1. Title GES 34 Use of Ni metal for Thermal Spraying	Version 5, 2015
Life cycle	Thermal Spraying – DU of Ni metal
Free short title	Use of Ni metal for Thermal Spraying
Systematic title based on use descriptor	SU: SU 3 Industrial manufacturing PC: PC 7 base metals and alloys PC 14 Metal surface treatment products PC 15 Non metal surface treatment products PC 38 welding and soldering products ERC: ERC 7 Industrial use of substances in closed systems ERC 5 Industrial use resulting in includsion into or onto a matrix ERC 12b Industrial processing of articles with abrasive techniques SPERC: Use of metals and metal compounds in metallic coatings PROC: PROC 0 Cleaning and Maintenance PROC 7 Industrial Spraying PROC 8b Transfer of substance into large containers PROC 9 Transfer of substance into small containers PROC 10 Roller application or brushing PROC 23 Open processing and transfer operations with minerals/metals at elevated temperature PROC 24 High (mechanical) energy work-up of substances bound in articles PROC 25 Other hot work operations with metals (welding/soldering)
Processes, tasks, activities covered (environment)	Use of Ni metal for thermal spraying (including hand-operated metal spraying using powder, semi-automatic metal spraying using powder or wire, plasma thermal spraying, and flame spraying)
Processes, tasks, activities covered (workers)	Contributing exposure scenario ES 34.1: PROC 8b, 9: Raw material handling Contributing exposure scenario ES 34.2: PROC 7, 10, 23, 24, 25: Hand operated metal spraying operations Contributing exposure scenario ES 34.3 PROC 7, 10, 23, 24, 25: Thermal spraying/coating operations Contributing exposure scenario ES 34.4: PROC 0: Cleaning and maintenance operations
2. Operational conditions and risk management measures	
2.1 Control of environmental exposure	
Environmental related free short title	Use of Ni metal for Thermal Spraying
Systematic title based on use descriptor (environment)	ERC7 - Industrial use of substances in closed systems ERC5 - Industrial use resulting in includsion into or onto a matrix ERC12b - Industrial processing of articles with abrasive techniques
Processes, tasks, activities covered (environment)	Use of Ni metal for Thermal Spraying
Environmental Assessment Method	Estimates based on the ARCHE/EUROMETAUX SPERC factsheet: Use of metals and metal compounds in metallic coating v1.1 are used for calculation of air PEC
Product characteristics	
Ni powder	
Amounts used	
Maximum daily use at a site	0.02 tonnes
Maximum annual use at a site	5 tonnes
Frequency and duration of use	
Pattern of release to the environment	Water: No discharge to water Air: 240 days per year per site
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	

Ni powder packed in small 5 kg cans is used and sprayed using a closed dispenser. The spraying process is done inside a cubicle with ventilation and filtration systems.

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

Thermal spraying shall be done in an enclosed system such as a sound proof booth with powerful ventilation.

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

Waste water:
No waste water is produced

Air:
Treatment of air emission by use of fabric or bag filters, ceramic filters, wet scrubbers, dry or semi-dry scrubbers or electrostatic precipitation
Efficiency 95-99 %,
The ventilation shall be equipped with highly efficient dust collectors with efficiency of 99% to 99.99% on particles that are less than 3 micron.
Release factor to air after on-site treatment: 5000 g/T (Sperc for industrial use in metallic coating)

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

Hazardous wastes from onsite risk management measures and solid or liquid wastes from production, use and cleaning processes should be disposed of separately to hazardous waste incineration plants or hazardous waste landfills as hazardous waste. Releases to the floor, water and soil are to be prevented. If the nickel content of the waste is elevated enough, internal or external recovery/recycling might be considered.

