



9.12. Exposure scenario 12: Use at industrial sites - Use of nanosilver in sintering processes for production of electronics

Product category used: PC 7: Base metals and alloys; PC 14: Metal surface treatment products; PC 33: Semiconductors

Sector of use: SU 16: Manufacture of computer, electronic and optical products, electrical equipment; SU 17: General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment.

Environment contributing scenario(s):		
CS 1	Use of nanosilver in sintering processes for production of electronics	ERC 5
Worker contributing scenario(s):		
CS 2	Handling of nanosilver in suspensions/pastes	PROC 8a , PROC 21, PROC 5
CS 3	Handling of nanosilver in suspensions/pastes in dedicated systems/filling lines	PROC 8b , PROC 9
CS 4	Mechanical treatment – application in open systems	PROC 10
CS 5	Application in closed systems	PROC 1 , PROC 2, PROC 3
CS 6	Spraying	PROC 7
CS 7	Hot processes	PROC 22 , PROC 25
CS 8	Cleaning & maintenance	PROC 8a , PROC 26, PROC 28

9.12.1. Env CS 1: Use of nanosilver in sintering processes for production of electronics (ERC 5)

Assessment entity group used for the assessment of this contributing scenario: Silver in nano form

9.12.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
<ul style="list-style-type: none"> Daily use amount at site: ≤ 0.014 tonnes/day <i>Continuous use, 220 days/year based on SPERC factsheet 'Use of metals in metallic coating v3'</i> Annual use amount at site: ≤ 0.272 tonnes/year
Technical and organisational conditions and measures
<ul style="list-style-type: none"> The substance should not be released to water <i>Emissions to surface water or to the sewage system are not allowed in this scenario</i> On site treatment of off-air: Electrostatic precipitators or wet electrostatic precipitators or cyclones or fabric/bag filter or ceramic/metal mesh filter according to the BAT Reference Document in the Non-Ferrous Metals Industry <i>Direct air emissions should be reduced by implementing one or more of the following RMMs (air concentration range for which the RMM is suitable is specified in parenthesis):</i> <ul style="list-style-type: none"> Electrostatic precipitators using wide electrode spacing: $5 - 15 \text{ mg/Nm}^3$ Wet electrostatic precipitators: $< 5 \text{ mg/Nm}^3$ Cyclones, but as primary collector: $< 50 \text{ mg/Nm}^3$ Fabric or bag filters: high efficiency in controlling fine particulate (melting): achieve emission values $< 5 \text{ mg/Nm}^3$. Membrane filtration techniques can achieve $< 1 \text{ mg/Nm}^3$ Ceramic and metal mesh filters. PM10 particles are removed: 0.1 mg/Nm^3 Wet scrubbers: $< 4 \text{ mg/Nm}^3$
Conditions and measures related to biological sewage treatment plant
<ul style="list-style-type: none"> Biological STP: None [Effectiveness Water: 0%]
Conditions and measures related to external treatment of waste (including article waste)



<ul style="list-style-type: none"> Particular considerations on the waste treatment operations: No (low concentration) <i>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 silver content of the waste is elevated enough, internal or external recovery/recycling might be considered.</i> <i>Appropriate waste codes: 06 05 02*, 08 01 11, 08 03 12*, 09 01 01*, 09 01 03*, 09 01 04*, 09 01 05*, 09 01 06*, 09 01 13*, 10 06 06*, 10 07 01, 10 07 02, 10 07 03, 10 07 04, 10 07 05, 11 01 09*, 15 01 10*, 15 02 02*, 16 01 18, 16 03 03*, 16 08 01, 16 11 04</i> <i>Suitable disposal: Hazardous waste produced during the manufacture and downstream use is sent to a recycler only marginal amounts are sent to a landfill or an incinerator. Waste containing silver is recycled for almost a 100%</i> <i>A detailed assessment has been performed on modelled and measured data and is reported in the Waste report (ARCHE, 2013)</i>
Other conditions affecting environmental exposure
<ul style="list-style-type: none"> Receiving surface water flow rate: $\geq 1.8E4$ m³/day Discharge rate of effluent: $\geq 2E3$ m³/day

9.12.1.2. Releases

The local releases to the environment are reported in the following table. Note that the releases reported do not account for the removal in the modelled biological STP.

