as personal protection equipment:

Eye and face protection:

Use protective goggles with face protection,

Hands protection:

Use protective gloves,

Skin protection:

Use acid resistant clothing,

Respiratory ways protection:

necessary when vapours/dusts are formed – gas mask (absorber of acidic vapours), dust mask equpped with filter suitable for determined air concentration, if the substance concentration is not known, apply respiratory ways isolation equipment.

Thermal hazards:

Not applicable

Hygiene means:

Immediately change contaminated clothing. Decontaminate clothing in water before reuse. Wash your hands and face after working with the substance. Do not eat and drink during substance handling.

8.2.3 Environmental exposure controls:

Environmental exposure should be controlled in compliance with national environment protection legislation in force.

SECTION 9. Physical and chemical properties

9.1 Information on basic physical and chemical properties:

- Appearance: dark-yellow or yellow-green, fine-crystalline powder;
- Odour: odourless;
- Level of odour perception: n.a.
- pH of saturated solution: about 1;
- Melting/: at temp. 103 °C - 110 °C loses crystallization water, anhydrous melt at temp. 280 °C; freezing point not determined
- Initial boiling point and boiling temperature range: n.a.
- Ignition temperature: n.a. inflammable product
- Evaporation rate: n.a.
- Flammability: n.a. inflammable product
- Low/high flammability point or high/low explosion point: n.a.
- Vapour pressure: n.a.
- Vapour density: n.a.
- Relative density: n.a.
- Bulk density: 1,88 g/cm3;
- Solubility in water: at temp. 20 °C – about 1,5 g/100 g of water;
- Distribution coefficient: n-octanol/ water: n.a.
- Spontaneous ignition temperature: n.a.

- Temperature of decomposition: at temp. about 840 °C decomposes with the release of nickel oxides and sulphur oxides; at temp. about 190 °C may sublime As_2SO_3;
- Viscosity: n.a.
- Explosion properties: n.a.
- Oxidizing properties: n.a.

9.2 Other information:
None

SECTION 10. Stability and reactivity

10.1 Reactivity:
When in contact with common metals, hydrogen releases. After heating up, the substance explosively reacts with aluminium and magnesium powder.

10.2 Chemical stability:
The substance is stable under normal conditions.

10.3 Possibility of hazardous reactions:
Not known

10.4 Conditions to avoid:
High temperature, accidental incompatible materials contact.

10.5 Incompatible materials:
Alkali and alkali soil metals – cause heating up, ignition of metal and explosion of released hydrogen. Contact with strong bases causes heating up of the mix and decomposition of NiSO4 to nickel (II) hydroxide.

10.6 Hazardous decomposition products:
In case of heating up to higher temperatures or fire, the following toxic products of decomposition are released: sulphur oxides (SO_2, SO_3), nickel oxides, arsenic oxides.

SECTION 11. Toxicological information

11.1 Information on toxicological effects

a) acute toxicity:

Acute toxicity (oral):

Due to the nickel (II) sulfate (VI) content product meets classification criteria as harmful after swallowing (Acute Tox. 4; H302).

After swallowing causes sharp pain, nausea, vomits, diarrhoea, oral cavity, throat and gullet burns.

Acute toxicity (inhalation):

Due to the nickel (II) sulfate (VI) content product meets classification criteria as harmful after inhaling (Acute Tox. 4; H332).

Vapours/dust have toxic action, create serious health risk in long-term exposure, may cause cancer, mucosae burns, dyspnoea, may cause sensitisation.

Acute toxicity(skin contact):
on the basis of available data the classification criteria are not met.

Toxic and lethal doses and concentartions:

$NiSO_4$:

LD_{50} (rat/females, oral): 361,9 mg/kg,
LC_{50} 4h (rat, inhalation): 2,48 mg/l,
LD_{50} (rat, skin): no data

H_2SO_4:

LD_{50} (rat, oral): 2140 mg/kg,
LC_{50} (rat, inhalation): 375 mg/m^3,
LC_{50} 4h (mouse, inhalation): 0,85 mg/l,
LC_{50} 8h (mouse, inhalation): 0,6 mg/l,
LD_{50} (rat, skin): no data

H_3AsO_4:

LD_{50} (mouse/females, oral): 160,4 mg/kg,
LD_{50} (mouse/females, oral): 141,4 mg/kg,
LC_{50} 4h (mouse/females, inhalation): 1,153 mg/l,
LC_{50} 4h (mouse/females, inhalation): 0,794 mg/l,
LD_{50} (rabbit/females, skin): 2300 mg/kg
LD_{50} (rabbit/females, skin): 1750 mg/kg

b) skin corrosion/irritation:
due to pH of the product it is classified as:
Skin Corr.;H314 The substance causes severe skin burns and eye damage.

c) serious eye damage/ eye irritating:
due to pH of the product it is classified as:
Skin Corr.;H314 The substance causes severe skin burns and eye damage.

d) respiratory tract or skin sensitization:
due to $NiSO_4$ content above concentration limit the product is classified as:
Skin Sens. 1; H317 – may cause an allergic skin reaction.;
Resp. Sens. 1; H334 – may cause allergy or asthma symptoms or breathing difficulties after inhalation.

e) reproductive cells mutagenicity:
due to $NiSO_4$ content above concentration limit the product is classified as:
Muta. 2; H341 – suspected of causing genetic defects;

f) carcinogenicity:
due to H_3AsO_4 content above concentration limit the product is classified as:
Carc. 1A; H350 – may cause cancer;

g) harmful for reproduction:

due to $NiSO_4$ content above concentration limit the product is classified as:
Repr. 1B; H360D – May damage the unborn child;
h) toxicity to specific organs – single exposure:
on the basis of available data the classification criteria are not met.
i) toxicity to specific organs – repeated exposure:
due to $NiSO_4$ content above concentration limit the product is classified as:
STOT RE 1; H372 – Causes damage to organs through prolonged or repeated exposure.
According to chemical safety assessment carried out for nickel (II) sulfate (VI) the respiratory way exposure causes danger in long-term or repeated exposure and damaged organs are lungs.
j) aspiration hazard:
on the basis of available data the classification criteria are not met.
Toxic action and other harmful actions for human body:
Arsenic and arsenic compounds are toxic for circulatory system, central and peripheral nervous system, liver and kidneys. Nickel causes disorders in the structure of nucleic acid leading to tumours of mouth, throat and lungs as well as nickel egzema.
Additional information:
Information related to possible exposure ways, product properties related symptoms and possible product exposure effects described in section 4.2.

SECTION 12. Ecological information

12.1 Toxicity:
On the basis of Chemical Safety Report for nickel (II) sulfate (VI) the product meets classification criteria as very toxic to aquatic life (Aquatic Acute 1; H400) and very toxic to aquatic life with long lasting effects **(**Aquatic Chronic 1; H410).
M factor for nickel (II) sulfate (VI) = 1.
Toxic concentration for aqueous animal and plant organisms:
$NiSO_4$:
LC_{50}/96h fish: *Oncorhynchus mykiss:* 15,3 mg/l
EC_{50}/48h crustaceans: *Ceriodaphnia dubia:* >82.1 < 133.1 mg/l (depending on water hardness and alkalinity)
EC_{50}/72h algae: *Pseudokirchnerella subcapitata*: > 81.5 < 148 µg/l (depending on water hardness and pH)
H_2SO_4:
LC_{50}/96h fish: *Lepomis macrochirus*: > 16 < 28 mg/l
EC_{50}/48h crustaceans: *Daphnia magna:* > 100mg/l
EC_{50}/72h algae: *Desmodesmus subspicatus:*
H_3AsO_4:
LC_{50}/96h fish: *Cyprinodon variegatus*: 28 mg/l

EC_{50}/48h crustaceans: *Americamysis bahia*: 6,6 mg/l
EC_{50}/72h algae: no data
Prediceted no effect concentrations (PNECs):
PNEC (surface water) – 3,6 µg soluble Ni/l
PNEC (marine water) – 8,6 µg soluble Ni/l
PNEC (soil) – 29,9 mg Ni/kg dry mass
PNEC (STP) – 0,33 mg Ni/l
PNEC birds, oral – 5,0 mg/kg mokrej masy
PNEC mammals, oral (rat) – 0,73 mg/kg wet mass

12.2 Persistence and degradability:

Product dissolves in contact with surface water. Environmental changes last until ions of Ni^{+2} react with ions of S^{-2}, CO_3^{-2} and precipitation of their sparingly soluble salts.

12.3 Bioaccumulative potential:

Nickel is easily bioaccumulated in phytoplankton and in other water plants. Daily human absorption varies in a range of 0,3-0,5 mg. Alimentary tract absorption in humans is below 10%. Low solubility compounds (metallic nickel dust, nickel sulfate and oxide) accumulate in lungs. Nickel sulfate solution is absorbed at 55-75% from skin in 24 hours. Nickel acquired with food and water is poorly absorbed and quickly excreted from organism. It is accumulated mainly in bones, parenchymal organs, heart and various glands. Nickel from the air is highly accumulated in lungs and transported to other organs.

12.4 Mobility in soil:

Nickel is an element with high mobility in the natural environment, the system soil - plant plays an important role in its circulation in ecosystems. Cultivated plants differ in ability to absorb nickel, although it is usually easily absorbed proportionally to the concentration in the soil until it reaches toxic levels. Nickel as a micronutrient in trace amounts is essential for plants. However, there are large differences in phytoaccumulation and phytotoxicity of nickel, depending on plant species, as well as the form in which nickel is present in the soil. Very important are also properties of soil such as pH, particle size distribution, organic matter content, as well as the interaction between nickel and other trace elements, e.g. cadmium (Cd), copper (Cu), zinc (Zn).

12.5 Results of PBT and vPvB assessment.

Product not classifies as PBT and vPvB.

12.6 Other adverse effects:

Not known.

SECTION 13. Disposal considerations

13.1 Waste treatment methods:

Do not dispose of to sewage system. Do not let the substance to contaminate surface and underground water and soil. Do not dispose of together with municipal waste. Consider the opportunity to reuse. Store the waste on hazardous waste dump yards in tight and durable containers.

Waste management according to the Directive of the European Parliament and Council 2008/98/EC of November 19th, 2008 on waste (Official Journal EC L 312 of 22.11.2008).
Disposable packages must be handed over to an authorized collector of package waste. Multiple use packages can be still used after previous cleaning.
Waste management according to the Directive of the European Parliament and Council 94/62/EC of December 20th, 1994 on packages and waste packages (Official Journal EC L 365 of 31.12.1994, with subsequent amendments).

SECTION 14. Transport information

14.1 UN number: 3260
14.2 UN proper shipping name:
ADR: CORROSIVE, SOLID, ACIDIC, INORGANIC, OTHERWISE NOT SPECIFIED
RID: CORROSIVE, ACIDIC, INORGANIC, SOLID, OTHERWISE NOT SPECIFIED
14.3 Transport hazard classes: RID/ADR: 8; IMDG: 8,
14.4 Packing group: RID/ADR: III; IMDG: III,
14.5 Environmental hazards:
Due to toxic effects of the semiproduct on aquatic organisms, means of transport should be labelled with the following mark:

14.6. Special precautions for the user:
Do not damage the containers. In case of unintentional product release, liquidate the leakage (seal, place damaged container in a protective packaging). Collect spilt substance into an acid resistant tank and dispose of as hazardous waste. Personal protection measures as described in section 8.8.2.
14.7. Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code:
n/a
Additional information:
Commercial name of material: Nickel sulphate
Class/Classification Code: RID/ADR: C2,
Limited quantities: RID/ADR 5 kg
Packing instructions:

- ADR: P002, IBC08, LP02, R001,
- RID: P002, DPPL08, LP02, R001,
- IMDG: P002, IBC08.

Warning labels: RID/ADR: 8, IMDG: 8

Hazard identification number: RID/ADR: 80
Special provisions: RID/ADR: 274; IMDG: 223, 274, 944
Other data: special provisions of 5.2.1.8 and 5.4.1.1.18 apply.

SECTION 15. Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture:

Nickel (II) sulfate (VI) is not covered by the regulations of the Decree (EC) No. 2037/2000 of the European Parliament and Council of 29th June, 2000 on substances depleting ozone layer (Official Journal L 244 of 29.09.2000, with subsequent amendments) or the Decree (EC) No. 850/2004 of the European Parliament and Council of April 29th, 2004, on permanent organic contamination and changing the Directive 79/117/EWG (Official Journal L 158 of 30.4.2004, with subsequent amendments).

Nickel (II) sulfate (VI) is not subject to regulations of the Decree of the European Parliament and Council (EC) No. 689/2008 of June 17th, 2008 on export and import of hazardous chemicals (Official Journal L 204 of 31.07.2008, with subsequent amendments).

Category of the substance according to Seveso Directive/substances listed in the annex I to the Directive of the Council 96/82/EC of December 9th, 1996, on control of significant breakdowns hazard related to hazardous substances (Official Journal L 192, 08/07/1998, with subsequent amendments): dangerous for the environment.

Nickel compounds are listed in the Annex X to the Decision No. 2455/2001/EC of the European Parliament and Council of November 20th, 2001, establishing the list of priority substances within the scope of water policy, changing the Directive 2000/60/EC (Official Journal L 331, 15/12/2001).

Provisions of law:

The Act of 25 February 2011 on chemical substances and their mixtures (Official Journal 11.63.322); Regulation (EC) No 1907/ 2007 of the European Parliament and Council of December 18th, 2006 on Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH), creating European Chemicals Agency, changing the Directive 1999/ 45/ EC as well as revoking the Council (EC) decree No 793193/ 93 as well as the Commission Directive (EC) No 1488/94 as well as the Council Directive 76/769/EWG and Council Directive 91/155/EEC, 93/67/EEC, 93/105/EC and 2000121/21/EC (Official Journal EC L 136 of 29.05.2007 with subsequent amendments); Regulation of the European Parliament and Council (EC) No. 1272/2008 dated December 16th, 2008 on classification, marking and packing hazardous substances and mixtures, changing and revoking the Directive 67/548/EWG and 1999/45/EWG as well as changing the Decree (EC) No. 1907/2006 (Official Journal EC L 353 of 31.12.2008 with subsequent amendments); Commission Regulation (EU) No 453/2010 of 20 May 2010 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (OJ L 133, with subsequent amendments); Regulation of the European Parliament and Council Regulation (EC) No 1336/2008 of 16 December 2008 amending Regulation (EC) No 648/2004 in order to adapt it to Regulation (EC) No 1272/2008 on classification, labeling and packaging of substances and mixtures (Official Journal. EU L 354 of 31 December 2008); Decree of the Minister of Labour and Social Policy of November 29th, 2002 on the highest allowable concentrations and intensities of substances harmful for health in the work environment (Official Journal 02.217.1833, with subsequent amendments); Act of August 19th, 2011 on transportation of hazardous goods (Official Journal 1367 2012.01.01); Act of December 14th, 2012, on waste (Official Journal 0.21.2013); Act of June 13th, 2013, on packages and packages waste (Official Journal 0.888.2013); Decree of the Board of Ministers of August 24th, 2004, on the list of works banned for adolescents and conditions of their employing for

some works. (Official Journal 04.200.2047, with subsequent amendments); Decree of the Board of Ministers of September 10th, 1996 on the list of works banned for women (Official Journal No. 114, item 545, with subsequent amendments).

15.2 Chemical safety assessment:

Chemical safety assessment of nickel (II) sulfate(VI) has been carried out. Chemical safety report is available at KGHM Polska Miedź S.A.

SECTION 16. Other information

Amendments have been made to following sections: 1, 2, 3, 8, 11, 12, 15, 16.

R and H phrases which have not been given in whole in sections 2-15:

R23/25 – Toxic by inhalation and if swallowed.
R35 – Causes severe burns.
R38 – Irritating to skin.
R49 - May cause cancer by inhalation.
H301 – Toxic if swallowed.
H315 – Causes skin irritation.
H318 – Causes serious eye damage.
H331 – Toxic if inhaled.
H350i – May cause cancer by inhalation.

Explanations of abbreviations and acronyms used in the MSDS:

CAS number – means numerical identification assigned to chemical substance by the American organization named Chemical Abstract Service (CAS), enabling substance identification.

Index number – it is an identification code given in part 3 of the annex VI to the Regulation of the European Parliament and Council (EC) No. 1272/2008 dated December 16th, 2008, on classification, marking and packing hazardous substances and mixtures, changing and revoking the Directive 67/548/EEC and 1999/45/EEC as well as changing the Regulation (EC) No 1907/2006.

WE number – the number assigned to chemical substance in EINECS - European Inventory of Existing Chemical Substances, or the number assigned to chemical substance in ELINCS - European List of Notified Chemical Substances or the number in chemical substances inventory included in "No-longer polymers" document.

Registration number – number given by ECHA after substance/semiproduct registration by the manufacturer/importer according to REACH Decree.

UN number – unequivocal marking of hazardous substances and goods assigned by United Nations Central Committee to provide international recognition and use.

Name according to IUPAC – name of a substance given by IUPAC - *International Union of Pure and Applied ChemistryCommittee*

NDS/TLV-TWA – the highest admissible concentration/threshold limit value – weighted average value – concentration of toxic chemical whose action on an employee during 8-hour daily shift and average

weekly time of work provided in the Labour Code, during the period of his occupational activity should not cause negative changes of his health condition and of health condition of his next generations.

NDSCh/TLV-STEL – the highest admissible short term concentration/short term exposure limit – weighted average of concentration of the specified, toxic chemical compound which should not cause negative changes of an employee health if present in the work environment for not longer than 15 minutes and not more often than twice per shift with occurrences separated by more than 1 hour.

LD_{50} – dose of toxic substance expressed in milligrams per kilogram of body mass necessary to kill 50% of the examined population within specified time.

LC_{50} – concentration of a substance in the inhaled air, expressed in milligrams per litre, which causes death of 50% of the examined population after specified period of exposure.

EC_{50} – substance dose expressed in milligrams per litre causing the given pharmacological effect (e.g. inhibition of growth) at 50% of the examined population within specified time.

Sources of information used during preparation of the MSDS:

- Own results of qualitative and quantitative analyses of nickel (II) sulphate;
- Chemical Safety Report for nickel (II) sulfate(VI); 2010;
- Chemical Safety Report for sulphuric acid; 2010;
- European Chemical Substance Information System (http://ecb.jrc_ec.europa.eu/esis/);
- TOXNET – Toxicology Data Network (http://toxnet. nlm.nih.dov/);
- ChemPortal – The Global Portal to Information on Chemical Substances (http://webnet3.oecd.org/eChemPortal/Home.aspx);
- "*CHEMISTRY – structure and reactions*". Author: Milton K. Snyder. Wydawnictwa Naukowo-Techniczne, Warszawa, 1975r.
- "*Encyclopaedia of technology*", vol. Chemistry, rev. N-T. Wyd. WNT, Warszawa, 1965r.
- „*Assessment of health risk of Wiślinka inhabitants related to impact of phosphgypsum dump*", Marek Biesiada i in., Instytut Medycyny Pracy i Zdrowia Środowiskowego; Sosnowiec, 2006.
- *„Nickel content and absorption by plants at various pH of natural soils and contaminated with cadmium or lead",* Jolanta Domańska, Ochrona Środowiska i Zasobów Naturalnych nr 40, 2009 r.

Necessary training: Post-related training within the scope of safe use of a substance considering its hazardous properties for humans and the environment.

Information contained in the material safety data sheet is to describe the product within the scope of safety requirements. User is responsible for taking any steps in order to meet the provisions of the national law and to create safe conditions for use of the product. User is held responsible for effects resulting from improper application of this product.

More information can be obtained under the telephone numbers given in section 1.

Table 84. Overview of generic exposure scenarios

GES #	Generic Exposure Scenarios		Contributing Exposure Scenarios	Volume (Tonnes)	Manufacture	Identified use					Applicable Use Descriptors				
	Sector/life cycle stage	Short Title (environment and health)	Title			Formulation	End use	Consumer use	Service life (for articles)	Waste Stage	SU	PC	PROC	AC	ERC or SpERC
	Nickel sulphate production				X										
GES 1		**Manufacture of Ni sulphate (copper refinery and smelter)**		538	X										**ERC 1**
GES 1		**Nickel sulphate production from copper refining**			X						**SU 9**				
ES 1.1			Reception of spent (Cu-Ni) electrolyte		X								PROC 2		
ES 1.2			Purification		X								PROC 22		
ES 1.3			Crystallization		X								PROC 2		
ES 1.4			Packaging		X								PROC 8b PROC 9		
ES 1.5			Cleaning and maintenance		X								PROC 0		
GES 2		**Solvent extraction of nickel sulphate leachate**			X						**SU 9**				**ERC 1**
ES 2.1			Charging		X								PROC 4		
ES 2.2			Purification		X								PROC 2		
ES 2.3			Solvent extraction		X								PROC 2		
ES 2.4			Packaging		X								PROC 8b PROC 9		
ES 2.5			Cleaning and maintenance		X								PROC 0		
GES 3		**Crystallisation from a purified nickel sulphate leachate**			X						**SU 9**				**ERC 1**
ES 3.1			Charging		X								PROC 1		
ES 3.2			Crystallisation		X								PROC 2		

GES #	Generic Exposure Scenarios		Contributing Exposure Scenarios	Volume (Tonnes)	Manufacture	Identified use					Applicable Use Descriptors				
	Sector/life cycle stage	Short Title (environment and health)	Title			Formulation	End use	Consumer use	Service life (for articles)	Waste Stage	SU	PC	PROC	AC	ERC or SpERC
ES 3.3			Drying		X								PROC 2		
ES 3.4			Packaging		X								PROC 2		
ES 3.5			Cleaning and maintenance		X								PROC 0		
	Downstream users of Nickel Sulphate														
GES 4		**Metal surface treatment: nickel electroplating, nickel electroconforming, electroless nickel plating**		**271**		**X**					**SU3 SU15**	**PC 14 PC 19**			**ERC 5**
ES 4.1			Operations involving dry salts			X							PROC 5 PROC 8a PROC 8b PROC 13 PROC 0		
ES 4.2			Operations with salt solutions			X							PROC 8a PROC 8b PROC 13 PROC 15 PROC 0		
GES 5		**Production of batteries using electrodes with nickel containing active material**		**796**		**X**					**SU3**	**PC 19**			**ERC 5**
ES 5.1			Raw material handling										PROC 4 PROC 8b		
ES 5.2			Manufacture of $NiSO_4$ solution										PROC 4 PROC 8b		
ES 5.3			Manufacture of positive {$Ni(OH)_2$ based} active mass										PROC 4 PROC 8b PROC 9 PROC 14		

GES #	Generic Exposure Scenarios		Contributing Exposure Scenarios	Volume (Tonnes)	Manufacture	Identified use					Applicable Use Descriptors				
	Sector/life cycle stage	Short Title (environment and health)	Title			Formulation	End use	Consumer use	Service life (for articles)	Waste Stage	SU	PC	PROC	AC	ERC or SpERC
													PROC 26		
ES 5.4			Manufacture of negative {$Cd(OH)_2$ doped with $Ni(OH)_2$ based} active mass										PROC 4 PROC 8b PROC 9 PROC 26		
ES 5.5			Manufacture of pocket plate electrodes										PROC 14 PROC 21		
ES 5.6			Nickel electroplating {maintenance of $NiSO_4$ electroplating solution & manufacture of electrode strip by nickel plating a steel strip}										PROC 4 PROC 8b PROC 9 PROC 26		
ES 5.7			Cleaning and maintenance										PROC 0		
GES 6		**Production of Ni salts from Ni Sulphate**		**1930**		**X**					**SU9**		**PROC 2 PROC 8b PROC 26 PROC 0**		**ERC 6a**
GES 7		**Use of nickel sulphate for the manufacturing of micronutrient additives for biogas production**		**1-10**		**X**					**SU 1**	**PC 12**			**ERC 2**
ES 7.1			**$NiSO_4$ reception**										**PROC 4 PROC 8b**		
ES 7.2			**Preparing the additive powder**										**PROC 3**		
ES 7.3			**Packaging**										**PROC 9**		
ES 7.4			**Palletising**										**PROC 3**		
ES 7.5			**Cleaning and maintenance**										**PROC 0**		

GES #	Generic Exposure Scenarios		Contributing Exposure Scenarios	Volume (Tonnes)	Manufacture	Identified use					Applicable Use Descriptors				
	Sector/life cycle stage	Short Title (environment and health)	Title			Formulation	End use	Consumer use	Service life (for articles)	Waste Stage	SU	PC	PROC	AC	ERC or SpERC
GES 8		**Production of nickel-containing pigments from $NiSO_4$**		**136**		**X**					**SU 3**	**PC 19**			**ERC 2 ERC 5 ERC 6a SPERC: production and formulation stage of metal compounds**
ES 8.1			**Raw material handling**			**X**							**PROC 8b**		
ES 8.2			**Mixing raw materials**			**X**							**PROC 2 PROC 5 PROC 26**		
ES 8.3			**Drying and calcining product**			**X**							**PROC 4 PROC 9 PROC 22**		
ES 8.4			**Dry milling**			**X**							**PROC 24**		
ES 8.5			**Wet milling, washing and drying**			**X**							**PROC 22 PROC 24**		
ES 8.6			**Blending and packaging**			**X**							**PROC 9**		
ES 8.7			**Cleaning and maintenance**			**X**							**PROC 0**		

9.2 Generic exposure scenarios for nickel sulphate production

9.2.1 INTRODUCTION TO NICKEL SULPHATE PRODUCTION

Nickel sulphate is produced as a by-product of production of copper and other metals and via the refining of nickel matte and nickel intermediates produced during the recyling of a variety of secondary materials (*e.g.* spent nickel catalysts, nickel/cobalt residues, copper-nickel alloys and drosses). These production processes are described in three GES in this section; nickel sulphate production from copper refining, solvent extraction of nickel sulphate leachate and crystallisation from purified nickel sulphate leachate.