Fraction of daily/annual use expected in waste:

- Nickel producers = 0.05 %
- DU: stainless steel and alloy steels = 0.6 %
- DU: nickel alloys, copper alloys, foundry, batteries, catalysts, chemicals, dyes and others = 0.5 %
- DU: Plating = 3%

Appropriate waste codes:

01 03 07*, 02 01 10*, 06 03 13*, 06 03 15*, 06 04 05*, 06 05 02*, 10 08 04, 10 08 08*, 10 08 09, 10 08 15*, 10 08 16, 10 10 03, 10 10 05*, 10 10 07*, 10 10 09*, 10 10 10, 10 10 11*, 11 02 07*, 12 01 03*, 12 01 04, 15 01 04*, 15 01 10*, 16 01 04*, 16 01 06*, 16 01 08*, 16 06 02*, 16 06 05, 16 08 02*, 16 08 03*, 17 04 07*, 17 04 09*, 19 09 04*, 19 10 02*, 19 12 03*

Suitable disposal: Keep separate and dispose of to either

- Hazardous waste incineration operated according to Council Directive 2008/98/EC on waste, Directive 2000/76/EC on the incineration of waste and the Reference Document on the Best Available Techniques for Waste Incineration of August 2006.
- Hazardous landfill operated under Directive 1999/31/EC.

Conditions and measures related to external recovery of waste

Shredders pre-treating metal wastes should have a maximum release factors to air of 0.0015 after RMM and no releases to water and soil.

Qmax, local(shredding)=26kg Ni/day

(Note: This Qmax, local for shredders is based on the existing information at the moment of the update. It will be reviewed when new information is available from the BREF for shredding)

2.2 Control of workers exposure for contributing exposure scenario 34.1

Raw Material Handling

Workers related free short title	Use of Ni metal for Thermal Spraying
Use descriptor covered	PROC 8b: Transfer of substance into large containers. PROC 9: Transfer of substance into small containers.

Processes, tasks, activities covered	Raw material handling activities include transfer of substances into small containers, filling of powder feed hoppers, sampling, and emptying of extraction system waste bins
Assessment Method	Estimation of exposure based on measured data and tier 1 model
Product characteristic	
Ni powder, wire, rod, or cord. Quantity and quality may vary (100% Ni or in mixture)	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
8 hour shift The actual pattern of exposure is determined by activity patterns, level of automation and mechanisation of activities.	
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	
All processes may be automated (eg. operation carried out from control room) depending on the facility. Employees may be required to manually open the doors to the spraying area at the end of each operation, remove the sprayed component and replace with another to be sprayed.	
Technical conditions and measures at process level (source) to prevent release	
Use of closed dispensers in a closed cubicle.	
Technical conditions and measures to control dispersion from source towards the worker	
The closed cubicle shall be equipped with LEV and filtration for transfer of powder into cans. Orinasal respiratory protection shall be worn whilst carrying out the filling of hoppers with powders and the emptying of the waste bins.	
Organizational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Use of respiratory protection equipment (RPE, APF 10) and the use of suitable impervious disposable gloves to reduce potential contact is required.	
2.3 Control of workers exposure for contributing exposure scenario 34.2	
Hand operated metal spraying operations.	
Workers related free short title	Use of Ni metal for Thermal Spraying
Use descriptor covered	PROC 7 – Industrial spraying PROC 10 – Low energy spreading and coating PROC 23 - Open processing and transfer operations with minerals/metals at elevated temperature PROC 24 - High (mechanical) energy work-up of substances bound in articles PROC 25 - Other hot work operations with metals (welding/soldering)
Processes, tasks, activities covered	Metal spraying operations in a spray booth.
Assessment Method	Estimation of exposure based on measured data and tier 1 model
Product characteristic	
Ni metal is present in the powder form at a concentration of 100% Ni or in mixture	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
8 hour shift depending on the facility. Operators perform spraying operations on average of 2 to 3 hours per 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	1980 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	

