1. Title GES 9 Powder metallurgy	Version 6, 2015
Life cycle	Powder metallurgy
Free short title	Use of nickel metal in powder metallurgy
Systematic title based on use descriptor	SU: SU 3: Industrial use SU 17: General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment PC: PC 0: Other uses ERC: ERC 5: Industrial use resulting in inclusion into or onto a matrix PROC: PROC 3: Use in closed batch process (synthesis or formulation) 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 14: Production of preparations or articles by tabletting, compression, extrusion, pelletisation 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 27a Production of metal powders (hot processes) PROC 0: Cleaning and maintenance
Processes, tasks, activities covered (environment)	Use of nickel metal or metal alloy is prepared in powder form and this is processed into solid components using powder metallurgy techniques
Processes, tasks, activities covered (workers)	Contributing exposure scenario CES 9.1 PROC 8b: Raw materials (crude powder) handling Contributing exposure scenario CES 9.2 PROC 3, PROC 22, PROC 27a: Powder preparation-Furnacing and atomisation Contributing exposure scenario CES 9.3 PROC 24: Powder finishing- crushing, milling and sieving Contributing exposure scenario CES 9.4 PROC 3: Powder blending and packaging Contributing exposure scenario CES 9.5 PROC 5, PROC 8b: Powder mixing Contributing exposure scenario CES 9.6 PROC 8b, PROC 14: Powder pressing Contributing exposure scenario CES 9.7 PROC 22: Sintering compacted form Contributing exposure scenario CES 9.8 PROC 14: Injection moulding Contributing exposure scenario CES 9.9 PROC 22: Post-sintering operations Contributing exposure scenario CES 9.10 PROC 0: Cleaning & Maintenance
2. Operational conditions and risk management measures	
Use of nickel metal in powder metallurgy	
Use of nickel metal in powder metallurgy	Use of nickel powder in production of parts by pressing, sintering, injection and moulding operations
Systematic title based on use descriptor (environment)	ERC 5: Industrial use resulting in inclusion into or onto a matrix
Processes, tasks, activities covered (environment)	Use of nickel powder in production of parts by pressing, sintering, injection and moulding operations.
Environmental Assessment Method	Estimated local concentrations based on measurements by industry and

	measured regional concentrations are used for calculation of PEC
Product characteristics	
Nickel powder < 200 µm, 1-50% nickel in product	
Amounts used	
Maximum daily use at a site	19 tonnes/ day (50th % emission days, max tonnage)
Maximum annual use at a site	4782 tonnes Ni/ yr (max, 2007)
Frequency and duration of use	
Pattern of release to the environment	248 days per year (50th %)
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	
None	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Waste water: No discharge via waste water **Air:** Treatment in exhaust system (fabric or bag filters) Release factor after on-site treatment: 0.01 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)	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 9.1	
Raw materials handling	
Workers related free short title	Use of nickel metal in powder metallurgy
Use descriptor covered	PROC 8b:Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities
Processes, tasks, activities covered	Iron (scrap iron and fine powder) and nickel (pellets and fine powder) are received into storage for processing.
Assessment Method	Estimation of inhalation exposure using a Tier 1 model (MEASE). Estimation of dermal exposure by read across from the electrolytic Ni refining.
Product characteristic	
Nickel metal as powder or pellets Nickel oxide (NiO) as powder	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
The raw materials handling process lasts for up to an hour over every 8 hour shift.	
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	Not relevant
Body weight	70 kg
Other given operational conditions affecting workers exposure	
LEV is required for processes that are not fully enclosed and are likely to give rise to Ni dust, such as discharging from bulk tanker or rail wagon into silos or intermediate storage. 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	
Inhalation: Automation with complete enclosure of nickel transfer operations is likely to give rise to insignificant exposures to inhalable Ni metal. 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 to extract the dust for processes that are not fully enclosed and are likely to give rise to Ni metal particulate such as discharging of tankers when sending the raw material to storage.	
Organisational measures to prevent /limit releases, dispersion and exposure	
Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: 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 FFP3 (EN149) or equivalent suitable respirator) is required for tasks where exposure to Ni-containing dust occurs or is likely to occur. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), and goggles. Other protective equipment e.g. special safety clothing should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing aerosols and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (*e.g.* according to EN 20346).	
2.3 Control of workers exposure for contributing exposure scenario 9.2	
Powderpreparation – furnacing (smelting, melting and alloying) and atomisation	

