9. EXPOSURE ASSESSMENT (and related risk characterisation)

9.0. Introduction

The need for this application relates to the import of a few proprietary products containing strontium chromate formulated outside the EU and imported for use in the EU. These imported products are for use as a final surface treatment to provide anti-corrosive properties in the production, maintenance, and/or repair of parts for the aerospace industry and derivative applications per specifications. In that respect, the Exposure Scenarios are identical to those in other parts of the aerospace industry. Here we refer to the Exposure Scenarios presented in the CCST application. Since the uses are identical, the Exposure Scenarios developed for CCST have been used, by agreement, as the basis for this application. The companies represented by this application have reviewed the Exposure Scenarios provided in the CCST application and confirmed that they are representative of the uses covered by this application. Further context and information has been added as appropriate.

Aerospace companies are principally engaged in carrying out the design, development, manufacture, maintenance, modification, overhaul, repair, or support of aerospace equipment, systems, or structures, plus any derivative uses (e.g., marine propulsion or power generation using products adapted from aerospace designs).

This exposure assessment sets out detailed Exposure Scenarios, including clear and enforceable Risk Management Measures (RMM) and Operational Conditions (OC), for specific activities within the scope of the Application for Authorisation.

The Exposure Scenarios are based on extensive input and data held by the European aerospace sector and affiliated industries. The same companies and facilities have reviewed and validated the Exposure Scenarios, including RMM and OC, in detail. The Exposure Scenarios presented are therefore unambiguous and demonstrated to be representative of good practice across the industry.

The Exposure Scenarios are conservative, meaning that exposure measurements or estimates represent the upper boundaries of exposure (representing the reasonable worst case). Due to the specialised and highly regulated nature of activities undertaken by aerospace companies and their supply chain (as explained in the AoA), the uses are well defined and uncertainty associated with the Exposure Scenarios is limited (this finding is supported by the data presented in the document). Minor differences in exposure conditions between facilities and companies occur occasionally and described in the Exposure Scenarios. In such cases, exposure levels take account of the least stringent RMM/OC and greater release parameters to over-estimate the risk.

This exposure assessment provides reliable estimates of current work place exposure levels across the EU. Most European countries regulate occupational work place exposure to hexavalent chromium [Cr(VI)]. National Occupational Exposure Limits (OELs) across Europe respect a range of eight-hour *Time Weighted Average* (TWA) values between 1 µg/m^3 and 100 µg/m^3. The US *Occupational Safety and Health Administration* (OSHA) OEL is at 5 µg/m^3. In 2014, France introduced a new OEL of 1 µg/m^3. This is one of the most stringent OELs currently anywhere in the World and industry has invested substantial research and investment to reduce exposure to this level. For countries in which the national standard is lower than the exposure estimates shown in the following exposure scenario, the expectation is companies comply with the national standards by improved technical or personal Risk Management Measures (RMMs) or by demonstrating through work place exposure measurement data that they meet the national requirements.

The Carcinogens and Mutagens Directive (2004/37/EC) requires each Member State to ensure employers reduce and replace use of hexavalent chromium substances, and the introduction of a new OEL in France provides one clear example of regulation by Member States to effect a reduction in workplace exposure to Cr(VI). Industry is proactively engaged in delivering continuous reduction through the development and implementation of appropriate RMMs.

Best practice across the industry is continually improving, driven by general awareness of workplace hygiene and increasingly stringent regulatory requirements. This commitment to reducing exposure also reflects the widespread recognition that surface treatment with Cr(VI) is critical for several industries and that alternatives are not available in the near-term. Potential workplace exposure to Cr(VI) has progressively reduced in recent years as the effectiveness and implementation of risk management measures has improved.

For this reason, the exposure assessment, based on both measured and modelled data, considers prevailing (rather than historic) practices so far as possible.

Surface treatment processes involving strontium chromate are very similar in nature. Even so, individual operators may implement different RMMs over various timeframes for their own reasons, reflecting considerations such as (but not limited to) the layout (and age) of the facility, the scale, frequency and duration of operations, the number of operators, the type of articles, and expenditure required.

9.0.1. Overview of uses and Exposure Scenarios

Tonnage information:

Assessed tonnage: 10 tonnes of strontium chromate per year, based on: 10 tonnes/year manufactured/imported [containing approximately 2.5 tonnes Cr(VI)]

The following table lists all the exposure scenarios (ES) assessed in this CSR.

Table 6. Overview of exposure scenarios and contributing scenarios

Identifiers	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
ES1 - IW1		Use at industrial site - Use of strontium chromate in primers applied by aerospace and defence companies and their associated supply chains - Use of strontium chromate in primers applied by aerospace and defence companies and their associated supply chains (ERC 5) - Delivery and storage of raw material (PROC 1) - Decanting, mixing and filling of guns, cups or small containers (PROC 5) - Surface treatment by spraying in spray cabin/spray booth (PROC 7) - Surface treatment by spraying outside of paint-booth (PROC 7) - Surface treatment by brushing/rolling (small to medium sized parts) (PROC 10) - Surface treatment by brushing (very small parts/touch-up) (PROC 10) - Cleaning of equipment – tools cleaning (closed system) (PROC 8b) - Cleaning and maintenance of equipment – tools cleaning (paint cabin) (PROC 8b) - Cleaning – paint cabin and ancillary areas g (PROC 8b) - Infrequent maintenance activities (PROC 8a) - Machining operations on small to medium sized parts containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24) - Machining operations on small to medium sized surfaces containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24) - Machining operations in large work areas on parts containing Cr(VI) including cleaning (PROC 21, 24) - Machining operations in large work areas on surfaces containing Cr(VI) including cleaning (PROC 21, 24) - Machining operations on parts containing Cr(VI) in small work areas including cleaning (PROC 21, 24) - Machining operations on surfaces containing Cr(VI) in small work areas including cleaning (PROC 21, 24) - Sanding of large surfaces containing Cr(VI) in large work areas	10 [2.5 Cr(VI)]

Identifiers	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
		including cleaning (PROC 21, 24) - Waste management (PROC 8b) - End of Life (PROC 8a)	
Manufacture: M-#, , Industrial end use at site: IW-#, Professional end use: PW-#, Consumer end use: C-#, Service life (by workers in industrial site): SL-IW-#, Service life (by professional workers): SL-PW-#, Service life (by consumers): SL-C-#.)			

9.0.2. Introduction to the assessment

9.0.2.1. Environment

Scope and type of assessment

The current Chemical Safety Report (CSR) and the associated exposure scenarios (ES) are tailored to support Application for Authorization (AfA) to continue the use of strontium chromate in primers applied by aerospace and defence companies and their associated supply chains after the sunset date in January 2019.

Strontium chromate has been included in Annex XIV to Regulation (EC) No 1907/2006 ('REACH') due to its intrinsic properties as being carcinogenic (Carc. 1B).

Following Regulation (EC) No 1907/2006, Article 62(4)(d), the CSR supporting an AfA needs to cover only those potential risks arising from the intrinsic properties specified in Annex XIV. Accordingly, only the potential human health risks related to the classification of strontium chromate as a carcinogen are considered in the current CSR. The dominating health effect resulting from the intrinsic hazardous properties of strontium chromate is lung cancer due to inhalation of dust and/or aerosols. Intestinal cancer following ingestion is identified as a potential risk: however, the dose-response relationship is lower than that for lung cancer, and generally not considered an important exposure route for workers.

Evaluation of any potential hazards to the environment is not required within the framework of this authorisation application. Health hazards may potentially relate to Cr(VI) exposure of the general population via the environment, and considered accordingly.