Table 9.36. Local releases to the environment

Release	Assessment entity	Release estimation method	Explanations
Water	Nano 34.2 - Silver in nano form	Estimated release factor	<p>Release factor before on site RMM: 0% Release factor after on site RMM: 0% Local release rate: 0 kg/day Explanation: There is no water involved in the process. Cleaning of the equipment is done with organic solvents. All liquid waste streams are checked for silver content for reclaim.</p>
Air	Nano 34.2 - Silver in nano form	Estimated release factor (based on SPERC Eurometaux SPERC 5.1.v3)	<p>Release factor before on site RMM: 0.2% Release factor after on site RMM: 0.2% Local release rate: 0.027 kg/day Explanation: release after RMM Default release factors are derived from a multi-metal background database of measured site-specific release factors collected from peer-reviewed EU Risk Assessment Reports under the former Directive of New and Existing Substances and REACH 2010 registration dossiers. The 90th percentile of reported site-specific release factors to air for 97 sites.</p>
Non agricultural soil	Nano 34.2 - Silver in nano form	Estimated release factor	<p>Release factor after on site RMM: 0%</p>

Releases to waste

Release factor to external waste: 0 %

9.12.1.3. Exposure and risks for the environment and man via the environment

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table. The exposure estimates have been obtained with EUSES 2.1.2 unless stated otherwise.

**Table 9.37. Exposure concentrations and risks for the environment and man via the environment**

Protection target	Assessment entity	Exposure concentration	Risk quantification
Fresh water	Nano 34.2 - Silver in nano form	Local PEC: 6.06E-6 mg/L RCR = 0.151	Final RCR = 0.151
Sediment (freshwater)	Nano 34.2 - Silver in nano form	Local PEC: 1.155 mg/kg dw RCR = 2.64E-3	Final RCR < 0.01
Marine water	Nano 34.2 - Silver in nano form	Local PEC: 1.91E-6 mg/L RCR = 2.22E-3	Final RCR < 0.01
Sediment (marine water)	Nano 34.2 - Silver in nano form	Local PEC: 0.364 mg/kg dw RCR = 8.31E-4	Final RCR < 0.01
Sewage Treatment Plant	Nano 34.2 - Silver in nano form	Local PEC: 0 mg/L RCR = 0	Final RCR < 0.01
Agricultural soil	Nano 34.2 - Silver in nano form	Local PEC: 0.096 mg/kg dw RCR = 0.068	Final RCR = 0.068
Man via environment - Inhalation (systemic effects)	Nano 34.2 - Silver in nano form	Concentration in air: 5E-7 mg/m ³ RCR = 2.17E-4	Final RCR < 0.01
Man via environment - Inhalation (local effects)	Nano 34.2 - Silver in nano form	Concentration in air: 5E-7 mg/m ³ RCR = 2.17E-4	Final RCR < 0.01
Man via environment - Oral	Nano 34.2 - Silver in nano form	Exposure via food consumption: 3.84 µg/kg bw/day (Measured data: See section 9.0.3.3) RCR = 0.035	Final RCR = 0.035
Man via environment - combined routes			Final RCR = 0.035

Remarks on measured exposure:

See section 9.0.3.3 for Nano 34.2 - Silver in nano form:

Identity of the substance used: Ag

Explanation: Worst case exposure of 3.84 µg Ag/kg bw/day from food (section 9.0.3.3) was taken forward to the risk characterisation.