Workers related free short title	Use of nickel metal in powder metallurgy
Use descriptor covered	PROC 3: Use in closed batch process (synthesis or formulation) PROC 22: Potentially closed processing operations with minerals/metals at elevated temperature PROC 27a Production of metal powders (hot processes)
Processes, tasks, activities covered	The feedstock is heated in a furnace and the melt is turned into a nickel-based powder by atomising the melt stream to produce fine, spherical or granular powder suitable for metal injection molding and other powder metallurgy work. The molten metal passes through the center portion of a pressure nozzle of a tundish through which a gas or liquid flows to divide the molten metal into droplets on exit from the nozzle. The melt stream may be sub-divided further by firing a jet of gas (in an inverted cone shape) from a ring nozzle (e.g. as slits around the lower edge of the exit from the pressure nozzle) into the stream to give a more finely divided powder with a narrower particle size range.
Assessment Method	Estimation of inhalation exposure using a Tier 1 model (MEASE). Estimation of dermal exposure by read across from stainless steel production

Product characteristic	
Molten stream of nickel metal or nickel alloy Crude Ni metal or alloyed Fe-Ni powder NiO powder	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
The furnacing (smelting, melting and alloying) and atomisation processes are continuous over every shift	
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	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Furnacing and atomisation is largely enclosed by design.	
Technical conditions and measures at process level (source) to prevent release	
Inhalation: Molten metal can emit metal and metal oxide fumes at high temperatures and particulate on cooling. Automation and complete enclosure of melting operations; transfer and processing of the molten stream and handling resulting powders e.g. filling operations (packaging for intermediate storage) with no manual intervention are not likely to give rise to significant exposures to inhalable Ni-containing powder, fume or dust. The process needs to be ventilated where not fully enclosed e.g. melt stream in order to control inhalation exposure to Ni metal fume and dust e.g. extraction to avoid discharge of fugitive emissions from furnace and atomiser into workplace air. Extraction/LEV of gases from high temperature processes to avoid discharge into workplace air. Dermal: Automation of processes where possible to minimise dermal contact.	
Technical conditions and measures to control dispersion from source towards the worker	
Extraction of gases and fume from hot automated and enclosed processes designed to remove gaseous side products (e.g. water vapour, sulfur gases) and applied to discharge points and transfer systems on the furnace and atomiser to prevent workplace exposure. LEV is required to extract the dust for processes that are not fully enclosed and are likely to give rise to Ni metal fume and particulate such as the melt stream. During cleaning use vacuum or (pressure) washing with water to remove dusts or powders containing Ni, NiO or other Ni compounds.	
Organisational measures to prevent /limit releases, dispersion and exposure	
Largely automated process operated from control room or separate control areas so operators are only at the plant for certain tasks and routine inspections, therefore exposure is intermittent. Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	

Inhalation: 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 FFP3 (EN149) or equivalent suitable respirator) is required for tasks where exposure to Ni-containing dust occurs. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), and goggles. Other protective equipment e.g. special safety clothing should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing aerosols and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (*e.g.* according to EN 20346).	
2.4 Control of workers exposure for contributing exposure scenario 9.3	
Powder finishing – crushing, milling and sieving	
Workers related free short title	Use of nickel metal in powder metallurgy
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	Drying (if water–atomised) and chemically reducing or 'mechanically' alloying the crude Ni powder product and crushing, milling and sieving the fine pure Ni metal or Fe-alloyed Ni powder product.
Assessment Method	Estimation of inhalation and dermal exposure using a Tier 1 model (MEASE)
Product characteristic	
Fine and crude Ni metal or alloyed Fe-Ni powder	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Drying, reducing, diffusion alloying, crushing, milling and sieving is continuous over every shift	
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	
Powder finishing is an enclosed process, carried out at high temperature and under an inert atmosphere.	
Technical conditions and measures at process level (source) to prevent release	
Operations are automated where possible to eliminate dermal exposure. The process needs to be ventilated where not fully enclosed in order to control inhalation exposure to Ni metal dust and fumes.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to extract the dust for processes that are not fully enclosed and are likely to give rise to Ni metal particulate such as releasing the sintered form from the kiln	
Organisational measures to prevent /limit releases, dispersion and exposure	
Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: Powered respirators with mask or hood (TH1 EN12941:1998 & TM1, 12492:1998), full face mask (EN136) fitted with a P2 (EN143) filter, half mask respirator {FMP2 filter EN 1827 mask & P2 filter (EN 143:2000) 140 mask} or FFP2 respirator (EN 149:2001) is required at process steps that are not fully enclosed and are likely to give rise to Ni dust or fumes where less contamination with nickel-containing dust is likely compared to 9.1 and 9.2. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), goggles and special safety clothing are required. Other protective equipment should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing dust and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (*e.g.* according to EN 20346).	
2.5 Control of workers exposure for contributing exposure scenario 9.4	
Powder blending and packaging	
Workers related free short title	Use of nickel metal in powder metallurgy

