CHEMICAL SAFETY REPORT

Use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers

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Substance Name: chromium trioxide

EC Number: 215-607-8

CAS Number: 1333-82-0

Registrant's Identity: Haas Group International SCM Ltd

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List of Abbreviations

ACH	Air Changes per Hour
AfA	Application for Authorization
APF	Assigned Protection Factor
ART	Advanced REACH Tool
CCC	Chemical Conversion Coating
CSA	Chemical Safety Assessment
CSR	Chemical Safety Report
CTAC	Chromium Trioxide REACH Authorization Consortium
ELR	Excess Lifetime Risk
ERC	Environmental Release Category
ES	Exposure Scenario
EUSES	European Union System for the Evaluation of Substances
GCCA	Global Chromates Consortium for Aerospace
LEV	Local Exhaust Ventilation
LOD	Limit of Detection
Min	Minutes
NOAEL	No Observed Adverse Effect Level
NTP	National Toxicology Program
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration (USA)
PEC	Predicted Environmental Concentration
PNEC	Predicted No Effect Concentration
PPE	Personal Protective Equipment
PROC	Process Category
RAC	Committee of Risk Assessment
RCR	Risk Characterisation Ratio
REACH	Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
RMM	Risk Management Measure
RPE	Respiratory Protective Equipment
SEA	Socio-Economic Analysis
SpERC	Specific Environmental Release Category
TWA	Time Weighted Average
WCS	Worker Contributing Scenario

9. EXPOSURE ASSESSMENT (and related risk characterisation)

9.0. Introduction

This exposure assessment aims to provide reliable estimates of current work place exposure levels relating to the import into the EU of a few proprietary products containing chromium trioxide. These products are imported because they are specified for use in surface treatment to provide anti-corrosive properties in the production, maintenance and/or repair of parts for the aerospace industry and derivative applications. Two types of surface treatment activity are covered by this application: conversion coatings and slurry (diffusion) coatings, the latter including high temperature slurry diffusion coatings and sacrificial coatings. In that respect, the Exposure Scenarios are identical to those for similar processes in other parts of the aerospace industry. Here we refer to the Exposure Scenarios presented in relation to aerospace use as part of the CTAC application. Since the uses are identical, the Exposure Scenarios developed for CTAC have been used, by agreement, as the basis for this application. The aerospace companies represented by this application have reviewed the Exposure Scenarios provided in the CTAC application and confirmed that they are representative of the uses covered by this application. Further context and information has been added as appropriate. For clarity, aerospace companies are principally engaged in carrying out the design, development, manufacture, maintenance, modification, overhaul, repair, or support of civil or military aerospace and defence equipment, systems, or structures, plus any derivative uses (e.g., marine propulsion or power generation using products originally designed for aerospace or defence use).

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 aerospace companies 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 specialized 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 are 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. Occupational work place exposure to hexavalent chromium [Cr(VI)] is regulated in most European countries. National Occupational Exposure Limits (OELs) across Europe respect a range of 8 hour *Time Weighted Average* (TWA) values between 1 µg/m^3 and 50 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 in place anywhere in the World and industry has invested substantial research and investment to continually reduce exposure to this level. Measurement data presented within the CSR are necessarily aggregated across several companies and over a period of several years. For countries in which the national OEL is lower than the exposure estimates shown in the following exposure scenario, companies are expected to comply with the national legislation 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) (hereafter referred to as Directive 2004/37/EC) requires each Member State to ensure employers reduce and replace use of Cr(VI) substances, and the introduction of a new OEL in France provides one clear example of regulation by Member States to effect a reduction in potential workplace exposure to Cr(VI). Industry is proactively engaged in delivering continuous reduction through the development and implementation of appropriate RMMs. Lip extraction on baths is one example of a type of Local Exhaust Ventilation (LEV) now commonly implemented to manage potential exposure to Cr(VI) across industry.

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 the use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers 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.

Operations in the use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers are very similar in nature, as can be seen from the Exposure Scenarios developed based on input from operators across the European industry. 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: 2.0 tonnes chromium trioxide/year based on:

- 2.0 tonnes chromium trioxide/year imported [containing approximately 1.0 tonne 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 chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers. (ERC 6b) - Delivery and storage of raw material (PROC 1) - Decanting of liquids (PROC 8b) - Mixing - liquids (PROC 5) - Re-filling of baths (PROC 8b) - Surface treatment by immersion/dipping (PROC 13) - Substance preparation and surface treatment by spraying in paint booth (PROC 8b, 7) - Surface treatment by brushing/or pen-stick use (small areas parts) (PROC 10) - Maintenance of equipment (PROC 8a) - Infrequent maintenance activities (PROC 8a) - Sampling (PROC 8b) - Machining operations on small to medium sized parts 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 on parts containing Cr(VI) in small work areas including cleaning (PROC 21, 24) - Storage of articles (PROC 1) - Waste management (PROC 8b)	2.0 [1.0 Cr(VI)]

Identifiers	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
Manufacture: M-#, Formulation: F-#, 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 the Application for Authorization (AfA) to continue use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers after the sunset date in September 2017. As described in the AoA, the specialty formulations covered by this application for authorisation of chromium trioxide are proprietary products manufactured by non-EU formulators and imported into the EEA for use on aerospace components. The supply chain for these products is not covered by other applications for authorization.