9.12.2. Worker CS 2: Handling of nanosilver in suspensions/pastes (PROC 8a, PROC 21, PROC 5)

Assessment entity group used for the assessment of this contributing scenario: Silver in nano form transfer of substance, weighing, mixing, blending handling, filling

9.12.2.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	MEASE 1.02.01
• Physical form of the used product: Liquid, including paste/slurry/suspension <i>In MEASE aqueous solution has been selected to reflect the very low fugacity of nano silver included in paste.</i>	MEASE 1.02.01
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 1 h/day	MEASE 1.02.01
Technical and organisational conditions and measures	
• Local exhaust ventilation: Yes, basic LEV such as canopy hood, movable capturing	MEASE 1.02.01



	Method
hood or other multi-purpose LEV (assumed effectiveness 50-80%) <i>LEV (generic) with 78% efficiency used in MEASE</i>	
• Occupational Health and Safety Management System: Advanced	MEASE 1.02.01
• Room ventilation: Enhanced (5 to 10 ACH)	MEASE 1.02.01
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: Chemical resistant dermal protection with basic employee training. (effectiveness >= 90%)	
• Respiratory protection: No <i>Not required unless the duration of the task would exceed 60 min per shift.</i>	MEASE 1.02.01
• Face/eye protection: No	
Other conditions affecting workers exposure	
• Place of use: Indoor	MEASE 1.02.01
• Operating temperature: <= 40 °C	MEASE 1.02.01

9.12.2.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.38. Exposure concentrations and risks for workers

Route of exposure and type of effects	Assessment entity	Exposure concentration	Risk quantification
Inhalation, systemic, long term	Nano 34.2 - Silver in nano form	2E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.263	Final RCR = 0.263
Inhalation, local, long term	Nano 34.2 - Silver in nano form	2E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.263	Final RCR = 0.263

9.12.3. Worker CS 3: Handling of nanosilver in suspensions/pastes in dedicated systems/filling lines (PROC 8b, PROC 9)

Assessment entity group used for the assessment of this contributing scenario: Silver in nano form transfer of substance, filling

9.12.3.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	MEASE 1.02.01
• Physical form of the used product: Liquid, including paste/slurry/suspension <i>In MEASE aqueous solution has been selected to reflect the very low fugacity of nano silver included in paste.</i>	MEASE 1.02.01
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	MEASE 1.02.01
Technical and organisational conditions and measures	
• Local exhaust ventilation: Yes, basic LEV such as canopy hood, movable capturing hood or other multi-purpose LEV (assumed effectiveness 50-80%) <i>LEV (generic) with 78% efficiency used in MEASE</i>	MEASE 1.02.01
• Occupational Health and Safety Management System: Advanced	MEASE 1.02.01
• Room ventilation: Enhanced (5 to 10 ACH)	MEASE 1.02.01
Conditions and measures related to personal protection, hygiene and health evaluation	



	Method
• Dermal protection: Chemical resistant dermal protection with basic employee training. (effectiveness $\geq 90\%$)	MEASE 1.02.01
• Respiratory protection: No	MEASE 1.02.01
• Face/eye protection: No	
Other conditions affecting workers exposure	
• Place of use: Indoor	MEASE 1.02.01
• Operating temperature: ≤ 40 °C	MEASE 1.02.01

9.12.3.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.39. Exposure concentrations and risks for workers

Route of exposure and type of effects	Assessment entity	Exposure concentration	Risk quantification
Inhalation, systemic, long term	Nano 34.2 - Silver in nano form	2E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.263	Final RCR = 0.263
Inhalation, local, long term	Nano 34.2 - Silver in nano form	2E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.263	Final RCR = 0.263

9.12.4. Worker CS 4: Mechanical treatment – application in open systems (PROC 10)

Assessment entity group used for the assessment of this contributing scenario: Silver in nano form inkjet printing, screen printing, brushing, dispensing, metallization process