Measures to prevent or limit release of Cr(VI) to the environment are provided as a best practice at facilities carrying out operations using Cr(VI). During painting operations, prevention of releases of all products to the aquatic environment is a matter of good practice. Water may be used in paint booths to capture residual paint and prevent release to the atmosphere; this water is recirculated and finally disposed as a hazardous waste. Treatment technology (on-site or off-site) to reduce hexavalent to trivalent chromium [Cr(III)] in wastewater is generally highly effective, such that residual concentrations of Cr(VI) in effluent are very low and often non-detectable, and may be considered negligible. Solid and liquid waste materials such as paper, filters, cans, personal protective equipment (PPE) and other equipment contaminated with paint containing Cr(VI) are collected and treated as hazardous waste where residual Cr(VI) can be effectively treated. In view of the risk management measures in place at the production facilities emissions to the aquatic environment associated with painting and sealing operations are effectively prevented.

Due to its low volatility, strontium chromate will not normally be present in air. Nevertheless, energetic processes such as spray painting or mechanical processes can release these substances into air in association with aerosols or particulate matter. All workspaces with potential release to air are equipped with exhaust ventilation systems to remove residual particulates from workers breathing zone: exhaust air is passed through filters or wet scrubbers according to best available technique (minimum 99% removal efficiency) before being released to atmosphere. While emissions to air are therefore very low, they have been considered in this assessment as a factor potentially contributing to Cr(VI) exposure of humans via the environment. The scope and type of the assessment of the pathway “man via the environment” discussion is in section 9.0.2.2 below.

Paints containing Cr(VI) are not directly or indirectly released to soil, and releases to soil are considered negligible

Table 7. Type of risk characterisation required for the environment

Protection target	Type of risk characterisation	Hazard conclusion (see section 7)
Freshwater	Not required	Not relevant
Sediment (freshwater)	Not required	Not relevant
Marine water	Not required	Not relevant
Sediment (marine water)	Not required	Not relevant
Sewage treatment plant	Not required	Not relevant
Air	Not required	Not relevant
Agricultural soil	Not required	Not relevant
Predator	Not required	Not relevant

Comments on assessment approach:

In accordance with Regulation (EC) No 1907/2006, Article 62(4)(d), potential risks to the environment need not be considered.

9.0.2.2. Man via environment

Scope and type of assessment

As discussed in 9.0.2.1., humans may potentially be exposed to strontium chromate via the environment. Since strict emission control measures are implemented, releases to the aquatic environment (and to soil), if any, are negligible, and the only relevant potential exposure path is inhalation of fine dust or particulates emitted from the facilities to air (see also "comments on assessment approach" below).

Within the current CSR, local concentrations (Clocal) of chromium in air resulting from industrial use emissions are modelled with EUSES 2.1.2., and expressed as Cr(VI).

The regional concentrations are reported in section 10.2.1.2 (see Table 41, "Predicted regional exposure concentrations (Regional PEC)") based on modeling with EUSES 2.1.2., and expressed as Cr(VI).

Table 8. Type of risk characterisation required for man via the environment

Route of exposure and type of effects	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1)
Inhalation: Local long-term	Quantitative	Lung cancer: ELR = 2.9E−02 per 1 µg Cr(VI)/m³ for 70 years
Oral: Local long-term	Not needed. Assume all inhaled material is respirable (worst case).	Intestinal cancer: ELR = 8.0E−04 per 1 µg Cr(VI)/kg bw/d for 70 years

Comments on assessment approach:

The risk assessment for humans exposed via the environment is restricted to inhalation of airborne residues of the chromates. The oral route (swallowing of the non-respirable fraction) does not need to be explicitly considered here since:

(i) the exposure calculations (airborne concentrations) do not provide different particle size fractions (inhalable/thoracic/respirable);

(ii) the excess lifetime risk (ELR) for intestinal cancer is one order of magnitude lower than that for lung cancer. The assessment of health impacts is therefore dominated by the potential risk of lung cancer due to inhalation of hexavalent chromium;

(iii) the document on a reference dose-response relationship for Cr(VI) compounds (RAC/27/2013/06 Rev.1) states, "*in cases where the applicant only provides data for the exposure to the inhalable particulate fraction, as a default, it will be assumed that all particles were in the respirable size range.*"

Therefore, in accordance with the above findings and provisions on the risk assessment for humans exposed via the environment, since the assumption is all particles are in the respirable size range, no exposure via the oral route needs to be considered.

This constitutes a worst-case approach, since the potential lung cancer risk, is an order of magnitude higher compared to the potential intestinal cancer risk, based on the dose-response relationships agreed by the Committee of Risk Assessment (RAC).

9.0.2.3. Workers

Scope and type of assessment

The scope of exposure assessment and type of risk characterisation required for workers are described in the following table based on the hazard conclusions presented in section 5.11.

Table 9. Type of risk characterisation required for workers

Route	Type of effect	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1)
Inhalation	Systemic long-term	Not needed	Not relevant
	Systemic acute	Not needed	Not relevant
	Local long term	Quantitative	Lung cancer: ELR = 4.0E−03 per 1 µg Cr(VI)/m³ for 40 years
	Local acute	Not needed	Not relevant
Dermal	Systemic long term	Not needed	Not relevant
	Systemic acute	Not needed	Not relevant
	Local long term	Not needed	Not relevant
	Local acute	Not needed	Not relevant
Eye	Local	Not needed	Not relevant

Comments on assessment approach related to toxicological hazard:

Strontium chromate has been included into Annex XIV to Regulation (EC) No 1907/2006 ('REACH') due to its intrinsic properties as being carcinogenic (Carc. 1B).

Following Regulation (EC) No 1907/2006, Article 62(4)(d), the CSR supporting an AfA needs to cover only those potential risks arising from the intrinsic properties specified in Annex XIV. The dominating health effect resulting from the intrinsic hazardous properties of strontium chromate is lung cancer due to inhalation of dust and/or aerosols.

Exposure estimates generated by ART 1.5 and measured exposure values are presented in this document in terms of Cr(VI).

The oral route (mucociliary clearance and swallowing of the non-respirable fractions) is not taken into account for the same reasons as already explained in the context of "man via environment" (section 9.0.2.1 above). In accordance with the RAC document on the dose-response relationship (RAC/27/2013/06 Rev.1), all particles are assumed in the respirable size range. Hence, no exposure via the oral route needs to be considered.

Comments on assessment approach related to physicochemical hazard:

Not relevant – physicochemical hazards are not subject of this chemical safety report.

General information on risk management related to toxicological hazard:

When handling solid strontium chromate or in cases in which exposure to airborne strontium chromate can occur (e.g. spraying), personnel are required to wear protective clothing, chemical-resistant gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles, and adequate respiratory protection (e.g. half- masks equipped with A2P3 filters[1]).

General information on risk management related to physicochemical hazard:

Not relevant – physicochemical hazards are not subject of this chemical safety report.

9.0.2.4. Consumers

Exposure assessment is not applicable as there are no consumer-related uses for strontium chromate.

[1] European standard EN 143 defines the classes of particle filters that can be attached to a facemask. A P3 filter is required to remove at least 99.95% of airborne particles at a filter penetration limit (at 95 L/min air flow)

9.1. Exposure scenario 1: Use at industrial site – Use of strontium chromate in primers applied by aerospace and defence companies and their associated supply chains.

This Exposure Scenario relates to the application of a surface coating of primers containing hexavalent chromium to articles. This process is typically to protect the part from corrosion and improve adhesion between metal and composite parts and may be carried out during production, maintenance, or repair.

The coating material generally contains less than 10 percent hexavalent chromium by weight (i.e. less than 40% strontium chromate by weight). Typically the strontium chromate content is much lower than this (e.g. <5% in bond primers and between 10-30% w/w in structural primer preparations. Industrial facilities receive the formulated product in sealed containers. The size, geometry, and area of the article determine the coating technique. Application of the coating material may be using a spray gun and/or brush (local/roller). A trained operator within a designated area applies the paint either automatically or manually. Following application, a drying/curing process is undertaken, either at room temperature or high temperature, under closed conditions (e.g., oven, autoclave) where no inhalation exposure is expected. Sometimes a coating may be 'touched-up' during maintenance or repair operations in- or outside a designated facility by small brush.