Metal spraying is performed in a booth using a hand-operated spray gun. The operator stands close to the face of the booth during spraying. Nickel is supplied to the gun in powder form and heated to the plastic or molten state in the oxy-fuel gas flame. It is propelled on to the prepared substrate by the expanding fuel gas. Booths are equipped with extraction systems. The ventilation or extraction systems are equipped with highly efficient dust collectors. Current technology is 99% to 99.99% efficient.	
Technical conditions and measures at process level (source) to prevent release	
Potential exposure may be reduced by increasing automation and mechanisation of the process.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV and/or booth extraction system is required.	
Organizational measures to prevent /limit releases, dispersion and exposure	
None.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Compressed air fed visor, RPE (FFP2, APF 10) and proper gloves is required. Half-face mask is optional.	
2.4 Control of workers exposure for contributing exposure scenario 34.3	
Thermal spraying/coating operations	
Workers related free short title	Use of Ni metal for Thermal Spraying
Use descriptor covered	PROC 7 – Industrial spraying PROC 10 – Low energy spreading and coating PROC 23 - Open processing and transfer operations with minerals/metals at elevated temperature PROC 24 - High (mechanical) energy work-up of substances bound in articles PROC 25 - Other hot work operations with metals (welding/soldering)
Processes, tasks, activities covered	Thermal spraying including flame spraying, arc spraying and plasma spraying.
Assessment Method	Estimation of exposure based on measured data and tier 1 model
Product characteristic	
Quantity and quality may vary (100% Ni or mixture in powder, wire, rod, or cord form)	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
<8 hour shift depending on the facility. Typically less than 4hrs of actual spraying time in a shift. The actual pattern of exposure is determined by activity patterns, use of control rooms and level of automation and mechanisation of activities.	
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	1500 cm^2
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
In flame spraying operations Nickel is supplied to spray guns in the form of powder, rod, cord or wire. This material is heated to molten state by the oxy-fuel flame and then propelled in atomized form on to a substrate by compressed air. Variations in the process include use of higher gas pressure to obtain finer atomization, the point of injection of nickel material and use of fuel to heat the nickel substance to molten state. For example, in HVOF (high velocity oxy fuel) spraying fuel gases are combusted and propelled at supersonic speeds. The powder is injected into the effluent stream of the HVOF device in a defined, controlled and continuous basis during spraying. Arc spraying utilises an electric arc between two nickel wires to melt their tips. A jet or jets of gas, usually compressed air, atomises the molten metal and projects the particles on to the prepared substrate. In plasma spraying, a plasma jet is used to heat the spray material to a molten state and project onto a substrate. Spraying operations are conducted in semi-automated or fully automated spray booths and operated from a control room. Over sprayed material is disposed using an extraction system. Spraying operations are conducted in semi-automated or fully automated spray booths and operated from a control room. Time spent spraying that is not directed at the substrate within the booths must be as short as possible.	
Technical conditions and measures at process level (source) to prevent release	
Closed system is required. Potential exposure may be reduced by increasing mechanisation and automation of the process.	
Technical conditions and measures to control dispersion from source towards the worker	
Closed process carried out with LEV and filtration systems. The worker is removed from the spraying operation by a ventilated enclosure (coating booth)	