9.12.4.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: ≤ 100 %	MEASE 1.02.01
• Physical form of the used product: Liquid, including paste/slurry/suspension <i>In MEASE aqueous solution has been selected to reflect the very low fugacity of nano silver included in paste.</i>	MEASE 1.02.01
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: ≤ 8 h/day	MEASE 1.02.01
Technical and organisational conditions and measures	
• Local exhaust ventilation: Yes, basic LEV such as canopy hood, movable capturing hood or other multi-purpose LEV (assumed effectiveness 50-80%) <i>LEV (generic) with 78% efficiency used in MEASE</i>	MEASE 1.02.01
• Occupational Health and Safety Management System: Advanced	MEASE 1.02.01
• Room ventilation: Enhanced (5 to 10 ACH)	MEASE 1.02.01
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: Chemical resistant dermal protection with basic employee training. (effectiveness $\geq 90\%$)	
• Respiratory protection: Yes (APF ≥ 10) <i>FFP2 mask during manual operations</i>	MEASE 1.02.01
• Face/eye protection: No	
Other conditions affecting workers exposure	



	Method
• Place of use: Indoor	MEASE 1.02.01
• Operating temperature: ≤ 40 °C	MEASE 1.02.01

9.12.4.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.40. Exposure concentrations and risks for workers

Route of exposure and type of effects	Assessment entity	Exposure concentration	Risk quantification
Inhalation, systemic, long term	Nano 34.2 - Silver in nano form	1E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.132	Final RCR = 0.132
Inhalation, local, long term	Nano 34.2 - Silver in nano form	1E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.132	Final RCR = 0.132

9.12.5. Worker CS 5: Application in closed systems (PROC 1, PROC 2, PROC 3)

Assessment entity group used for the assessment of this contributing scenario: Silver in nano form
Screen printing

9.12.5.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: ≤ 100 %	MEASE 1.02.01
• Physical form of the used product: Liquid, including paste/slurry/suspension <i>In MEASE aqueous solution has been selected to reflect the very low fugacity of nano silver included in paste.</i>	MEASE 1.02.01
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: ≤ 8 h/day	MEASE 1.02.01
Technical and organisational conditions and measures	
• Local exhaust ventilation: Yes, basic LEV such as canopy hood, movable capturing hood or other multi-purpose LEV (assumed effectiveness 50-80%) <i>LEV (generic) with 78% efficiency used in MEASE</i>	MEASE 1.02.01
• Occupational Health and Safety Management System: Advanced	MEASE 1.02.01
• Room ventilation: Enhanced (5 to 10 ACH)	MEASE 1.02.01
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: Chemical resistant dermal protection with basic employee training. (effectiveness ≥ 90 %)	
• Respiratory protection: No	MEASE 1.02.01
• Face/eye protection: No	
Other conditions affecting workers exposure	
• Place of use: Indoor	MEASE 1.02.01
• Operating temperature: ≤ 40 °C	MEASE 1.02.01

9.12.5.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.41. Exposure concentrations and risks for workers



Route of exposure and type of effects	Assessment entity	Exposure concentration	Risk quantification
Inhalation, systemic, long term	Nano 34.2 - Silver in nano form	2E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.263	Final RCR = 0.263
Inhalation, local, long term	Nano 34.2 - Silver in nano form	2E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.263	Final RCR = 0.263

9.12.6. Worker CS 6: Spraying (PROC 7)

Assessment entity group used for the assessment of this contributing scenario: Silver in nano form spraying

9.12.6.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 5 %	MEASE 1.02.01
• Physical form of the used product: Liquid, including paste/slurry/suspension <i>Medium emission potential selected in MEASE</i>	MEASE 1.02.01
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 1 h/day	MEASE 1.02.01
Technical and organisational conditions and measures	
• Local exhaust ventilation: Yes, specifically designed LEV such as receiving hoods (assumed effectiveness >= 80-90%) <i>Integrated LEV with 90% efficiency used in MEASE</i>	MEASE 1.02.01
• Occupational Health and Safety Management System: Advanced	MEASE 1.02.01
• Room ventilation: Enhanced (5 to 10 ACH)	MEASE 1.02.01
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: Chemical resistant dermal protection with basic employee training. (effectiveness >= 90%)	
• Respiratory protection: Yes (APF >= 20)	MEASE 1.02.01
• Face/eye protection: No	
Other conditions affecting workers exposure	
• Place of use: Indoor	MEASE 1.02.01
• Operating temperature: <= 40 °C	MEASE 1.02.01