Estimated and measured environmental (*i.e.,* in freshwater, marine aquatic, air and terrestrial compartments) and occupational (*i.e.,* process-specific occupational hygiene data from personal/static monitoring) exposure data for nickel suphate production, are detailed in Appendix D3 (section 1; environment), Appendix D4 (human health), and Appendix D5 (MvE) and provide full details on the exposure and risk characterisation data used in the GES. Detailed information on the environmental tiered approach for site-specific exposure assessment and risk characterization is found in Appendix D1. Detailed information on local exposure calculation factors and regional ambient backgrounds can be found in Appendix D2.

As discussed in section 9.1, since it was not possible to attribute emissions to any specific process/activity, the environmental exposure assessment was conducted for nickel sulphate production sites as a whole. Conversely, the occupational exposure assessment was broken down by process/activity. Therefore, three GES are successively presented in the following sections, for the different nickel sulphate production processes, each one includes process-specific human exposure information and a common production sector environmental assessment element. In addition, secondary poisoning, WWTP, STP and MvE assessments are presented in separate sections for the entire nickel sulphate production sector.

9.2.2 GES 1: NICKEL SULPHATE PRODUCTION FROM COPPER REFINING

1. Title **GES 1 Nickel sulphate production from copper refining**	
Life cycle	Manufacture of Ni sulphate
Free short title	Nickel sulphate production from copper refining
Systematic title based on use descriptor	SU: SU9 - Manufacture of fine chemicals PC: Not relevant ERC: ERC1 – Manufacture of substances PROC: PROC 2 - Use in closed, continuous process with occasional controlled exposure (e.g. sampling) PROC 22 - Potentially closed processing operations with minerals/metals at elevated temperature PROC 8b - Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 9 - Transfer of substance or preparation into small containers (dedicated filling line, in-cluding weighing) PROC 0 - Cleaning and maintenance
Processes, tasks, activities covered (environment)	Manufacture of Ni sulphate in refineries
Processes, tasks, activities covered (workers)	Electrolytic refining of spent (Cu-Ni) electrolyte from copper anode production and recrystallisation of $NiSO_46H_2O$ or $NiSO_42H_2O$ from this nickel sulphate $NiSO_4$ solution Contributing exposure scenario ES 1.1: PROC 2: Reception of spent (Cu-Ni) electrolyte obtained from electrolysis (of Ni-containing Cu anode to give Cu cathode) from the copper refinery Contributing exposure scenario ES 1.2: PROC 22: Purification by de-copperisation of spent electrolyte to give a $NiSO_4$ solution

	Contributing exposure scenario ES 1.3: PROC 2: Concentration of the $NiSO_4$ solution by volume reduction and precipitation/crystallisation of $NiSO_46H_2O$ or $NiSO_42H_2O$ from the $NiSO_4$ solution Contributing exposure scenario ES 1.4: PROC 8b, PROC 9: Packaging of moist $NiSO_46H_2O$ or $NiSO_42H_2O$ crystals Contributing exposure scenario ES 1.5: PROC 0: Cleaning and Maintenance reported as examples of regular and service maintenance
2. Operational conditions and risk management measures	
2.1 Control of environmental exposure	
Environmental related free short title	Manufacture of Ni sulphate (copper refinery and smelter)
Systematic title based on use descriptor (environment)	ERC1 – Manufacture of substances
Processes, tasks, activities covered (environment)	Manufacture of Ni sulphate in refineries
Environmental Assessment Method	Measured local and regional concentrations are used for calculation of PEC
Product characteristics	
Solids, low grade dust Average particle size (as diameter) range from approx. 0.05 to 0.2 mm	
Amounts used	
Maximum daily use at a site	1.5 tonnes/day (50^{th} % emission days, 25^{th} % tonnage)
Maximum annual use at a site	538 tonnes (25^{th} %, 2007)
Frequency and duration of use	
Pattern of release to the environment	350 days per year per site (50^{th}%)
Environment factors not influenced by risk management	
Receiving surface water flow rate	18000 m^3/d
Dilution capacity, freshwater	10 (default) m^3/d
Dilution capacity, marine	100 (default) m^3/d
Other given operational conditions affecting environmental exposure	
None	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Waste water: On-site waste water treatment plant (chemical precipitation) Efficiency: ->99% removal Release factor after on-site treatment: To freshwater and marine water: 5.90 g/T (10^{th} %) **Air:** Treatment of air emission (filters, wet or dry scrubber). Efficiency: ->99% removal Release factor after on-site treatment: 72.5 g/T (max)	
Organizational measures to prevent/limit release from site	
None	
Conditions and measures related to municipal sewage treatment plant	
Municipal Sewage Treatment Plant (STP)	Not relevant
Discharge rate of the Municipal STP	Not relevant
Incineration of the sludge of the Municipal STP	Not relevant
Conditions and measures related to external treatment of waste for disposal	
Ni bearing waste shall be recovered or recycled if possible. Ni bearing waste shall be considered hazardous if the Ni content is above the generic cutoffs (for mixtures) as stated in regulation (EC) No. 1272/2008. Ni bearing waste mixtures may be assessed as substances according to regulation (EC) No. 1272/2008 criteria. Disposal of Ni bearing waste shall comply with local, state or national waste legislation and remains the responsibility of the waste treatment operator.	
Conditions and measures related to external recovery of waste	
Not applicable	
2.2 Control of workers exposure for contributing exposure scenario 1.1	
Reception of spent (Cu-Ni) electrolyte obtained from electrolysis (of Ni-containing Cu anode to give Cu cathode) from the	

copper refinery	
Workers related free short title	Manufacture of Ni sulphate Nickel sulphate production from copper refining
Use descriptor covered	PROC 2
Processes, tasks, activities covered	Reception of spent (Cu-Ni) electrolyte obtained from electrolysis (of Ni-containing Cu anode to give Cu cathode) from the copper refinery
Assessment Method	Estimation using a Tier 1 model.
Product characteristic	
Solids, low grade dust Average particle size (as diameter) range from approx. 0.05 to 0.2 mm Concentration of nickel in solid is 22-32 % depending on hydrate and moisture levels.	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation, mechanisation and provision of containment by plant applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
The Cu-Ni spent electrolyte is pumped in pipes from the copper refinery into the purification plant.	
Technical conditions and measures at process level (source) to prevent release	
The transfer of the spent electrolyte solution shall be totally enclosed with no emission to the workplace.	
Technical conditions and measures to control dispersion from source towards the worker	
None	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Dermal: Use of properly designed gloves is required for operations where direct contact is possible Inhalation: Use of RPE (APF 40) is required for operations where exposure to Ni dust or powder is possible.	
2.3 Control of workers exposure for contributing exposure scenario 1.2	
Purification by de-copperisation of spent electrolyte to give a $NiSO_4$ solution	
Workers related free short title	Manufacture of Ni sulphate Nickel sulphate production from copper refining
Use descriptor covered	PROC 22
Processes, tasks, activities covered	Purification by de-copperisation of spent electrolyte to give a $NiSO_4$ solution
Assessment Method	Estimation of exposure based on measured data and by use of a Tier 1 model.
Product characteristic	
Solids, low grade dust Average particle size (as diameter) range from approx. 0.05 to 0.2 mm Concentration of nickel in solid is 22-32 % depending on hydrate and moisture levels.	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation, mechanisation and provision of containment by plant applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant

Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	1980 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
The copper impurity is removed from this electrolyte by evaporation/crystallisation (Cu as copper sulphate, $CuSO_4$) and electrowinning by cascade electrolysis (of Cu as cathode) to give a $NiSO_4$ solution.	
Technical conditions and measures at process level (source) to prevent release	
The evaporation of the spent electrolyte solution and precipitation of $CuSO_4$ shall be fully enclosed. Electrowinning is usually carried out in open cascade electrolysis cells.	
Technical conditions and measures to control dispersion from source towards the worker	
None	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
PPE is required for all production processes after reception of spent electrolyte and for maintenance, cleaning, and non-routine production (clearing up spills and clearing obstructions inside pant) activities. Inhalation exposure to mists from this process is controlled by full or half- face respirator e.g. 3M 6800, Protection factor, APF = 20 (based on use of P3), Protection factor, APF = 40 for particulate given by full face mask EN136 with EN 143 filter. Acid resistant gloves are required to control skin exposure to liquid splashes which may occur during both de-copperisation processes.	
2.4 Control of workers exposure for contributing exposure scenario 1.3	
Concentration of the $NiSO_4$ solution by volume reduction and precipitation/crystallisation of $NiSO_46H_2O$ or $NiSO_42H_2O$ from the $NiSO_4$ solution	
Workers related free short title	Manufacture of Ni sulphate Nickel sulphate production from copper refining
Use descriptor covered	PROC 2
Processes, tasks, activities covered	Concentration of the $NiSO_4$ solution by volume reduction and precipitation/crystallization multi-hydrated ($NiSO_46H_2O$ or $NiSO_42H_2O$) $NiSO_4$ from the $NiSO_4$ solution
Assessment Method	Estimation of exposure based on measured data
Product characteristic	
Solids, low grade dust Average particle size (as diameter) range from approx. 0.05 to 0.2 mm Concentration of nickel in solid is 22-32 % depending on hydrate and moisture levels.	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation, mechanisation and provision of containment by plant applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
The resulting $NiSO_4$ solution is heated (submerged arc burners) and concentrated by evaporation under reduced pressure. The $NiSO_46H_2O$ or $NiSO_42H_2O$, is crystallised out of solution in a crystallising unit {surface (coat and coil) cooled crystallisers} and separated from the solution by centrifugation or filtration (belt filter). Washed $NiSO_46H_2O$, recovered on the belt filter, is redissolved to produce a commercial $NiSO_4$ solution. The solid product(s) $NiSO_46H_2O$ or $NiSO_42H_2O$ is (are) moist after recovery. The waste solution and washings, containing sulfuric acid, is directed to a storage container from which it is neutralised and disposed.	
Technical conditions and measures at process level (source) to prevent release	
The concentrated solution shall be piped from the evaporator into an enclosed crystallising unit. The steam and sulfuric acid mist from the enclosed evaporator shall be extracted and the airflow cleaned by demisters and condensers. The moist	

$NiSO_46H_2O$ or $NiSO_42H_2O$ solid shall be recovered from solution using either i) a partially enclosed belt filter, with extraction fitted close to the openings at both ends of the belt filter casing, or ii) a centrifuge which is closed by design.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV shall be installed on the belt filters. Fixed capturing hoods located in close proximity of and directed at the source of emission for belt filters and packaging units are required. The design shall enable that the work is performed in the capture zone of the ventilation system and the capture zone shall be indicated at the workplace.	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
PPE is required for all production processes after reception of spent electrolyte and for maintenance, cleaning, and non-routine production (clearing up spills and clearing obstructions inside pant) activities. There is little particulate emission from the moist product. Inhalation exposure to mists generated during separation and skin exposure to liquid splashes, mists or the $NiSO_46H_2O$ or $NiSO_42H_2O$ solid during operating the centrifuge and routing the sulfuric acid solution to a treatment plant are controlled by RPE and acid proof gloves respectively. Full or half- face respirator e.g. 3M 6800, Protection factor = 20 (based on use of P3), Protection factor = 40 for particulate given by full face mask EN136 with EN 143 filter should be available for instances of unforeseen release of mists from evaporators. Acid proof gloves are required to control skin exposure to any liquid splashes and during cleaning of spills. These activities shall be automated and closed.	
2.5 Control of workers exposure for contributing exposure scenario 1.4	
Packaging of moist $NiSO_46H_2O$ or $NiSO_42H_2O$ crystals	
Workers related free short title	Manufacture of Ni sulphate Nickel sulphate production from copper refining
Use descriptor covered	PROC 8b, PROC 9
Processes, tasks, activities covered	Packaging of moist $NiSO_46H_2O$ or $NiSO_42H_2O$ crystals
Assessment Method	Estimation of exposure based on measured data
Product characteristic	
Solids, low grade dust Average particle size (as diameter) range from approx. 0.05 to 0.2 mm Concentration of nickel in solid is 22-32 % depending on hydrate and moisture levels.	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation, mechanisation and provision of containment by plant applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
The hydrated nickel sulphate is weighed and packed into bulk containers (1000 kg) or other forms of packaging. Bagging is usually carried out by a worker using a manually operated bagging unit and then warehoused.	
Technical conditions and measures at process level (source) to prevent release	
Enclosement is required for screw conveyors that transfer the moist $NiSO_46H_2O$ or $NiSO_42H_2O$ to the packaging units where it is bagged into bulk containers (big bags).	
Technical conditions and measures to control dispersion from source towards the worker	
LEV shall be installed on bagging units in the packaging area at the end of the production process. Fixed capturing hoods located in close proximity of and directed at the source of emission for belt filters and packaging units are required. The design shall enable that the work is performed in the capture zone of the ventilation system and the capture zone shall be indicated at the workplace.	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
PPE is required for all production processes after reception of spent electrolyte and for maintenance, cleaning, and non-	

routine production (clearing up spills and clearing obstructions inside pant) activities. Acid proof gloves and full or half- face respirator e.g. 3M 6800, Protection factor = 20 (based on use of P3), Protection factor = 40 for particulate given by full face mask EN136 with EN 143 filter are required to control any dermal and inhalation exposure to particulate $NiSO_4 6H_2O$ or $NiSO_4 2H_2O$.	
2.5 Control of workers exposure for contributing exposure scenario 1.5	
Cleaning and Maintenance reported as examples of regular and service maintenance	
Workers related free short title	Manufacture of Ni sulphate Nickel sulphate production from copper refining
Use descriptor covered	PROC 0
Processes, tasks, activities covered	Cleaning and Maintenance reported as examples of regular and service maintenance
Assessment Method	Estimation of exposure based on measured data
Product characteristic	
Solids, low grade dust Average particle size (as diameter) range from approx. 0.05 to 0.2 mm Concentration of nickel in solid is 22-32 % depending on hydrate and moisture levels.	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Routine inspections of evaporators are made every 4-12 weeks. Major maintenance works are performed every 4-5 years.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
The inspection includes: cleaning of the installation (by flushing with hot water), checking burners and the integrity of the evaporator lining and repairing any leaks in this system.	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical conditions and measures to control dispersion from source towards the worker	
None	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
During cleaning and maintenance dermal exposure shall be controlled by wearing acid proof gloves and inhalation exposure to mists and particulates shall be controlled by use of full or half- face respirator e.g. 3M 6800, Protection factor = 20 (based on use of P3), Protection factor = 40 for particulate given by full face mask EN136 with EN 143 filter.	
3. Exposure and risk estimation	

Environment

ERC 1
Manufacture of Ni sulphate (copper refinery and smelter)

compartment	Unit	PNEC	$PEC_{Regional}$	C_{local}	PEC	RCR	Methods for calculation of environmental concentration
Freshwater	µg/L	3.6	2.9	0.32	3.22	0.91	Measured values, Tier 3-RWC
Marine	µg/L	8.6	0.3	0.03	0.33	0.04	
Terrestrial	mg/kg	29.9	16.2	0.10	16.3	0.55	
STP	mg Ni/kg	0.33	-	-	-	-	Waste water is not connected to an STP

Workers

ES 1.1
PROC 2: Reception of spent (Cu-Ni) electrolyte obtained from electrolysis (of Ni-containing Cu anode to give Cu cathode) from the copper refinery

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure

Dermal					
Acute systemic	mgNi/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00005	0.11	Exposure modeled using MEASE, a Tier 1 model for PROC2. It is assumed that Ni solids have medium dustiness and have concentration more than 25%. Only incidental exposure is assumed through non-direct handling. Use of properly designed gloves is assumed
Inhalation					
Acute systemic	mg Ni/m³	16	0.039	0.002	3 x long-term exposure estimate
Acute local	mg Ni/m³	0.7	0.039	0.056	
Long-term systemic and local	mg Ni/m³	0.05	0.013	0.26	Exposure modeled using MEASE, a Tier 1 model for PROC2. It is assumed that Ni solids have medium dustiness and have concentration more than 25%. Only incidental exposure is assumed through non-direct handling of a closed system without breaches. The use of RPE of APF 40 is also assumed.
ES 1.2 PROC 22: Purification by de-copperisation of spent electrolyte to give a $NiSO_4$ solution					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00005	0.11	Exposure modeled using MEASE, a Tier 1 model for PROC 22. It is assumed that Ni solids have medium dustiness and have concentration more than 25%. Only incidental exposure is assumed through non-direct handling of non-dispersive use process. Use of gloves is also assumed.
Inhalation					
Acute systemic	mg Ni/m³	16	0.018	0.001	3 x long-term exposure estimate for 'evaporator
Acute local	mg Ni/m³	0.7	0.018	0.03	

					and filter' operator
Long-term systemic and local	mg Ni/m³	0.05	0.006	0.12	Highest of two personal, inhalable exposure measurements for 'evaporator and filter' operator
ES 1.3 PROC 2: Concentration of the $NiSO_4$ solution by volume reduction and precipitation/crystallisation of $NiSO_46H_2O$ or $NiSO_42H_2O$ from the $NiSO_4$ solution					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	Not reported	<1	Qualitative assessment[1]
Inhalation					
Acute systemic	mg Ni/m³	16	0.018	0.001	3 x long-term exposure estimate for 'evaporator and filter' operator
Acute local	mg Ni/m³	0.7	0.018	0.03	
Long-term systemic and local	mg Ni/m³	0.05	0.006	0.12	Single personal, inhalable exposure measurement for 'evaporator and filter' operator
[1] Dermal exposure likely to be sufficiently controlled by prevention of acid burns					
ES 1.4 PROC 8b, PROC 9: Packaging of moist NiSO46H2O crystals					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00067	1.5 excl. PPE <1 with gloves	75th percentile (full body exposure) based on packaging data from an analogous operation (packaging of $NiSO_46H_2O$). Qualitative assessment[1]
Inhalation					
Acute systemic	mg Ni/m³	16	0.03 0.06	0.002 0.004	3 x long-term respirable exposure value for filling and loading to containers. Inhalable value estimated as twice the respirable exposure level
Acute local	mg Ni/m³	0.7	0.03 0.06	0.043 0.086	
Long-term systemic and local	mg Ni/m³	0.05	0.01 0.02	0.20 0.4	Personal, respirable measurement taken during filling and loading to containers. Inhalable value estimated as twice the respirable exposure level

[1] Dermal exposure likely to be sufficiently controlled by prevention of acid burns

ES 1.5
PROC 0: Cleaning and Maintenance reported as examples of regular and service maintenance

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00067	1.5 excl. PPE <1 with gloves	75th percentile (full body exposure) based on packaging data from an analogous operation (packaging of $NiSO_46H_2O$). Qualitative assessment[1]
Inhalation					
Acute systemic	mg Ni/m³	16	0.24	0.015	3 x long-term inhalable exposure value (estimated as twice the respirable exposure level)
Acute local	mg Ni/m³	0.7	0.24	0.343	
Long-term systemic and local	mg Ni/m³	0.05	0.08	1.6 excl. RPE By use of RPE (APF 20): 0.08	Inhalable value estimated as twice the respirable exposure level (personal, respirable value was the maximum result of 4 measurement ranges for evaporators and crystalliser service)

NR: Not Relevant

[1] Dermal exposure likely to be sufficiently controlled by prevention of acid burns

4. Guidance to evaluate whether a site works inside the boundaries set by the ES

Environment
Scaling tool: Metals EUSES IT tool (free download: http://www.arche-consulting.be/Metal-CSA-toolbox/du-scaling-tool)

Scaling of the release to air and water environment includes:
Refining of the release factor to air and waste water and/or and the efficiency of the air filter and wastewater treatment facility.

Scaling of the PNEC for aquatic environment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Scaling of the PNEC for soil compartment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Workers
Scaling considering duration and frequency of use
Collect process monitoring data with an inhalable sampler. The simultaneous use of a respirable sampler is encouraged. Use aerosol particle size information, when available, to confirm the appropriate use of the inhalable DNEL of 0.05 mg Ni/m³. Respirable fraction exposure levels should be kept below 0.01 mg Ni/m³. See Appendix D6 for site-specific guidance on exposure data collection and Appendices C2 for further details on DNEL derivation.