Use descriptor covered	PROC 3: Use in closed batch process (synthesis or formulation)
Processes, tasks, activities covered	The pure Ni, alloyed Fe-Ni and powder mixes with binder and release agents are combined packaged into big bags or drums.
Assessment Method	Estimation of inhalation and dermal exposure by read across from carbonyl Ni refining
Product characteristic	
Nickel metal & Ni metal-based alloy powders	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Powder packaging is continuous over every shift	
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	
Packaging is partially enclosed and can involve considerable manual intervention	
Technical conditions and measures at process level (source) to prevent release	
Releasing the powder from the blender or intermediate storage into containers should be enclosed and automated where possible. The process needs to be ventilated where not fully enclosed in order to control inhalation exposure to Ni metal dust.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to extract the dust for processes that are not fully enclosed and are likely to give rise to Ni metal particulate such as releasing the final powder product through the dispensing spout in to the drum.	
Organisational measures to prevent /limit releases, dispersion and exposure	
Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: Powered respirators with mask or hood (TH3 EN 146/EN 12941 & TM3 EN 147/EN 12942) or full face mask (EN136) fitted with a P3 filter is required at process steps that are not fully enclosed and are likely to give rise to Ni dust or fumes where heavy contamination with nickel-containing dust is likely. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), goggles and special safety clothing are required. Other protective equipment should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing dust and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (*e.g.* according to EN 20346).	
2.6 Control of workers exposure for contributing exposure scenario 9.5	
DSU Powder Mixing (for pressing or injection moulding)	
Workers related free short title	Use of nickel metal in powder metallurgy
Use descriptor covered	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
Processes, tasks, activities covered	This involves the blending of a pressing lubricant or an organic binder with the metal or metal alloy powder.
Assessment Method	Estimation of dermal exposure by read across from magnet production
Product characteristic	
Nickel metal	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
The powder mixing process is continuous over every 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	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Mixing of the Ni powder and other ingredients in the mixer and the conveying of powder and feedstock is enclosed and automated.	
Technical conditions and measures at process level (source) to prevent release	
Opening of bags or drums and charging (tipping of the Ni powder from the containers into the dispensing bin and piping from the bin into the mixer) and emptying the mixer is automated and enclosed where possible. The process needs to be ventilated where not fully enclosed in order to control inhalation exposure to Ni metal dust.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to extract the dust for processes that are not fully enclosed and are likely to give rise to Ni metal particulate such as opening of bags and charging and discharging of mixers to prepare the mixed powder	
Organisational measures to prevent /limit releases, dispersion and exposure	
Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: 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 FFP3 (EN149) or equivalent suitable respirator) is required for tasks where exposure to Ni-containing dust occurs. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), and goggles. Other protective equipment e.g. special safety clothing should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing aerosols and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (e.g. according to EN 20346).	
2.7 Control of workers exposure for contributing exposure scenario 9.6	
Powder pressing	
Workers related free short title	Use of nickel metal in powder metallurgy
Use descriptor covered	PROC 8b:Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities PROC 14: Production of preparations or articlesby tabletting, compression, extrusion, pelletisation
Processes, tasks, activities covered	In die pressing the mixed powder is pressed in a mould made up of a rigid tool set comprising a die, punches and mandrels or core rods in die pressing. In isostatic pressing, hydrostatic pressure is applied to the mould in a pressurised vessel
Assessment Method	Estimation of dermal exposure using a Tier 1 model (MEASE)
Product characteristic	
Fine Ni metal or alloyed Fe-Ni powder. Ni metal or alloyed Fe-Ni in a bulk form.	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
The powder pressing process is continuous over every 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	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Powder pressing is enclosed.	
Technical conditions and measures at process level (source) to prevent release	
Filling and opening of moulds is automated and enclosed where possible. The process needs to be ventilated where not fully enclosed in order to control inhalation exposure to Ni metal dust.	
Technical conditions and measures to control dispersion from source towards the worker	