9.12.6.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.42. Exposure concentrations and risks for workers

Route of exposure and type of effects	Assessment entity	Exposure concentration	Risk quantification
Inhalation, systemic, long term	Nano 34.2 - Silver in nano form	4E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.526	Final RCR = 0.526
Inhalation, local, long term	Nano 34.2 - Silver in nano form	4E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.526	Final RCR = 0.526

9.12.7. Worker CS 7: Hot processes (PROC 22, PROC 25)

Assessment entity group used for the assessment of this contributing scenario: Silver in nano form



sintering, drying, burning, firing at 800 °C

9.12.7.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	MEASE 1.02.01
• Physical form of the used product: Liquid, including paste/slurry/suspension <i>In MEASE solid low dustiness has been selected to reflect the low fugacity of nano silver included in paste.</i>	MEASE 1.02.01
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	MEASE 1.02.01
Technical and organisational conditions and measures	
• Local exhaust ventilation: Yes, specifically designed LEV such as receiving hoods (assumed effectiveness >= 80-90%) <i>Integrated LEV with 90% efficiency used in MEASE</i>	MEASE 1.02.01
• Occupational Health and Safety Management System: Advanced	MEASE 1.02.01
• Room ventilation: Enhanced (5 to 10 ACH)	MEASE 1.02.01
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: Chemical resistant dermal protection with basic employee training. (effectiveness >= 90%)	
• Respiratory protection: Yes (APF >= 20)	MEASE 1.02.01
• Face/eye protection: No	
Other conditions affecting workers exposure	
• Place of use: Indoor	MEASE 1.02.01
• Operating temperature: <= 400 °C	MEASE 1.02.01

9.12.7.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.43. Exposure concentrations and risks for workers

Route of exposure and type of effects	Assessment entity	Exposure concentration	Risk quantification
Inhalation, systemic, long term	Nano 34.2 - Silver in nano form	5E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.658	Final RCR = 0.658
Inhalation, local, long term	Nano 34.2 - Silver in nano form	5E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.658	Final RCR = 0.658

9.12.8. Worker CS 8: Cleaning & maintenance (PROC 8a, PROC 26, PROC 28)

Assessment entity group used for the assessment of this contributing scenario: Silver in nano form cleaning and maintenance operations, removal of residuals from e.g. filters/overspill or as waste, equipment is cleaned using organic solvents in closed installations.

9.12.8.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	MEASE 1.02.01
• Physical form of the used product: Liquid, including paste/slurry/suspension	MEASE 1.02.01



	Method
<i>In MEASE aqueous solution has been selected to reflect the very low fugacity of nano silver included in paste.</i>	
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	MEASE 1.02.01
Technical and organisational conditions and measures	
• Local exhaust ventilation: No <i>Not in operation during cleaning and maintenance</i>	MEASE 1.02.01
• Occupational Health and Safety Management System: Advanced	MEASE 1.02.01
• Room ventilation: Enhanced (5 to 10 ACH)	MEASE 1.02.01
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: Chemical resistant dermal protection with basic employee training. (effectiveness >= 90%)	
• Respiratory protection: Yes (APF >= 10)	MEASE 1.02.01
• Face/eye protection: No	
Other conditions affecting workers exposure	
• Place of use: Indoor	MEASE 1.02.01
• Operating temperature: <= 40 °C	MEASE 1.02.01

9.12.8.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.44. Exposure concentrations and risks for workers

Route of exposure and type of effects	Assessment entity	Exposure concentration	Risk quantification
Inhalation, systemic, long term	Nano 34.2 - Silver in nano form	5E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.658	Final RCR = 0.658
Inhalation, local, long term	Nano 34.2 - Silver in nano form	5E-3 mg/m ³ (MEASE 1.02.01) RCR = 0.658	Final RCR = 0.658