For further information and guidance on exposure scenarios, available tools, and scaling options, please visit the Nickel Consortia exposure scenario library at the following link: http://www.nickelconsortia.org/exposure-scenario-library.html

9.2.3 GES 2: NICKEL SULPHATE PRODUCTION: SOLVENT EXTRACTION OF NICKEL SULPHATE LEACHATE

1. Title **GES 2 Solvent extraction of nickel sulphate leachate**	
Life cycle	Manufacture of Ni sulphate
Free short title	Solvent extraction of nickel sulphate leachate Nickel sulphate production from other leaching processes
Systematic title based on use descriptor	SU: SU9 - Manufacture of fine chemicals PC: Not relevant ERC: ERC1 – Manufacture of substances PROC: PROC4 – Use in batch and other process (synthesis) where opportunity for exposure arises PROC2 – Use in closed, continuous process with occasional controlled exposure (e.g. sampling) PROC8b - Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC9 - Transfer of substance or preparation into small containers (dedicated filling line, including weighing) PROC0 – Cleaning and maintenance
Processes, tasks, activities covered (environment)	Manufacture of Ni sulphate in refineries
Processes, tasks, activities covered (workers)	Purification (of an impure nickel sulphate, $NiSO_4$, solution) by precipitation and solvent extraction and recrystallisation (of nickel sulphate hexahydrate, $NiSO_4.6H_2O$) from this nickel sulphate $NiSO_4$ solution Contributing exposure scenario ES 2.1: PROC 4: Impure $NiSO_4$ and nickel carbonate, $NiCO_3$, are charged into a reactor and dissolved in sulfuric acid together with the solution of crude $NiSO_4.6H_2O$ to give an impure $NiSO_4$ solution Contributing exposure scenario ES 2.2: PROC 2: Purification of the impure $NiSO_4$ solution by precipitation and separation of iron, Fe, and copper, Cu from solution Contributing exposure scenario ES 2.3: PROC 2: Removal of cobalt, Co, by solvent extraction of the purified $NiSO_4$ solution and recrystallisation (from the raffinate), separation and drying of $NiSO_4.6H_2O$ Contributing exposure scenario ES 2.4: PROC 8b, PROC 9: Packaging of $NiSO_46H_2O$ into bags Contributing exposure scenario ES 2.5: PROC 0: Cleaning and Maintenance reported as examples
2. Operational conditions and risk management measures	
2.1 Control of environmental exposure	
Environmental related free short title	Manufacture of Ni sulphate (copper refinery and smelter)
Systematic title based on use descriptor (environment)	ERC1 – Manufacture of substances
Processes, tasks, activities covered (environment)	Manufacture of Ni sulphate in refineries
Environmental Assessment Method	Measured local and regional concentrations are used for calculation of PEC
Product characteristics	
Solid, low grade dust Powder	
Amounts used	
Maximum daily use at a site	1.5 tonnes/day (50^{th} % emission days, 25^{th} % tonnage)
Maximum annual use at a site	538 tonnes (25^{th} %, 2007)
Frequency and duration of use	
Pattern of release to the environment	350 days per year per site (50^{th} %)

Environment factors not influenced by risk management	
Receiving surface water flow rate	18000 m^3/d
Dilution capacity, freshwater	10 (default) m^3/d
Dilution capacity, marine	100 (default) m^3/d
Other given operational conditions affecting environmental exposure	
None	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Waste water: On-site waste water treatment plant (chemical precipitation) Efficiency: ->99% removal Release factor after on-site treatment: To freshwater and marine water: 5.90 g/T (10^{th} %) **Air:** Treatment of air emission (filters, wet or dry scrubber). Efficiency: ->99% removal Release factor after on-site treatment: 72.5 g/T (max)	
Organizational measures to prevent/limit release from site	
None	
Conditions and measures related to municipal sewage treatment plant	
Municipal Sewage Treatment Plant (STP)	Not relevant
Discharge rate of the Municipal STP	Not relevant
Incineration of the sludge of the Municipal STP	Not relevant
Conditions and measures related to external treatment of waste for disposal	
Ni bearing waste shall be recovered or recycled if possible. Ni bearing waste shall be considered hazardous if the Ni content is above the generic cutoffs (for mixtures) as stated in regulation (EC) No. 1272/2008. Ni bearing waste mixtures may be assessed as substances according to regulation (EC) No. 1272/2008 criteria. Disposal of Ni bearing waste shall comply with local, state or national waste legislation and remains the responsibility of the waste treatment operator.	
Conditions and measures related to external recovery of waste	
Not applicable	
2.2 Control of workers exposure for contributing exposure scenario 2.1	
Impure $NiSO_4$ and nickel carbonate, $NiCO_3$, are charged into a reactor and dissolved in sulfuric acid together with the solution of crude $NiSO_4.6H_2O$ to give an impure $NiSO_4$ solution	
Workers related free short title	Manufacture of Ni sulphate Solvent extraction of nickel sulphate leachate
Use descriptor covered	PROC 4 – Use in batch and other process (synthesis) where opportunity for exposure arises
Processes, tasks, activities covered	Impure $NiSO_4$ and nickel carbonate, $NiCO_3$, are charged into a reactor and dissolved in sulfuric acid together with the solution of crude $NiSO_4.6H_2O$ to give an impure $NiSO_4$ solution
Assessment Method	Estimation of exposure using a Tier 1 model.
Product characteristic	
Solid, low grade dust. Ni concentration > 25 % Powder	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation and mechanisation applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	70 kg

Other given operational conditions affecting workers exposure	
The reactor is charged by enclosed tipping of crude $NiSO_4$ and $NiCO_3$ from bulk containers bags and piping of sulfuric acid and crude $NiSO_4$ solution into the reactor.	
Technical conditions and measures at process level (source) to prevent release	
The reactor shall be closed during the leaching of the $NiSO_4$ and $NiCO_3$ into the H_2SO_4 solution.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to control inhalation exposure to particulate generated during loading reactor.	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities. RPE is required to control inhalation exposure to particulate generated during loading reactor. Gloves are also required to control against any skin contact with the raw materials.	
2.3 Control of workers exposure for contributing exposure scenario 2.2	
Purification of the impure $NiSO_4$ solution by precipitation and separation of iron, Fe, and copper, Cu from solution	
Workers related free short title	Manufacture of Ni sulphate Solvent extraction of nickel sulphate leachate
Use descriptor covered	PROC2 – Use in closed, continuous process with occasional controlled exposure (e.g. sampling)
Processes, tasks, activities covered	Purification of the impure $NiSO_4$ solution by precipitation and separation of iron, Fe, and copper, Cu from solution
Assessment Method	Estimation of exposure using a Tier 1 model.
Product characteristic	
Aqueous Solution. Concentration of Ni > 25%.	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation and mechanisation applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
Cu and Fe are precipitated chemically or by evaporation/crystallisation in a closed reactor and separated from the solution by a covered belt filter/open filter press. These solids are sent off site for waste disposal by landfill.	
Technical conditions and measures at process level (source) to prevent release	
Precipitation and filtration of Cu and Fe impurities are largely closed operations.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to control inhalation exposure to particulate generated during filter press operation.	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities. Masks are required to control inhalation exposure during certain tasks. Gloves are also required to control against any dermal exposure to Cu and Fe solids being stored in preparation for being sent to landfill.	
2.4 Control of workers exposure for contributing exposure scenario 2.3	
Removal of cobalt, Co, by solvent extraction of the purified $NiSO_4$ solution and recrystallisation (from the raffinate), separation and drying of $NiSO_4.6H_2O$	
Workers related free short title	Manufacture of Ni sulphate Solvent extraction of nickel sulphate leachate

Use descriptor covered	PROC2 – Use in closed, continuous process with occasional controlled exposure (e.g. sampling)
Processes, tasks, activities covered	Removal of cobalt, Co, by solvent extraction of the purified $NiSO_4$ solution and recrystallisation (from the raffinate), separation and drying of $NiSO_4.6H_2O$
Assessment Method	Estimation of exposure using a Tier 1 model.
Product characteristic	
Solid, low grade dust, and solution Powder	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation and mechanisation applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
The filtrate, containing $NiSO_4$, is pumped to the enclosed solvent extraction unit where it is purified to give $NiSO_4$ in the raffinate. The $NiSO_46H_2O$ is crystallised from the raffinate in the crystalliser and then these crystals are transferred to the drier in enclosed conveyors.	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical conditions and measures to control dispersion from source towards the worker	
Solvent extraction, crystallising and drying shall be enclosed and fitted with LEV to control inhalation exposure to mists. LEV is required to control inhalation exposure to particulate generated during drying and to vapours during volume reduction and (unspecified) masks are required for certain (unspecified) tasks	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities. RPE is required to control inhalation exposure in certain (unidentified) tasks. Gloves are required to control dermal exposure.	
2.5 Control of workers exposure for contributing exposure scenario 2.4	
Packaging of $NiSO_46H_2O$ into bags	
Workers related free short title	Manufacture of Ni sulphate Solvent extraction of nickel sulphate leachate
Use descriptor covered	PROC8b - Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC9 - Transfer of substance or preparation into small containers (dedicated filling line, including weighing)
Processes, tasks, activities covered	Packaging of $NiSO_46H_2O$ into bags
Assessment Method	Estimation of exposure based on measured data
Product characteristic	
Solid, low grade dust Powder	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation and mechanisation applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	

Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
The crystals are transferred from the drier in an enclosed conveyor to the packaging station where they are packed in 25 kg bags on an automated bagging line and into big bags (1000 kg) on an enclosed manually operated bagging unit. Filling big bags (1000 kg) is manually operated but largely enclosed (securing the spout of the empty big bag over the fill point, initiating/terminating the automatic filling of the bag, removing the spout of the big bag from the filling nozzle and manually closing the full bag). The powder is allowed to settle in the big bags before removing them from the filling nozzle. Big bags are then driven to the warehouse.	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical conditions and measures to control dispersion from source towards the worker	
The filling nozzles shall be fitted with LEV.	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities.	
2.5 Control of workers exposure for contributing exposure scenario 2.5	
Cleaning and Maintenance reported as examples	
Workers related free short title	Manufacture of Ni sulphate Solvent extraction of nickel sulphate leachate
Use descriptor covered	PROC 0 – Cleaning and maintenance
Processes, tasks, activities covered	Cleaning and Maintenance reported as examples
Assessment Method	Estimation of exposure based on aTier 1 model
Product characteristic	
Solid, low grade dust Powder	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Not given	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	960 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
Cleaning of premises typically includes wet cleaning of floors and cleaning of plant and equipment by dry (vacuuming) and wet (power washing) methods. Maintenance includes opening of pipes and reactors and can occasionally include opening of equipment in order to inspect for blockages, leaks and damage and carry out repairs.	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to control inhalation exposure to fumes, particulate and liquid aerosols generated	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities. (Unspecified) masks are required for certain (unspecified) tasks. Gloves are required to control dermal exposure to particulate and liquid splashes to the skin.	
3. Exposure and risk estimation	

Environment

ERC 1
Manufacture of Ni sulphate (copper refinery and smelter)

compartment	Unit	PNEC	$PEC_{Regional}$	C_{local}	PEC	RCR	Methods for calculation of environmental concentration
Freshwater	µg/L	3.6	2.9	0.32	3.22	0.91	Measured values, Tier 3-RWC
Marine	µg/L	8.6	0.3	0.03	0.33	0.04	
Terrestrial	mg/kg	29.9	16.2	0.10	16.3	0.55	
STP	mg Ni/kg	0.33	-	-	-	-	Waste water is not connected to an STP

Workers

ES 2.1
PROC 4: Impure $NiSO_4$ and nickel carbonate, $NiCO_3$, are charged into a reactor and dissolved in sulfuric acid together with the solution of crude $NiSO_4.6H_2O$ to give an impure $NiSO_4$ solution

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00005	0.113	Exposure modeled using MEASE, a Tier 1 model for PROC 4. It is assumed that Ni solids have medium dustiness and have concentration more than 25%. Only incidental exposure is assumed through non-direct handling of non-dispersive use process. Use of gloves is also assumed.
Inhalation					
Acute systemic	mg Ni/m^3	16	0.099	0.006	3 x long-term exposure estimate
Acute local	mg Ni/m^3	0.7	0.099	0.14	
Long-term systemic and local	mg Ni/m^3	0.05	0.033	0.66	Exposure modeled using MEASE, a Tier 1 model for PROC 4. It is assumed that Ni solids have medium dustiness and have concentration more than 25%. Only incidental exposure is assumed through non-direct handling of non-dispersive use process. Use RPE (APF = 40) and LEV are assumed.

ES 2.2
PROC 2: Purification of the impure $NiSO_4$ solution by precipitation and separation of iron, Fe, and copper, Cu from solution.

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00005	0.11	Exposure modeled using MEASE, a Tier 1 model for PROC 2. It is assumed that Ni is handled as a solution with Ni concentration more than 25%. Only incidental exposure is assumed through non-direct handling of non-dispersive use process. Use of gloves is also assumed.
Inhalation					
Acute systemic	mg Ni/m^3	16	0.003	< 0.01	3 x long-term exposure estimate
Acute local	mg Ni/m^3	0.7	0.003	< 0.01	
Long-term systemic and local	mg Ni/m^3	0.05	0.001	0.02	Exposure modeled using MEASE, a Tier 1 model for PROC 2. It is assumed that Ni is handled as a solution with Ni concentration more than 25%.Only incidental exposure is assumed through non-direct handling of non-dispersive use process. Use RPE (APF = 20) and LEV are assumed.
ES 2.3 PROC 2: Removal of cobalt, Co, by solvent extraction of the purified $NiSO_4$ solution and recrystallisation (from the raffinate), separation and drying of $NiSO_4.6H_2O$					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00005	0.11	Exposure modeled using MEASE, a Tier 1 model for PROC 2. It is assumed that Ni solids have medium dustiness and have concentration more than 25%. Only incidental exposure is assumed through non-

					direct handling of non-dispersive use process. Use of gloves is also assumed.
Inhalation					
Acute systemic	mg Ni/m^3	16	0.018	< 0.01	3 x long-term exposure estimate
Acute local	mg Ni/m^3	0.7	0.018	< 0.025	
Long-term systemic and local	mg NI/m^3	0.05	0.006	0.12	Exposure modeled using MEASE, a Tier 1 model for PROC 2. It is assumed that Ni solids have medium dustiness and have concentration more than 25%. Only incidental exposure is assumed through non-direct handling of non-dispersive use process. Use of RPE (APF = 20) and LEV are assumed.
ES 2.4 PROC 8b, PROC 9: Packaging of $NiSO_46H_2O$ into bags					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00067	1.5 excl. PPE <1 with gloves	75th percentile (full body exposure) based on packaging data from an analogous operation (packaging of $NiSO_46H_2O$). Qualitative assessment[1]
Inhalation					
Acute systemic	mg Ni/m^3	16	0.03	<0.01	3 x long-term interpolated 75th percentile value aggregated over all activities
Acute local	mg Ni/m^3	0.7	0.03	0.04	
Long-term systemic and local	mg Ni/m^3	0.05	0.01	0.2	75th percentile value of personal exposure measurements (n=12) aggregated over all activities
[1] Dermal exposure likely to be sufficiently controlled by use of rigger gloves					
ES 2.5 PROC 0: Cleaning and Maintenance reported as examples					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of

					exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00003	0.068	Calculated using MEASE, a tier 1 model for PROC 10 for a solid of medium dustiness with non dispersive use and non-direct handling for less than 240 minutes. Use of properly designed gloves and only incidental exposure is assumed.
Inhalation					
Acute systemic	mg Ni/m³	16	0.099	0.006	3 x long-term exposure estimate
Acute local	mg Ni/m³	0.7	0.099	0.14	
Long-term systemic and local	mg Ni/m³	0.05	0.033	0.66	Calculated using MEASE, a tier 1 model for PROC 10 for a solid of medium dustiness with non dispersive use and non-direct handling for less than 240 minutes. Use of LEV and RPE (APF=20) is assumed.

NR: Not Relevant

Acute local inhalation
Based on respirable size aerosols. Equivalent inhalable fraction levels expected to be at least 3-fold higher

4. Guidance to evaluate whether a site works inside the boundaries set by the ES

Environment

Scaling tool: Metals EUSES IT tool (free download: http://www.arche-consulting.be/Metal-CSA-toolbox/du-scaling-tool)

Scaling of the release to air and water environment includes:
Refining of the release factor to air and waste water and/or and the efficiency of the air filter and wastewater treatment facility.

Scaling of the PNEC for aquatic environment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Scaling of the PNEC for soil compartment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Workers

Scaling considering duration and frequency of use
Collect process monitoring data with an inhalable sampler. The simultaneous use of a respirable sampler is encouraged. Use aerosol particle size information, when available, to confirm the appropriate use of the inhalable DNEL of 0.05 mg Ni/m3. Respirable fraction exposure levels should be kept below 0.01 mg Ni/m³. See Appendix D6 for site-specific guidance on exposure data collection and Appendix C2 for further details on DNEL derivation.

For further information and guidance on exposure scenarios, available tools, and scaling options, please visit the Nickel Consortia exposure scenario library at the following link: http://www.nickelconsortia.org/exposure-scenario-library.html

9.2.4 GES 3: CRYSTALLISATION (OF NICKEL SULPHATE HEXAHYDRATE, $NiSO_4.6H_2O$) FROM A PURIFIED NICKEL SULPHATE $NiSO_4$ LEACHATE

1. Title **GES 3 Crystallisation from a purified nickel sulphate leachate**	
Life cycle	Manufacture of Ni sulphate
Free short title	Crystallisation from a purified nickel sulphate leachate Nickel sulphate production from nickel matte
Systematic title based on use descriptor	SU: SU9 - Manufacture of fine chemicals PC: Not relevant ERC: ERC1 – Manufacture of substances PROC: PROC1 – Use in closed process (synthesis), no likelihood of exposure PROC2 – Use in closed, continuous process with occasional controlled exposure (e.g. sampling) PROC0 – Cleaning and maintenance
Processes, tasks, activities covered (environment)	Manufacture of Ni sulphate in refineries
Processes, tasks, activities covered (workers)	Crystallisation (of nickel sulphate hexahydrate, $NiSO_4.6H_2O$) from a purified nickel sulphate $NiSO_4$ leachate Contributing exposure scenario ES 3.1: PROC 1: A purified $NiSO_4$ leachate solution is obtained ready for processing Contributing exposure scenario ES 3.2: PROC 2: Crystallisation and separation of $NiSO_4.6H_2O$ from this $NiSO_4$ solution Contributing exposure scenario ES 3.3: PROC 2: Drying of $NiSO_4.6H_2O$ Contributing exposure scenario ES 3.4: PROC 2: Packaging of $NiSO_46H_2O$ Contributing exposure scenario ES 3.5: PROC 0: Cleaning and Maintenance
2. Operational conditions and risk management measures	
2.1 Control of environmental exposure	
Environmental related free short title	Manufacture of Ni sulphate (copper refinery and smelter)
Systematic title based on use descriptor (environment)	ERC1 – Manufacture of substances
Processes, tasks, activities covered (environment)	Manufacture of Ni sulphate in refineries
Environmental Assessment Method	Measured local and regional concentrations are used for calculation of PEC
Product characteristics	
Solid, low grade dust 50% of powder has diameter ~1 mm	
Amounts used	
Maximum daily use at a site	1.5 tonnes/day (50^{th} % emission days, 25^{th} % tonnage)
Maximum annual use at a site	538 tonnes (25^{th} %, 2007)
Frequency and duration of use	
Pattern of release to the environment	350 days per year per site (50^{th} %)
Environment factors not influenced by risk management	
Receiving surface water flow rate	18000 m^3/d
Dilution capacity, freshwater	10 (default) m^3/d
Dilution capacity, marine	100 (default) m^3/d
Other given operational conditions affecting environmental exposure	
None	
Technical conditions and measures at process level (source) to prevent release	
None	

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Waste water: On-site waste water treatment plant (chemical precipitation) Efficiency: ->99% removal Release factor after on-site treatment: To freshwater and marine water: 5.90 g/T (10th %) **Air:** Treatment of air emission (filters, wet or dry scrubber). Efficiency: ->99% removal Release factor after on-site treatment: 72.5 g/T (max)	
Organizational measures to prevent/limit release from site	
None	
Conditions and measures related to municipal sewage treatment plant	
Municipal Sewage Treatment Plant (STP)	Not relevant
Discharge rate of the Municipal STP	Not relevant
Incineration of the sludge of the Municipal STP	Not relevant
Conditions and measures related to external treatment of waste for disposal	
Ni bearing waste shall be recovered or recycled if possible. Ni bearing waste shall be considered hazardous if the Ni content is above the generic cutoffs (for mixtures) as stated in regulation (EC) No. 1272/2008. Ni bearing waste mixtures may be assessed as substances according to regulation (EC) No. 1272/2008 criteria. Disposal of Ni bearing waste shall comply with local, state or national waste legislation and remains the responsibility of the waste treatment operator.	
Conditions and measures related to external recovery of waste	
Not applicable	
2.2 Control of workers exposure for contributing exposure scenario 3.1	
A purified $NiSO_4$ leachate solution is obtained ready for processing	
Workers related free short title	Manufacture of Ni sulphate Crystallisation from a purified nickel sulphate leachate
Use descriptor covered	PROC 1 – Use in closed process (synthesis), no likelihood of exposure
Processes, tasks, activities covered	A purified $NiSO_4$ leachate solution is obtained ready for processing
Assessment Method	Estimation of exposure using a Tier 1 model
Product characteristic	
Solid, low grade dust 50% of powder has diameter ~1 mm	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation and mechanisation applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	240 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
All activities are largely run from control room when operators are not required to directly observe or intervene in the process. The reactor is charged by piping purified $NiSO_4$ solution into the reactor.	
Technical conditions and measures at process level (source) to prevent release	
None given	
Technical conditions and measures to control dispersion from source towards the worker	
None given	
Organisational measures to prevent /limit releases, dispersion and exposure	
Training to reinforce good practice and hygiene issues and exposure and biological monitoring of operators is regularly performed.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator	

meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities. Gloves are required to control dermal exposure when charging the reactor.	
2.3 Control of workers exposure for contributing exposure scenario 3.2	
Crystallisation and separation of $NiSO_4.6H_2O$ from this $NiSO_4$ solution	
Workers related free short title	Manufacture of Ni sulphate Crystallisation from a purified nickel sulphate leachate
Use descriptor covered	PROC2 – Use in closed, continuous process with occasional controlled exposure (e.g. sampling)
Processes, tasks, activities covered	Crystallisation and separation of $NiSO_4.6H_2O$ from this $NiSO_4$ solution
Assessment Method	Estimation of exposure using a Tier 1 model
Product characteristic	
Solid, low grade dust 50% of powder has diameter ~1 mm	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation and mechanisation applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
All activities are largely run from control room when operators are not required to directly observe or intervene in the process. The $NiSO_4$ solution is evaporated under reduced pressure, the hydrated nickel sulphate, $NiSO_46H_2O$, crystallises out of the concentrated solution in the crystalliser and is separated from the solution by centrifugation. This activity is automated and enclosed.	
Technical conditions and measures at process level (source) to prevent release	
Leaching, evaporation/crystallisation/centrifugation shall be enclosed with high level of containment. Evaporation shall be carried out under negative pressure.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV ishall be used to extract the gases and vapours generated during heating and evaporating the solution.	
Organisational measures to prevent /limit releases, dispersion and exposure	
Training to reinforce good practice and hygiene issues and exposure and biological monitoring of operators is regularly performed.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities.	
2.4 Control of workers exposure for contributing exposure scenario 3.3	
Drying of $NiSO_4.6H_2O$	
Workers related free short title	Manufacture of Ni sulphate Crystallisation from a purified nickel sulphate leachate
Use descriptor covered	PROC2 – Use in closed, continuous process with occasional controlled exposure (e.g. sampling)
Processes, tasks, activities covered	Drying of $NiSO_4.6H_2O$
Assessment Method	Estimation of exposure using a Tier 1 model
Product characteristic	
Solid, low grade dust 50% of powder has diameter ~1 mm	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts.	