Operating conditions and risk management measures are specified to limit potential worker (inhalation and dermal) exposure to various components in the paint and environmental exposure through application of the coating. Spray booths with wet or dry filters are provided for spray applications. Air extraction units and local exhaust ventilation (LEV) are provided to minimize concentrations of hexavalent chromium and other components of the coating in the workplace air. Personal protective equipment is specified to minimize potential inhalation and dermal exposure. Once the coating has been applied, the equipment is cleaned. Equipment maintenance is on regular basis.

Workers are skilled, and receive regular chemical risk management training how to wear the Personal Protective Equipment properly. Regular housekeeping is also in place and management systems are in place ensuring high standard of operational procedures.

Environment contributing scenario(s):	
Use of strontium chromate in primers applied by aerospace and defence companies and their associated supply chains.	ERC 5
Worker contributing scenario(s):	
Delivery and storage of raw material	PROC 1
Decanting, mixing and filling of guns, cups or small containers	PROC 5
Surface treatment by spraying in spray cabin/spray booth	PROC 7
Surface treatment by spraying outside of paint-booth	PROC 7
Surface treatment by brushing/rolling (small to medium sized parts)	PROC 10
Surface treatment by brushing (very small parts/touch-up)	PROC 10
Cleaning of equipment – tools cleaning (closed system)	PROC 8b
Cleaning and maintenance of equipment – tools cleaning (paint cabin)	PROC 8b
Cleaning – paint cabin and ancillary areas	PROC 8b
Infrequent maintenance activities	PROC 8a
Machining operations on small to medium sized parts containing Cr(VI) on an extracted bench/extraction booth including cleaning	PROC 21, 24
Machining operations on small to medium sized surfaces containing Cr(VI) on an extracted bench/extraction booth including cleaning	PROC 21, 24
Machining operations in large work areas on parts containing Cr(VI) including cleaning	PROC 21, 24
Machining operations in large work areas on surfaces containing Cr(VI) including cleaning	PROC 21, 24
Machining operations on parts containing Cr(VI) in small work areas including cleaning	PROC 21, 24

Machining operations on surfaces containing Cr(VI) in small work areas including cleaning	PROC 21, 24
Sanding of large surfaces containing Cr(VI) in large work areas including cleaning	PROC 21, 24
Waste management	PROC 8b
End of Life	PROC 8a

Subsequent service life exposure scenario(s):

Not relevant

Explanation on the approach taken for the ES

Modelled data supported by measurement data, if available, is basis for occupational exposure estimates. For some activities, inhalation exposure has been estimated using the exposure model '*Advanced REACH Tool 1.5' or 'ART'*[2]. ART is calibrated to assess exposure to inhalable dust, vapours, and mists; this Exposure Scenario is within the scope of ART. The figures obtained by modelling are considered to be worst-case estimates: supportive evidence for the conservative character of the modelled estimates is provided by comparison with relevant measured exposure data (measured concentrations of particulate residues of Cr(VI) in air), where available; such analysis indeed indicates that ART is a reasonable but conservative tool for estimating exposure of Cr(VI) in the scope of this assessment. Selection of appropriate values for each model parameters is in close cooperation with directly involved companies from the aerospace and affiliated industries, as indicated elsewhere in this document. Where the sample size and sampling strategy is adequate (i.e. personal sampling data) the risk characterisation relies on the measured exposure values; in other cases the results of the exposure modelling were used as adequate measurement data was not available.

This detailed Exposure Scenario has been developed based on information provided by multiple companies involved in this activity. Companies provided details of the conditions under which the activity was carried out as well as the duration and frequency of each task. This information was verified during visits of facilities carrying out the surface coating activities described here.

The frequency of a specific activity in the worker sub-scenarios is expressed as daily activity unless otherwise stated. As long-term exposure is the relevant period for long-term health effects, the duration of exposure per day as set out in the ES is expressed as *average* duration per day over a longer period (e.g. 2 hours each day are equal to 4 hours every second day). Therefore, it can be seen that the duration of exposure per day is not the same as the *maximum* allowed duration in any one day.

All sub-scenarios, which are based on modelled values, provide worst-case estimates using in general the highest exposure duration and the lowest level of personal protection reported. Furthermore, in the scenarios a maximum level of the concentration of strontium chromate in the mixture is applied. In most of the applications, the concentration will be much lower. Therefore, many companies will in reality stay below the estimated exposure.

[2] The use of ART for workers exposure assessment under REACH is described in ECHA's updated Guidance on Information Requirements and chemical safety assessment R.14.

9.1.1. Environmental contributing scenario 1: Use of strontium chromate in primers applied by aerospace and defence companies and their associated supply chains.

Hexavalent chromium releases to the environment are carefully controlled by industry and monitored by regulators. The volume of hexavalent chromium (as strontium chromate) depends on the scale of the facility.

Air emissions relating to local exhaust ventilation (LEV) or extraction systems are filtered (e.g. using HEPA filters) or passed through wet scrubbers to remove particulates prior to release to atmosphere. Information from facilities indicates that removal efficiency of at least 99% is typical for industry. Companies regularly monitor and report hexavalent chromium emissions as part of permit conditions. Releases are often beneath detection limits and extended sampling times are necessary to quantify releases.

For the coating applications described here, the production facility is strictly separated from the wastewater stream, i.e. there is only very low release of Cr(VI) to the aquatic environment, if at all. Water in scrubbers or filters is generally recycled and occasionally replaced, with resulting material being treated as a waste.

Facilities may have on-site wastewater treatment facilities that act to reduce the hexavalent chromium to trivalent chromium. The solids are precipitated and the supernatant is discharged from the site. The treatment process is very efficient and concentrations of hexavalent chromium in treated water are below detection limits.

Waste materials containing Cr(VI) are classified and treated as hazardous wastes according to EU and national regulations.

These conditions are reflected in the environmental contributing scenario below.

9.1.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
▪ *See below*
Technical and organisational conditions and measures
▪ Air emission abatement: at least 99% efficiency. ▪ Negligible discharge of Cr(VI) in wastewater from the site ▪ All solid waste and any liquid waste is collected and either the collected waste is directly forwarded to an external waste management company, or Cr(VI) in wastewater is reduced to Cr(III) on-site, and the treated waste is forwarded to an external waste management company (licenced contractor) for disposal as hazardous waste
Conditions and measures related to sewage treatment plant
▪ Not applicable – negligible discharge of Cr(VI) in wastewater from the site
Conditions and measures related to treatment of waste (including article waste)
▪ Collection of all solid and liquid waste, elimination of Cr(VI) from waste water, disposal as hazardous waste by an external waste management company (licenced contractor)
Other conditions affecting environmental exposure
▪ Exhaust air is passed through filters or wet scrubbers according to best available technique (minimum efficiency 99 %)

9.1.1.2. Releases

Point source emission data for strontium chromate were not available for this application.

Instead, assuming the use of 2.5t Cr(VI) per year in total at 100 sites, average use per site would be 0.025t Cr(VI) per year. It is conservatively assumed activities are carried out for 25 days per year.

This number was used for estimating the exposure concentration through EUSES.

The local releases to the environment are reported in the following table.

Table 10. Local releases to the environment

Release	Release factor estimation method	Explanation / Justification
Air	Release factor	**Initial release factor:** 50% (ERC based) **Final release factor:** 0.5% (after air abatement) **Local release rate:** 0.005 kg/day

9.1.1.3. 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.