LEV is required to extract the dust for processes that are not fully enclosed and are likely to give rise to Ni metal particulate such as releasing the form from the mould	
Organisational measures to prevent /limit releases, dispersion and exposure	
(Semi) automated process operated from control room or separate control areas so operators are only at the plant for certain tasks and routine inspections, therefore exposure is intermittent. Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: Powered respirators with mask or hood (TH1 EN12941:1998 & TM1, 12492:1998), full face mask (EN136) fitted with a P2 (EN143) filter, half mask respirator {FMP2 filter EN 1827 mask & P2 filter (EN 143:2000) 140 mask} or FFP2 respirator (EN 149:2001) is required at process steps that are not fully enclosed and are likely to give rise to Ni dust or fumes where less contamination with nickel-containing dust is likely compared to 9.1 and 9.2. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), goggles and special safety clothing are required. Other protective equipment should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing dust and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (e.g. according to EN 20346).	
2.8 Control of workers exposure for contributing exposure scenario 9.7a	
Continuous sintering	
Workers related free short title	Use of nickel metal in powder metallurgy
Use descriptor covered	PROC 22: Potentially closed processing operations with minerals/metals at elevated temperature
Processes, tasks, activities covered	Solid phase sintering of the compacted form involves heating of the material, usually in an inert atmosphere, to a temperature that is below the melting point of the major constituent. If a minor constituent forms a liquid phase at the sintering temperature then the process is known as liquid phase sintering. Techniques such as powder (closed-die hot) forging may then be applied to conventionally cold pressed and sintered forms and to one-step hot compacted forms.
Assessment Method	Estimation of dermal exposure using a Tier 1 model (MEASE)
Product characteristic	
Ni metal or alloyed Fe-Ni powder or Ni or Fe-Ni in a bulk form	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Sintering is continuous over every shift	
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	
Continuous sintering is an enclosed process, carried out at high temperature and under an inert atmosphere.	
Technical conditions and measures at process level (source) to prevent release	
Charging and emptying the kiln is automated where possible to eliminate dermal exposure. The process needs to be ventilated where not fully enclosed or where there is some manual intervention in order to control inhalation exposure to Ni metal dust.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to extract the dust for processes that are not fully enclosed and are likely to give rise to Ni metal particulate or fume such as releasing the sintered form from the kiln	
Organisational measures to prevent /limit releases, dispersion and exposure	
Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: 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 FFP3 (EN149) or equivalent suitable respirator) is required for	

emergencies and non-routine tasks where exposure to Ni-containing dust is possible e.g. spills or leaks from breaches in transfer systems. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), and goggles. Other protective equipment e.g. special safety clothing should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing aerosols and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (e.g. according to EN 20346).	
2.9 Control of workers exposure for contributing exposure scenario 9.7b	
Batch sintering	
Workers related free short title	Post-sintering
Use descriptor covered	PROC 22: Potentially closed processing operations with minerals/metals at elevated temperature
Processes, tasks, activities covered	The sintered part is finished using techniques such as shot peening, hardening, annealing, steam treatment and local cold deformation (rolling of the surface layers of a sintered form with a meshing rolling tool).
Assessment Method	Estimation of dermal exposure using a Tier 1 model (MEASE)
Product characteristic	
Ni metal or alloyed Fe-Ni powder or Ni or Fe-Ni in a bulk form	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Batch sintering is intermittent over every 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	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Batch sintering requires loading and unloading of forms into the kiln and is likely enclosed during the sintering process which is carried out at high temperature and pressure.	
Technical conditions and measures at process level (source) to prevent release	
Charging and emptying the kiln requires manual intervention. The kiln needs to be ventilated during the sintering process where not fully enclosed or where there is some manual intervention in order to control inhalation exposure to Ni metal dust.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to extract the dust and fumes for processes that are not fully enclosed and are likely to give rise to Ni metal containing particulate such as releasing the sintered form from the kiln	
Organisational measures to prevent /limit releases, dispersion and exposure	
Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: 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 FFP3 (EN149) or equivalent suitable respirator) is required for emergencies and non-routine tasks where exposure to Ni-containing dust is possible e.g. spills or leaks from breaches in transfer systems. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), and goggles. Other protective equipment e.g. special safety clothing should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing aerosols and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (e.g. according to EN 20346).	
2.10 Control of workers exposure for contributing exposure scenario 9.8	
Injection moulding	
Workers related free short title	Use of nickel metal in powder metallurgy
Use descriptor covered	PROC 14: Production of preparations or articles by tabletting, compression,