The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation and mechanisation applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
All activities are largely run from control room when operators are not required to directly observe or intervene in the process. The crystals are dried using a vacuum belt filter and transferred in an enclosed conveyor to intermediate storage silos.	
Technical conditions and measures at process level (source) to prevent release	
Filtering of leachate is carried out using open filter presses.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to control inhalation exposure to particulates during release from the filter and packaging. LEV is also used to extract the gases and vapours generated during drying of the $NiSO_46H_2O$	
Organisational measures to prevent /limit releases, dispersion and exposure	
Training to reinforce good practice and hygiene issues and exposure and biological monitoring of operators is regularly performed.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities.	
2.5 Control of workers exposure for contributing exposure scenario 3.4	
Packaging of $NiSO_46H_2O$	
Workers related free short title	Manufacture of Ni sulphate Crystallisation from a purified nickel sulphate leachate
Use descriptor covered	PROC2 – Use in closed, continuous process with occasional controlled exposure (e.g. sampling)
Processes, tasks, activities covered	Packaging of $NiSO_46H_2O$
Assessment Method	Estimation of exposure based on measured data
Product characteristic	
Solid, low grade dust 50% of powder has diameter ~1 mm	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
All production workers generally work 8 hour shifts. The actual pattern of exposure is determined by the amount of manual and driving work, use of control rooms and level of automation and mechanisation applicable to activities. Duration of exposure ranges from 0.5h/8h to 7h/8h.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
All activities are largely run from control room when operators are not required to directly observe or intervene in the process. There is automated packaging of $NiSO_4$.6H2O crystals small jet bags (25 kg) and stacking the full jet bags onto and shrink wrapping filled pallets. Filling big bags (1000 kg) is manually operated but largely enclosed (securing the spout of the empty big bag over the fill point, initiating/terminating the automatic filling of the bag, removing the spout of the big bag from the filling nozzle and manually closing the full bag). The powder is allowed to settle in the big bags before removing them form the filling nozzle which are fitted with LEV. Pallets and big bags are then driven to the warehouse.	
Technical conditions and measures at process level (source) to prevent release	
Packaging and transfer systems shall be enclosed and the level of containment high.	
Technical conditions and measures to control dispersion from source towards the worker	

LEV shall be installed on bagging lines and units in the packaging area at the end of the production process (Reduction factor = 0.1). Fixed capturing hoods shall be located in close proximity of and directed at the source of emission for belt filters and packaging units. The design shall enable that the work is performed in the capture zone of the ventilation system and the capture zone shall be indicated at the workplace. LEV is required to control inhalation exposure to particulates during release from the filter and packaging.
Organisational measures to prevent /limit releases, dispersion and exposure
Training to reinforce good practice and hygiene issues and exposure and biological monitoring of operators is regularly performed.
Conditions and measures related to personal protection, hygiene and health evaluation
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities.
2.5 Control of workers exposure for contributing exposure scenario 3.5
Cleaning and Maintenance

Workers related free short title	Manufacture of Ni sulphate Crystallisation from a purified nickel sulphate leachate
Use descriptor covered	PROC 0 – Cleaning and maintenance
Processes, tasks, activities covered	Cleaning and Maintenance
Assessment Method	Estimation of exposure using a Tier 1 model

Product characteristic
Solid, low grade dust 50% of powder has diameter ~1 mm
Amounts used
Not relevant
Frequency and duration of use/exposure
Duration of task maximum 4 hours
Human factors not influenced by risk management

Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	960 cm^2
Body weight	70 kg

Other given operational conditions affecting workers exposure
Unspecified instructions for cleaning, maintenance and emergency procedures are followed
Technical conditions and measures at process level (source) to prevent release
None given
Technical conditions and measures to control dispersion from source towards the worker
None given
Organisational measures to prevent /limit releases, dispersion and exposure
Training to reinforce good practice and hygiene issues and exposure and biological monitoring of operators is regularly performed.
Conditions and measures related to personal protection, hygiene and health evaluation
Air-assisted filtering visor with P3 filter element (Willson Turbovisor) Protection = 20 (based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) and rigger gloves are required for all activities. Inhalation to vapours, mists and particulates and skin exposure to mists, liquids splashes and particulates shall be controlled by RPE and gloves when undertaking maintenance and cleaning work.
3. Exposure and risk estimation
Environment

ERC 1
Manufacture of Ni sulphate (copper refinery and smelter)

compartment	Unit	PNEC	$PEC_{Regional}$	C_{local}	PEC	RCR	Methods for calculation of environmental concentration
Freshwater	µg/L	3.6	2.9	0.32	3.22	0.91	Measured values, Tier 3-RWC
Marine	µg/L	8.6	0.3	0.03	0.33	0.04	
Terrestrial	mg/kg	29.9	16.2	0.10	16.3	0.55	
STP	mg Ni/kg	0.33	-	-	-	-	Waste water is not connected to an STP

Workers

ES 3.1
PROC 1: A purified $NiSO_4$ leachate solution is obtained ready for processing

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00005	0.114	Exposure estimated using MEASE for PROC 1 (> 25% concentration, non-direct handling, non-dispersive use, intermittent exposure for more than 4 hours, and use of gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.003	< 0.001	3 x long-term exposure estimate
Acute local	mg Ni/m^3	0.7	0.003	0.004	
Long-term systemic and local	mg Ni/m^3	0.05	0.001	0.002	Exposure estimated using MEASE for PROC 1 (medium dustiness solid, > 25% concentration, non-direct handling, non-dispersive use, intermittent exposure for more than 4 hours, and use of RPE (APF=20))

ES 3.2
PROC 2: Crystallisation and separation of $NiSO_4.6H_2O$ from this $NiSO_4$ solution

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00005	0.113	Exposure estimated using MEASE for PROC 2 (> 25% concentration, non-direct handling, non-dispersive use, intermittent exposure for more than 4 hours, and use of gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.018	0.001	3 x long-term inhalable exposure estimate
Acute local	mg Ni/m^3	0.7	0.018	0.026	
Long-term systemic and local	mg Ni/m^3	0.05	0.006	0.12	Long-term exposure estimate based on a single measurement taken during 'operating evaporator and filter'during an analogous

					activity ($NiSO_4.6H_2O$ recovery (from solution) operation for $NiSO_4.6H_2O$ produced from a purified spent electrolyte)
ES 3.3 PROC 2: Drying of $NiSO_4.6H_2O$					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00005	0.113	Exposure estimated using MEASE for PROC 2 (> 25% concentration, non-direct handling, non-dispersive use, intermittent exposure for more than 4 hours, and use of gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.33	0.02	3 x long-term exposure estimate
Acute local	mg Ni/m^3	0.7	0.33	0.47	
Long-term systemic and local	mg Ni/m^3	0.05	0.11	2.2 (excluding RPE) By use of RPE (APF 20): 0.11	Exposure estimated using MEASE for PROC 2 (medium dustiness solid, > 25% concentration, non-direct handling, non-dispersive use, intermittent exposure for more than 4 hours
ES 3.4 PROC 2:Packaging of $NiSO_46H_2O$					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00067	1.5 excl. PPE[1] <1 with gloves	75th percentile of personal measurements (n=8; full body) taken during packaging of $NiSO_4$ and nickel hydroxycarbonate. It was assumed that all exposure consisted of $NiSO_4$ Qualitative assessment[2]

Inhalation					
Acute systemic	mg Ni/m³	16	0.069	0.004	3 x long-term 75th percentile personal exposure estimate for packaging
Acute local	mg Ni/m³	0.7	0.069	0.096	
Long-term systemic and local	mg Ni/m³	0.05	0.023	0.46	75th percentile of personal, inhalable measurements (n=7) for packaging. Packaging value includes $NiSO_4$ and nickel hydroxycarbonate, as the packaging was carried out in same area and the operators rotate between both

[1] Estimated exposure exceed the DNEL (dermal), suitable gloves and clothing should be worn to minimize skin contact with Ni species and the associated risk of sensitization.
[2] Dermal exposure likely to be sufficiently controlled by use of rigger gloves

ES 3.5
PROC 0: Cleaning and Maintenance

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00003	0.68	Exposure estimated using MEASE for PROC 10 (> 25% concentration, non-direct handling, non-dispersive use, intermittent exposure for the maximum of 4 hours, and use gloves)
Inhalation					
Acute systemic	mg Ni/m³	16	0.045	0.003	3 X long-term exposure estimate
Acute local	mg Ni/m³	0.7	0.045	0.064	
Long-term systemic	mg Ni/m³	0.05	0.015	0.3	Exposure estimated using MEASE for PROC 10 (low dustiness solid, > 25% concentration, non-direct handling, non-dispersive use, intermittent exposure for the maximum of 4 hours, and use RPE (APF = 20))
Long-term local	mg Ni/m³	0.05	0.015	0.3	

NR: Not Relevant

Acute local inhalation
Based on respirable size aerosols. Equivalent inhalable fraction levels expected to be at least 3-fold higher

4. Guidance to evaluate whether a site works inside the boundaries set by the ES

Environment
Scaling tool: Metals EUSES IT tool (free download: http://www.arche-consulting.be/Metal-CSA-toolbox/du-scaling-tool)

Scaling of the release to air and water environment includes:
Refining of the release factor to air and waste water and/or and the efficiency of the air filter and wastewater treatment facility.

Scaling of the PNEC for aquatic environment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Scaling of the PNEC for soil compartment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Workers
Scaling considering duration and frequency of use
Collect process monitoring data with an inhalable sampler. The simultaneous use of a respirable sampler is encouraged. Use aerosol particle size information, when available, to confirm the appropriate use of the inhalable DNEL of 0.05 mg Ni/m^3. Respirable fraction exposure levels should be kept below 0.01 mg Ni/m^3. See Appendix D6 for site-specific guidance on exposure data collection and Appendix C2 for further details on DNEL derivation.

For further information and guidance on exposure scenarios, available tools, and scaling options, please visit the Nickel Consortia exposure scenario library at the following link: http://www.nickelconsortia.org/exposure-scenario-library.html

9.2.4.1 Summary of the secondary poisoning exposure and risk characterisation assessment for nickel sulphate production

The methodology applied to assess secondary poisoning for nickel sulphate production is extracted from the European Union Risk Assessment for Nickel (2008/2009). A detailed report on the methodology used to derive the $PNEC_{oral}$ and bioaccumulation factors (BAF) are provided in Appendix D3.

Table 85. Freshwater aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (European Otter)

Expsure Scenario	PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	PEC_{oral} mollusk (mg/kg wet mollusk)	PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1	PEC/PNEC Aquatic mammal (European Otter) PNEC=2.3 mg/kg; RAF=0.025
1	0.0032	0.0029	0.83	0.07	0.01
2	0.0032	0.0029	0.82	0.07	0.01

Table 86. Marine aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (Harbor seal). Two scenarios are assumed: C. edule present and C. edule absent.

PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	PEC_{oral} mollusk (mg/kg wet mollusk)		PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1		PEC/PNEC Aquatic mammal (Harbor seal) PNEC=4.6 mg/kg; RAF=0.025	
		C. edule present BAF=1631 L/kg	*C.edule* absent BAF= 270 L/kg	*C.edule* present BAF=1631 L/kg	*C.edule* absent BAF=270 L/kg	*C.edule* present BAF=1631 L/kg	*C.edule* absent BAF=270 L/kg
0.00033	0.0003	0.51	0.085	0.04	0.01	0.003	0.0005

Table 87. Terrestrial food chain: concentration, PECoral and risk characterisation for worm-eating birds and mammals

PEC in soil compartment (mg/kg)	Regional soil background concentration (mg/kg)	PEC_{oral} local Tissue + gut 100% worms (mg/kg ww)	PEC_{oral} local Tissue + gut 30% worms 70% isopods (mg/kg ww)	PEC/PNEC Birds (starling) PNEC=8.5 mg/kg RAF=1	PEC/PNEC Mammals (shrew) 100% worms PNEC=0.12 mg/kg RAF=0.036	PEC/PNEC Mammals (shrew) 30% worms 70% isopods PNEC=0.12 mg/kg RAF=0.025
16.30	16.20	2.40	0.98	0.28	0.72	0.21

9.2.4.2 Porewater concentrations in the soil compartment for nickel sulphate production

The derived $PEC_{porewater}$ for the generic scenario is 0.025 mg Ni/L. More details for the calculation of the $PEC_{porewater}$ are provided in Appendix D3.

Table 88. Predicted Exposure Concentrations (PEC) in porewater

$PEC_{local\ porewater}$ (mg/L)
0.025

9.2.4.3 Atmospheric compartment for nickel sulphate production

An overview of the local air concentrations and PEC in the air compartment are provided in the assessment for Man via the Environment below or Appendix D5.

9.2.4.4 Exposure concentrations in on site waste water treatment plants (WWTP) for nickel sulphate production

The calculated Nickel concentrations in the effluent of the on-site WWTP are used further in the risk characterisation (see Appendix D3). For the freshwater compartment, the calculated effluent concentration for the on-site WWTP is 0.005 mg/L.

Table 89. Concentrations in on-site waste water treatment plant

Information type	Calculated effluent concentration in on-site WWTP (mg/L)
Selected for GES Freshwater	0.005
Selected for GES Marine	0.005

9.2.4.5 Man via Environment exposure and risk characterisation assessments for production of Nickel Sulphate

For each sector, an overview of the range of operational conditions (OC) and predicted C_{local} air and PEC air are given below. To assess whether a site is compliant with the GES, the predicted C_{local} needs to be compared to 11.5 ng Ni/m^3 or the measured PEC needs to be compared to the DNEL of 20 ng Ni/m^3. An assessment of predicted level of compliance for this sector based on site-specific measured or predicted exposures is provided in Section 5 of Appendix D5.

Table 90. Sector overview

	tonnage (T Ni/year)	daily emissions to air (kg Ni/d)	release factor to air (g Ni/T)	Emission days to air per site (d/y)	C_{local}, air* (ng Ni/m^3)	PEC air$ (ng Ni/m^3)
min	257	0.01	7	200	1	10
max	1840	0.21	72	365	8	16
median	914	0.14	68	350	2	11

*: based on different air models (EUSES, GPM, IFDM)
$: based on C_{local} predicted + regional background
.

9.3 Generic exposure scenarios for downstream users of nickel sulphate

9.3.1 INTRODUCTION

This section describes the potential exposure to nickel sulphate from the environmental and occupational standpoints for the downstream uses made known to the Nickel Consortia before the 1st of November 2009. Additional uses made known after this REACH legal deadline will be added when registration dossier updates occur; as of January 2011, no new uses were idenitifed to the Nickel Consortia. The exposure assessment and risk characterisation covered by the current DUs GES are likely to be refined over time due to the iterative process of the exposure scenarios communication in the supply chain.

The actual identified downstream uses of nickel sulphate cover the following sectors:

- Metal surface treatment – nickel electroplating, nickel electroforming and electroless nickel plating
- Production of batteries using positive nickel electrodes);
- Production of nickel salts from nickel sulphate
- Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
- Use of nickel sulphate in pigment ptoduction

Estimated and measured environmental (*i.e.,* in freshwater, marine aquatic, air and terrestrial compartments) and occupational (*i.e.,* process-specific occupational hygiene data from personal/static monitoring) exposure data for nickel sulphate production, are detailed in Appendix D3 (section 1- environment), Appendix D5 (MvE) and Appendix D4 (section 1-human health) and provide full details on the exposure and risk characterisation data used in the GES. Detailed information on the environmental tiered approach for site-specific exposure assessment and risk characterization is found in Appendix D1. Detailed information on local exposure calculation factors and regional ambient backgrounds can be found in Appendix D2.

As discussed in section 9.1, since it was not possible to attribute emissions to any specific process/activity, the environmental exposure assessment was conducted for nickel sulphate production sites as a whole. Conversely, for many of the GES the occupational exposure assessment was broken down by process/activity.

Secondary poisoning, WWTP, and the MvE assessments are presented in separate sections for each of the use sector.

9.3.2 GES 4: METAL SURFACE TREATMENT

1. Title **GES 4 Metal surface treatment – nickel electroplating, nickel electroforming and electroless nickel plating**	
Life cycle	End use – DU of Ni sulphate
Free short title	Metal surface treatment – nickel electroplating, nickel electroforming and electroless nickel plating
Systematic title based on use descriptor	SU: SU 3 Industrial use

	SU 15 Manufacture of fabricated metal products PC: PC 19 Intermediate use PC 14 Metal Surface Treatment Products ERC: ERC5: Industrial use resulting in inclusion into or onto a matrix PROC: PROC 5: Mixing or blending in batch processes for formulation of preparations and articles (multistage and/or significant contact) PROC 8a: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities PROC 8b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 13: Treatment of articles by dipping and pouring PROC 15: Use as laboratory reagent PROC 0: Cleaning and maintenance
Processes, tasks, activities covered (environment)	Nickel electroplating without topcoat Nickel electroplating with chromium topcoat Nickel electroplating with other topcoats such as gold, silve, brass or organic compounds Nickel composite electroplating such as nickel plus silicon carbide Nickel electroforming Electroless nickel plating
Processes, tasks, activities covered (workers)	Contributing exposure scenario ES 4.1: Operations involving dry salts Contributing exposure scenario ES 4.2: Operations with salt solutions
2. Operational conditions and risk management measures	
2.1 Control of environmental exposure	
Environmental related free short title	Metal surface treatment – Nickel electroplating, nickel electroforming and electroless nickel plating
Systematic title based on use descriptor (environment)	ERC5: Industrial use resulting in inclusion into or onto a matrix
Processes, tasks, activities covered (environment)	Nickel electroplating without topcoat Nickel electroplating with chromium topcoat Nickel electroplating with other topcoats such as gold, silver, brass or organic compounds Nickel composite electroplating such as nickel plus silicon carbide Nickel electroforming Electroless nickel plating
Environmental Assessment Method	Estimates based on monitoring local and regional concentrations are used for calculation of PEC
Product characteristics	
Ni sulphate: Dry powder of approximately 100 %or solution of 25-50%	
Amounts used	
Maximum daily use at a site	ES 1: 0.05 tonnes/day (median 50th % emission days, 50th % tonnage) ES 2: 1.23 tonnes/day (median 50th % emission days, 75th % tonnage) ES 3: 0.02 tonnes/day (median 50th % emission days, 25th % tonnage)
Maximum annual use at a site	ES 1: 11 tonnes (median 50th %, 2007); Discharge to STP ES 2: 271 tonnes (75th %, 2007); Discharge to STP ES 3: 3.9 tonnes (25th %, 2007); Direct discharge
Frequency and duration of use	
Pattern of release to the environment	220 days per year per site (median 50th %)
Environment factors not influenced by risk management	
Receiving surface water flow rate	ES 1 discharge to STP: 1.8xE4 m^3/d ES 2 discharge to STP: 2.0xE6 m^3/d ES 3 direct discharge: 1.6xE2 m^3/d
Dilution capacity, freshwater	ES 1: 10 (50th %) ES 2: 1000 (max) ES 3: 10 (50th %)
Dilution capacity, marine	100 (default)

Other given operational conditions affecting environmental exposure	
None	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Waste water: On-site wastewater treatment in a physico-chemical treatment plant by chemical precipitation, sedimentation, filtration or a combination. Efficiency: 95 - >99% Off-site waste water treatment plant, community sewer system Efficiency 40% ES 1 freshwater Discharge to STP and Marine: 131 g/T (median) ES2 freshwater Discharge to STP: 827 g/T (75%) ES 3 Direct discharge to freshwater: 63 g/T (25th %) **Air:** Treatment of stack air emission by wet scrubbers. Efficiency 99% Release factor after on-site treatment: 80 g/T (max)	
Organizational measures to prevent/limit release from site	
None	
Conditions and measures related to municipal sewage treatment plant	
Municipal Sewage Treatment Plant (STP)	Yes
Discharge rate of the Municipal STP	2000 m^3/d (default)
Incineration of the sludge of the Municipal STP	No – sludge is applied to agricultural soil
Conditions and measures related to external treatment of waste for disposal	
Ni bearing waste shall be recovered or recycled if possible. Ni bearing waste shall be considered hazardous if the Ni content is above the generic cutoffs (for mixtures) as stated in regulation (EC) No. 1272/2008. Ni bearing waste mixtures may be assessed as substances according to regulation (EC) No. 1272/2008 criteria. Disposal of Ni bearing waste shall comply with local, state or national waste legislation and remains the responsibility of the waste treatment operator.	
Conditions and measures related to external recovery of waste	
Not applicable	
2.2 Control of workers exposure for contributing exposure scenario ES 4.1	
Operations involving dry salts	
Workers related free short title	Metal surface treatment – nickel electroplating, nickel electroforming and electroless nickel plating
Use descriptor covered	PROC 5: Mixing or blending in batch processes for formulation of preparations and articles (multistage and/or significant contact) PROC 8a: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities PROC 8b: Transfer of substance or preparation (charging/discharging from/to vessels/large containers at dedicated facilities PROC 13: Treatment of articles by dipping and pouring PROC 0: Cleaning and maintenance
Processes, tasks, activities covered	Raw material handling Preparation of Ni sulphate solution Cleaning and maintenance
Assessment Method	Estimation of exposure based on measured data and a Tier 1 model
Product characteristic	
Ni sulphate: Dry powder of approximately 100 % or solution of 25-50%	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Addition of Ni sulphate to tank ranging from once per shift to once every 2 or 3 weeks	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant

Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Ni sulphate is supplied and handled in dry form. Ambient temperature and humidity should apply. Maintain clean workplace to prevent accumulation of powders and dusts on surfaces. Use of water or vacuum fitted with HEPA filter to clear spilled material or accumulations of dust within the work area. Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release	
Automation and enclosure of processes where possible	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for operations involving handling powder in open workspace such as ripping and tipping sacks, weighing, mixing, adding powders to solution	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: Use of RPE (FP3; APF = 20) is required for cleaning and maintenance operations involving dusts and powders. Dermal: Gloves and other suitable protective clothing are required to minimise dermal contact with powder	
2.3 Control of workers exposure for contributing exposure scenario ES 4.2	
Operations with salt solutions	
Workers related free short title	Metal surface treatment – nickel electroplating, nickel electroforming and electroless nickel plating
Use descriptor covered	PROC 8a: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities PROC 8b: Transfer of substance or preparation (charging/discharing from/to vessels/large containers at dedicated facilities PROC 13: Treatment of articles by dipping and pouring PROC 15: Use as laboratory reagent PROC 0: Cleaning and maintenance
Processes, tasks, activities covered	Addition Ni sulphate to tank Dipping of items to be coated Removal of coated items Rinsing of coated items Removal of spent solution/rinse water from tank Wastewater handling – rinse water Cleaning and maintenance
Assessment Method	Estimation of exposure based on measured data
Product characteristic	
Ni sulphate: Solution of 25-50%	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Ni sulphate is added to the plating bath in solution. Plating process involves immersion of piece into plating tank followed by immersion of piece into rinse tanks. Temperature of plating baths is typically 25-75°C. Plating bath is agitated by bubbling air through the electrolyte solution to ensure even availability of Ni salt to piece being plated. Maintain a clean workplace. Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release	
Automation and enclosure of processes should be used where possible	

Plating is either manual, semi-automated or automated:
Manual plating - parts are placed on racks or hangers and manually transferred from tank to tank
Semi-automated plating - parts are manually loaded on to jigs that are moved between the baths using an overhead hoist
Automated plating – as semi-automated process except jigs moved electronically

If no LEV, automation and enclosure of the following processes: Addition of solutions to plating tanks, dipping and removal of pieces to be plated (plating and rinsing tanks) are required (fluids may directly pumped in and out of tanks, dipping process may be entirely automated and enclosed)

Tank should be covered if not enclosed (e.g. by use of floating cover). Storage vessels used for electroplating solutions should be capped.