Chromium trioxide has been included in Annex XIV to Regulation (EC) No 1907/2006 ('REACH') due to its intrinsic properties as being carcinogenic (Carc. 1A) and mutagenic (Mut. 1B).

Following REACH, 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 chromium trioxide as a carcinogenic and mutagenic toxicant are considered in the current CSR. The dominating health effect resulting from the intrinsic hazardous properties of chromium trioxide is lung cancer due to inhalation of dust and/or aerosols. Intestinal cancer following ingestion is also identified as a potential risk: however, the dose-response relationship is lower than that for lung cancer, and ingestion is 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 are considered accordingly.

Measures to prevent or limit release of Cr(VI) to the environment are provided as best practice at facilities carrying out operations using chromium trioxide. During industrial surface treatment operations, prevention of releases of substances to the aquatic environment is a matter of good practice. Treatment technology (on-site or off-site) to reduce Cr(VI) 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 containing Cr(VI) is collected and treated as hazardous waste where residual Cr(VI) can be effectively safely treated. In view of the risk management measures in place at the production facilities, emissions to the aquatic environment associated with industrial surface treatment operations are effectively prevented. Therefore, any potential risk for carcinogenicity due to exposure to chromium trioxide via the food chain is considered negligible.

Due to its low volatility, chromium trioxide will not normally be present in air. Nevertheless, energetic processes can release chromium trioxide into air. Except in case of very low content of Cr(VI) during occasional release (e.g. infrequent surface treatment using small quantities of Cr(VI) where exposure potential is very low), 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” is discussed in section 9.0.2.2 below.

Cr(VI) is neither directly nor indirectly released to soil and releases to soil are therefore 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 REACH, 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 chromium trioxide via the environment. Since strict emission control measures are implemented, releases to the aquatic environment (and also 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) from emissions to air from industrial use are modelled with EUSES 2.1.2., and expressed as Cr(VI).

The regional concentrations are reported in section 10.2.1.1 (see Table 40, "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 chromium trioxide. The oral route (swallowing of the non-respirable fraction) does not need to be explicitly considered 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 risk of lung cancer due to inhalation of Cr(VI);

(iii) the document on a reference dose-response relationship for Cr(VI) compounds (RAC/27/2013/06 Rev.1) states that "*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 it is assumed that all particles are in the respirable size range hence 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 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:

Chromium trioxide has been included into Annex XIV to Regulation (EC) No 1907/2006 ('REACH') due to its intrinsic properties as being carcinogenic (Carc. 1A) and mutagenic (Mut. 1B).

Following REACH, 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 chromium trioxide is lung cancer due to inhalation of dust and/or aerosols.

Exposure estimates generated by ART 1.5., or measured values are given in terms of Cr(VI) and are expressed as 8 hour Time Weighted Average (TWA).

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) it has to be assumed that all particles are 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 CSR.

General information on risk management related to toxicological hazard:

Potential exposure of worker handling chromium trioxide during industrial use is restricted to the lowest possible level.

Aqueous solutions of chromium trioxide are expected to entail only a low potential for generating mists, not requiring Respiratory Protective Equipment (RPE). Nevertheless, protective clothing, chemical-resistant gloves, and goggles are mandatory for those tasks involving handling of the liquid formulation. When the formation of aerosols is likely in the chemical conversion and slurry coating processes and the covering of baths and LEV is not sufficient to minimize Cr(VI) exposure, adequate respiratory protection (e.g. half-face equipped with A2P3[1] filters) is worn additionally.

General information on risk management related to physicochemical hazard:

Not relevant – physicochemical hazards are not subject of this CSR.

9.0.2.4. Consumers

Exposure assessment is not applicable as there are no consumer-related uses for chromium trioxide.

9.1. Exposure scenario 1: Use at industrial site - Use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers

Use of chromium trioxide by aerospace companies and their suppliers within the scope of this document include chemical conversion and slurry coating applications. These coatings provide various critical functions (e.g. protecting the metal from corrosion, increasing wear resistance, providing an adhesive base, electrical and thermal properties, and chemical resistance).

Specifically, the ES includes (is limited to):

- Chemical conversion coating (CCC), which is a chemical process applied to a substrate producing a surface layer containing a compound of the substrate metal and other chemical species from the process solution.
- Slurry coatings including sacrificial coatings (which have a lower electrode potential than the substrate to be protected)) and diffusion coatings and paints (process based on the coating material diffusing into the substrate at high temperatures) for corrosion protection.

For conversion coatings, the main form of application is dipping or immersion of parts in a tank or through a series of tanks containing solutions in closed or open systems. The solution containing Cr(VI) additionally is applied by spraying and occasionally, by brush or with a pen-stick, especially to small localised areas.

Paint-type slurries used in slurry sacrificial and diffusion coatings are applied by standard air atomizing spraying, by dipping, swabbing or roller, then dried and cured in air at 260ºC or above (chemical modifiers can be added to some coatings to reduce cure temperature to as low as 190ºC).

Concentrations of Cr(VI) in the surface coating may be below or above detection levels. Machining operations, like fettling, drilling, riveting, edging, abrading, or sanding, might be necessary during industrial post-treatment of coated parts. Therefore, exposure to Cr(VI) dust during these activities is possible.

Operating conditions and risk management measures are specified to limit worker (inhalation and dermal) exposure to various components in the treatment solution and environmental exposure. LEV and coverage of baths during treatment are technical means to minimize concentrations of Cr(VI) and other components of treatment solutions in the workplace air. Personal Protective Equipment (PPE) is also specified to minimize potential inhalation and dermal exposure. Equipment is maintained regularly.