Table 11. Exposure concentrations and risks for the environment

Protection target	Exposure concentration	Risk characterisation
Freshwater	Not relevant	
Sediment (freshwater)	Not relevant	
Marine water	Not relevant	
Sediment (marine water)	Not relevant	
Predator (freshwater)	Not relevant	
Predator (marine water)	Not relevant	
Top predator (marine water)	Not relevant	
Sewage treatment plant	Not relevant	
Air	**Local PEC:** 9.521E-8 mg/m³	
Agricultural soil	Not relevant	
Predator (terrestrial)	Not relevant	
Man via Environment - Inhalation	**Local PEC:** 9.521E-8 mg/m³	Based on the dose-response relationship derived by the RAC, considering a 70 year exposure time (24h/day, 7d/week), the following excess lifetime risk for the general population is derived based on the estimated exposure: 2.76E-03 per 1000 exposed.
Man via Environment - Oral	Not relevant	

Conclusion on risk characterisation

The estimated exposure concentration of 9.52E-8 mg/m³ mg/m^3 is derived via EUSES is used as worst-case estimate of $Plocal_{air,ann.}$ and used as the basis for risk characterisation for man via the environment.

Based on the dose-response relationship derived by the RAC, considering a 70 year exposure time (24h/day, 7d/week), the following excess lifetime risk for the general population is derived based on the estimated exposure:

2.76E-03 per 1000 exposed.

As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.2. Worker contributing scenario 1: Delivery and storage of raw material (PROC 1)

9.1.2.1. Conditions of use

The strontium chromate containing formulation is delivered in sealed containers and stored in a chemical storage room for dangerous chemicals. There is no potential for exposure.

	Method
Product (article) characteristics	
• Concentration of Cr(VI) in mixture: Minor (5 – 10%)	Qualitative
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: < 8 hours	Qualitative
Technical and organisational conditions and measures	
• General ventilation: Basic general ventilation (1-3 air changes per hour)	Qualitative
• Containment: Closed system (minimal contact during routine operations)	Qualitative
• Local exhaust ventilation: No	Qualitative
• Occupational Health and Safety Management System: Advanced	Qualitative
Conditions and measures related to personal protection, hygiene and health evaluation	
• Respiratory Protection: No	Qualitative
Other conditions affecting workers exposure	
• Place of use: Indoor	Qualitative
• Process temperature (for liquid): <= 40 °C	Qualitative

9.1.2.2. Exposure and risks for workers

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

Table 12. Exposure concentrations and risks for workers

Route of exposure and type of effects	Exposure concentration	Risk characterization
Inhalation, local, long-term	**0 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0 per 1000 exposed workers

Conclusion on risk characterisation

There is no potential for exposure. The qualitatively determined exposure estimate of 0 µg Cr(VI)/m³ is used as the basis for risk characterisation.

An excess lifetime risk of 0 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship.

9.1.3. Worker contributing scenario 2: Decanting, mixing and filling of guns, cups or small containers (PROC 5)

The container is opened either in a dedicated room or in the spray booth for mixing and stirred, either automatically or manually, using a handheld tool, to achieve a good consistency in the paint. Occasionally

small quantities of other components (e.g. thinner) are added prior to filling into paint guns, cups, or small containers. Local exhaust ventilation is present. This scenario describes, as worst-case scenario, the manual mixing as an open process and without any respiratory protection. The model also applies a maximum concentration level of strontium chromate [and so Cr(VI)]. In most cases, the concentration will be much lower.

9.1.3.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: – Minor (5 – 10%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Activities with agitated surfaces	ART 1.5
▪ Situation: Open surface < 0.1 m²	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No	ART 1.5

9.1.3.2. Exposure and risks for workers

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

Table 13. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.17 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.68 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.17 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions[3] regarding exposure.

An excess lifetime risk of 0.68 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.4. Worker contributing scenario 3: Surface treatment by spraying in spray cabin/spray booth (PROC 7)

Small to medium sized parts are sprayed in a spray cabin or spray booth with air extraction systems in place. Workers wear at least half-face masks with P3 filter. This is not a continuous task during the full-shift.

More than 50 personal sampling and static measurement data from 2010-2017 from four EU countries were available from 11 companies. Results from ten sites could be used for exposure assessment. Because a sufficient number (29) of data from personal sampling were available, the exposure assessment is based on these data (as suggested in the Technical Guidance document R.14). The results by site are attached as Annex A1. Additionally, results of the static sampling are shown (Annex A2).

Individual company data have been comprehensively evaluated. The number of sampling data provided by each of the companies varied (e.g. different number of measurements conducted, different number of years reported), so the data were aggregated per company in the first instance. In a second step, data were aggregated across all the companies that provided data, giving equal weight to each company in the data set.

The estimation below therefore considers already the effectiveness of local exhaust ventilation (reflected by the measured values) which is standard in spray rooms/both.

[3] These include:

- highest reported exposure duration for each task (whereas the exposure duration is normally lower)
- minimum reported RMM (e.g. automation, enclosure, extract ventilation) to reduce exposure
- lowest level of personal protection (whereas the level of personal protection will normally be higher in practice)
- use of the 90th percentile value as representative for the exposure situation.

While any one individual site may represent the situation for one of these assumptions (e.g. highest reported exposure duration), no individual site represents the worst case for each assumption. Furthermore, these assumptions have multiplicative effect, such that the level of conservatism built into the health assessment increases by orders of magnitude as a result.

The values reported below include an estimate of the effectiveness of respiratory protection. Effectiveness of respiratory protection was assessed using the company information on type of mask and filter used and the protection factors (APFs) provided by either the *German BG rule "BGR/GUV-R190"* from December 2011 or alternatively, if available, the APF provided by the manufacturer of the respiratory protection equipment. Respiratory protection is always worn during spraying.

9.1.4.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	Measured data
▪ Concentration of Cr(VI) in mixture: Minor (5 - 10%)	Measured data
▪ Process temperature: Room temperature	Measured data
▪ Vapour pressure of substance: < 0.01 Pa	Measured data
▪ Viscosity: Low	Measured data
Activity emission potential	
▪ Duration of activity: < 120 min	Measured data
▪ Primary emission source located in the breathing zone of the worker: Yes	Measured data
▪ Activity class: Surface spraying of liquids	Measured data
▪ Situation: Moderate application rate (0.3 - 3 l/minute)	Measured data
▪ Spray direction: In any direction (including upwards)	Measured data
▪ Spray technique: Spraying with no or low compressed air use	Measured data
Surface contamination	
▪ Process fully enclosed? No	Measured data
▪ Effective housekeeping practices in place? Yes	Measured data
Dispersion	
▪ Work area: Spray room	Measured data
▪ Type: Down-flow spray room	Measured data
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	Measured data
▪ Secondary: No localized controls (0.0 % reduction)	Measured data
▪ Work area: Down-flow spray room (80.00 % reduction)	Measured data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *When spraying medium parts in paint booth minimum at least half-mask with A2P3 filter (APF 30 according to German BG rule 190) is worn* *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measured data

9.1.4.2. Exposure and risks for workers

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

Table 14. Exposure concentrations adjusted for RPE and risks for workers – inhalation, local, long-term

PROC	Description	N*	Arithmetic Mean	Geometric Mean	90th Percentile	RCR
PROC 7	Spray painting in spray cabin/booth	29	0.025 µg/m³	0.007 µg/m³	**0.055 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.22 per 1000 exposed workers

* N = number of measurements

Conclusion on risk characterisation

The 90th percentile value of the personal sampling data adjusted for respiratory protection of 0.055 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case).

An excess lifetime risk of 0.22 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.5. Worker contributing scenario 4: Surface treatment by spraying outside of paint-booth (PROC 7)

Occasionally spraying is conducted on limited surfaces outside a paint booth, e.g. directly on airplanes. Depending on the amount of paint used (exposure potential) either half-face or full-face masks are in use. Local extraction may or may not be available. For the purpose of this exposure assessment, it is assumed that it takes place two times a week, using less than one liter of paint, without exhaust air extraction and using a half-face mask. The model also applies a maximum concentration level of strontium chromate [and so Cr(VI)]. In most cases, the concentration will be much lower.