Organizational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Use of respiratory protective equipment (RPE, APF 10) for operators carrying out metal spraying operations, in the form of Kemira, backpack filteres, compressed air fed visor, disposable FFP2 half face mask, or orinasal respirators, and proper gloves is required.	
2.5 Control of workers exposure for contributing exposure scenario 34.4	
Cleaning and Maintenance Operations	
Workers related free short title	Use of Ni metal for Thermal Spraying
Use descriptor covered	PROC 0: cleaning and maintenance
Processes, tasks, activities covered	Cleaning and maintenance of machinery
Assessment Method	Estimation of exposure based on measured data and tier 1 model
Product characteristic	
Quantity and quality may vary (100% Ni or mixture in powder, wire, rod, or cord form)	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
<8 hour shift depending on the facility, however the cleaning of machinery is done less than 10% of the work shift (coating and handling of parts is the focus of the work shift. The actual pattern of exposure is determined by activity patterns, use of control rooms and level of automation and mechanisation of activities.	
Human factors not influenced by risk management	
Respiration volume under conditions of use	Light to medium level work, 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	Not relevant
Other given operational conditions affecting workers exposure	
Cleaning and maintenance work of plant and premises can include scheduled regular and intermittent/occasional tasks of long and short duration which lead to potentially high exposures to dust. The cleaning work is done with the use of HEPA vacuums, not compressed air to control the exposures (not sweeping or blowing off with compressed air). Maintain clean workplace 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	
None	
Technical conditions and measures to control dispersion from source towards the worker	
Cleaning of the area is carried out by the operators using a HEPA filtered vacuum cleaner.	
Organizational measures to prevent /limit releases, dispersion and exposure	
None	
Conditions and measures related to personal protection, hygiene and health evaluation	
Employees carrying out the cleaning work must wear a disposable overall and a disposable half face mask respirator conforming to European Standard EN149 FFP2 Use of RPE (Racal Airstream, or similar, powered helmet respirator, fitted with either a P2 or P3 particulate filter) is required. Face shields and Pulsafe airline-fed visors is required for use when carrying out cleaning operations.	
3. Exposure and risk estimation	

Environment

ERC 5, 7, 12b,
Use of Ni metal for Thermal Spraying

compartment	Unit	PNEC	$PEC_{Regional}$	C_{local}	PEC	RCR	Methods for calculation of environmental concentration and PNEC
Freshwater	µg/L	-	-	-	-	-	No emission to water
Marine	µg/L	-	-	-	-	-	No emission to water
Sediment	mg/kg	-	-	-	-	-	No emission to water
Terrestrial	mg/kg	29.9	16.2	0.01	16.21	0.54	Estimated values, Tier 3-RWC
STP	mg/L	0.33	-	-	-	-	No emission to water

Workers

ES 34.1
PROC 8b, 9: Raw material handling.

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mgNi/kg/day	-	NR		
Acute local	mgNi/cm^2/day	-	NR		
Long-term systemic	mgNi/kg/day	-	NR		
Long-term local	mgNI/cm^2/day	0.035	0.00005	0.0014	Exposure calculated using MEASE, a Tier 1 model for PROC 8b. The process is assumed to be carried out in a closed system without breaches, with direct handling of a solid with medium dustiness. It is assumed that workers wear gloves and only incidental exposure occurs.
Inhalation					
Acute local	mgNi/m^3	4	< 0.01	< 0.0025	Based on two personal sampling measurements during a transfer operation
Long-term systemic and local	mgNi/m^3	0.05	< 0.01	< 0.2	Assumed to be same as acute exposure as a conservative estimate in the absence of measured data.

ES 34.2
PROC 7, 10, 23, 24, 25: Hand operated metal spraying operations

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mgNi/kg/day	-	NR		
Acute local	mgNi/cm^2/day	-	NR		
Long-term systemic	mgNi/kg/day	-	NR		
Long-term local	mgNi/cm^2/day	0.035	0.00005	0.0014	Exposure calculated using MEASE, a Tier 1 model for PROC 7. The process is assumed to be carried out in a closed system without breaches, with non-direct handling. It is assumed that workers wear gloves and only incidental exposure occurs.
Inhalation					
Acute local	mgNi/m^3	4	0.56	0.14	Maximum of 4 available short-term personal monitoring measurements taken during hand operated metal spraying using powder.
Long-term systemic	mgNi/m^3	0.05	< 0.05	< 1.0	Estimated 75th percentile

and local					value from monitoring data (n = 635) for thermal spraying operations. Some measurements used RPE (FFP2), proper gloves, LEV. 92% of measured values were ≤ 0.05. Therefore, the 75th percentile exposure value is most likely to be < 0.05.