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

Environment contributing scenario(s):	
Use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers	ERC6b
Worker contributing scenario(s):	
Delivery and storage of raw material	PROC 1
Decanting – liquids	PROC 8b
Mixing – liquids	PROC 5
Re-filling of baths	PROC 8b
Surface treatment by immersion/dipping	PROC 13
Substance preparation and surface treatment by spraying in paint booth	PROC 8b, 7
Surface treatment by brushing/or pen-stick use (small areas parts)	PROC 10
Maintenance of equipment	PROC 8a
Infrequent maintenance activities	PROC 8a
Sampling	PROC 8b
Machining operations on small to medium sized parts 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 on parts containing Cr(VI) in small work areas including cleaning	PROC 21, 24
Storage of articles	PROC 1
Waste management	PROC 8b

Subsequent service life exposure scenario(s):
Relevant for some applications only, as set out in Exposure Scenarios

Explanation on the approach taken for the ES

Occupational exposure estimates are based on measured data and/or on modelled data. Inhalation exposure has been estimated using the exposure model '*Advanced REACH Tool 1.5' or 'ART'*[2]. ART is a second tier model 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. Appropriate values for each model parameters have been selected 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.

The 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

[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, Vers. 2, May 2010. Background information for ART are provided in: Fransman W., Cherrie J., van Tongeren M., Schneider T., Tischer M., Schinkel J., Marquart H., Warren, N.D., Spankie S., Kromhout H., Tielemans E. Development of a mechanistic model for the Advanced REACH Tool (ART). Version 1.5, January 2013.

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, 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. Therefore many companies will stay below the estimated exposure.

In view of the strict separation of the production facility from the wastewater stream any releases to the aquatic environment are essentially negligible. Chromium trioxide is contained within the preparation and the water used to rinse out the equipment and the treated article is collected and recycled or disposed of in specialist facilities. Additional on-site treatment of any waste containing Cr(VI) [reduction to Cr(III), vacuum evaporation], additionally ensures negligible release of Cr(VI) to water. This is reflected in the environmental contributing scenario below.

9.1.1. Environmental contributing scenario 1: Use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers

Cr(VI) releases to the environment are carefully controlled by industry and monitored by regulators.

Except in case of very low content of Cr(VI) during occasional release (e.g. infrequent surface treatment using small quantities of Cr(VI) where exposure potential is very low, air emissions relating to LEV or extraction systems are filtered (e.g. HEPA filter) 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 Cr(VI) emissions as part of permit conditions. Releases are often beneath detection limits.

For the applications in the use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers described here, wastewater releases from the production facility are strictly controlled, i.e. there is only very low release of Cr(VI) to the aquatic environment, if any. Water in scrubbers or filters is generally recycled and occasionally replaced, with resulting material being treated as a waste in accordance with relevant waste management regulations.

Facilities may have on-site wastewater treatment facilities that act by vacuum evaporation or by reduction of Cr(VI) to Cr(III). The solids are precipitated and the supernatant is discharged from the site. These treatment processes are very efficient and concentrations of Cr(VI) in treated water is usually below detection limits.

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

9.1.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
▪ Daily use at site: <= 0.0002 tonnes/day [as Cr(VI)]
▪ Annual use at a site: <= 0.05 tonnes/year [as Cr(VI)]
▪ Percentage of tonnage used at regional scale: = 33 %
Technical and organisational conditions and measures
▪ Air emission abatement: at least 99% efficiency. For operations where exposure potential is low [i.e. operations are infrequent using only small quantities of Cr(VI)] air emission abatement may not be required. ▪ Negligible discharge of Cr(VI) in wastewater from the site ▪ All solid 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, or treated by vacuum evaporation. The treated wastewater is discharged to municipal sewage system. Any solid or slurry waste is either recycled or 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, reuse disposal as hazardous waste by an external waste management company (licenced contractor)
Other conditions affecting environmental exposure
▪ When needed, exhaust air is passed through filters or wet scrubbers according to best available technique (minimum efficiency 99 %).

9.1.1.2. Releases

For the use of chromium trioxide containing formulations for chemical conversion and slurry coating applications by aerospace companies and their suppliers' activities, no specific air emission data (i.e. measurement of release to the atmosphere) were available. Facilities conducting these activities also have different other uses of chromium trioxide and chromates at the same facility and it is not possible to estimate the likely small contribution of chemical conversion and slurry coating applications on the total air emissions of the facilities. For that reason air emissions are conservatively estimated based on modelling with EUSES 2.1.2.

Significant loss of the substance as a gas or vapour will not occur as chromium trioxide has a high melting point and is of low volatility. Loss of the substance as a particulate is likely to be minimal as it is non-dusty. The ERC 6b release factor of 0.1% was selected as initial release factor representing an absolute worst-case and likely unrealistic assumption.

Air emissions relating to local exhaust ventilation (LEV) or extraction systems are filtered 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.

Therefore the final release factor is set to 0.001%. The maximum local tonnage estimate used for the local release rate is 0.2 kg/day; this is considered very conservative with respect to information provided by industry regarding annual tonnage used per site and the total tonnage of chromium trioxide in this use.