9.1.5.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Minor (5 - 10%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 30 min	ART 1.5
▪ Frequency of activity: 2 days/week	ART 1.5 (extended)
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Surface spraying of liquids	ART 1.5
▪ Situation: Very low application rate (< 0.03 l/minute)	ART 1.5
▪ Spray direction: In any direction (including upwards)	ART 1.5
▪ Spray technique: Spraying with no or low compressed air use	ART 1.5

	Method
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors/outdoors	ART 1.5
▪ Room size: 3000m^3	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *When spraying outside paint booth (e.g. on airplanes) at least half- mask with A2P3 filter (minimum APF 30 according to German BG rule 190) is worn* *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.1.5.2. Exposure and risks for workers

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

Table 15. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**40 µg/m³** (ART 1.5 prediction, 90th percentile value)	
Further adjusted for frequency and RPE	**0.53 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 2.13 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.53 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 2.13 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.6. Worker contributing scenario 5: Surface treatment by brushing/rolling (small to medium sized parts) (PROC 10)

While the usual application method is by spraying, additionally for rather small areas, surface treatment is done by brushing/rolling under exhaust ventilation. For the purpose of this exposure assessment, it is assumed that brush application takes place daily with up to 1-hour exposure/day on a yearly average. The model also applies a maximum concentration level of strontium chromate [and so Cr(VI)]. In most cases, the concentration will be much lower.

9.1.6.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Minor (5 - 10%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Spreading of liquid products	ART 1.5
▪ Situation: Spreading of liquids at surfaces or work pieces 0.1 - 0.3 m² / hour	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No (0.0 % reduction) *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.1.6.2. Exposure and risks for workers

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

Table 16. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.57 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 2.28 per 1000 exposed workers

Results of personal sampling

Six personal sampling results from 2015-2016 and from one site are available for the brush application. All results were below the measurement specific LOD of 0.75 µg Cr(VI)/m³.

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.57 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 2.28 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.7. Worker contributing scenario 6: Surface treatment by brushing (very small parts/touch-up) (PROC 10)

The usual application method is by spraying. Additionally for smaller areas, surface treatment is also done by brushing or touch-up. This may happen indoors and outdoors. For the purpose of this exposure assessment, it is assumed that it takes place daily with 30 min exposure/day on a yearly average. The model also applies a maximum concentration level of strontium chromate [and so Cr(VI)]. In most cases, the concentration will be much lower. Potential for inhalation exposure is not expected by this activity.

9.1.7.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Minor (5 - 10%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 30 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Spreading of liquid products	ART 1.5

	Method
▪ Situation: Spreading of liquids at surfaces or work pieces < 0.1 m² / hour	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors/outdoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

Results of personal sampling

Three personal sampling results from 2017 and from 1 site are available for this type of application. All results were below the measurement specific LOD of 0.06 µg Cr(VI)/m³ as 8h TWA.

9.1.7.2. Exposure and risks for workers

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

Table 17. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.28 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 1.12 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.28 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 1.12 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is

acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.8. Worker contributing scenario 7: Cleaning of equipment – tools cleaning (closed system) (PROC 8b)

Tools (e.g. spray guns) are cleaned with solvent in a closed system. The model also applies a maximum concentration level of strontium chromate [and so Cr(VI)]. In most cases, the concentration will be much lower.

9.1.8.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Minor (5 - 10%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Handling of contaminated objects	ART 1.5
▪ Situation: Activities with treated/contaminated objects (surface 0.1-0.3 m²)	ART 1.5
▪ Contamination level: Contamination 10-90 % of surface	ART 1.5
Surface contamination	
▪ Process fully enclosed? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.1.8.2. Exposure and risks for workers

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

Table 18. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.017 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.07 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.017 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 0.07 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.9. Worker contributing scenario 8: Cleaning and maintenance of equipment – tools cleaning (paint cabin) (PROC 8b)

The worker who conducted spraying cleans tools (e.g. paint guns, brushes) with water or solvent in the spray cabin, paint shop, or paint mixing room. If maintenance is required, it is conducted in the same step under same conditions. The model also applies a maximum concentration level of strontium chromate [and so Cr(VI)]. In most cases, the concentration will be much lower.

9.1.9.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Minor (5 - 10%)	ART 1.5
▪ Process temperature: Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Handling of contaminated objects	ART 1.5
▪ Situation: Activities with treated/contaminated objects (surface 0.1-0.3 m²)	ART 1.5
▪ Contamination level: Contamination 10-90 % of surface	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	

	Method
▪ Work area: Indoors (Spray room/paint mixing room)	ART 1.5
▪ Room size: Any size workroom	ART 1.5
▪ Ventilation rate: Specialised room ventilation with more than 10 ACH	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Work area: Any size workroom	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.1.9.2. Exposure and risks for workers

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

Table 19. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.089 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.36 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.089 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 0.36 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.10. Worker contributing scenario 9: Cleaning – paint cabin and ancillary areas (PROC 8b)

The workers who conducted spraying, under the same operational conditions conduct cleaning of the paint shop or booth and of any ancillary areas often. Walls and the floor of the spray area might be covered with protective film/foil before spraying. After spraying this is removed and stored in a tank for contaminated waste... The model below provides, as worst case, exposure estimates for cleaning without air extraction in operation and without respiratory protection. The model also applies a maximum concentration level of strontium chromate [and so Cr(VI)]. In most cases, the concentration will be much lower.

9.1.10.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Minor (5 - 10%)	ART 1.5
▪ Process temperature: Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Handling of contaminated objects	ART 1.5
▪ Situation: Activities with treated/contaminated objects (surface > 3 m²)	ART 1.5
▪ Contamination level: Contamination 10-90 % of surface	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoor	ART 1.5
▪ Type: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.1.10.2. Exposure and risks for workers

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

Table 20. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.17 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.68 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.17 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 0.68 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.11. Worker contributing scenario 10: Infrequent maintenance activities (PROC 8a)

Maintenance activities on equipment like the exhaust system or the removal and replacement of filters may need more time and might create higher exposure potential. As worst case for these activities, the model below provides exposure estimates for the removal and replacement of filters that is assumed to be conducted one time per month with duration up to 4 hours. The model also applies a maximum concentration level of strontium chromate [and so Cr(VI)]. In most cases, the concentration will be much lower.

9.1.11.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5
▪ Dustiness: Fine Dust	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
▪ Concentration of Cr(VI) in mixture: Minor (5 - 10%)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 240 min	ART 1.5
▪ Frequency of activity: 1 time/month	ART 1.5 (extended)
▪ Activity class: Handling of contaminated solid objects or paste	ART 1.5
▪ Situation: Handling of objects with visible contamination (object covered with fugitive dust from surrounding dusty activities)	ART 1.5
▪ Handling type: Careful handling, involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner.	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5

	Method
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *During maintenance activities at least half-mask with A2P3 filter (APF 30 according to German BG rule 190) is worn* *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.1.11.2. Exposure and risks for workers

Table 21. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**130 µg/m³** (ART 1.5 prediction, 90th percentile value)	
Further adjusted for frequency and RPE	**0.22 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.87 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.22 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 0.87 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.12. Worker contributing scenario 11: Machining operations on small to medium sized parts containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24)

During assembly, maintenance and/or repair, small to medium sized solid parts are drilled or cut on a dedicated workbench fitted with air extraction. Cleaning due to contamination during the machining process is included in this scenario because it is conducted under the same operational conditions and risk management measures as the machining activities.