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

LEV is required for operations where mists may be created including addition of solutions to plating tanks, dipping and removal of pieces to be plated (plating and rinsing tanks)

Organisational measures to prevent /limit releases, dispersion and exposure

None

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

Inhalation: Use of RPE is required for cleaning and maintenance operations.
Dermal: Gloves and other suitable protective clothing are required to minimise dermal contact with solution (acid resistant)

3. Exposure and risk estimation

Environment

ERC 5:
Metal surface treatment – nickel electroplating, nickel electroforming and electroless nickel plating

Compartment	Unit	PNEC	$PEC_{Regional}$	C_{local}	PEC	RCR	Methods for calculation of environmental concentrations
Freshwater ES 1	µg Ni/L	3.55	2.9	0.14	3.04	0.86	Measured values, Tier 3-RWC
Freshwater ES 2	µg Ni/L	3.55	2.9	0.22	3.12	0.88	
Freshwater ES 3	µg Ni/L	3.55	2.9	0.44	3.34	0.94	
Marine	µg Ni/L	8.6	0.3	6.43	6.73	0.78	
Terrestrial ES 2 - sludge application	mg Ni/kg	29.9	16.2	9.56	25.76	0.86	
Terrestrial ES 2 – no sludge application	mg Ni/kg	29.9	16.2	0.01	16.21	0.54	
STP ES 1	mg Ni/kg	0.33	-	-	0.01	0.04	
STP ES 2	mg Ni/kg	0.33	-	-	0.306	0.926	

Workers

ES 4.1
PROC 5, 8a, 8b, 13, 0: Operations involving dry salts

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00003	0.068	Exposure estimated using MEASE for PROC 8a (> 25% concentration, non-direct handling, intermittent exposure for 60-240 minutes, and

					use of gloves)
Inhalation					
Acute systemic	mg Ni/m³	16	0.5	0.031	Estimated 75th percentile short term exposure for handling of dry $NiSO_4$ powder with LEV in place
Acute local	mg Ni/m³	0.7	0.5	0.714 excl. RPE By use of RPE (P3, APF 20): 0.09	
Long-term systemic and local	mg Ni/m³	0.05	0.033	0.66	Exposure estimated using MEASE for PROC 8a (>25% concentration, solid, medium dustiness, Use of LEV, RPE (APE 20))

ES 4.2
PROC 8a, 8b, 13, 15, PROC 0: Operations with salt solutions

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	$7x10^{-5}$	0.16	Estimated 75th percentile exposure to soluble nickel associated with electroplating based on the EU RAR (2008-2009). Assumes suitable protective clothing employed
Inhalation					
Acute systemic	mg Ni/m³	16	0.06	0.004	3 x the estimated 75th percentile exposure to airborne soluble Ni
Acute local	mg Ni/m³	0.7	0.06	0.086	
Long-term systemic and local	mg Ni/m³	0.05	0.02	0.4	Estimated 75th percentile exposure to airborne soluble Ni assuming manual plating process with effective LEV in place

NR: Not Relevant

Acute local inhalation
Based on respirable size aerosols. Equivalent inhalable fraction levels expected to be at least 3-fold higher

4. Guidance to DU to evaluate whether he works inside the boundaries set by the ES

Environment
Scaling tool: Metals EUSES IT tool (free download: http://www.arche-consulting.be/Metal-CSA-toolbox/du-scaling-tool)

Scaling of the release to air and water environment includes:
Refining of the release factor to air and waste water and/or and the efficiency of the air filter and wastewater treatment facility.

Scaling of the PNEC for aquatic environment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Scaling of the PNEC for soil compartment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Workers
Scaling considering duration and frequency of use
Collect process monitoring data with an inhalable sampler. The simultaneous use of a respirable sampler is encouraged. Use aerosol particle size information, when available, to confirm the appropriate use of the inhalable DNEL of 0.05 mg Ni/m^3. Respirable fraction exposure levels should be kept below 0.01 mg Ni/m^3. See Appendix D6 for site-specific guidance on exposure data collection and Appendix C2 for further details on DNEL derivation.

For further information and guidance on exposure scenarios, available tools, and scaling options, please visit the Nickel Consortia exposure scenario library at the following link: http://www.nickelconsortia.org/exposure-scenario-library.html

9.3.2.1 Summary of secondary poisoning exposure and risk characterisation assessments for metal surface treatment

The methodology applied to assess secondary poisoning is extracted from the European Union Risk Assessment for Nickel (2008/2009). A detailed report on the methodology used to derive the $PNEC_{oral}$ and bioaccumulation factors (BAF) are provided in Appendix D3.

Table 91. Freshwater aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (European Otter)

Selected exposure scenario (ES)	PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	PEC_{oral} mollusk (mg/kg wet mollusk)	PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1	PEC/PNEC Aquatic mammal (European Otter) PNEC=2.3 mg/kg; RAF=0.025
ES 1: df=10	0.0030	0.0029	0.79	0.07	0.01
ES 2: df=100	0.0030	0.0029	0.80	0.07	0.01
ES 3: df=1000	0.0032	0.0029	0.82	0.07	0.01

Table 92. Marine aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (Harbor seal). Two scenarios are assumed: C. edule present and C. edule absent.

PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	PEC_{oral} mollusk (mg/kg wet mollusk)		PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1		PEC/PNEC Aquatic mammal (Harbor seal) PNEC=4.6 mg/kg; RAF=0.025	
		C. edule present BAF=1631 L/kg	*C.edule* absent BAF= 270 L/kg	*C.edule* present BAF=1631 L/kg	*C.edule* absent BAF=270 L/kg	*C.edule* present BAF=1631 L/kg	*C.edule* absent BAF=270 L/kg
0.0042	0.0003	3.65	0.60	0.3	0.05	0.02	0.007

Table 93. Terrestrial food chain: concentration, PECoral and risk characterisation for worm-eating birds and mammals

Selected exposure scenarios	PEC in soil compartment (mg/kg)	Regional soil background concentration (mg/kg)	PEC_{oral} local Tissue + gut 100% worms (mg/kg ww)	PEC_{oral} local Tissue + gut 30% worms 70% isopods (mg/kg ww)	PEC/PNEC Birds (starling) PNEC=8.5 mg/kg RAF=1	PEC/PNEC Mammals (shrew) 100% worms PNEC=0.12 mg/kg RAF=0.036	PEC/PNEC Mammals (shrew) 30% worms 70% isopods PNEC=0.12 mg/kg RAF=0.025
ES 1: sludge application	25.76	16.20	3.11	1.27	0.37	0.93	0.26
ES 2: no sludge application	16.2	16.2	2.4	0.98	0.28	0.72	0.20

9.3.2.2 Summary of porewater concentrations in the soil compartment for metal surface treatment

The derived $PEC_{porewater}$ for the generic scenario is 0.03 mg Ni/L. More details for the calculation of the $PEC_{porewater}$ are provided in Appendix D3.

Table 94. Predicted Exposure Concentrations (PEC) in porewater

$PEC_{local\ porewater}$ (mg/L)
0.04

9.3.2.3 Summary of atmospheric compartment for metal surface treatment

An overview of the local air concentrations and PEC in the air compartment are provided in the assessment for Man via the Environment below or Appendix D5.

9.3.2.4 Summary of exposure concentrations in on site waste water treatment plants (WWTP) for metal surface treatment

Table 95 reports the calculated Ni concentrations in the effluent of the on-site WWTP (see Appendix D3

Table 95. Concentrations in on-site waste water treatment plant

Selected exposure scenarios	Calculated effluent concentration in on-site WWTP (mg/L)
ES 1: freshwater STP-df - 10	0.04
ES 2: freshwater STP-df - 100	5.66
ES 3: freshwater STP-df - 1000	0.01
ES marine	0.90

9.3.2.5 Summary of Man via Environment exposure and risk characterisation assessments for metal surface treatment

For each sector, an overview of the range of operational conditions (OCs) and predicted C_{local} air and PEC air are given below. To assess whether a site is compliant with the GES, the predicted C_{local} needs to be compared

to 11.5 ng Ni/m^3 or the measured PEC needs to be compared to the DNEL of 20 ng Ni/m^3. An assessment of predicted level of compliance for this sector based on site-specific measured or predicted exposures is provided in Section 5 of Appendix D5.

Table 96. Sector overview

	tonnage (T Ni/year)	daily emissions to air (kg Ni/d)	release factor to air (g Ni/T)	Emission days to air per site (d/y)	C_{local}, air* (ng Ni/m^3)	PEC air$ (ng Ni/m^3)
min	4	<0.01	15	220	<1	9
max	1500	0.24	4000	336	43	52
median	14	0.08	2032	235	12	12

**: based on EUSES air model*

$: based on C_{local} predicted + regional background depending on available information.

For two companies calculations were based on a SPERC with a release factor of 4000 g/T.

9.3.3 GES 5: PRODUCTION OF BATTERIES

1. Title GES 5 Production of batteries using electrodes with nickel containing active materials	
Life cycle	Intermediate use – DU of $NiSO_4$
Free short title	Production of batteries
Systematic title based on use descriptor	SU: SU 3 Industrial use PC: PC 19 – intermediate use ERC: ERC5 Industrial use resulting in inclusion into or onto a matrix PROC: PROC 4: Use in batch and other process (synthesis) where opportunity for exposure arises PROC 8b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 9: Transfer of substance or preparation into small containers (dedicated filling line, including weighing) PROC 14: Production of preparations or articles by tabletting, compression, extrusion, pelletisation PROC 26: Handling of inorganic substances at ambient temperature PROC 0 : Cleaning and maintenance
Processes, tasks, activities covered (environment)	Production of batteries using electrodes with nickel containing active materials
Processes, tasks, activities covered (workers)	CES 5.1: PROC 4 & 8b: Raw materials handling CES 5.2: PROC 4 & 8b: Manufacture of $NiSO_4$ solution CES 5.3: PROC 4, 8b, 9, 14 & 26: Manufacture of positive {$Ni(OH)_2$ based} active mass CES 5.4: PROC 4, 8b, 9 & 26: Manufacture of negative {($Cd(OH)_2$ doped with $Ni(OH)_2$ based activie mass} CES 5.5: PROC 14 & PROC 21: Manufacture of pocket plate electrodes CES 5.6: PROC 4, 8b, & 26: Nickel electroplating {maintenance of $NiSO_4$ electroplating solution & manufacture of electrode strip by nickel plating a steel strip} CES 5.7: PROC 0: Cleaning and maintenance *CES: Contributing Exposure Scenario
2. Operational conditions and risk management measures	
2.1 Control of environmental exposure	
Environmental related free short title	Production of batteries using positive nickel electrodes
Systematic title based on use descriptor (environment)	ERC5: Industrial use resulting in inclusion into or onto a matrix

Processes, tasks, activities covered (environment)	Production of batteries using electrodes with nickel containing active materials
Environmental Assessment Method	Estimates based on monitoring local and regional concentrations are used for calculation of PEC.
Product characteristics	
$NiSO_4$ solution and $NiSO_4$ $6H_2O$ powder	
Amounts used	
Maximum daily use at a site	2.9 tonnes/day (median 50th % emission days, max tonnage)
Maximum annual use at a site	796 tonnes (max, 2007)
Frequency and duration of use	
Pattern of release to the environment	276 days per year (median 50th %)
Environment factors not influenced by risk management	
Receiving surface water flow rate	2xE6 m^3/d
Dilution capacity, freshwater	1000 (max)
Dilution capacity, marine	100 (default)
Other given operational conditions affecting environmental exposure	
None	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Waste water: On-site waste water treatment in a physico-chemical treatment plant by chemical precipitation or one of the following measures: Sedimentation, Filtration, Electrolysis, Reverse osmosis, or ion exchange. Release factor after on-site treatment: To freshwater and marine water: 42.7 g/T **Air:** Treatment in exhaust system (fabric or bag filters, electrostatic precipitation, ceramic filters, wet, dry or semi-dry scrubbers) Efficiency 99% removal Release factor after on-site treatment: 25.4 g/T	
Organizational measures to prevent/limit release from site	
None	
Conditions and measures related to municipal sewage treatment plant	
Municipal Sewage Treatment Plant (STP)	No
Discharge rate of the Municipal STP	Not relevant
Incineration of the sludge of the Municipal STP	Not relevant
Conditions and measures related to external treatment of waste for disposal	
Ni bearing waste shall be recovered or recycled if possible. Ni bearing waste shall be considered hazardous if the Ni content is above the generic cutoffs (for mixtures) as stated in regulation (EC) No. 1272/2008. Ni bearing waste mixtures may be assessed as substances according to regulation (EC) No. 1272/2008 criteria. Disposal of Ni bearing waste shall comply with local, state or national waste legislation and remains the responsibility of the waste treatment operator.	
Conditions and measures related to external recovery of waste	
Not applicable	
2.2 Control of workers exposure for contributing exposure scenario ES 5.1	
Raw material handling	
Workers related free short title	Production of batteries
Use descriptor covered	PROC 4: Use in batch and other process (synthesis) where opportunity for exposure arises PROC 8b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities
Processes, tasks, activities covered	Unbagging $NiSO_4 6H_2O$ involves receiving, opening and emptying of bags of $NiSO_4 6H_2O$
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.
Product characteristic	
Nickel sulphate powder, $NiSO_4 6H_2O$	
Amounts used	
Not relevant	

Frequency and duration of use/exposure	
Unbagging 20 kg of $NiSO_46H_2O$ takes between 10 and 20 minutes once per month.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
$NiSO_46H_2O$ is delivered in bags which are (manually) hooked onto a conveyer system which transports it to the ventilated 'slicing post' where the bag is opened manually and the contents poured into a vessel or holding container. Apply ambient temperature and humidity. Maintenance of clean workplace to prevent accumulation of powders and dusts on surfaces. Handling procedures should be designed to eliminate requirement for dermal contact. Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: Automation with some manual intervention (lifting and securing bags of $NiSO_4$ $6H_2O$) but not complete enclosure of transfer operations are likely to give rise to significant exposures to inhalable $NiSO_46H_2O$ Dermal: Automation of processes should be used where possible to eliminate dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes that are not fully enclosed or processes likely to give rise to $NiSO_46H_2O$ dust	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: Use of RPE is required where exposure to $NiSO_46H_2O$ aerosol and dust is possible, required for example where process steps are not fully enclosed. Dermal: Gloves suitable for handling powders and other suitable protective clothing are required where direct contact with $NiSO_46H_2O$ could occur	
2.3 Control of workers exposure for contributing exposure scenario ES 5.2	
Manufacture of the $NiSO_4$ solution	
Workers related free short title	Production of batteries
Use descriptor covered	PROC 4: Use in batch and other process (synthesis) where opportunity for exposure arises PROC 8b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities
Processes, tasks, activities covered	Preparation of $NiSO_4$ solution by dissolving nickel briquettes in sulphuric acid and filtering and pumping the solution into a vessel
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.
Product characteristic	
$NiSO_4$ solution	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
8 hour shift	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Maintenance of clean workplace to prevent accumulation of powders and dusts on surfaces. Handling procedures should be designed to eliminate requirement for dermal contact. Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: Complete enclosure of mixing and transfer operations are unlikely to give rise to significant exposures to inhalable $NiSO_4$ mist or dust Dermal: Automation of processes should be used where possible to eliminate dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes that are not fully enclosed or processes likely to give rise to $NiSO_4$ mists	

Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: Use of RPE is required where exposure to $NiSO_4$ aerosol and mist is possible. Dermal: Waterproof acid resistant gloves are required where contact with $NiSO_4$ solution occurs.	
2.4 Control of workers exposure for contributing exposure scenario ES 5.3	
Manufacture of positive {$Ni(OH)_2$ based} active mass	
Workers related free short title	Production of batteries
Use descriptor covered	PROC 4: Use in batch and other process (synthesis) where opportunity for exposure arises PROC 8b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 9: Transfer of substance or preparation into small containers (dedicated filling line, including weighing) PROC 14: Production of preparations or articles by tabletting, compression, extrusion, pelletisation PROC 26: Handling of inorganic substances at ambient temperature
Processes, tasks, activities covered	$NiSO_4$ solution is mixed with caustic soda or sodium carbonate in order to precipitate $Ni(OH)_2$ which is mixed with other ingredients to make a positive active mass material for use in electrode production.
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.
Product characteristic	
$NiSO_4$ solution {and $Ni(OH)_2$}	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
A dry powder mass which is fed/pressed into tablet/briquettes and may be sealed inside strips to form into pocket plates is largely $Ni(OH)_2$ but may contain some residual $NiSO_4$. Maintenance of clean workplace to prevent accumulation of powders and dusts on surfaces. Handling procedures should be designed to eliminate requirement for dermal contact. Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: Partly enclosed operations are likely to give rise to significant exposures to inhalable $Ni(OH)_2$ or likely to generate Ni-containing mists or dust. However, the likelihood of these aerosols containing and giving rise to significant $NiSO_4$ exposure is low. Reduced pressure in the production systems can be used to reduce exposure. Dermal: Automation of processes should be used where possible to eliminate dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes that are not fully enclosed or operated under reduced pressure.	
Organisational measures to prevent /limit releases, dispersion and exposure	
Segregation of workers in a control room from where they run the operation on the factory floor.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: Use of RPE is required where exposure to $NiSO_4$ aerosol and mist is possible. Dermal: Waterproof acid resistant gloves are required where contact with $NiSO_4$ solution occurs.	
2.5 Control of workers exposure for contributing exposure scenario ES 5.4	
Manufacture of negative {Cd(OH)2 doped with Ni(OH)2 based} active mass	
Workers related free short title	Production of batteries
Use descriptor covered	PROC 4: Use in batch and other process (synthesis) where opportunity for exposure arises PROC 8b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities

	PROC 9: Transfer of substance or preparation into small containers (dedicated filling line, including weighing) PROC 26: Handling of inorganic substances at ambient temperature
Processes, tasks, activities covered	$NiSO_4$ solution is mixed with CdO and the mixture treated to give a negative active mass material for use in electrode production.
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.
Workers related free short title	
Product characteristic	
$NiSO_4$ solution	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure A $Cd(OH)_2$ based negative active mass may contain traces of unreacted $NiSO_4$ which is used to make the $Ni(OH)_2$ component of the negative active mass. Maintenance of clean workplace to prevent accumulation of powders and dusts on surfaces. Handling procedures should be designed to eliminate requirement for dermal contact. Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release Inhalation: Partly enclosed operations are likely to give rise to some exposures to inhalable $Ni(OH)_2$ or likely to generate Ni-containing mists or dusts arising from unreacted $NiSO_4$. However, the likelihood of these aerosols containing and giving rise to significant $NiSO_4$ exposure is low. Reduced pressure in the production systems can be used to reduce exposure. Dermal: Automation of processes should be used where possible to eliminate dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker LEV is required for processes that are not fully enclosed or operated under reduced pressure.	
Organisational measures to prevent /limit releases, dispersion and exposure Segregation of workers in a control room from where they run the operation on the factory floor.	
Conditions and measures related to personal protection, hygiene and health evaluation Inhalation: Use of RPE is required where exposure to $NiSO_4$ aerosol and mist is possible. Dermal: Waterproof acid resistant gloves are required where contact with $NiSO_4$ solution occurs.	
2.6 Control of workers exposure for contributing exposure scenario ES 5.5	
Manufacture of electrodes as pocket plate electrodes	
Workers related free short title	Production from $Ni(OH)_2$ of batteries using nickel electrodes
Use descriptor covered	PROC 14: Production of preparations or articles by tabletting, compression, extrusion, pelletisation PROC 21: Low energy manipulation of substances bound in materials and/or articles
Processes, tasks, activities covered	Preparing 'electrode' strips and tablets
Assessment Method	Not Relevant (Ni sulphate not present)
Product characteristic	
Ni as $Ni(OH)_2$ electrodes	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	

Maintenance of a clean workplace is used to prevent accumulation of powders and dusts on surfaces. Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: Partly enclosed operations are likely to give rise to significant exposures to inhalable $Ni(OH)_2$ or likely to generate Ni-containing mists or dust. Reduced pressure in or enclosure of the production systems can be used to reduce exposure. Dermal: Automation of processes should be used where possible to eliminate dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes that are not fully enclosed or operated under reduced pressure.	
Organisational measures to prevent /limit releases, dispersion and exposure	
Segregation of workers in a control room from where they can run the operation on the factory floor.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: RPE (FFP3) {approved with regard to EN 149} is required for not fully enclosed processes. Dermal: Gloves suitable for handling powders and other suitable protective clothing are required where direct contact with $Ni(OH)_2$ could occur.	
2.5 Control of workers exposure for contributing exposure scenario ES 5.6	
Nickel electroplating {maintenance of $NiSO_4$ electroplating solution & manufacture of electrode strip by nickel plating a steel strip}	
Workers related free short title	Production of batteries
Use descriptor covered	PROC 4: Use in batch and other process (synthesis) where opportunity for exposure arises PROC 8b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 26: Handling of inorganic substances at ambient temperature
Processes, tasks, activities covered	Nickel electroplating of strips and of other 'jigged' items using a $NiSO_4$ rich solution
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.
Product characteristic	
$NiSO_4$ solution and $NiSO_4 6H_2O$ powder (and Ni plated strips)	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Maintenance of clean workplace to prevent accumulation of powders and dusts on surfaces. Handling procedures should be designed to eliminate requirement for dermal contact. Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: Automation and enclosure of strip plating with some manual intervention (topping up $NiSO_4$ solution with $NiSO_4 6H_2O$ and jigging work pieces for bath electroplating) are likely to give rise to some exposures to inhalable $NiSO_4$ mist and $NiSO_4 6H_2O$ dust Dermal: Automation of processes should be used where possible to eliminate dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes that are not fully enclosed or processes likely to give rise to $NiSO_4$ mists or dusts	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: Use of RPE and/ or face visor is required where exposure to $NiSO_4$ aerosol, mist and splashes is possible. Dermal: Waterproof acid resistant gloves are required where contact with $NiSO_4$ solution occurs.	
Other given operational conditions affecting workers exposure	
Maintenance of clean workplace to prevent accumulation of powders and dusts on surfaces. Handling procedures should be designed to eliminate requirement for dermal contact.	