Table 10. Local releases to the environment

Release	Release factor estimation method	Explanation / Justification
Air	Release factor	**Initial release factor:** 0.1% **Final release factor:** 0.001% **Local release rate:** 2E-6 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	-

Protection target	Exposure concentration	Risk characterisation
Air	**Local PEC:** 3.808E-10 mg/m³	-
Agricultural soil	Not relevant	-
Predator (terrestrial)	Not relevant	-
Man via Environment – Inhalation	**Local PEC:** 3.808E-10 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 up to age 89 is derived he general population is derived based on the estimated exposure: 1.1E-05 per 1000 exposed
Man via Environment - Oral	Not relevant	-

<u>Conclusion on risk characterisation</u>

The modelled $PEClocal_{air,ann}$ of 3.808E-10 mg Cr(VI)/m³ mg/m³ is estimated as sum of $Clocal_{air,ann}$ and $PECregional_{air}$ and used as the basis for risk characterisation for man via the environment.

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

1.1E-05 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)

Formulations containing chromium trioxide are delivered as aqueous solution in sealed containers and stored in a chemical storage room. There is no potential for worker exposure.

9.1.2.1. Conditions of use

	Method
Product (article) characteristics	
▪ Substance as such/in a mixture Concentration of Cr(VI): < 25%	Qualitative
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 1 hour ▪ Frequency of activity: infrequent	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	

	Method
▪ Place of use: Indoor	Qualitative
▪ Process temperature (for liquids and solids): Room temperature	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 characterisation
Inhalation, local, long-term	**0 µg/m^3**	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)/m^3 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 of liquids (PROC 8b)

The formulations containing chromium trioxide may be decanted in (smaller) containers for re-filling of baths or for further mixing. This may be conducted under exhaust ventilation or increased mechanical room ventilation but is not considered for modelling.

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: < 25%	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low[3]	ART 1.5
Activity emission potential	
▪ Duration of activity: < 15 min ▪ Frequency of activity: 1 time/week (reduction factor of 0.2 applied	ART 1.5 ART 1.5 (extended) [4]

[3] The viscosities of the formulations in scope of this dossier are characterized as low viscosity. In addition, this is the most conservative (worst case) option in the ART model.

[4] The exposure model ART 1.5 does not include protection factors for the use of respiratory protection and no option to account for activities which do not take place every working day. Because these are important factors to be considered in the assessment of long-term exposure, the ART model has been extended by incorporating both parameters in the calculation of the final exposure estimate, where appropriate.

	Method
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Falling liquids	ART 1.5
▪ Situation: Transfer of liquid product with flow of 1–10 l/min	ART 1.5
▪ Containment level: Handling that reduces contact between product and adjacent air.	ART 1.5
▪ Loading type: Splash loading, where the liquid dispenser remains at the top of the reservoir and the liquid splashes freely	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: 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	ART 1.5

9.1.3.2. Exposure and risks for workers

Table 13. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	1.3 µg/m³ (90th percentile value)	
Further adjusted for frequency	**0.26 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure 1.04 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.26 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure[5].

An excess lifetime lung cancer risk of 1.04 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. 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)/m^3] might be an over-estimate.

9.1.4. Worker contributing scenario 3: Mixing - liquids (PROC 5)

The aqueous solution may be mixed before re-filling of baths.

9.1.4.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: < 25%	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low[3]	ART 1.5
Activity emission potential	
▪ Duration of activity: < 30 min ▪ Frequency of activity: 1 time/week (reduction factor of 0.2 applied)	ART 1.5 ART 1.5 (extended)
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Activities with undisturbed surfaces (no aerosol formation)	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: 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	ART 1.5

[5] These include:

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

9.1.4.2. Exposure and risks for workers

Table 14. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	0.64 µg/m³ (90th percentile value)	
Further adjusted for frequency	**0.13 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.51 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.13 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 0.51 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. 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: Re-filling of baths (PROC 8b)

The chromium trioxide solution or slurry is transferred to and manually filled into the bath. In the case of conversion coating, this may be completed for adjustment of the concentration in the bath. In the case of slurry coating, this is completed for refilling of the bath. This scenario covers as worst-case similar activities in which a complete emptying and re-filling of a bath is conducted (without LEV) - only rarely needed (less than 1 time per year).

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: < 25%	ART 1.5
▪ Process temperature: Above room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low[3]	ART 1.5
Activity emission potential	
▪ Duration of activity: < 10 min ▪ Frequency of activity: 1 time/week (reduction factor of 0.2 applied)	ART 1.5 ART 1.5 (extended)
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5

	Method
▪ Activity class: Falling liquids	ART 1.5
▪ Situation: Transfer of liquid product with flow of 10 –100 l/min	ART 1.5
▪ Containment level: Open process	ART 1.5
▪ Loading type: Splash loading, where the liquid dispenser remains at the top of the reservoir and the liquid splashes freely	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

9.1.5.2. Exposure and risks for workers

Table 15. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	0.95 µg/m³ (90th percentile value)	
Further adjusted for frequency	**0.19 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality 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/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 0.76 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

9.1.6. Worker contributing scenario 5: Surface treatment by immersion/dipping (PROC 13)

Use of chromium trioxide for chemical conversion coating applications by aerospace companies and their suppliers by dipping/immersion is conducted in sequential process steps within a series of tanks that contain treatment, cleaning and other related solutions.

Before treatment, parts are prepared by degreasing, stripping, rinsing in several bathes. Lifting tools (hoists and racks) are used to move the parts which are placed on tools from one tank to another one. There is no direct exposure to Cr(VI) but workers could be exposed as they are stand up near the CCC bath during parts preparation.