ES 34.3
PROC 7, 10, 23, 24, 25: Thermal spraying including flame spraying, arc spraying and plasma spraying

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mgNi/kg/day	-	NR		
Acute local	mgNi/cm²/day	-	NR		
Long-term systemic	mgNi/kg/day	-	NR		
Long-term local	mgNi/cm²/day	0.035	0.00005	0.0014	Exposure calculated using MEASE, a Tier 1 model for PROC 7. The process is assumed to be carried out in a closed system without breaches, with non-direct handling. It is assumed that workers wear gloves and only incidental exposure occurs.
Inhalation					
Acute local	mgNi/m³	4	< 0.15	< 0.0375	3x the long-term exposure estimate based on measured data.
Long-term systemic and local	mgNi/m³	0.05	< 0.05	< 1.0	Estimated 75th percentile value from monitoring data (n = 635) for thermal spraying operations. Some measurements used RPE (FFP2), proper gloves, LEV. 92% of measured values were ≤ 0.05. Therefore, the 75th percentile exposure value is most likely to be < 0.05.

ES 34.4
PROC 0: Cleaning and maintenance operations

	Unit	DNEL	Exposure concentration	RCR	Methods for calculation of exposure
Dermal					
Acute systemic	mgNi/kg/day	-	NR		
Acute local	mgNi/cm²/day	-	NR		
Long-term systemic	mgNi/kg/day	-	NR		
Long-term local	mgNi/cm²/day	0.035	0.00005	0.0014	Exposure calculated using MEASE for PROC 10. The process is assumed to be

					carried out in a closed system without breaches, with non-direct handling. It is assumed that workers wear gloves and only incidental exposure occurs.
Inhalation					
Acute local	mgNi/m^3	4	0.59	0.147	The maximum of 6 available short-term measurements taken during repair operations. RPE, powered helmet respirator /face shields, gloves, LEV
Long-term systemic and local	mgNi/m^3	0.05	0.028	0.56	Exposure calculated using MEASE for PROC 10. The process is assumed to be carried out in a closed system without breaches. It is assumed that LEV is used and that only incidental exposure occurs to >25% Ni content in preparations.

NR: Not Relevant

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

4. Guidance to evaluate whether the 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).

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

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..

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.eu/exposure-scenario-library.html

Man via Environment exposure and risk characterisation assessments for thermal spraying

Inhalation is the critical exposure pathway for humans via the environment. The PEC for air at site neighbouring residential areas should be lower than the chronic inhalation DNEL for the general public of 20 ng Ni/m^3 as annual average in PM_{10} in order to demonstrate adequate control of risk (RCR < 1) for Man via the Environment

(MvE).

Hereto a Generic safe use Exposure Scenario for MvE was developed based on the EUSES model. The MvE GES is defined as the product of tonnage (T) and emission factor to air (EF) being lower than 18000 g Ni/year. The value of 18000 g Ni/year is derived by using EUSES model to back-calculate the product of T and EF that results in a local air concentration (C_{local}) of 15.5 ng Ni/m^3. The value of 15.5 is derived from the difference between the DNEL of 20 ng Ni/m^3 and the EU regional background concentration ($C_{regional}$) of 4.5 ng Ni/m^3 (P90 annual concentration for 2012).

Generic safe use ES for all sectors according to Tier 1 (EUSES model)

Sector	**Tonnage (Ni T /year)**	**Emission factor (g Ni/T)**	**Tonnage × emission factor (g /year)**	**C_{local} (ng/m^3)**	**$C_{regional}$ (ng/m^3)**	**PEC_{local} (ng/m^3)**	**RCR = PEC/DNEL (DNEL= 20 ng/m^3)**
All	T	EF	T × EF < 18000	<15.5	4.5*	<20	<1

**: EU average of country P90 annual Ni concentrations (2012)*

If a site is not compliant with these conditions, meaning that the product of tonnage and emission factor is above 18000 g Ni/year, a tiered approach including site-specific modelling can be applied to demonstrate safe use