Oral: Good workplace hygiene practice

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

Inhalation: Automation and enclosure of strip plating are unlikely to give rise to exposures to inhalable $NiSO_4$ mist and $NiSO_4$ $6H_2O$ dust except where manual intervention is required for some elements of the task e.g. topping up $NiSO_4$ solution with $NiSO_4$ $6H_2O$ and jigging work pieces for bath electroplating.
Dermal: Automation of processes should be used where possible to eliminate dermal contact.

2.6 Control of workers exposure for contributing exposure scenario ES 5.7

PROC 0 : Cleaning and maintenance

Workers related free short title	Production of batteries
Use descriptor covered	PROC 0: cleaning and maintenance
Processes, tasks, activities covered	Cleaning and maintenance of plant and premises
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.

Product characteristic

$NiSO_4$ solution and $NiSO_4 6H_2O$ dust

Amounts used

Not relevant

Frequency and duration of use/exposure

4 hour duration within an 8 hour shifts

Human factors not influenced by risk management

Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	960 cm^2
Body weight	Not relevant

Other given operational conditions affecting workers exposure

Maintenance of clean workplace to prevent accumulation of powders and dusts on surfaces.
Handling procedures should be designed to eliminate requirement for dermal contact.
Oral: Good workplace hygiene practice

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

General ventilation provision to the premises

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

None

Organisational measures to prevent /limit releases, dispersion and exposure

None

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

Inhalation: Use of RPE is required because exposure to $NiSO_4$ aerosol and mist is likely.
Dermal: Waterproof acid resistant gloves are required where contact with $NiSO_4$ solution occurs.

3. Exposure and risk estimation

Environment

ERC 5
Production of batteries using positive nickel electrodes

Compartment	Unit	PNEC	$PEC_{Regional}$	C_{local}	PEC	RCR	Methods for calculation of environmental concentrations
Freshwater	µg Ni/L	3.55	2.9	0.17	3.07	0.86	Measured values, Tier 3-RWC
Marine	µg Ni/L	8.6	0.3	1.67	1.97	0.23	
Terrestrial	mg Ni/kg	29.9	16.2	0.01	16.3	0.54	
STP	mg Ni/kg	0.33	-	-	-	-	Waste water is not connected to an STP

Workers

ES 5.1
PROC 4 & 8b: Raw materials handling

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		

Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.000003	7x10^{-3}	90th percentile from MEASE modelling (PROC8b, exposure duration <15 mins, LEV, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.082	5.13x 10^{-3}	The higher of 2 static exposure values for the unbagging of $NiSO_46H_2O$. LEV is assumed to be in place
Acute local	mg Ni/m^3	0.7	0.082	0.12	
Long-term systemic and local	mg Ni/m^3	0.05	Not applicable	Not applicable	This operation is not of long term duration..

ES 5.2
PROC 4 & 8b: Manufacture of the $NiSO_4$ solution

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00003	0.07	90th percentile from MEASE modeling (PROC 4, enclosed, LEV, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.066	4.13x10^{-3}	3 x the long term inhalation exposure.
Acute local	mg Ni/m^3	0.7	0.066	0.0943	
Long-term systemic and local	mg Ni/m^3	0.05	0.022	0.44	The highest of 3 personal inhalable nickel exposure measurements

ES 5.3
PROC 4, 8b, 9, 14 & 26: Manufacture of positive {$Ni(OH)_2$ based} active mass

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00001	0.023	90th percentile from MEASE modeling (PROC 4, enclosed, segregated workers, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.468	0.03	Estimated as 3x the estimated 75th percentile long term exposure concentration reported as
Acute local	mg Ni/m^3	0.7	0.468	0.67	

					'paste mixing'
Long-term systemic and local	mg Ni/m^3	0.05	0.156	3.12 excl RPE[1] By use of RPE (P3, APF 20): 0.156	The 75th percentile value for long term exposure measurements reported as 'paste mixing'

ES 5.4
PROC: 4, 8b, 9 & 26 Manufacture of negative {Cd(OH)2 doped with Ni(OH)2 based} active mass

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.00001	0.023	90th percentile from MEASE modeling (PROC 4, enclosed, segregated workers, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.006	3.75x10-^{4}	Exposure to $NiSO_4$ is not relevant for this activity. Ni is only in the form of Ni Dihydroxide.
Acute local	mg Ni/m^3	0.7	0.006	8.6x10^{-3}	
Long-term systemic and local	mg Ni/m^3	0.05	0.002	0.04	The higher of 2 personal 'inhalable nickel' exposure measurements

ES 5.5
PROC 14 & 21: Manufacture of pocket plate electrodes

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	Not Applicable		Exposure to $NiSO_4$ is not relevant for this process/activity. Ni is only in the form of Ni dihydroxide
Inhalation					
Acute systemic	mg Ni/m^3	16	Not Applicable		Exposure to $NiSO_4$ is not relevant for this process/activity. Ni is only in the form of Ni dihydroxide
Acute local	mg Ni/m^3	0.7	Not Applicable		
Long-term systemic and local	mg Ni/m^3	0.05	Not Applicable		

ES 5.6
PROC 4, 8b & 26: Nickel electroplating {maintenance of $NiSO_4$ electroplating solution & manufacture of electrode strip by nickel plating a steel strip}

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00003	0.07	90th percentile from MEASE modeling (PROC 4, enclosed, LEV, gloves)
Inhalation					
Acute systemic	mg Ni/m³	16	0.0426	0.003	3 x the long term inhalation exposure.
Acute local	mg Ni/m³	0.7	0.0426	0.061	
Long-term systemic and local	mg Ni/m³	0.05	0.0142	0.3	The highest of 5 static exposure measurements for nickel electroplating from a $NiSO_4$ rich solution

ES 5.7
PROC 0: Cleaning and maintenance

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.000018	$4.1x10^{-3}$	90th percentile from MEASE modeling (PROC 10, 4 h duration, GV, RPE, gloves)
Inhalation					
Acute systemic	mg Ni/m³	16	1.026	0.002	3 x 75th percentile personal, inhalable for raw materials handling in analogous process
Acute local	mg Ni/m³	0.7	1.026	0.26	
Long-term systemic and local	mg Ni/m³	0.05	0.342 0.017	6.84 0.34 By use of RPE (APF 20)	75th percentile personal, inhalable for raw materials handling in analogous process

NR: Not relevant

[1] Estimated long term mean exposure concentrations for paste preparation operations are likely to exceed the DNEL and appropriate RPE fitted with a FFP3 filter should be used to reduce operator exposure to less than the DNEL and prevent the risk of respiratory cancer, respiratory toxicity or possible reproductive effects.

Acute local inhalation
Based on respirable size aerosols. Equivalent inhalable fraction levels expected to be at least 3-fold higher

4. Guidance to DU to evaluate whether he works inside the boundaries set by the ES

Environment
Scaling tool: Metals EUSES IT tool (free download: http://www.arche-consulting.be/Metal-CSA-toolbox/du-scaling-tool)

Scaling of the release to air and water environment includes:
Refining of the release factor to air and waste water and/or and the efficiency of the air filter and wastewater treatment facility.

Scaling of the PNEC for aquatic environment by using a tiered approach for correction for bioavailability and background concentration (Clocal approach). See Appendix D1

Scaling of the PNEC for soil compartment by using a tiered approach for correction for bioavailability and background concentration (Clocal approach). See Appendix D1

Workers
Scaling considering duration and frequency of use
Collect process monitoring data with an inhalable sampler. The simultaneous use of a respirable sampler is encouraged. Use aerosol particle size information, when available, to confirm the appropriate use of the inhalable DNEL of 0.05 mg Ni/m3. Respirable fraction exposure levels should be kept below 0.01 mg Ni/m3. See Appendix D6 for site-specific guidance on exposure data collection and Appendix C2 for further details on DNEL derivation.

For further information and guidance on exposure scenarios, available tools, and scaling options, please visit the Nickel Consortia exposure scenario library at the following link: http://www.nickelconsortia.org/exposure-scenario-library.html

9.3.3.1 Summary of secondary poisoning exposure and risk characterisation assessments for the production of batteries using positive nickel electrodes

The methodology applied to assess secondary poisoning is extracted from the European Union Risk Assessment for Nickel (2008/2009). A detailed report on the methodology used to derive the $PNEC_{oral}$ and bioaccumulation factors (BAF) are provided in Appendix D3.

Table 97. Freshwater aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (European Otter)

Selected exposure scenario	PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	PEC_{oral} mollusk (mg/kg wet mollusk)	PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1	PEC/PNEC Aquatic mammal (European Otter) PNEC=2.3 mg/kg; RAF=0.025
ES 1	0.0036	0.0029	0.88	0.07	0.01
ES 2	0.0030	0.0029	0.80	0.07	0.01

Table 98. Marine aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (Harbor seal). Two scenarios are assumed: C. edule present and C. edule absent

PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	PEC_{oral} mollusk (mg/kg wet mollusk)		PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1		PEC/PNEC Aquatic mammal (Harbor seal) PNEC=4.6 mg/kg; RAF=0.025	
		C. edule present BAF=1631 L/kg	*C.edule* absent BAF= 270 L/kg	*C.edule* present BAF=1631 L/kg	*C.edule* absent BAF=270 L/kg	*C.edule* present BAF=1631 L/kg	*C.edule* absent BAF=270 L/kg
0.0016	0.0003	0.25	1.52	0.02	0.12	0.001	0.008

Table 99. Terrestrial food chain: concentration, PECoral and risk characterisation for worm-eating birds and mammals

PEC in soil compartment (mg/kg)	Regional soil background concentration	PEC_{oral} local Tissue + gut 100% worms	PEC_{oral} local Tissue + gut 30% worms	PEC/PNEC Birds (starling)	PEC/PNEC Mammals (shrew)	PEC/PNEC Mammals (shrew)

	(mg/kg)	(mg/kg ww)	70% isopods (mg/kg ww)	PNEC=8.5 mg/kg RAF=1	100% worms PNEC=0.12 mg/kg RAF=0.036	30% worms 70% isopods PNEC=0.12 mg/kg RAF=0.025
16.21	16.20	2.4	0.98	0.28	0.72	0.20

9.3.3.2 Summary of porewater concentrations in the soil compartment for the production of batteries using positive nickel electrodes

The derived $PEC_{porewater}$ for the generic scenario is 0.025 mg Ni/L. More details for the calculation of the $PEC_{porewater}$ are provided in Appendix D3.

Table 100. Predicted Exposure Concentrations (PEC) in porewater

$PEC_{local\ porewater}$ (mg/L)
0.025

9.3.3.3 Summary of the atmospheric compartment for the production of batteries using positive nickel electrodes

An overview of the local air concentrations and PEC in the air compartment are provided in the assessment for Man via the Environment below or Appendix D5.

9.3.3.4 Summary of exposure concentrations in on site waste water treatment plants (WWTP) for the production of batteries using positive nickel electrodes

Table 101 reports the calculated Ni concentration in the effluent of the on-site WWTP (see Appendix D3).

Table 101. Concentrations in on-site waste water treatment plant

Selected exposure scenarios	Calculated effluent concentration in on-site WWTP (mg/L)
ES 1: freshwater	0.013
ES 2: freshwater	0.23
ES marine	0.23

9.3.3.5 Summary of Man via Environment exposure and risk characterisation assessments for production of batteries using positive nickel electrodes

For each sector, an overview of the range of operational conditions (OCs) and predicted C_{local} air and PEC air are given below. To assess whether a site is compliant with the GES, the predicted C_{local} needs to be compared to 11.5 ng Ni/m^3 or the measured PEC needs to be compared to the DNEL of 20 ng Ni/m^3. An assessment of predicted level of compliance for this sector based on site-specific measured or predicted exposures is provided in Section 5 of Appendix D5.

Table 102. Sector overview

	tonnage (T Ni/year)	daily emissions to air (kg Ni/d)	release factor to air (g Ni/T)	Emission days to air per site (d/y)	C_{local}, air* (ng Ni/m³)	PEC air$ (ng Ni/m³)
min	175	<0.01	2	247	< 1	1
max	796	0.06	25	360	11	19
median	715	0.04	14	276	7	12

**: based on EUSES air model*

$: based on measured values and C_{local} predicted + regional background depending on available information..

9.3.4 GES 6: PRODUCTION OF NICKEL SALTS FROM NICKEL SULPHATE

1. Title **GES 6 Production of Ni salts from Ni sulphate**	
Life cycle	End use - DU of Ni sulphate
Free short title	Production of Ni salts from Ni sulphate Production of Ni salts to be used in production of catalysts
Systematic title based on use descriptor	SU: SU9 Manufacture of fine chemicals PC: Not relevant ERC: ERC 6a: Industrial use resulting in manufacture of another sub-stance (use of intermediates) PROC: PROC 2: Use in closed, continuous process with occasional controlled exposure PROC 8b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 26: Handling of solid inorganic substances at ambient temperature PROC 0: Cleaning and maintenance
Processes, tasks, activities covered (environment)	Production of Ni salts from Ni sulphate
Processes, tasks, activities covered (workers)	Raw materials handling, reaction with other chemicals, filtering and drying of product, packing, cleaning and maintenance
2. Operational conditions and risk management measures	
2.1 Control of environmental exposure	
Environmental related free short title	Production of Ni salts from Ni sulphate
Systematic title based on use descriptor (environment)	ERC 6a: Industrial use resulting in manufacture of another sub-stance (use of intermediates)
Processes, tasks, activities covered (environment)	Production of Ni salts from Ni sulphate
Environmental Assessment Method	Estimates based on monitoring local and regional concentrations are used for calculation of PEC
Product characteristics	
Ni sulphate solution: 10-50%, Ni sulphate salt: 100%	
Amounts used	
Maximum daily use at a site	5.36 tonnes/day (median 50th % emission days, 75th % tonnage)
Maximum annual use at a site	1930 tonnes (75th %, 2007)
Frequency and duration of use	
Pattern of release to the environment	360 days per year (median 50th %)
Environment factors not influenced by risk management	
Receiving surface water flow rate	2xE6 m³/d
Dilution capacity, freshwater	1000 (median)
Dilution capacity, marine	100 (default)
Other given operational conditions affecting environmental exposure	
Not given	
Technical conditions and measures at process level (source) to prevent release	
Not given	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	

Waste water: On site waste water treatment in a physico-chemical plant by chemical precipitation, sedimentation, filteration or a combination of methods. Efficiency up to 99.9% Release factor after on-site treatment: To freshwater and marine water: 91.2 g/T (75th %) **Air:** Treatment of air emission in exhaust system with fabric or bag filters, ceramic filters or wet scrubbers. Efficiency 99.9% Release factor after on-site treatment: 59.6 g/T (75th %)	
Organizational measures to prevent/limit release from site	
None	
Conditions and measures related to municipal sewage treatment plant	
Municipal Sewage Treatment Plant (STP)	No
Discharge rate of the Municipal STP	Not relevant
Incineration of the sludge of the Municipal STP	Not relevant
Conditions and measures related to external treatment of waste for disposal	
Ni bearing waste shall be recovered or recycled if possible. Ni bearing waste shall be considered hazardous if the Ni content is above the generic cutoffs (for mixtures) as stated in regulation (EC) No. 1272/2008. Ni bearing waste mixtures may be assessed as substances according to regulation (EC) No. 1272/2008 criteria. Disposal of Ni bearing waste shall comply with local, state or national waste legislation and remains the responsibility of the waste treatment operator.	
Conditions and measures related to external recovery of waste	
Not applicable	
2.2 Control of workers exposure	
Production of Ni salts from Ni sulphate	
Workers related free short title	Production of Ni salts from Ni sulphate
Use descriptor covered	PROC 2: Use in closed, continuous process with occasional controlled exposure PROC 8b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 26: Handling of solid inorganic substances at ambient temperature PROC 0: Cleaning and maintenance
Processes, tasks, activities covered	Raw materials handling, reaction with other chemicals, filtering and drying of product, packing, cleaning and maintenance
Assessment Method	Estimation of exposure based on measured data
Product characteristic	
Ni sulphate solution: 10-50%, Ni sulphate salt: 100%	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Maintain clean workplace to prevent accumulation of powders and dusts on surfaces. Use of water or vacuum cleaner with HEPA filter to remove dust from workplace during cleaning and maintenance. Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release	
Processes shall be automated and enclosed. Enclosure of reaction, filtration and drying systems, automation and enclosure of packing dry product is required.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required at work stations where dry powders are handled	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	

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

Inhalation: RPE is required for cleaning and maintenance operations and where exposure to dry powders and/or dust and/or spray solution is possible.
Dermal: For contact with Ni sulphate solution, gloves and other appropriate protective clothing suitable for working with aqueous solutions and acids are required.
For dermal contact with dried product, gloves and other suitable protective clothing suitable for handling powders are required

3. Exposure and risk estimation

Environment

ERC 6a
Production of Ni salts from Ni sulphate

Compartment	Unit	PNEC	$PEC_{Regional}$	C_{local}	PEC	RCR	Methods for calculation of environmental concentrations
Freshwater	µg Ni/L	3.55	2.9	0.18	3.08	0.87	Measured values, Tier 3-RWC
Marine	µg Ni/L	8.6	0.3	1.75	2.05	0.24	
Terrestrial	mg Ni/kg	29.9	16.2	0.04	16.2	0.54	
STP	mg Ni/kg	0.33	-	-	-	-	Waste water is not connected to an STP

Workers

Production of Ni salts from Ni sulphate

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.0004	0.9	Worst case estimate for use of Ni sulphate in chemicals production. Use of gloves and other suitable protective clothing will minimise exposure level.
Inhalation					
Acute systemic	mg Ni/m^3	16	1.0	0.063	10 x the reasonable worst case of shift, mean concentration for handling of dry Ni sulphate powders with LEV in place. A factor of 10 takes account of the extreme variability in exposure concentration through time that arises during powder handling operations. Exposures would be 10 x lower for entirely automated
Acute local	mg Ni/m^3	0.7	1.0	1.4 With RPE: 0.07	

					and enclosed handling of powders
Long-term systemic and local	mg Ni/m³	0.05	0.1	2 With enclosure and automation: 0.2	Reasonable worst case shift mean concentration based on expert judgement and experience in other industrial settings where powders are handled. LEV is assumed rather than enclosure and automation. Exposures would be 10 x lower for entirely automated and enclosed handling of powders
NR: Not Relevant Acute local inhalation Based on respirable size aerosols. Equivalent inhalable fraction levels expected to be at least 3-fold higher					

4. Guidance to DU to evaluate whether he works inside the boundaries set by the ES

Environment

Scaling tool: Metals EUSES IT tool (free download: http://www.arche-consulting.be/Metal-CSA-toolbox/du-scaling-tool)

Scaling of the release to air and water environment includes:
Refining of the release factor to air and waste water and/or and the efficiency of the air filter and wastewater treatment facility.

Scaling of the PNEC for aquatic environment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Scaling of the PNEC for soil compartment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Workers

Scaling considering duration and frequency of use
Collect process monitoring data with an inhalable sampler. The simultaneous use of a respirable sampler is encouraged. Use aerosol particle size information, when available, to confirm the appropriate use of the inhalable DNEL of 0.05 mg Ni/m³. Respirable fraction exposure levels should be kept below 0.01 mg Ni/m³. See Appendix D6 for site-specific guidance on exposure data collection and Appendix C2 for further details on DNEL derivation.

For further information and guidance on exposure scenarios, available tools, and scaling options, please visit the Nickel Consortia exposure scenario library at the following link: http://www.nickelconsortia.org/exposure-scenario-library.html

9.3.4.1 Summary of secondary poisoning exposure and risk characterisation assessments for the production of nickel salts from nickel sulphate

The methodology applied to assess secondary poisoning is extracted from the European Union Risk Assessment for Nickel (2008/2009). A detailed report on the methodology used to derive the $PNEC_{oral}$ and bioaccumulation factors (BAF) are provided in Appendix D3.

Table 103. Freshwater aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (European Otter)

PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	PEC_{oral} mollusk (mg/kg wet mollusk)	PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1	PEC/PNEC Aquatic mammal (European Otter) PNEC=2.3 mg/kg; RAF=0.025
0.0031	0.0029	0.81	0.07	0.01

Table 104. Marine aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (Harbor seal). Two scenarios are assumed: C. edule present and C. edule absent

PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	PEC_{oral} mollusk (mg/kg wet mollusk)		PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1		PEC/PNEC Aquatic mammal (Harbor seal) PNEC=4.6 mg/kg; RAF=0.025	
		C. edule present BAF=1631 L/kg	*C.edule* absent BAF= 270 L/kg	*C.edule* present BAF=1631 L/kg	*C.edule* absent BAF=270 L/kg	*C.edule* present BAF=1631 L/kg	*C.edule* absent BAF=270 L/kg
0.002	0.0003	1.9	0.31	0.15	0.03	0.01	0.003

Table 105. Terrestrial food chain: concentration, PECoral and risk characterisation for worm-eating birds and mammals

PEC in soil compartment (mg/kg)	Regional soil background concentration (mg/kg)	PEC_{oral} local Tissue + gut 100% worms (mg/kg ww)	PEC_{oral} local Tissue + gut 30% worms 70% isopods (mg/kg ww)	PEC/PNEC Birds (starling) PNEC=8.5 mg/kg RAF=1	PEC/PNEC Mammals (shrew) 100% worms PNEC=0.12 mg/kg RAF=0.036	PEC/PNEC Mammals (shrew) 30% worms 70% isopods PNEC=0.12 mg/kg RAF=0.025
16.24	16.20	2.40	0.98	0.28	0.72	0.20

9.3.4.2 Summary of porewater concentrations in the soil compartment for the production of nickel salts from nickel sulphate

The derived $PEC_{porewater}$ for the generic scenario is 0.03 mg Ni/L. More details for the calculation of the $PEC_{porewater}$ are provided in Appendix D3 .

Table 106. Predicted Exposure Concentrations (PEC) in porewater

$PEC_{local\ porewater}$ (mg/L)
0.03

9.3.4.3 Summary of atmospheric compartment for the production of nickel salts from nickel sulphate

An overview of the local air concentrations and PEC in the air compartment are provided in the assessment for Man via the Environment below or Appendix D5.

9.3.4.4 Summary of exposure concentrations in on site waste water treatment plants for the production of nickel salts from nickel sulphate

Table 107 reports the calculated and measured Ni concentration in the effluent of the on-site WWTP.