	extrusion, pelletisation
Processes, tasks, activities covered	The mixed powder and binder are combined and heated then injected into a mould. The injection moulded part is released from the mould (as the green body) and is de-bound (binder removal to make the brown body) to make it ready for sintering..
Assessment Method	Estimation of inhalation and dermal exposure using a Tier 1 model (MEASE)

Product characteristic	
Fine Ni metal or alloyed Fe-Ni powder	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Injection moulding is continuous over every shift	
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	
Injection moulding is enclosed and carried out at high temperature and pressure.	
Technical conditions and measures at process level (source) to prevent release	
Charging the barrel (for heating and mixing together the feedstock and binder) and releasing and debinding the form should be enclosed and automated where possible. The process needs to be ventilated where not fully enclosed in order to control inhalation exposure to Ni metal-based dust.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to extract the dust for processes that are not fully enclosed and are likely to give rise to Ni metal containing particulate such as releasing the form from the moulding machine	
Organisational measures to prevent /limit releases, dispersion and exposure	
Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: Powered respirators with mask or hood (TH1 EN12941:1998 & TM1, 12492:1998), full face mask (EN136) fitted with a P2 (EN143) filter, half mask respirator {FMP2 filter EN 1827 mask & P2 filter (EN 143:2000) 140 mask} or FFP2 respirator (EN 149:2001) is required at process steps that are not fully enclosed and are likely to give rise to Ni dust or fumes where contamination with nickel-containing dust is likely. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), goggles and special safety clothing are required. Other protective equipment should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing dust and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (*e.g.* according to EN 20346).	

2.10 Control of workers exposure for contributing exposure scenario 9.9	
Post-sintering operations	
Workers related free short title	Use of nickel metal in powder metallurgy
Use descriptor covered	PROC 22: Potentially closed processing operations with minerals/metals at elevated temperature
Processes, tasks, activities covered	The sintered part is finished using techniques such as shot peening, hardening, annealing, steam treatment and local cold deformation (rolling of the surface layers of a sintered form with a meshing rolling tool).
Assessment Method	Estimation of dermal and inhalation exposure are read across from magnet production
Product characteristic	
Nickel metal and alloyed Fe-Ni powder and bulk form.	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	

Post-sintering is continuous over every 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	Not relevant
Body weight	Not relevant
Other given operational conditions affecting workers exposure	
Post-sintering finishing operations are enclosed and automated.	
Technical conditions and measures at process level (source) to prevent release	
The process needs to be ventilated where not fully enclosed in order to control inhalation exposure to Ni metal dust.	
Technical conditions and measures to control dispersion from source towards the worker	
LEV is required to extract the dust for processes that are not fully enclosed and are likely to give rise to Ni metal particulate such as releasing the form from deboning and post-sintering treatments.	
Organisational measures to prevent /limit releases, dispersion and exposure	
Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	
Inhalation: 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 FFP3 (EN149) or equivalent suitable respirator) is required for emergencies and non-routine tasks where exposure to Ni-containing dust is possible e.g. spills or leaks from breaches in transfer systems. It is important to note that the disposable mask FFP1 (with APF = 4) is not recommended for use with Ni-containing aerosols. Dermal: Suitable gloves (EN 374, protection level 6, PVC or equivalent), and goggles. Other protective equipment e.g. special safety clothing should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing aerosols and other relevant workplace hazards may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (e.g. according to EN 20346).	
2.11 Control of workers exposure for contributing exposure scenario 9.10	
Cleaning and maintenance	
Workers related free short title	Use of nickel metal in powder metallurgy
Use descriptor covered	PROC: 0 Cleaning and maintenance
Processes, tasks, activities covered	Cleaning and maintenance of plant and premises
Assessment Method	Estimation of dermal and inhalation exposure using a Tier 1 model (MEASE)
Product characteristic	
Ni metal and alloyed Fe-Ni powder and broken forms.	
Amounts used	
Not relevant	
Frequency and duration of use/exposure	
Duration of exposure during cleaning and maintenance is considered to average 1 hour per day for powder metallurgy.	
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	
Local (where appropriate) and general exhaust ventilation. Vacuuming or suitable wet removal methods for cleaning settled dust etc. from plant and premises. Avoid inappropriate cleaning methods such as dry brushing.	
Organisational measures to prevent /limit releases, dispersion and exposure	
Regular training in work hygiene practices and proper use of PPE.	
Conditions and measures related to personal protection, hygiene and health evaluation	