This scenario covers also machining operations with a longer duration of activity but with a higher level of respiratory protection, e.g. by using a half-mask with P3 filter (APF 30) or a full-face mask with P3 filter (APF 400).

The Cr(VI) weight fraction of the part is assumed less than 0.1 percent. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way[4] (i.e. 0.5 % concentration in the product would lead to an increase of the exposure estimate by a factor of 5). If needed, OCs and RMMs could be adjusted for that different situation.

9.1.12.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 0.1 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 180 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Equipment level: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood /Vacuum cleaner (HEPA filter with at least 99.00 % reduction)	ART 1.5 (extended)
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5

[4] The exposure model ART applies a linear relationship

	Method
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 10] [Effectiveness Inhal: 90%] *If individual workplace monitoring data do not confirm negligible exposure below 1 µg/m³ (e.g. < 0.1 µg/m³), additional protection adapted to such measured exposure is required ([e.g., half or quarter mask with P2 filter (APF 10 according to German BG rule 190)]*.	ART 1.5 (extended)

9.1.12.2. Exposure and risks for workers

Table 22. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	1.1 µg/m³ (ART 1.5 prediction, 90th percentile value)	
Further adjusted for RPE	**0.11 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.44 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.11 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 0.44 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.13. Worker contributing scenario 12: Machining operations on small to medium sized surfaces containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24)

During assembly, maintenance and/or repair, small to medium sized surfaces are fettled, abraded, or sanded on a dedicated workbench fitted with air extraction. Cleaning due to contamination during the machining process is included in this scenario because it is conducted under the same operational conditions and risk management measures as the machining activities.

This scenario covers also machining operations with a longer duration of activity but with a higher level of respiratory protection e.g. by using a full-face mask with P3 filter and air supply (APF 1000).

The Cr(VI) content of the surface is assumed less than 13 percent. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way. If needed, OCs and RMMs could be adjusted for that different situation.

9.1.13.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 13 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 180 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Equipment level: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood /Vacuum cleaner (HEPA filter with at least 99.00 % reduction)	ART 1.5 (extended)
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 400] [Effectiveness Inhal: 99.75 %] *If individual workplace monitoring data do not confirm negligible exposure below 1 µg/m³ (e.g. < 0.1 µg/m³), additional protection adapted to such measured exposure is required [e.g., full-face mask with P3 filter (APF 400 according to German BG rule 190)].*	ART 1.5 (extended)

9.1.13.2. Exposure and risks for workers

Table 23. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	150 µg/m³ (ART 1.5 prediction, 90th percentile value)	
Further adjusted for RPE	**0.375 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 1.5 per 1000 exposed workers

Measured Data for WCS 12:

Personal sampling data are available. The activities represent slightly different situations, due to the size of the parts machined and the type of tools used, as described below. Some variation can be expected from facility to facility, and the situations described below are considered typical of such activities.

1. Situation: Mechanical treatment of very small parts. The small sample size (n = 3) a does not allow for using the measured data as the basis for exposure estimation. However, the measured value is presented as supportive evidence for the appropriateness of model estimates:

   Measured exposure (personal sampling, arithmetic mean): **0.05 µg /m³**, (90th percentile 0.05 µg/m³), all measurement results below the detection limit (0.1 µg Cr(VI)/m³). This value does not account for respiratory protection.

   The measured values indicate that the estimated exposure from the ART model (based on the solid material *stone* as metal is currently not an available option in ART), which resulted in an exposure estimate of 0.375 µg Cr(VI)/m³ and which accounted for respiratory protection overestimated exposure for this situation by a factor of 3000.

2. Situation: Mechanical treatment of small to medium sized parts. The small sample size (n = 3) does not allow for using the measured data as the basis for exposure estimation. However, the measured value is presented as supportive evidence for the appropriateness of model estimates:

   Measured exposure (personal sampling, taking respiratory protection but with a much lower APF into account, arithmetic mean): **0.27 µg Cr(VI)/m³** (90th percentile 0.28 µg/m³).

   The measured values indicate that the estimated exposure from the ART model (based on the solid material *stone* as metal is currently not an available option in ART), which resulted in an exposure estimate of 0.375 µg Cr(VI)/m³ likely produced a considerable overestimation of exposure.

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.375 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 1.5 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.14. Worker contributing scenario 13: Machining operations in large work areas on parts containing Cr(VI) including cleaning (PROC 21, 24)

Solid parts are manually drilled, riveted, or cut outside a booth in large work areas. Cleaning after machining is included in this scenario because it is conducted under the same operational conditions and risk management measures as the machining activities.

This scenario covers also machining operations with a longer duration of activity but with a higher level of respiratory protection, e.g. by using a half- mask with P3 filter (APF 30) or a full-face mask with P3 filter (APF 400).

The Cr(VI) weight fraction of the part is assumed less than 0.1 percent. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way (i.e. 0.5 % concentration in the product would lead to an increase of the exposure estimate by a factor of 5). If needed, OCs and RMMs could be adjusted for that different situation.

9.1.14.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 0.1 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Large workrooms only	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Wetting at the point of release/on-tool extraction/vacuum cleaning (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 10] [Effectiveness Inhal: 90%] *If individual workplace monitoring data do not confirm negligible exposure below 1 µg/m³ (e.g. < 0.1 µg/m³), additional protection adapted to such measured exposure is required ([e.g., half or quarter mask with P2 filter (APF 10 according to German BG rule 190)]*.	ART 1.5 (extended)

9.1.14.2. Exposure and risks for workers

Table 24. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**2.0 µg/m³** (ART 1.5 prediction, 90th percentile value)	
Further adjusted for RPE	**0.20 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.8 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.20 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 0.8 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.15. Worker contributing scenario 14: Machining operations in large work areas on surfaces containing Cr(VI) including cleaning (PROC 21, 24)

Surfaces are manually fettled, abraded, or sanded outside a booth in large work areas. Cleaning after machining is included in this scenario because it is conducted under the same operational conditions and risk management measures as the machining activities.

This scenario covers also of machining operations which a longer duration of activity but with a higher level of respiratory protection.

The Cr(VI) content of the surface is assumed less than 13 percent. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way. If needed, OCs and RMMs could be adjusted for that different situation.

9.1.15.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 13 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5

	Method
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Large workrooms only	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Wetting at the point of release/on-tool extraction/vacuum cleaning (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 400] [Effectiveness Inhal: 99.75%] *At least full face mask with P3 filter (APF 400 according to German BG rule 190) is worn* *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.1.15.2. Exposure and risks for workers

Table 25. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	270 µg/m³ (ART 1.5 prediction, 90th percentile value)	
Further adjusted for RPE	**0.675 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 2.7 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.675 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 2.7 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

Measured Data for WCS 13 and 14:

Personal sampling data are available representing a mixture of activities described in WCS 17 and 18. The small sample size (n = 7) does not allow for using the measured data as the basis for exposure estimation. However, the measured value is presented as supportive evidence for the appropriateness of model estimates:

Measured exposure (personal sampling, taking respiratory protection but with a much lower APF into account, arithmetic mean): **0.39 µg Cr(VI)/m³**, (90th percentile 0.5 µg/m³).

The measured values indicate that the ART model (based on the solid material *stone* as metal currently is not an available option in ART), which resulted in an exposure estimate of 0.20 and 0.675 µg Cr(VI)/m³ respectively, likely produced an overestimation of exposure for machining activities on the surface of parts.

9.1.16. Worker contributing scenario 15: Machining operations on parts containing Cr(VI) in small work areas including cleaning (PROC 21, 24)

Parts are drilled, riveted, or cut in comparable small work areas. Cleaning after machining is included in this scenario because it is conducted under the same operational conditions and risk management measures as the machining activities.

In small work areas, no air extraction or other localised controls (e.g. wetting, vacuum cleaning) may be available. This scenario assumes the absence of any localised control.