The parts are then placed in the CCC bath through the upper opened surface of the tank and immersed. The liquid is tempered up to 30°C. Workers are potentially exposed to Cr(VI) as they are near the bath during parts CCC process. However, due to the type of coating process, no aerosol development is expected and exposure potential therefore is low.

Finally, articles and tools are removed from the bath using the lifting tools, drained above the bath during few seconds and then rinsed in several water tanks. Then articles are dried before to be removed from the tools and demasked. Workers are potentially exposed to Cr(VI) as they are near the bath during removals tasks. However, due to the type of coating process, no aerosol development is expected and exposure potential therefore is low.

The CCC baths containing Cr(VI) are equipped with extract ventilation during the treatment process. Baths might be covered or partially covered.

Slurry coatings are occasionally applied by dipping/immersion in a single bath containing the coating formulation at ambient temperature. The process involving chromium trioxide for slurry coating is the same as that for CCC; there is no pre-treatment for slurry coating, but as these pre-treatment steps do not involve use of chromium trioxide this difference is not significant in terms of this AfA. The articles are placed in and removed from the bath using lifting tools, as is the case for conversion coating. The baths containing Cr(VI) are equipped with extract ventilation during the treatment process. As described above, workers are potentially exposed to Cr(VI) as they are near the bath during removal tasks. However, due to the type of coating process, no aerosol development is expected and exposure potential therefore is low. There are no substantive differences in this process when it is completed for chemical conversion and slurry coating.

For both slurry and CCC, cleaning of equipment is not a separate task but conducted by those employees working in the bath area as part of their normal working procedure. For very small baths, a special vacuum cleaner is used each time in the normal process.

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: Small (1 - 5%)	ART 1.5
▪ Process temperature: Above temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low[3]	ART 1.5
Activity emission potential	
▪ Duration of activity: < 1 h	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Activities with relatively undisturbed surfaces (no aerosol formation)	ART 1.5

	Method
▪ Situation: Open surface 1 - 3 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

9.1.6.2. Exposure and risks for workers

Table 16. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	0.023 µg/m³ (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.092 per 1000 exposed workers

<u>Conclusion on risk characterisation</u>

The modelled exposure estimate (ART 1.5) of 0.023 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 0.092 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. 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: Substance preparation and surface treatment by spraying in paint booth (PROC 8b, 7)

Slurry coatings (and occasionally CCC) are applied by HVLP spray gun. Following mixing/agitation of the sealed drum containing the proprietary slurry (<5% w/w chromium trioxide) or conversion coating (<1% w/w chromium trioxide), the paint gun is filled and the coating applied by spraying. The activity is carried out in a paint spray booth that is supplied with exhaust ventilation. The flow of air through the booth should be evenly distributed and the average cross draft velocity over the horizontal cross section should be no less than 100 feet per minute when the exhaust bank of filters are loaded to the manufacturer's recommended maximum pressure drop. The worker is supplied with a full-face mask with air supply or half-face mask with P3 filter. The article is cured in an air circulating oven at high temperature. The oven may be vented and all wastewater, including from cleaning the gun and booth, is segregated. The cured coating contains no Cr(VI). This application might be repeatedly conducted during one shift.

9.1.7.1 Conditions of use

9.1.7.1.1 Mix coating

The worker mixes the components of the preparation with the appropriate ratio, as applicable. The substances are mixed mechanically using a specific mixer (e.g. see Fig. 1). The preparation is made in a special area (e.g. laboratory) near the paint booth.

Fig. 1: Preparation and mixing of substances.

	Method
Product (article) characteristics	
▪ Substance in a mixture ▪ Concentration of Cr(VI): < 1-5 %[6]	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 5 min	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Good natural ventilation	Measurement data
▪ Local exhaust ventilation: Yes	Measurement data
▪ Occupational Health and Safety Management System: Advanced	Measurement data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature: Room temperature	Measurement data

[6] Concentration of Cr(VI) is <5% and may be <1%. For the purpose of modelling, a concentrations range of 1-5% was selected to be conservative.

9.1.7.1.2 Filling of paint gun

The worker fills the hand-paint gun after filtration of the mixture with a specific particulate filter mesh, volume of coating is about 100 ml (compare Fig. 2).

Fig. 2: Filling of the hand-paint gun.

	Method
Product (article) characteristics	
▪ Substance in a mixture Concentration of Cr(VI): < 1-5 %[5]	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 5 min	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Good natural ventilation	Measurement data
▪ Local exhaust ventilation: No	Measurement data
▪ Occupational Health and Safety Management System: Advanced	Measurement data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes, at least half-face mask with P3 filter	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature: Room temperature	Measurement data

9.1.7.1.3 Masking and degreasing

Before application, surfaces not to be coated are masked by application of a masking tape. During maintenance or repair (as opposed to production), the parts may be sandblasted and degreased to remove existing surface coating. The worker is outside the closed sandblasting cabin. The worker could be exposed to dust during the opening and closure of cabin doors. Also see the following picture (Fig. 3).

Fig. 3: Preparation of the coating process: Masking and sandblasting.