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.
Inhalation:Use of air-assisted filtering visor, masks or hood with P3 filter element for plant or premises heavily contaminated with nickel-containing dust or spills {APF ~20 based on use of powered respirator meeting EN12492 requirement or FFP3 (EN149) or equivalent suitable respirator}. RPE with a lower APF of 10 {air-assisted filtering visor, masks or hood with P2 filter element including powered respirators meeting the EN12492 TM1 or EN 12941 TH1 requirement or the FFP2 (EN149) or equivalent suitable respirator} may be used for cleaning and maintenance work where the plant or premises is less heavily contaminated with nickel-containing dust or spills.
Dermal: Use of suitable chemical gloves (EN 374, protection level 6, PVC or equivalent), goggles and special safety clothing is required to control dermal exposure, Protective equipment should be chosen based on activities being undertaken, potential for exposure to airborne nickel-containing dust and other relevant workplace hazards and may include protective suit with hood (conforming to EN13982-1 Type 5) and safety shoes (e.g. according to EN 20346).

3. Exposure and risk estimation

Environment

ERC 5
Powder metallurgy: Use of nickel powder in production of parts (articles)

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	16.20	0.54	Estimated values, Tier 3-RWC
STP	mg/L	0.33	-	-	-	-	No emission to water

Workers

ES 9.1
PROC 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	0.035	0.002	0.06	Read across 90th percentile for personal exposure (hands &arms) measurement reported for an analogous raw material handling operation in electrolytic Ni refining.
Inhalation					
Acute local	mg Ni/m^3	4	1.95	0.05	3 x long-term exposure estimate
Long-term systemic and local	mg Ni/m^3	0.05	0.65	13 (excluding RPE)	90th percentile exposure estimate using MEASE for PROC 8b {ind,

			0.033	0.65 By use of RPE (APF 20)	Ni>25%, NDH, NDU, incidental exposure, duration >240 minutes, LEV, RPE, gloves}
ES 9.2 PROC 3, PROC 22, PROC 27a: Powder preparation-Furnacing and atomisation					
	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	0.035	0.00007	0.002	Read across 90th percentile for personal exposure (hands &arms) measurement reported for an analogous alloying and melting process in stainless steel production.
Inhalation					
Acute local	mg Ni/m^3	4	1.95	0.05	3 x long-term exposure estimate
Long-term systemic and local	mg Ni/m^3	0.05	0.65 0.033	13 (excluding RPE) 0.65 By use of RPE (APF 20)	90th percentile exposure estimate using MEASE for PROC 27a {ind, Ni>25%, NDH, NDU, incidental exposure, duration >240 minutes, LEV, RPE, gloves}
ES 9.3 PROC 24: Powder finishing- crushing, milling and sieving					
	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	0.035	0.00005	0.0014	90th percentile from MEASE modelling (PROC 22 and 24 {Ni content >25%, industrial, NDU, NDH, incidental

					exposure, LEV, duration >240 minutes, gloves}
Inhalation					
Acute local	mg Ni/m³	4	1.17	0.03	3 x long-term exposure estimate
Long-term systemic and local	mg Ni/m³	0.05	0.39 0.039	7.8 (excluding RPE) 0.78 By use of RPE (APF 10)	90th percentile from MEASE modelling (PROC 24 {Ni content >25%, industrial, NDU, NDH, incidental exposure, LEV, duration >240 minutes, gloves}
ES 9.4 PROC 3: Powder blending and 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	0.035	0.001	0.03	Read across 90th percentile for personal exposure (hands and arms) measurement reported for an analogous alloying and melting process in carbonyl nickel refining (GES 1 Nickel production by carbonyl
Inhalation					
Acute local	mg Ni/m³	4	3.3	0.825	10 x long-term exposure estimate
Long-term systemic &local	mg Ni/m³	0.05	0.33 0.0165	6.6 (excluding RPE) 0.33 By use of RPE (APF 20)	Read across based on 43 static exposure measurements reported for packaging of carbonyl nickel powder (GES 1.3)