The Cr(VI) weight fraction of the part is assumed less than 0.1 percent. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way (i.e. 0.5 % concentration in the product would lead to an increase of the exposure estimate by a factor of 5). If needed, OCs and RMMs could be adjusted for that different situation.

9.1.16.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 0.1 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Small workrooms only	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 400] [Effectiveness Inhal: 99.75%] *If individual workplace monitoring data do not confirm negligible exposure below 1 µg/m³ (e.g. < 0.1 µg/m³), additional protection adapted to such measured exposure is required ([e.g., full-face mask with P3 filter (APF 400 according to German BG rule 190)]*.	ART 1.5 (extended)

9.1.16.2. Exposure and risks for workers

Table 26. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	64 µg/m³ (ART 1.5 prediction, 90th percentile value)	
Further adjusted for RPE	**0.16 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.64 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.16 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 0.64 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.17. Worker contributing scenario 16: Machining operations on surfaces containing Cr(VI) in small work areas including cleaning (PROC 21, 24)

Small surfaces are fettled, edged, abraded, or sanded in comparable small work areas. Cleaning after machining is included in this scenario because it is conducted under the same operational conditions and risk management measures as the machining activities.

In small work areas, no air extraction or other localised controls (e.g. wetting, vacuum cleaning) may be available. This scenario assumes the absence of any localised control.

The Cr(VI) content of the surface is assumed less than 13 percent. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way. If needed, OCs and RMMs could be adjusted for that different situation.

9.1.17.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 13%	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5

	Method
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Small workrooms only	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Wetting at the point of release (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 1000] [Effectiveness Inhal: 99.9%] *If individual workplace monitoring data do not confirm negligible exposure below 1 µg/m³, localised controls and/or additional protection adapted to such measured exposure is required. Such measures could include for example use of wetting agent and/or use of vacuum extraction (with HEPA filter) to reduce airborne concentrations and/or full face mask with P3 filter and air supply (APF 1000 according to German BG rule 190).*	ART 1.5 (extended)

9.1.17.2. Exposure and risks for workers

Table 27. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	830 µg/m³ (ART 1.5 prediction, 90th percentile value)	
Further adjusted for RPE	**0.83 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 3.32 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.83 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 3.32 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

Measured Data for WCS 15 and 16:

Personal sampling data representing a mixture of activities described in WCS 19 and 20 are available. The small sample size (n = 11) does not allow for using the measured data as the basis for exposure estimation. However, the measured value is presented as supportive evidence for the appropriateness of model estimates:

Measured exposure (personal sampling, taking respiratory protection (with a lower APF than specified in this worker-contributing scenario) into account, arithmetic mean): **0.28 µg Cr(VI)/m³**, (90^{th} percentile 0.18 µg/m³).

The measured values indicate that the ART model (based on the solid material *stone* as metal currently is not an available option in ART), which resulted in an exposure estimate of 0.16 and 0.83 µg Cr(VI)/m³ respectively, likely produced an overestimation of exposure in both WCS.

9.1.18. Worker contributing scenario 17: Sanding of large surfaces containing Cr(VI) in large work areas including cleaning (PROC 21, 24)

Large sized parts, e.g. aircrafts, helicopters; wings are sanded in a specifically designed large room with restricted access. Continuous air ventilation is provided from the roof to the floor, including adequate filter systems. Full-face respirators with air supply, gloves, and overalls are worn. This activity can be conducted over a full-shift but then not every day (i.e. once per week). For the purpose of this exposure assessment, it is assumed that it takes place daily with 2h exposure/day.

The Cr(VI) content of the surface is assumed less than 13 percent. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way. If needed, OCs and RMMs could be adjusted for that different situation.

9.1.18.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 13%	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 120 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Abrasive blastings	ART 1.5
▪ Situation: Abrasive blasting of very large surfaces	ART 1.5
▪ Spray direction: In any direction (including upwards)	ART 1.5
▪ Technique: Dry abrasive blasting	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Downward laminar flow booth	ART 1.5
▪ Equipment level: No barriers or screens	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Wetting at the point of release/on-tool extraction/vacuum cleaning (90.00 % reduction)	ART 1.5

	Method
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Work area: No barriers or screens (80.00 % reduction)	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 1000] [Effectiveness Inhal: 99.9%] *When sanding large parts (e.g. airplanes, helicopters etc.) full face mask with P3 filter and air supply (minimum APF 1000 according to German BG rule 190) is worn* *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.1.18.2. Exposure and risks for workers

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

Table 28. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	1200 µg/m³ (ART 1.5 prediction, 90th percentile value)	
Further adjusted for RPE	**1.2 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 4.8 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 1.2 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 4.8 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship.

9.1.19. Worker contributing scenario 18: Waste management (PROC 8b)

Waste from paint spraying or brushing is collected as part of cabin/tools cleaning processes, waste from machining processes as part of cleaning processes described above is collected in closed tanks for contaminated waste which further are collected by licensed waste management companies for treatment, incineration and disposal of incineration residues to contaminated landfill.

The equipment is cleaned by flushing or washing the equipment with water or solvent; all wastewater/waste solvent is collected and treated as hazardous waste. Other waste materials including used paint containers, rags, paper, film, foil, filters, sludge, overalls, and protective gloves are treated as a hazardous waste.

The scenario below describes the transfer of such type of waste to the storage area.

9.1.19.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5
▪ Dustiness: Fine Dust	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
▪ Powder weight fraction [Cr(VI)]: Minor (5 – 10%)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 30 min	ART 1.5
▪ Activity class: Handling of contaminated solid objects or paste	ART 1.5
▪ Situation: Handling of objects with visible contamination (object covered with fugitive dust from surrounding dusty activities)	ART 1.5
▪ Handling type: Normal handling, involves regular work procedures.	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Low level containment (90.00 % reduction)5	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *During waste transfer activities with potential to exposure to airborne hexavalent chromium at least half-mask with A2P3 filter (APF 30 according to German BG rule 190) is worn* *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

[5] Low-level containment can, e.g., be described as “Physical containment or enclosure of the source of emission. The air within the enclosure is not actively ventilated or extracted. The enclosure is not opened during the activity.” [Advanced REACH Tool (ART) version 1.5].

9.1.19.2. Exposure and risks for workers

Table 29. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**5.7 µg/m³** (ART 1.5 prediction, 90th percentile value)	
Further adjusted for RPE	**0.19 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.76 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.19 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 4).

An excess lifetime risk of 0.76 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.20. Worker contributing scenario 19: End of Life (PROC 8a)

At the end of life, parts are collected in designated, secure boxes and sent to a licensed scrap dealer who treats the metals according to EU and national requirements. The aerospace industry has specialist waste contractors familiar with these requirements.

All Aircraft parts must, as part of aviation requirement [AMC 145.A.42; AMC M.A. 504 (d)(2) and AMC M.A. 504 (e)] to avoid suspect unapproved parts, be destroyed to avoid reuse. All other parts, at end of life, are collected and sent to a licensed scrap dealer or waste contractor who treats the metals according to EU and national requirements.

10. RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

10.1. Human health

10.1.1. Workers

Workers in the surface treatment process could conduct some combinations of tasks (sub-scenarios). The core activities will be the sequential process steps of the application in baths for which potential exposure is estimated using available measurement data.

For most ancillary activities, exposure estimates have been prepared by modeling. By nature, the exposure models used provide worst-case estimates in order to be assuredly conservative and to apply across a broad range of activities and situations. Accordingly, modeling may provide results that are so over-conservative as to be rather unrealistic, depending on the basic assumptions of the model and the specificity, the quality and the currency of the underlying model database.

Furthermore, taking into account the various details of processes carried on and risk management measures applied by different companies, each of the sub-scenarios represents a worst-case scenario by using the lowest level of OCs, and RMMs reported for that one specific activity. Summing exposure estimates across sub-scenarios further amplifies the impact of conservative or worst-case assumptions across activities, resulting in potentially substantial over-estimates of potential exposure.