Table 107. Concentrations in on-site waste water treatment plant

Information type	Calculated effluent concentration in on-site WWTP (mg/L)
Selected for GES Freshwater	0.24
Selected for GES Marine	0.24

9.3.4.5 Summary of Man via Environment exposure and risk characterisation assessments for production of nickel salts from nickel sulphate

For each sector, an overview of the range of operational conditions (OCs) and predicted C_{local} air and PEC air are given below. To assess whether a site is compliant with the GES, the predicted C_{local} needs to be compared to 11.5 ng Ni/m^3 or the measured PEC needs to be compared to the DNEL of 20 ng Ni/m^3. An assessment of predicted level of compliance for this sector based on site-specific measured or predicted exposures is provided in Section 5 of Appendix D5.

Table 108. Sector overview

	tonnage (T Ni/year)	daily emissions to air (kg Ni/d)	release factor to air (g Ni/T)	Emission days to air per site (d/y)	C_{local}, air* (ng Ni/m^3)	PEC air$ (ng Ni/m^3)
min	177	<0.01	1	200	< 1	9
max	51113	4.93	72	365	31	40
median	967	0.11	20	355	2	11

*: based on different air models (EUSES, GPM, IFDM)
$: based on C_{local} predicted + regional background

9.4 New generic exposure scenarios for 2012 updates

This section contains two new generic exposure scenario for the use of nickel sulphate. These uses were reported after the 2010 registration.

9.4.1. GES 7: USE OF NICKEL SULPHATE IN THE MANUFACTURING OF MICRONUTRIENT ADDITIVES FOR BIOGAS PRODUCTION

1. Title **GES 7: Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production**	
Life cycle	Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
Free short title	Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
Systematic title based on use descriptor	SU: SU 1: Agriculture PC: PC 12: fertilizer ERC: ERC 2: Formulation of preparations

	PROC: PROC 3: Use in closed batch process (synthesis or formulation) PROC 4: Use in batch and other process (synthesis) where opportunity for exposure arises PROC 8b:Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 9: Transfer of chemicals into small containers (dedicated filling line) PROC 0 – Cleaning and maintenance
Processes, tasks, activities covered (environment)	Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
Processes, tasks, activities covered (workers)	Contributing exposure scenario ES 7.1: PROC 4 and PROC 8b: Nickel sulfate reception Contributing exposure scenario ES 7.2: PROC 3 Preparing the additive powder Contributing exposure scenario ES 7.3: Proc 9: Packaging Contributing exposure scenario ES 7.4: PROC 3 Palletising Contributing exposure scenario ES 7.5: PROC 0: Cleaning and Maintenance
2. Operational conditions and risk management measures	
2.1 Control of environmental exposure	
Environmental related free short title	Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
Systematic title based on use descriptor (environment)	ERC2 – Formulation of preparations
Processes, tasks, activities covered (environment)	Manufacture of Ni sulphate-containing micronutrient additives for biogas production
Environmental Assessment Method	Not Relevant (no release to water or air)
Product characteristics	
Powder and liquid (solution of $NiSO_4$)	
Amounts used	
Maximum daily use at a site	25 kg
Maximum annual use at a site	1-10 tonnes
Frequency and duration of use	
Pattern of release to the environment	No appreciable release to the environment
Environment factors not influenced by risk management	
Receiving surface water flow rate	Not relevant
Dilution capacity, freshwater	Not relevant
Dilution capacity, marine	Not relevant
Other given operational conditions affecting environmental exposure	
None	
Technical conditions and measures at process level (source) to prevent release	
There is no discharge to sewer or river. A dust aspiration system used to collect particles that are directed back to the mixing system (thus no release to air).	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Waste water: There are no discharges to a sewer or river. **Air:** Technical aspiration is present to avoid dust emissions to the environment. A filtration system is present that re-circulates particles back to the mixing system. When the filter elements are reaching their end of life they are replaced.	
Organizational measures to prevent/limit release from site	
None	
Conditions and measures related to municipal sewage treatment plant	
Municipal Sewage Treatment Plant (STP)	Not relevant
Discharge rate of the Municipal STP	Not relevant
Incineration of the sludge of the Municipal STP	Not relevant

Conditions and measures related to external treatment of waste for disposal	
Ni bearing waste shall be recovered or recycled if possible. Ni bearing waste shall be considered hazardous if the Ni content is above the generic cutoffs (for mixtures) as stated in regulation (EC) No. 1272/2008. Ni bearing waste mixtures may be assessed as substances according to regulation (EC) No. 1272/2008 criteria. Disposal of Ni bearing waste shall comply with local, state or national waste legislation and remains the responsibility of the waste treatment operator.	
Conditions and measures related to external recovery of waste	
Waste water is collected in a separate waste IBC and removed by an authorized waste company.	
2.2 Control of workers exposure for contributing exposure scenario 7.1	
Nickel sulfate reception	
Workers related free short title	Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
Use descriptor covered	PROC 4: Use in batch and other process (synthesis) where opportunity for exposure arises PROC 8b:Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities
Processes, tasks, activities covered	$NiSO_4$ powder and solution are obtained ready for processing and placed in a dispensing bin.
Assessment Method	Estimation of exposure using a Tier 1 model (MEASE)
Product characteristic	
Hydrated nickel sulphate hexahydrate, $NiSO_46H_2O$ (solid powder), or in solution	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Duration of exposure is considered to be less than 4 hours per day for nutrient manufacture especially when this production process is not continuous and where this product line is one of a range of products manufactured on site for the agricultural or energy etc. sectors.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
All activities are carried out manually by the worker. The reactor is charged by tipping $NiSO_4$ powder or pouring $NiSO_4$ solution into the dispensing bin.	
Technical conditions and measures at process level (source) to prevent release	
None given	
Technical conditions and measures to control dispersion from source towards the worker	
None given	
Organisational measures to prevent /limit releases, dispersion and exposure	
Training to reinforce good practice and hygiene issues are performed. The reception of raw materials for the manufacturing of micronutrient additives is a non-continuous operation and/or takes place for no more than 4 hours per day	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor, masks or hood with P3 filter element (Assigned Protection Factor = 40 based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) is required for charging the dispensing bin where exposure to $NiSO_4$ containing mist or dust is possible. Chemical gloves with EN 374, protection level 6 are required to control dermal exposure when charging the dispensing bin.	
2.3 Control of workers exposure for contributing exposure scenario 7.2	
Preparing the additive (for biogas production) powder or solutions	
Workers related free short title	Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
Use descriptor covered	PROC 3: Use in closed batch process (synthesis or formulation)
Processes, tasks, activities covered	Preparing the additive (for biogas production) powder or solutions
Assessment Method	Estimation of exposure using a Tier 1 model (MEASE)
Product characteristic	
Hydrated nickel sulphate hexahydrate, $NiSO_46H_2O$ (solid powder), or in solution, $NiSO_4$	
Amounts used	

Not relevant	
Frequency and duration of use/exposure	
Duration of exposure is considered to be less than 4 hours per day for nutrient manufacture especially when this production process is not continuous and where this product line is one of a range of products manufactured on site for the agricultural or energy etc. sectors.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	240 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
All activities are largely run from a control room or from a control booth (in sight of the process when they are required to observe the process directly) except when operators are required to inspect or intervene in the process and make any adjustments from the control booth or on the factory floor based on what is observed. The $NiSO_4$ solution is piped from the dispensing bin to the blender. This activity is automated and enclosed.	
Technical conditions and measures at process level (source) to prevent release	
Transfer and mixing systems shall be enclosed with high level of containment.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV shall be used to extract the particulate during the mixing and transferring operations.	
Organisational measures to prevent /limit releases, dispersion and exposure	
Training to reinforce good practice and hygiene issues.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor, masks or hood with P3 filter element (Assigned Protection Factor ~20 based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection) is required for entry into the production area for inspections/emergency situations where exposure to $NiSO_4$ containing mist or dust is possible. Chemical gloves with EN 374, protection level 6, are required for entry into the production area for inspections/emergency situations in order to control dermal exposure where exposure to $NiSO_4$ containing mist or dust is possible.	
2.4 Control of workers exposure for contributing exposure scenario 7.3	
Packaging	
Workers related free short title	Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
Use descriptor covered	PROC 9: Transfer of substance or preparation into small containers (dedicated filling line, including weighing)
Processes, tasks, activities covered	Packaging
Assessment Method	Estimation of exposure using a Tier 1 model (MEASE)
Product characteristic	
Ni/$NiSO_4$-containing powder	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Duration of exposure is considered to be less than 1 hour per day for nutrient manufacture where some manual intervention is required during the packaging operation but may be longer when operating a fully automated packaging line or if wearing RPE.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
All activities except filled bag removal from the packaging (valve bag filling) station are automated with a high level of containment.	
Technical conditions and measures at process level (source) to prevent release	
Filled bag self-seals through an internal valve system and this prevents dust escaping from the bag.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to control inhalation exposure to particulates during product release into the packaging and sealing of the filled packaging.	

Organisational measures to prevent /limit releases, dispersion and exposure	
Training to reinforce good practice and hygiene issues	
Conditions and measures related to personal protection, hygiene and health evaluation	
None reported.	
2.5 Control of workers exposure for contributing exposure scenario 7.4	
Palletising	
Workers related free short title	Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
Use descriptor covered	PROC 3: Use in closed batch process (synthesis or formulation)
Processes, tasks, activities covered	Palletising and wrapping of filled bags of biogas nutrient
Assessment Method	Estimation of exposure using a Tier 1 model (MEASE)
Product characteristic	
Solid or solution	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Duration of exposure is considered to be less than 1 hour per day for nutrient manufacture especially when this production process is not continuous and where this product line is one of a range of products manufactured on site for the agricultural or energy etc. sectors	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	240 cm^2
Body weight	70 kg
Other given operational conditions affecting workers exposure	
The structure of bag used for packaging the micronutrients limits dust released from filled bags and hence exposure. Activities involve handling the filled bags of biogas nutrient powder which are considered a leak-proof packaging system.	
Technical conditions and measures at process level (source) to prevent release	
None reported	
Technical conditions and measures to control dispersion from source towards the worker	
None reported	
Organisational measures to prevent /limit releases, dispersion and exposure	
Training to reinforce good practice and hygiene issues and exposure	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor, masks or hood with P3 filter element (Assigned Protection Factor ~20 based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection). Chemical gloves with EN 374, protection level 6 are required to control dermal exposure when palletising the filled bags.	
2.5 Control of workers exposure for contributing exposure scenario 7.5	
Cleaning and Maintenance	
Workers related free short title	Use of nickel sulphate in the manufacturing of micronutrient additives for biogas production
Use descriptor covered	PROC 0 – Cleaning and maintenance
Processes, tasks, activities covered	Cleaning and Maintenance
Assessment Method	Estimation of exposure using a Tier 1 model (MEASE)
Product characteristic	
Solid and solution	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Duration of exposure is considered to be less than 1 hour per day for nutrient manufacture especially when this production process is not continuous and where this product line is one of a range of products manufactured on site for the agricultural or energy etc. sectors	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work is routinely undertaken ~10 m^3/d
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	960 cm^2

Body weight	70 kg
Other given operational conditions affecting workers exposure	
None	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical conditions and measures to control dispersion from source towards the worker	
None	
Organisational measures to prevent /limit releases, dispersion and exposure	
Training to reinforce good practice and hygiene issues	
Conditions and measures related to personal protection, hygiene and health evaluation	
Air-assisted filtering visor, masks or hood with P3 filter element (Assigned Protection Factor ~20 based on use of powered respirator meeting EN12492 requirement or equivalent suitable P3 level protection). Chemical gloves with EN 374, protection level 6 are required to control dermal exposure Inhalation to mists and particulates and skin exposure to mists, liquids splashes and particulates shall be controlled by RPE and gloves when undertaking maintenance and cleaning work.	

3. Exposure and risk estimation

Environment

ERC 2

compartment	Unit	PNEC	$PEC_{Regional}$	C_{local}	PEC	RCR	Methods for calculation of environmental concentration
Freshwater	µg/L	3.6	-	-	-	-	-
Marine	µg/L	8.6	-	-	-	-	-
Terrestrial	mg/kg	29.9	-	-	-	-	-
STP	Mg/kg	0.33	-	-	-	-	-

Workers

ES 7.1

PROC 4 and PROC 8b: Nickel sulfate reception

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.00044	0.000018	0.041	Modelled exposure data using MEASE for PROC 8b (incidental exposure, duration 4 hours, GV, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.078	0.0049	3 x long-term modeled estimate with use of RPE (APF 40)
Acute local	mg Ni/m^3	0.7	0.078	0.11	
Long-term systemic and local	mg Ni/m^3	0.05	1.026 0.026	20.52 (excluding RPE) By use of RPE (APF 40) 0.52	90^{th} percentile exposure estimate using MEASE for PROC 1 {incidental exposure, duration 4 hours, RPE (APF=40), gloves}

ES 7.2

PROC 3: Preparing the additive (for biogas production) powder or solutions

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute	mg	-	NR		

systemic	Ni/kg/day				
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00003	0.068	Modelled exposure data using MEASE for PROC 3 {incidental exposure, enc, LEV, duration 4 hours, gloves}
Inhalation					
Acute systemic	mg Ni/m³	16	0.141	0.009	3 x long-term inhalable modeled estimate
Acute local	mg Ni/m³	0.7	0.141	0.201	
Long-term systemic and local	mg Ni/m³	0.05	0.047	0.94	90th percentile exposure estimate using MEASE for PROC 3 {incidental exposure, enc, LEV, duration 4 hours, gloves}
ES 7.3 PROC 9: Packaging					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.00086 0.00043	1.95 0.98 for 4 h exposure duration and when this duration is exceeded worker would have to wash hands and replace gloves in order to continue working	Read across 75th percentile for personal exposure measurement (face) reported for an analogous operation for packaging of $NiSO_4 6H_2O$ and nickel hydroxycarbonate
Inhalation					
Acute systemic	mg Ni/m³	16	0.23	0.0144	10 x long-term inhalable read-across estimate. A factor of 10 was used because of the substantial short term variability of exposure concentrations during powder handling operations
Acute local	mg Ni/m³	0.7	0.23	0.33	
Long-term systemic and local	mg Ni/m³	0.05	0.023	0.46	Read across 75th percentile for personal exposure measurements reported for an analogous operation for packaging of $NiSO_4 6H_2O$ and nickel hydroxycarbonate
ES 7.4 PROC 3: Palletising					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					

Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.000002	<0.01	90th percentile exposure estimate using MEASE for PROC 3 {incidental exposure, duration 4 hours, gloves}
Inhalation					
Acute systemic	mg Ni/m³	16	0.069	0.004	10 x long-term inhalable read-across estimate. A factor of 10 was used because of the substantial short term variability of exposure concentrations during powder handling operations
Acute local	mg Ni/m³	0.7	0.069	0.099	
Long-term systemic and local	mg Ni/m³	0.05	0.023	0.46	90th percentile exposure estimate using MEASE for PROC 3 {incidental exposure, duration 4 hours, gloves}
ES 7.5 PROC 0: Cleaning and Maintenance					
	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR		
Acute local	mg Ni/cm²/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm²/day	0.00044	0.000006	0.014	90th percentile exposure estimate using MEASE for PROC 10 {incidental exposure, duration 1 hour, general ventilation, RPE, gloves}
Inhalation					
Acute systemic	mg Ni/m³	16	0.0972	0.006	3 x long-term inhalable modeled estimate
Acute local	mg Ni/m³	0.7	0.0972	0.14	
Long-term systemic and local	mg Ni/m³	0.05	0.324 0.0324	6.5 (excluding RPE) By use of RPE (APF 10) 0.65	90th percentile exposure estimate using MEASE for PROC 10 {incidental exposure, duration 1 hour, general ventilation, RPE, gloves}
NR: Not Relevant <u>Acute local inhalation</u> Based on respirable size aerosols. Equivalent inhalable fraction levels expected to be at least 3-fold higher					

4. Guidance to evaluate whether a site works inside the boundaries set by the ES

Environment

Scaling tool: Metals EUSES IT tool (free download: http://www.arche-consulting.be/Metal-CSA-toolbox/du-scaling-tool)

Scaling of the release to air and water environment includes:
Refining of the release factor to air and waste water and/or and the efficiency of the air filter and wastewater treatment facility.

Scaling of the PNEC for aquatic environment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Scaling of the PNEC for soil compartment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1

Workers
Scaling considering duration and frequency of use
Collect process monitoring data with an inhalable sampler. The simultaneous use of a respirable sampler is encouraged. Use aerosol particle size information, when available, to confirm the appropriate use of the inhalable DNEL of 0.05 mg Ni/m³. Respirable fraction exposure levels should be kept below 0.01 mg Ni/m³. See Appendix D6 for site-specific guidance on exposure data collection and Appendix C2 for further details on DNEL derivation.

For further information and guidance on exposure scenarios, available tools, and scaling options, please visit the Nickel Consortia exposure scenario library at the following link: http://www.nickelconsortia.org/exposure-scenario-library.html

9.4.1.1 Summary of the secondary poisoning exposure and risk characterisation assessment for nickel sulphate production

Not relevant

9.4.1.2 Porewater concentrations in the soil compartment for the use of nickel sulphate in the manufacturing of micronutrient additions for biogas production

Not relevant

9.4.1.3 Atmospheric compartment for the manufacturing of micronutrient additions for biogas production

Not relevant

9.4.1.4 Exposure concentrations in on site waste water treatment plants (WWTP) for the manufacturing of micronutrient additions for biogas production

Not relevant

9.4.1.5 Man via Environment exposure and risk characterisation assessments the manufacturing of micronutrient additions for biogas production

Not relevant

9.4.2 GES 8: PRODUCTION OF NICKEL-CONTAINING PIGMENTS FROM NICKEL SULPHATE

1. Title **GES 8 Production of nickel-containing pigments**	
Life cycle	Formulation – DU of $NiSO_4$
Free short title	Production of nickel-containing inorganic pigments from $NiSO_4$
Systematic title based on use descriptor	**SU:** SU 3 Industrial use

	PC: Not relevant **ERC:** ERC 2: Formulation of preparations ERC 5: Industrial use resulting in includsion into or onto a matrix ERC 6a: Industrial use resulting in manufacture of another substance (use of intermediates) SPERC for the production and formulation stage of metal compounds **PROC:** PROC 2 Use in closed, continuous process with occasional controlled exposure (*e.g.* sampling) PROC 4 Use in batch and other process (synthesis) where opportunity for exposure arises PROC 5 Mixing or blending in batch processes for formulation of preparations and articles (multistage and/or significant contact) PROC 8b Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 9 Transfer of substance or preparation into small containers (dedicated filling line, including weighing) PROC 22: Potentially closed processing operations with minerals/metals at elevated temperature PROC 24 High mechanical energy workup of substances bound in materials or articles PROC 26 Handling of solid inorganic substances at ambient temperature
Processes, tasks, activities covered (environment)	Production of inorganic pigments: Dosing and mixing; Drying (if wet mixing); Calcination (charge); Calcination (discharge); Milling (dry or wet); Washing (optional); Drying (if washed); Mixing and/or packaging; Laboratory; Cleaning and maintenance
Processes, tasks, activities covered (workers)	Contributing exposure scenario ES 8.1 PROC 8b: Raw materials handling Contributing exposure scenario ES 8.2 PROC 2, PROC 5, PROC 26: Mixing raw materials Contributing exposure scenario ES 8.3 PROC 4, PROC 9, PROC 22: Drying and Calcining product Contributing exposure scenario ES 8.4 PROC 24: Dry milling Contributing exposure scenario ES 8.5 PROC 22, PROC 24: Wet milling, Washing and Drying Contributing exposure scenario ES 8.6 PROC 9: Blending and packaging Contributing exposure scenario ES 8.7 PROC 0: Cleaning and maintenance
2. Operational conditions and risk management measures	
2.1 Control of environmental exposure	
Environmental related free short title	Production of nickel-containing inorganic pigments from $NiSO_4$
Systematic title based on use descriptor (environment)	ERC2: Formulation of preparations SPERC data for metals and metal compounds for the production and formulation stage of metal compounds such as pigments.
Processes, tasks, activities covered (environment)	Production of inorganic pigments: Dosing and mixing; Drying (if wet mixing); Calcination (charge); Calcination (discharge); Milling (dry or wet); Washing (optional); Drying (if washed); Mixing and/or packaging; Laboratory; Cleaning and maintenance
Environmental Assessment Method	Estimates based on monitoring local and regional concentrations are used for calculation of PEC. SPERCS data for metal and metal compounds are used in order to estimate releases to wastewater for a generic ES with discharge to municipal STP.
Product characteristics	
The tonnage is based on Ni originating from the use of NiO as well as other Ni compounds used at same sites.	
Amounts used	
Maximum daily use at a site	0.4 tonnes (median 50th % emission days, max tonnage)
Maximum annual use at a site	136 tonnes (max, 2007)
Frequency and duration of use	

Pattern of release to the environment	351 days per year per site (median 50th %)
Environment factors not influenced by risk management	
Receiving surface water flow rate	ES 1 Discharge to STP: 200,000 m^3/d ES 2 Direct discharge: 175,000 m^3/d (50th %)
Dilution capacity, freshwater	ES 1 Discharge to STP: 100 ES 2 Direct discharge: 1000 (max)
Dilution capacity, marine	100 (default)
Other given operational conditions affecting environmental exposure	
None	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Waste water: ES 1 Discharge to STP: Off-site wastewater treatment plant, municipal STP Release factor is based on SPERC data for metals and metal compounds for the production and formulation stage of metal compounds such as pigments (90th % release factor for wastewater 0.02%). Release factor: 200 g/T ES 2 Direct discharge: On-site wastewater treatment by chemical precipitation and filtration. Efficiency: 90% Release factor after on-site treatment: 51.5 g/T **Air:** ES 1 and ES 2: Treatment of air emissions by fabric or bag filters. Release factor to air after on-site treatment: 40 g/T (max)	
Organizational measures to prevent/limit release from site	
None	
Conditions and measures related to municipal sewage treatment plant	
Municipal Sewage Treatment Plant (STP)	Yes for ES 1 Discharge to STP
Discharge rate of the Municipal STP	2000 m^3/d (default)
Incineration of the sludge of the Municipal STP	The sludge is applied to agricultural soil
Conditions and measures related to external treatment of waste for disposal	
Ni bearing waste shall be recovered or recycled if possible. Ni bearing waste shall be considered hazardous if the Ni content is above the generic cutoffs (for mixtures) as stated in regulation (EC) No. 1272/2008. Ni bearing waste mixtures may be assessed as substances according to regulation (EC) No. 1272/2008 criteria. Disposal of Ni bearing waste shall comply with local, state or national waste legislation and remains the responsibility of the waste treatment operator.	
Conditions and measures related to external recovery of waste	
Not applicable	
2.2 Control of workers exposure for contributing exposure scenario ES 8.1	
Raw materials handling	
Workers related free short title	Production of nickel-containing inorganic pigments from $NiSO_4$
Use descriptor covered	PROC 8b Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities
Processes, tasks, activities covered	Raw materials handling as reception & dissolution of $NiSO_4$
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.
Product characteristic	
$NiSO_4$ is supplied as a powder which is prepared as a solution for pigment processing	
Amounts used	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant

Area of skin contact with the substance under conditions of use	480 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Manual opening of $NiSO_4$ bags and manual tipping or automatic discharge of $NiSO_4$ powders and other ingredients, including water, into the reactor Oral: Good workplace hygiene practice.	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: The manual opening of bags and tipping of the $NiSO_4$ powder from the bags into the reactor is likely to give rise to significant exposures to inhalable $NiSO_4$. The automated closed conveying of $NiSO_4$ feedstock into reactors and wetting or dissolving of this powder is unlikely to give rise to significant exposures to inhalable $NiSO_4$. Dermal: The manual opening of bags and tipping of the $NiSO_4$ powder from the bags into the reactor is likely to give rise to significant dermal exposures to $NiSO_4$ dust.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes that are not fully enclosed and are likely to give rise to $NiSO_4$ dust, such as opening of bags, charging of reactors or preparing solutions of $NiSO_4$.	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: RPE (FFP1, 2 or 3) {approved with regard to EN 149} is required at process steps that are not fully enclosed and are likely to give rise to Ni dust or fumes. Dermal: Suitable gloves (PVC or equivalent), goggles and special safety clothing are required.	
2.3 Control of workers exposure for contributing exposure scenario ES 8.2	
Mixing raw materials	
Workers related free short title	Production of nickel-containing inorganic pigments from $NiSO_4$
Use descriptor covered	PROC 2: Use in closed, continuous process with occasional controlled exposure (*e.g.* sampling) PROC 5: Mixing or blending in batch processes for formulation of preparations and articles (multistage and/or significant con-tact) PROC 26:Handling of solid inorganic substances at ambient temperature
Processes, tasks, activities covered	Wet or dry automatic mixing of raw materials
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.
Product characteristic	
$NiSO_4$ in a solution and/or wet powder mixture	
Amounts used	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	1980 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Dry or wet (stirring suspensions or solutions) mixing together of all raw materials in a closed reactor Oral: Good workplace hygiene practice.	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: The automated closed conveying of product mix from the wet process is unlikely to give rise to significant exposures to inhalable $NiSO_4$. Automated open conveying of product mix from the dry process may give rise to significant exposures to inhalable $NiSO_4$. Dermal: Containment of the processes should be used where possible to eliminate dermal contact	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes that are not automated or enclosed and are likely to give rise to $NiSO_4$ dust, such as open conveying of dry product mix.	

Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: RPE (FFP1, 2 or 3) {approved with regard to EN 149} is required at process steps that are not fully enclosed and are likely to give rise to Ni dust or fumes. Dermal: Suitable gloves (PVC or equivalent), goggles and special safety clothing are required.	
2.4 Control of workers exposure for contributing exposure scenario ES 8.3	
Drying and calcining of product	
Workers related free short title	Production of nickel-containing inorganic pigments from $NiSO_4$
Use descriptor covered	PROC 4 Use in batch and other process (synthesis) where opportunity for exposure arises PROC 9 Transfer of substance or preparation into small containers (dedicated filling line, including weighing) PROC 22: Potentially closed processing operations with minerals/metals at elevated temperature
Processes, tasks, activities covered	Drying and calcining of wet product mix or calcining of dry product mix
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.
Product characteristic	
Wet granules of or dry $NiSO_4$-containing suspension/mixture	
Amounts used	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	420 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Continuous and automated drying and calcining operation can be performed in tunnel ovens or rotary kilns. During operation of the 'discontinuous' drying and calcining processes, the mixture of raw materials is (manually or automatically) loaded into crucibles and conveyed through the oven on wagons. Then the calcined product is unloaded (manually or automatically) from the crucible and transferred to milling. Oral: Good workplace hygiene practice.	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: The calcining of product mix where ovens are not fully enclosed and where there are manual interventions is likely to give rise to significant exposures to inhalable $NiSO_4$. Automated open conveying of product from the calciner may give rise to significant exposures to inhalable $NiSO_4$. Dermal: Automation and containment of the processes should be used where possible to eliminate dermal contact	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes not fully enclosed and likely to give rise to $NiSO_4$ dust, such as calcining the product in crucibles in a tunnel oven	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: RPE (FFP1) {approved with regard to EN 149} at process steps that are not fully enclosed and are likely to give rise to Ni containing dust , *e.g.* handling of the final product. When handling powders of particle diameter below 10 µm, RPE (FFP2) {approved with regard to EN 149} is required. Dermal: Suitable gloves (PVC or equivalent), goggles and special safety clothing are required.	
2.5 Control of workers exposure for contributing exposure scenario ES 8.4	
Dry milling	
Workers related free short title	Production of nickel-containing inorganic pigments from $NiSO_4$
Use descriptor covered	PROC 24 High mechanical energy workup of substances bound in materials or articles
Processes, tasks, activities covered	Milling of calcined product to a powder
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.

Product characteristic	
Solid Ni-containing calcined product	
Amounts used	
Frequency and duration of use/exposure	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	1980 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
The dry calcined product is milled in an enclosed ball mill and conveyed to packaging. Oral: Good workplace hygiene practice.	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: Not fully enclosed powder transfer operations are likely to give rise to significant exposures to inhalable Ni Dermal: Automation of processes should be used where possible to eliminate dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes not fully enclosed and that are likely to give rise to $NiSO_4$ containing dust	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: RPE (FFP1) {approved with regard to EN 149} at process steps that are not fully enclosed and are likely to give rise to Ni containing dust , *e.g.* handling of the final product. When handling powders of particle diameter below 10 µm, RPE (FFP2) {approved with regard to EN 149} is required. Dermal: Suitable gloves (PVC or equivalent), goggles and special safety clothing are optional.	
2.6 Control of workers exposure for contributing exposure scenario ES 8.5	
Wet milling, Washing and Drying	
Workers related free short title	Production of nickel-containing inorganic pigments from $NiSO_4$
Use descriptor covered	PROC 22 Potentially closed processing operations with minerals/metals at elevated temperature PROC 24 High mechanical energy workup of substances bound in materials or articles
Processes, tasks, activities covered	Calcined $NiSO_4$ products containing salts are ground wet, washed to eliminate excess of soluble salts and dried
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on Tier 1 model.
Product characteristic	
Solid Ni-containing calcined product	
Amounts used	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	1980 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
The dry calcined product is milled wet then washed and dried (atomisers, jet drier) Oral: Good workplace hygiene practice.	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: Not fully enclosed operations for powder drying and transfer are likely to give rise to significant exposures to inhalable Ni Dermal: Automation of processes should be used where possible to eliminate dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes not fully enclosed and likely to give rise to $NiSO_4$-containing dust	
Organisational measures to prevent /limit releases, dispersion and exposure	

None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: RPE (FFP1,) {approved with regard to EN 149} is minimum required for handling final product. Dermal: Suitable gloves (PVC or equivalent), goggles and special safety clothing are optional.	
2.7 Control of workers exposure for contributing exposure scenario ES 8.6	
Blending and packaging	
Workers related free short title	Production of nickel-containing inorganic pigments from $NiSO_4$
Use descriptor covered	PROC 9 Transfer of substance or preparation into small containers (dedicated filling line, including weighing)
Processes, tasks, activities covered	The calcined powder product is blended with additives and packed (bags or big bags)
Assessment Method	Estimation of inhalation exposure based on measured data. Estimation of dermal exposure based on read across from similar process for $NiSO_4$ powder.
Product characteristic	
Ni-containing powder pigment	
Amounts used	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant
Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Oral: Good workplace hygiene practice	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: Automated drum and big bag filling with some manual interventions (such as loading of empty /unloading of full drums, closing of lids and manually adding or removing pellets to achieve the correct mass) during the filling of drums with $NiSO_4$ powder) are likely to give rise to significant exposures to $NiSO_4$ powder and dust Dermal: Automation of processes should be used where possible to eliminate dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required for processes not fully enclosed and that are likely to give rise to $NiSO_4$-containing dust	
Organisational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: RPE (FFP1,) {approved with regard to EN 149} is minimum required for handling final product. When handling powders of particle diameter below 10 µm, RPE (FFP2) {approved with regard to EN 149} is required. Dermal: Suitable gloves (PVC or equivalent), goggles and special safety clothing are required.	
2.8 Control of workers exposure for contributing exposure scenario ES 8.7	
Cleaning and maintenance	
Workers related free short title	Production of nickel-containing inorganic pigments from $NiSO_4$
Use descriptor covered	PROC 0: Cleaning and maintenance
Processes, tasks, activities covered	Cleaning and maintenance operations are regularly performed on-site. This involves cleaning and maintenance of equipment and installations used for handling of raw materials and final product
Assessment Method	Estimation of inhalation exposure and dermal exposure based on Tier 1 model.
Product characteristic	
Variable includes powders and more coarse residues	
Amounts used	
Frequency and duration of use/exposure	
8 hour shifts	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Not relevant
Room size and ventilation rate	Not relevant

Area of skin contact with the substance under conditions of use	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
None	
Technical conditions and measures at process level (source) to prevent release	
None	
Technical conditions and measures to control dispersion from source towards the worker	
Local and general exhaust ventilation	
Organisational measures to prevent /limit releases, dispersion and exposure	
Oral: Good workplace hygiene practice	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: RPE (FFP1, APF 20) is required. Dermal: Suitable gloves (PVC or equivalent), goggles and special safety clothing are required.	

3. Exposure and risk estimation

Environment

ERC2, ERC 5, ERC 6a SPERC: Production and formulation of metal compounds
Production of nickel-containing inorganic pigments from NiO

Compartment	Unit	PNEC	$PEC_{Regional}$	C_{local}	PEC	RCR	Methods for calculation of environmental concentrations
Freshwater ES1 Discharge to STP	µg Ni/L	3.55	2.9	0.17	3.07	0.86	Measured values, Tier 3-RWC
Freshwater ES2 Direct discharge	µg Ni/L	3.55	2.9	0.08	2.98	0.84	
Marine ES1 and ES2	µg Ni/L	8.6	0.3	0.82	1.12	0.13	
Terrestrial ES1 Discharge to STP	mg Ni/kg	29.9	16.2	0.73	16.93	0.57	
Terrestrial ES2 Direct discharge	mg Ni/kg	29.9	16.2	0.002	16.2	0.54	
STP	mg Ni/kg	0.33	-	-	0.023	0.07	

Workers

ES 8.1
PROC 8b: Raw Materials Handling (reception & dissolution of $NiSO_4$)

	Unit	DNEL $NiSO_4$	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR	-	
Acute local	mg Ni/cm^2/day	-	NR	-	
Long-term systemic	mg Ni/kg/day	-	NR	-	
Long-term local	mg Ni/cm^2/day	0.00044	6×10^{-6}	0.014	90th percentile from MEASE modeling (PROC 8b, enclosed, LEV, <1 h duration, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.018	1.13×10^{-3}	Estimated as 3 x the long-term value.
Acute local	mg Ni/m^3	0.7	0.018	0.026	
Long-term systemic	mg Ni/m^3	0.05	0.006	0.12	Based on 7 personal

					exposure measurements for dosing and mixing
Long-term local	mg Ni /m^3	0.05	0.006	0.12	

ES 8.2
PROC 2, PROC 5 & PROC 26: Mixing (preparation of granular pigment precursor)

	Unit	DNEL $NiSO_4$	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR	-	
Acute local	mg Ni/cm^2/day	-	NR	-	
Long-term systemic	mg Ni/kg/day	-	NR	-	
Long-term local	mg Ni/cm^2/day	0.00044	6 x 10^{-6}	0.014	90th percentile from MEASE modelling (PROC 5, enclosed, LEV., <1 h duration, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.009	5.63 x10^{-4}	Estimated as 3x the long-term value.
Acute local	mg Ni/m^3	0.7	0.009	0.013	
Long-term systemic	mg Ni/m^3	0.05	0.003	0.06	Based on 8 personal exposure measurements for dosing and mixing
Long-term local	mg Ni /m^3	0.05	0.003	0.06	

ES 8.3
PROC 22: Drying and calcining product

	Unit	DNEL $NiSO_4$	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR	-	
Acute local	mg Ni/cm^2/day	-	NR	-	
Long-term systemic	mg Ni/kg/day	-	NR	-	
Long-term local	mg Ni/cm^2/day	0.00044	0.00005	0.114	90th percentile from MEASE modelling (PROC22, LEV, duration >4 h, with manual intervention as incidental handling, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.06	3.8 x10^{-3}	3 x long term exposure measurement for charging the crucibles.
Acute local	mg Ni/m^3	0.7	0.06	0.09	
Long-term systemic	mg Ni/m^3	0.05	0.02	0.4	Based on 8 personal exposure measurements assigned to charging the crucibles.
Long-term local	mg Ni /m^3	0.05	0.02	0.4	

ES 8.4
PROC22: Dry Milling

	Unit	DNEL $NiSO_4$	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					

Acute systemic	mg Ni/kg/day	-	NR	-	
Acute local	mg Ni/cm^2/day	-	NR	-	
Long-term systemic	mg Ni/kg/day	-	NR	-	
Long-term local	mg Ni/cm^2/day	0.00044	0.00003	0.07	90th percentile from MEASE modelling (PROC22, enclosed, duration > 4 h, automated, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.12	7.5 x10^{-3}	Estimated as 3x the long-term value. A factor of 3 was considered sufficient to account for the limited dataset.
Acute local	mg Ni/m^3	0.7	0.12	0.17	
Long-term systemic	mg Ni/m^3	0.05	0.04	0.8	Based on a single personal exposure measurement, reported for milling. Assumed to be inhalable fraction.
Long-term local	mg Ni /m^3	0.05	0.04	0.8	
ES 8.5 PROC 24: Wet milling, washing and drying					
	Unit	DNEL $NiSO_4$	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR	-	
Acute local	mg Ni/cm^2/day	-	NR	-	
Long-term systemic	mg Ni/kg/day	-	NR	-	
Long-term local	mg Ni/cm^2/day	0.00044	0.00003	0.07	90th percentile from MEASE modelling (PROC24, enclosed, duration > 4 h, automated, gloves)
Inhalation					
Acute systemic	mg Ni/m^3	16	0.012	7.5 x10^{-3}	Estimated as 3x the long-term value. A factor of 3 was considered sufficient to account for the limited dataset.
Acute local	mg Ni/m^3	0.7	0.012	0.017	
Long-term systemic	mg Ni/m^3	0.05	0.004	0.08	Based on a single personal exposure measurement for drying final product
Long-term local	mg Ni /m^3	0.0	0.004	0.08	
ES 8.6 PROC 9: Mixing and/or packaging					
	Unit	DNEL $NiSO_4$	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR	-	
Acute local	mg Ni/cm^2/day	-	NR	-	
Long-term systemic	mg Ni/kg/day	-	NR	-	
Long-term local	mg Ni/cm^2/day	0.00044	0.00086 0.00043	1.95 0.98 for 4 h exposure	Read across 75th percentile for personal exposure measurement (face) reported for an analogous operation for packaging of $NiSO_46H_2O$

				duration and when this duration is exceeded worker would have to wash hands and replace gloves in order to continue working	and nickel hydroxycarbonate
Inhalation					
Acute systemic	mg Ni/m³	16	0.3	0.02	10 x long term exposure measurement based on handling powders during packaging. A factor of 10 was considered sufficient to account for the limited dataset.
Acute local	mg Ni/m³	0.7	0.3	0.43	
Long-term systemic	mg Ni/m³	0.05	0.03	0.6	Based on 5 personal exposure measurements for mixing and/or packaging
Long-term local	mg Ni /m³	0.05	0.03	0.6	
ES 8.7 PROC 0: Cleaning and Maintenance					
	Unit	DNEL $NiSO_4$	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mg Ni/kg/day	-	NR	-	
Acute local	mg Ni/cm²/day	-	NR	-	
Long-term systemic	mg Ni/kg/day	-	NR	-	
Long-term local	mg Ni/cm²/day	0.00044	0.00003	0.07	90th percentile from MEASE modelling (PROC10, no direct handling, non dispersive techniques, < 4 hours, gloves)
Inhalation					
Acute systemic	mg Ni/m³	16	1.026	0.064	3 x read across exposure value
Acute local	mg Ni/m³	0.7	1.026	1.47 excl. RPE By use of RPE (P3, APF 10): 0.15.	
Long-term systemic	mg Ni/m³	0.05	0.342	6.84 excl. RPE By use of RPE (P3,	Based on a read across from an solution/suspension preparation operation in the catalyst industry

				APF 20): 0.34	
Long-term local	mg Ni /m³	0.05	0.342	6.84 excl. RPE By use of RPE (P3, APF 20): 0.34	
NR: Not Relevant Acute local inhalation Based on respirable size aerosols. Equivalent inhalable fraction levels expected to be at least 3-fold higher					

4. Guidance to DU to evaluate whether he works inside the boundaries set by the ES

Environment

Scaling tool: Metals EUSES IT tool (free download: http://www.arche-consulting.be/Metal-CSA-toolbox/du-scaling-tool)

Scaling of the release to air and water environment includes:
Refining of the release factor to air and waste water and/or and the efficiency of the air filter and wastewater treatment facility.

Scaling of the PNEC for aquatic environment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1.

Scaling of the PNEC for soil compartment by using a tiered approach for correction for bioavailability and background concentration (C_{local} approach). See Appendix D1.

Workers

Scaling considering duration and frequency of use
Collect process monitoring data with an inhalable sampler. The simultaneous use of a respirable sampler is encouraged. Use aerosol particle size information, when available, to confirm the appropriate use of the inhalable DNEL of 0.05 mg Ni/m³. Respirable fraction exposure levels should be kept below 0.01 mg Ni/m3. See Appendix D6 for site-specific guidance on exposure data collection and Appendix C2 for further details on DNEL derivation.

For further information and guidance on exposure scenarios, available tools, and scaling options, please visit the Nickel Consortia exposure scenario library at the following link: http://www.nickelconsortia.org/exposure-scenario-library.html

9.4.2.1 Summary of secondary poisoning exposure and risk characterisation assessments for production of nickel containing pigments from nickel sulphate

The methodology applied to assess secondary poisoning is extracted from the European Union Risk Assessment for Nickel (2008-2009). A detailed report on the methodology used to derive the $PNEC_{oral}$ and bioaccumulation factors (BAF) are provided in Appendix D3.

Table 109. Freshwater aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (European Otter)

Selected exposure Scenario	PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	$PEC_{oral\ mollusk}$ (mg/kg wet mollusk)	PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1	PEC/PNEC Aquatic mammal (European Otter) PNEC=2.3 mg/kg; RAF=0.025
Selected for ES 1 Freshwater – to STP	0.0031	0.0029	0.80	0.07	0.009
Selected for ES 2 Freshwater –	0.0030	0.0029	0.79	0.07	0.009

direct discharge to water					

Table 110. Marine aquatic food chain: concentration, PECoral and risk characterisation for mollusk-eating birds (Oystercatcher) and mammals (Harbor seal). Two scenarios are assumed: C. edule present and C. edule absent.

PEC_{local} water (mg/L)	$PEC_{regional}$ water (mg/L)	$PEC_{oral\ mollusk}$ (mg/kg wet mollusk)		PEC/PNEC Aquatic bird (Oystercatcher) PNEC=12.3 mg/kg; RAF=1		PEC/PNEC Aquatic mammal (Harbor seal) PNEC=4.6 mg/kg; RAF=0.025	
		C. edule present BAF=1631 L/kg	*C. edule* absent BAF=270 L/kg	*C. edule* present BAF=1631 L/kg	*C. edule* absent BAF=270 L/kg	*C. edule* present BAF=1631 L/kg	*C. edule* absent BAF=270 L/kg
0.0011	0.0003	1.13	0.19	0.092	0.015	0.0061	0.0010

Table 111. Terrestrial food chain: concentration, PECoral and risk characterisation for worm-eating birds and mammals

PEC in soil compartment (mg/kg)	Regional soil background concentration (mg/kg)	$PEC_{oral\ local}$ Tissue + gut 100% worms (mg/kg ww)	$PEC_{oral\ local}$ Tissue + gut 30% worms 70% isopods (mg/kg ww)	PEC/PNEC Birds (starling) PNEC=8.5 mg/kg RAF=1	PEC/PNEC Mammals (shrew) 100% worms PNEC=0.12 mg/kg RAF=0.036	PEC/PNEC Mammals (shrew) 30% worms 70% isopods PNEC=0.12 mg/kg RAF=0.025
Selected for Exposure Scenario 1 – STP scenario sludge application	16.93	16.20	2.45	1.00	0.29	0.74
Selected for Exposure Scenario 2 no sludge application	16.20	16.20	2.40	0.98	0.28	0.72

9.4.2.2 Summary of porewater concentrations in the soil compartment for production of nickel containing pigments from nickel sulphate

The derived $PEC_{porewater}$ for the generic scenario is 0.025 mg Ni/L. More details for the calculation of the $PEC_{porewater}$ are provided in Appendix D3.

Table 112. Predicted Exposure Concentrations (PEC) in porewater

Exposure scenario selected	PEC local porewater (mg Ni/L)
Selected for Exposure Scenario 1 – STP scenario sludge application	0.026
Selected for Exposure Scenario 2 no sludge application	0.025

9.4.2.3 Summary of atmospheric compartment for production of nickel containing pigments from nickel sulphate

An overview of the local air concentrations and PEC in the air compartment are provided in the assessment for Man via the Environment below or Appendix D5.

9.4.2.4 Summary of exposure concentrations in on site waste water treatment plants (WWTP) for production of nickel containing pigments from nickel sulphate

Table 113 reports the calculated Ni concentration in the effluent of the on-site WWTP (see Appendix D3).

Table 113. Concentrations in on-site waste water treatment plant

Selected exposure scenarios	Calculated effluent concentration in on-site WWTP (mg Ni/L)
Selected for ES 2 Freshwater – direct discharge to water	0.11
Selected for ES Marine	0.11

9.4.2.5 Summary of Man via Environment exposure and risk characterisation assessments for production of nickel containing pigments from nickel sulphate

For each sector, an overview of the range of operational conditions (OCs) and predicted C_{local} air and PEC air are given below. To assess whether a site is compliant with the GES, the predicted C_{local} needs to be compared to 11.5 ng Ni/m^3 or the measured PEC needs to be compared to the DNEL of 20 ng Ni/m^3. An assessment of predicted level of compliance for this sector based on site-specific measured or predicted exposures is provided in Section 5 of Appendix D5.

Table 114. Sector overview

	tonnage (T/year)	daily emissions to air (kg/d)	release factor to air (g/T)	Emission days to air per site (d/y)	C_{local}, air* (ng Ni/m^3)	PEC air$ (ng Ni/m^3)
min	257	0.01	7	200	1	10
max	1840	0.21	72	365	8	16
median	690	0.14	68	350	2	11

**: based based on different air models (EUSES, GPM, IFDM)*
$: based on C_{local} predicted + regional background.

10. RISK CHARACTERISATION (CSR SECTION 10 IS COMBINED WITH CSR SECTION 9 ABOVE)

The content regarding Risk Characterisation was combined with the Exposure Assessment content located in CSR Section 9. Please refer to CSR Section 9 for Risk Characterisation.