	Method
Product (article) characteristics	
▪ Substance in a mixture Concentration of Cr(VI): < 1-5 %[5]	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 5 min	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Good natural ventilation	Measurement data
▪ Local exhaust ventilation: No	Measurement data
▪ Occupational Health and Safety Management System: Advanced	Measurement data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes, at least half-face mask with P3 filter	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature: Room temperature	Measurement data

9.1.7.1.4. Spraying in paint booth

The coating is sprayed by the worker using a hand-held gun within an open or closed booth. The picture below shows an example of an open paint booth which is in a work area segregated from other areas. Mechanical exhaust ventilation is present in the workshop (area). Specific local exhaust ventilation is installed in the booths, each equipped with HEPA filters. Paint booths with an open front are furthermore equipped with a water curtain. Open paint booths are in a separate area, accessible through a door. The coating is applied in several layers until the specific thickness is reached. The coating process is shown in the picture below (Fig. 4).

Fig. 4: Manual application of several coating layers in open paint booth.

	Method
Product (article) characteristics	
▪ Substance in a mixture Concentration of Cr(VI): < 1-5 %[5]	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 30 min	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Good natural ventilation	Measurement data
▪ Local exhaust ventilation: Yes	Measurement data
▪ Occupational Health and Safety Management System: Advanced	Measurement data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: yes, at least half-face mask with P3 filter	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: Spray room/Paint booth	Measurement data
▪ Process temperature: Room temperature	Measurement data

9.1.7.1.5 Article drying

Articles are allowed to dry off for 15 minutes under ambient conditions or at around 80°C-150°C in a specific oven and then may be moved (e.g. by an automatic hoist) from the paint booth to the curing oven.

	Method
Product (article) characteristics	
▪ Substance in a mixture Concentration of Cr(VI): residual	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 15 min	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Good natural ventilation	Measurement data
▪ Local exhaust ventilation: No	Measurement data
▪ Occupational Health and Safety Management System: Advanced	Measurement data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes, at least half-face mask with P3 filter	Measurement data
Other conditions affecting workers exposure	

	Method
▪ Place of use: Indoor	Measurement data
▪ Process temperature: High	Measurement data

9.1.7.1.6 Article curing

Following slurry coating, articles are cured at high temperature (500-650ºC) in an oven for up to around three hours. No workers are present. Articles are moved by an automatic hoist from the paint booth to the oven, and from the oven to the storage area. This task is not relevant for CCC.

	Method
Product (article) characteristics	
▪ Substance in a mixture Concentration of Cr(VI): residual	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 180 min	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Good natural ventilation	Measurement data
▪ Local exhaust ventilation: No	Measurement data
▪ Occupational Health and Safety Management System: Advanced	Measurement data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature: High	Measurement data

9.1.7.1.7 Tools cleaning (spray cabin)

Paint guns and tools are cleaned with water or solvent in a specific area of the spray room /booth by the worker who conducted spraying under exhaust extraction. Waste material eliminated in a specific tank for contaminated waste.

	Method
Product (article) characteristics	
▪ Substance in a mixture Concentration of Cr(VI): < 1-5 %[5]	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 15 min	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Good natural ventilation	Measurement data
▪ Local exhaust ventilation: Yes	Measurement data
▪ Occupational Health and Safety Management System: Advanced	Measurement data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes, at least half-face mask with P3 filter	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: I Spray room/Paint booth	Measurement data
▪ Process temperature: Room temperature	Measurement data

9.1.7.2 Exposure and risks for workers

Twenty-eight personal sampling data from 2012-2015 in five EU countries are available from six companies (see Annex A). These data relate to slurry coating processes. These measurement data cover the whole process, including all the steps described above. The exposure assessment is based on these data. In five of the six companies, all measurement results were below the LOD of the respective measurement. As the concentration of Cr(VI) in CCC formulations is less than 1% w/w (compared to less than 5% w/w in slurry coatings), CCC operations are carried out far less frequently and there are no significant differences in other relevant exposure parameters, the measurement data for slurry coatings can be considered conservatively representative of CCC spraying processes.

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).

All estimations do not account for varying duration of exposure and frequency of exposure through the different companies but assume to reflect full-shift exposure on a daily basis as worst case.

The effectiveness of respiratory protection was assessed using the company information on type of mask and filter used and, if available, the APF provided by the manufacturer of the RPE. In a few cases the protection factors (APFs) for the RPE were not provided by the manufacturer. Here the APF determined according to the *German BG rule "BGR/GUV-R190"* from December 2011 have been used[7].

The exposure concentrations and RCR are reported in the following table.

Table 17. Exposure concentrations and risks for workers – inhalation, local, long-term

	N*	NC**	Arithmetic Mean (NC)	Geometric Mean (NC)	90th Percentile (NC)	RCR
Measurement results	**28**	**6**	**5.09 µg/m³**	**2.04 µg/m³**	**11.06 µg/m³**	
Accounting for RPE	**28**	**6**	**0.09 µg/m³**	**0.01 µg/m³**	**0.27 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 1.08 per 1000 exposed workers

* N = number of data from personal sampling data
** NC = number of **aggregated** company data (see text)

<u>Conclusion on risk characterisation</u>

The 90^{th} percentile value of the personal sampling data adjusted for respiratory protection of 0.27 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 1.08 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

9.1.8. Worker contributing scenario 7: Surface treatment by brushing or pen-stick use

[7] The BGR/GUV-R190 rule was selected because it is published, transparent and provides a robust basis for respiratory protection assessment and, if so necessary, adaptation.