Therefore, simply combining data and model-based exposure estimates for different tasks in the ES will necessarily lead to an unrealistic worst-case overall exposure estimate.

Nevertheless, several possible combinations of sub-scenarios representing the highest possible combined exposure estimate (as the 90th percentile value of the data or model-based exposure distribution) have been evaluated.

An aircraft painter usually will perform painting operations, for example: mixing of paint components and filling into spray gun, spraying of the paint, cleaning of painting equipment; or mixing of paint components, painting by brush/pencil, cleaning of painting equipment.

An aircraft mechanic will concentrate on machining operations. Examples for these occupations might be grinding of painted surfaces for subsequent adhesive bonding or drilling of painted parts for subsequent part assembly.

The different types of operation may be even performed in a different part of the facility or entirely different company. However, in some situations there is a combination of painting and machining activities possible.

For example, a painter prepares the paint (WCS 2), conducts machining operations like cutting or grinding in the booth on parts or surfaces (WCS 11 or 12), then conducts spraying in the booth (WCS 3) and finally cleans the tools in the booth (WCS 8). This would result in a maximum combined exposure of 0.69 µg/m³.

In the rather unlikely case, that one operator would conduct all machining operations in one day (WCSs 11-16); the combined exposure estimate would be 2.35 µg/m³. However, the applicants are on the opinion that the modelled machining scenarios provide a considerable overestimation of exposure.

A further possibility, and finally used to derive the combined exposure estimate, would be the following scenario: a painter prepares the paint (WCS 2), then conducts spraying in and outside the spray booth (WCS 3 and 4) and finally cleans the tools in the booth (Use 2, WCS 8). This would result in a combined exposure of 0.84 µg/m³.

As a result and for use in the SEA, a maximum individual exposure value of 0.85 µg Cr(VI)/m³ is seen as a reasonable basis for calculation.

In this case, an excess lifetime lung cancer risk of 3.38 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

10.1.2. Consumer

Not relevant as there is no consumer use.

10.2. Environment (combined for all emission sources)

10.2.1. All uses (regional scale)

10.2.1.1. Regional exposure

Environment

The regional predicted environmental concentration (PEC regional) and the related risk characterisation ratios when a PNEC is available are presented in the table below.

The PEC regional has been estimated with EUSES.

Table 30. Predicted regional exposure concentrations (Regional PEC)

Protection target	Regional PEC	RCR
Freshwater	Not relevant	Not relevant
Sediment (freshwater)	Not relevant	Not relevant
Marine water	Not relevant	Not relevant
Sediment (marine water)	Not relevant	Not relevant
Air	1.768E-15 mg/m³	Not relevant
Agricultural soil	Not relevant	Not relevant

Man via environment

The exposure to man via the environment from regional exposure and the related risk characterisation ratios are presented in the table below. The exposure concentration via inhalation is equal to the PEC air.

Table 31. Regional exposure to man via the environment

Route	Regional exposure	RCR
Inhalation	1.768E-15 mg/m³	Based on the dose-response relationship derived by the RAC, considering a 70 year exposure time (24h/day, 7d/week), the following excess lifetime risk for the general population is derived based on the estimated exposure: 5.13E-11 per 1000 exposed.
Oral	Not relevant	Not relevant

10.2.2. Local exposure due to all wide dispersive uses

Not relevant as there are not several wide dispersive uses covered in this CSR.

10.2.3. Local exposure due to combined uses at a site

Not relevant as there are no combined uses at a site.

Annex CSR spray application - results of personal sampling from 10 sites

Calculations based on aggregated company/site data Use 1 spray application in booth - personal sampling											
Company	**Period**	**Total no. of measurements**	**Arithmetic Mean µg/m³ (no RPE)**	**Arithmetic Mean µg/m³ (with RPE)**	**Geometric Mean µg/m³ (with RPE)**	**90th Percentile µg/m³ (with RPE)**	**LEV**	**Process type**	**RPE**	**Duration (min)**	**LOD of the measurements**
A	2012	2	1.25	0.003	0.003	0.003	yes	Manual	yes	240	All values below measurement specific LOD
B	2015-2016	4	0.78	0.043	0.042	0.050	yes	Manual	yes	240	All values below measurement specific LOD
C	2012	1	2.50	0.006	0.006	0.006	yes	Manual	yes	88	Value below measurement specific LOD
D	2015-2016	11	1.13	0.003	0.002	0.004	yes	Manual	yes	366-461	6 values below measurement specific LOD
E	2012	1	5.00	0.170	0.170	0.170	yes	Manual	yes	120	Value below measurement specific LOD
F	2010-2017	3	0.70	0.002	0.001	0.003	yes	Manual	yes	12-303	All values below measurement specific LOD
G	2014	3	0.11	0.011	0.011	0.011	yes	Manual	yes	120	All values below measurement specific LOD
I	2015	2	3.13	0.008	0.007	0.010	yes	Manual	yes	45-60	No value below measurement specific LOD
L	2015	1	1.85	0.005	0.005	0.005	yes	Manual	yes	120	Value below measurement specific LOD
N	2012	1	0.50	0.001	0.001	0.001	yes	Manual	yes	323	Value below measurement specific LOD

Annex CSR spray application - results of static sampling from 5 sites

Company	Year	Results[3] µg/m³	Process type	Tasks performed/sampling location	Sampling duration (min)	Sampling type
A	2012	< 20	manual	Spraying of epoxy based paints that contain Strontium Chromate (PROC)	240	static
A	2012	< 20	manual	Spraying of epoxy based paints that contain Strontium Chromate (PROC)	240	static
C	2012	< 6.0	manual	1.5 m from operator spraying onto an ignition box	89	static
D	2014	< 0.775	manual	0.5 m from operator painting	398	static
D	2014	< 0.775	manual	0.5 m from operator painting	394	static
D	Feb-15	< 0.725	manual	Adjacent to the outside of the spray booth	426	static
D	Apr-15	< 0.75	manual	0.5 m from operator painting	375	static
D	Mar 2016	< 0.75	manual	Adjacent to the outside of spray booth	359	static
D	May 2016	2	manual	Adjacent to the inside of the booth wall (3m from operator spraying)	371	static
D	Jul-16	< 1.0	manual	Adjacent to the outside of spray booth	421	static
D	Jul-16	< 1.0	manual	Adjacent to the outside of spray booth	464	static
D	Aug-16	< 1.0	manual	Adjacent to the outside of spray booth	435	static
D	Aug-16	< 1.0	manual	Adjacent to the outside of spray booth	435	static
D	Aug-16	< 1.0	manual	Middle of booth approximately 0.1m below roof filters	439	static
D	Aug-16	< 1.0	manual	Left hand side of booth – 1.5m from middle – approximately 0.1m below roof filters	437	static
D	Aug-16	< 1.0	manual	Right hand side of booth – 1.5m from middle – approximately 0.1m below roof filters	437	static
D	Oct-16	< 3.0	manual	On mixing bench in paint shop preparation room	379	static
D	Oct-16	< 3.0	manual	Adjacent to bunded chemical storage in paint shop preparation room	377	static
D	Oct-16	< 3.0	manual	On mixing bench in paint shop preparation room	389	static
D	Oct-16	< 3.0	manual	Adjacent to bunded chemical storage in paint shop preparation room	388	static
F	2010	< 1.0	manual	1 m from front of large spray booth	304	static
F	2013	< 3.0	manual	3 m from operator paint spraying	152	static
F	2013	< 1.0	manual	2 m from operator paint spraying	147	static
F	2017	< 0.3	manual	Adjacent to booth entrance	12	static
N	2012	< 1.0	manual	Approximately 2m from booth	324	static