ES 9.5
PROC 5, 8a: DSU Powder mixing

	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	0.035	0.02	0.6	Read across 90th percentile for personal exposure measurement (hands & arms) reported for an analogous powder and machine setting operations in magnet production
Inhalation					
Acute local	mg Ni/m³	4	1.47	0.37	3 x long-term exposure estimate
Long-term systemic and local	mg Ni/m³	0.05	0.49 0.0245	9.8 (excluding RPE) 0.49 By use of RPE (APF 20)	75th percentile value from 9 personal exposure measurements

ES 9.6
PROC 8b, 14: Powder pressing

	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	0.035	0.02	0.6	Read across 90th percentile for personal exposure measurement (hands, & arms &) reported for an analogous powder and machine setting operations in magnet production
Inhalation					
Acute local	mg Ni/m³	4	0.39	0.1	3 x long-term exposure estimate

Long-term systemic and local	mg Ni/m³	0.05	0.13 0.013	2.6 (excluding RPE) 0.26 By use of RPE (APF 10)	75th percentile value from 21 personal exposure measurements
ES 9.7a PROC 22: Continuous sintering					
	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	0.035	0.00003	8.6×10^{-4}	90th percentile exposure estimate using MEASE for PROC 22 {incidental exposure, duration 8 hour, LEV, RPE, gloves}
Inhalation					
Acute local	mg Ni/m³	4	0.0309	0.0077	3 x long-term exposure estimate
Long-term systemic and local	mg Ni/m³	0.05	0.0103	0.21	75th percentile value from 9 personal exposure measurements
ES 9.7b PROC 22: Batch sintering					
	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	0.035	0.0001	2.9×10^{-3}	90th percentile exposure estimate using MEASE for PROC 22 {incidental exposure, duration 15-60 mins, LEV, RPE, gloves}
Inhalation					
Acute local	mg Ni/m³	4	1.8	0.45	3 x long-term exposure estimate
Long-term systemic &local	mg Ni/m³	0.05	0.6	12	Single exposure

			0.035	0.6 withRPE (APF = 20)	measurement verified by MEASE for PROC 22 {Ni>25%incidental exposure, duration 8 hour, LEV, RPE, gloves}
ES 9.8 PROC 14: Injection moulding					
	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	0.035	0.00005	0.0014	90th percentile exposure estimate using MEASE for PROC 14 {incidental exposure, duration 8 hour, LEV, RPE, gloves}
Inhalation					
Acute local	mg Ni/m³	4	0.39	0.1	3 x long-term exposure estimate
Long-term systemic and local	mg Ni/m³	0.05	0.13 0.013	2.6 (excluding RPE) 0.26 By use of RPE (APF 10)	90th percentile exposure estimate using MEASE for PROC 14 {incidental exposure, duration 8 hour, LEV, RPE, gloves}
ES 9.9 PROC 22: Post-sintering					
	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	0.035	0.002	0.06	Read across 90h percentile for personal exposure measurement (hands & arms) reported for an analogous grinding operation for metallurgical processing of nickel powder

Inhalation					
Acute local	mg Ni/m^3	4	0.09	0.0225	3 x long-term exposure estimate
Long-term systemic and local	mg Ni/m^3	0.05	0.03	0.6	Read across from highest of 4 personal exposure measurements from an analogous grinding operation in magnet production after comparison with 5 (lower) personal exposure measurements for this task

ES 9.10
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/cm^2/day	-	NR		
Long-term systemic	mg Ni/kg/day	-	NR		
Long-term local	mg Ni/cm^2/day	0.035	0.00001	3 x 10^{-4}	90th percentile exposure estimate using MEASE for PROC 10 {Ni> 25%, ind, incidental exposure, NDU, NDH, duration 15-60 mins, GV, RPE, gloves}
Inhalation					
Acute local	mg Ni/m^3	4	1.71	0.428	3 x long-term inhalable modeled estimate
Long-term systemic and local	mg Ni/m^3	0.05	0.57 0.029	11.4 (excluding RPE) By use of RPE (APF 20) 0.58	90th percentile exposure estimate using MEASE for PROC 10 {Ni> 25%, ind, incidental exposure, NDU, NDH, duration 15-60 mins, GV, RPE, gloves}

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 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).

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 (e.g., ≤10% of nickel mass in respirable fraction). 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 powder metallurgy

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