(small sized areas) (PROC 10)

For small sized areas, CCC or slurry coating might be conducted by brushing or by use of a pen-stick. This task concerns localized treatments on surfaces with electrical current or not (new parts needing a localized treatment, new parts needing a repair due to defects in bath production, or worn parts in service needing to be repaired). It concerns production and maintenance technicians. For the purpose of the exposure assessment, it has been assumed that it will be carried out 1 h/day every day.

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: Small (1 - 5%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low[3]	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 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: 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	ART 1.5

9.1.8.2. Exposure and risks for workers

The exposure concentrations and 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	**0.23 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.92 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.23 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 0.92 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. 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: Maintenance of equipment (PROC 8a)

Worker in the maintenance department are responsible for maintenance (incl. control) and repair. For more regular maintenance of the baths and related equipment (e.g. LEV, pumps, panels etc.), it is conservatively assumed that it will happen for 60 minutes one time every two weeks. Regular maintenance is conducted when the bath solutions are at ambient temperature. Worst case assumption for potential inhalation exposure for this activity is that these workers would be exposed to the same level of Cr(VI) as workers conducting the CCC processes (i.e. assuming a background concentration of Cr(VI) within the work area equivalent to that present during CCC (see WCS 5), even if no CCC takes place) and that LEV is off. Adequate PPE is always worn (protective clothing, chemical-resistant gloves, goggles).

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: Small (1 - 5%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low[3]	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min ▪ Frequency of activity: 1 time/2 weeks (reduction factor of 0.1 applied)	ART 1.5 ART (extended)
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Activities with relatively undisturbed surfaces (no aerosol formation)	ART 1.5
▪ Situation: Open surface 1 - 3 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: 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	ART 1.5

9.1.9.2. Exposure and risks for workers

Table 19. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output (WCS 5)	0.023 µg/m³ (90th percentile value)	
Further adjusted for frequency	**2.3E-3µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 9.2E-3 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 2.3E-03 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 9.2E-03 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

9.1.10. Worker contributing scenario 9: 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 a duration up to 4 hours. The model also applies a maximum concentration level of chromium trioxide [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: 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)]: Small (1 - 5%)	ART 1.5
Activity emission potential	
▪ Duration of activity: 240 min	ART 1.5
▪ Frequency of activity: 1 time/month (reduction factor of 0.05 applied)	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

	Method
▪ 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
▪ 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*	ART 1.5 (extended)

9.1.10.2. Exposure and risks for workers

Table 20. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	53.0 µg/m³ (90th percentile value)	
Further adjusted for frequency and RPE	**0.088 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.35 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.088 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 0.35 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. 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: Sampling (PROC 8b)

One or more samples are drawn at the bath(s) and then transferred in a closed flask to the laboratory. It is conservatively assumed that sampling is conducted one time per week.

9.1.11.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Small (1 - 5%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low[3]	ART 1.5
Activity emission potential	
▪ Duration of activity: < 30 min ▪ Frequency of activity: 1 time/week (reduction factor of 0.2 applied)	ART 1.5 ART 1.5 (extended)
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Activities with relatively undisturbed surfaces (no aerosol formation)	ART 1.5
▪ Situation: Open surface 1 - 3 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

9.1.11.2. 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		
ART model output	0.011 µg/m³ (90th percentile value)	
Further adjusted for frequency	**2.2E-3 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 8.8E-3 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 2.2E-3 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 8.8E-3 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. 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)

This scenario only applies to such surface treatment applications which result in the presence of residual Cr(VI) concentrations on the final product.

During assembly maintenance and/or repair small to medium sized solid parts are drilled, fettled, abraded, sanded or cut on a dedicated work bench 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 (APF 400).

The Cr(VI) weight fraction of the part is assumed to be < 0.1 %. 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.

9.1.12.1. 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: < 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
▪ 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 30] [Effectiveness Inhal: 96.67 %] *At least half or quarter mask with P3 filter (APF 30 according to German BG rule 190) is worn if workplace monitoring data do not confirm negligible exposure clearly below 1 µg/m³ (e.g. < 0.1 µg/m³)*	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		
ART model output	0.38 µg/m³ (90th percentile value)	
Further adjusted for RPE	**0.013 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.05 per 1000 exposed workers

<u>Conclusion on risk characterisation</u>

The modelled exposure estimate (ART 1.5) of 0.013 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 0.05 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. 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 in large work areas on parts containing Cr(VI) including cleaning (PROC 21, 24)

This scenario only applies to such surface treatment applications which result in the presence of residual Cr(VI) concentrations on the final product.

Solid parts are manually drilled, riveted, fettled, abraded, sanded 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 full face mask with P3 filter (APF 400).

The Cr(VI) weight fraction of the part is assumed to be < 0.1 %. 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: < 0.1 %	ART 1.5

	Method
▪ 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: < 30 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 (90.00 % reduction)/ vacuum cleaning	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: 10 air changes per hour (ACH)	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 %] *At least half or quarter mask with P3 filter (APF 30 according to German BG rule 190) is worn if workplace monitoring data do not confirm negligible exposure clearly below 1 µg/m³ (e.g. < 0.1 µg/m³)*	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		
ART model output	0.83 µg/m³ (90th percentile value)	
Further adjusted for RPE	**0.028 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.11 per 1000 exposed workers

Conclusion on risk characterisation
The modelled exposure estimate (ART 1.5) of 0.028 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 0.11 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. 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**.**

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

Parts are drilled, riveted, fettled, abraded, sanded 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 to be < 0.1 %. 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.

9.1.14.1. 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	

	Method
▪ 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: 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%] *Full face mask with P3 filter (APF 400 according to German BG rule 190) is worn if workplace monitoring data do not confirm negligible exposure clearly below 1 µg/m³ (e.g. < 0.1 µg/m³)* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable 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]	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		
ART model output	32 µg/m³ (90th percentile value)	
Further adjusted for RPE	**0.08 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.32 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.08 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 5).

An excess lifetime risk of 0.32 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.

9.1.15. Worker contributing scenario 14: Storage of articles (PROC 1)

The finished articles are stored in a separate storage area. There is no potential for inhalation exposure.

9.1.15.1. Conditions of use

	Method
Product (article) characteristics	
• Concentration of substance Cr(VI) in article: Non detectable or very low	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
• 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/outdoors	Qualitative
• Process temperature (for solids): ambient	Qualitative

9.1.15.2. Exposure and risks for workers

The exposure concentrations and RCR are reported in the following table.

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality 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 lung cancer risk of 0 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

9.1.16.1. Worker contributing scenario 15: Waste management (PROC 8b)

Very low amounts of Cr(VI), if any, are released from wastewater treatment systems. There is no potential of inhalation exposure from the wastewater treatment systems because sampling before discharging to public sewage system is a short-term activity and the concentration of Cr(VI) is very low if detectable at all. Therefore, potential of inhalation exposure and risk is assessed as negligible and is not further assessed.

Other process waste (e.g. empty containers, canisters, pencils, masking material) are stored in closed containers which further are collected by licensed waste management companies for treatment, incineration and disposal of incineration residues to licensed landfills.

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

9.1.16.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5
▪ Dustiness: Firm granules, flakes or pellets	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
▪ Powder weight fraction [Cr(VI)]: Small (1 – 5%)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 15 min	ART 1.5
▪ Activity class: Handling of contaminated solid objects or paste	ART 1.5
▪ Situation: Handling of objects with limited residual dust (thin layer visible)	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

	Method
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: 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	ART 1.5

9.1.16.2. 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	**0.037 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.15 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.037 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 0.15 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. 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: End of Life

All aircraft parts, at end of life, 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. 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 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 process of use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers could conduct some combinations of tasks (sub-scenarios). The core activities will be the sequential process steps of the application in baths and the slurry coating processes.

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 out and risk management measures applied by different companies, each of the sub-scenarios represents a worst-case scenario by using the lowest level of operational conditions 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. As a clear example, summing up all exposure estimates from the worker sub-scenarios in section 9.1. would result in an unrealistic individual exposure duration.

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.

A possible combination of sub-scenarios is the combination of WCS 2-5 and 10, activities in relation to the CCC application in baths. The combined exposure estimate (as the 90th percentile value of model-based exposure distribution) of these activities would be 0.60 µg/m³.

A further possible combination of activities would be the machining activities (WCS 11-13). The combined exposure estimate (as the 90th percentile value of model-based exposure distribution) of these activities would be 0.121 µg/m³. In general, and as mentioned in the respective CSR WCSs, the ART 1.5 model does not have a specific assessment option for metallic objects but only for stone. The model is therefore not ideal, however, it is conservative. There are measurement data available for comparable substances and these data show that model estimates in all cases considerably overestimated worker exposure. Therefore, any combination of model-based values would result in unrealistic values.

In summary, the applicants find the combined exposure estimate of 0.60 µg/m³ for all CCC bath related activities, in which the same workers could be involved, reasonably representing worst-case combined exposure.

In this case, an excess lifetime lung cancer risk of 2.4 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 RCRs when a PNEC is available are presented in the table below.

The PEC regional have been estimated with EUSES.

Table 26. Predicted regional exposure concentrations (Regional PEC)

Protection target	Regional PEC	Risk characterisation
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	1.867E-18 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 RCRs are presented in the table below. The exposure concentration via inhalation is equal to the PEC air.

Table 27. Regional exposure to man via the environment

Route	Regional exposure	Risk characterisation
Inhalation	1.867E-18 mg/m³ mg/m³	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 70 year exposure time (24h/day, 7d/week), the following excess lifetime lung cancer mortality risk for the general population is derived based on the estimated exposure: 5.41E-14 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 A

Details of slurry coating process measurement data for WCS 6: Substance preparation and surface treatment by spraying in paint booth

Site	Year	Measurement Result (µg/m3)	Adjusted for RPE efficiency (µg/m3)
Site A	2015	< 1	0.0167
Site A	2015	< 1	0.0167
Site A	2015	< 1	0.0167
Site B	2012	< 1.3	0.0007
Site B	2012	< 1.3	0.0007
Site B	2014	2.5	0.0025
Site B	2014	5	0.0050
Site B	2014	20	0.0200
Site C	2014	< 0.2	0.0100
Site D	2013	< 10	0.0050
Site E	2012	< 1	0.0005
Site E	2013	< 8	0.0040
Site E	2014	< 8	0.0040
Site F	2015	1	0.0333
Site F	2015	20	0.6667
Site F	2015	16	0.5333
Site F	2015	16	0.5333
Site F	2015	1.9	0.0633
Site F	2015	35	1.1667
Site F	2015	14	0.4667
Site F	2015	43	1.4333
Site F	2015	9	0.3000
Site F	2015	14	0.4667
Site F	2015	41	1.3667
Site F	2015	< 1	0.0167
Site F	2015	12	0.4000
Site F	2015	9	0.3000
Site F	2015	2.4	0.0800