CHEMICAL SAFETY REPORT

(1) Formulation of mixtures of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers

(2) Use of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers

Substance Name: sodium chromate

EC Number: 231-889-5

CAS Number: 7775-11-3

Applicant's Identity: Aviall Services Inc ; Haas Group International SCM Ltd

9. EXPOSURE ASSESSMENT (and related risk characterisation)

9.0. Introduction

The need for this application relates to the import into and formulation within the EU of a few proprietary products containing sodium chromate. These formulations are specified for use in conversion coating, as a final surface treatment to provide an anti-corrosive seal following anodising, or as pickling and/or etching during pre-treatment in the production, maintenance and/or repair of parts for the aerospace industry and derivative applications. In that respect, the Exposure Scenarios are identical to those in other parts of the aerospace industry for the same uses. Here we refer to the Exposure Scenarios presented in the CCST application. Since the uses are identical the Exposure Scenarios developed for CCST have been used, by agreement, as the basis for this application. The companies represented by this application have reviewed the Exposure Scenarios provided in the CCST application and confirmed that they are representative of the uses covered by this application. Further context and information has been added as appropriate.

Aerospace companies are principally engaged in carrying out the design, development, manufacture, maintenance, modification, overhaul, repair, or support of 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 the European aerospace sector and affiliated industries. The same companies and facilities have reviewed and validated the Exposure Scenarios, including RMM and OC, in detail. The Exposure Scenarios presented are therefore unambiguous and demonstrated to be representative of good practice across the industry.

The Exposure Scenarios are conservative, meaning that exposure measurements or estimates represent the upper boundaries of exposure (representing the reasonable worst case). Due to the specialised and highly regulated nature of activities undertaken by aerospace companies and their supply chain (as explained in the AoA), the uses are well defined and uncertainty associated with the Exposure Scenarios is limited (this finding is supported by the data presented in the document). Minor differences in exposure conditions between facilities and companies occur occasionally and 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-estimates 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 $\mu g/m^3$ and 50 $\mu g/m^3$. The US *Occupational Safety and Health Administration* (OSHA) OEL is at 5 $\mu g/m^3$. In 2014, France introduced a new OEL of 1 $\mu g/m^3$. This is one of the most stringent OEL currently in place anywhere in the World and industry has invested substantial research and investment to continually reduce exposure to this level. For countries in which the national standard is lower than the exposure estimates shown in the following exposure scenario, companies are expected to comply with the national standards by improved technical or personal Risk Management Measures (RMMs) or by demonstrating through work place exposure measurement data that they meet the national requirements.

The Carcinogens and Mutagens Directive (2004/37/EC) requires each Member State to ensure employers reduce and replace use of hexavalent chromium substances, and the introduction of a new OEL in France provides one clear example of regulation by Member States to effect a reduction in workplace exposure to Cr(VI). Industry is proactively engaged in delivering continuous reduction through the development and implementation of appropriate RMMs. Lip extraction on plating baths and local exhaust ventilation are examples of RMMs now commonly implemented to manage potential exposure to Cr(VI) across industry.

Best practices in exposure control across the industry are continually improving, driven by greater understanding and wider awareness of health risks, increases in workplace hygiene effectiveness and increasingly stringent regulatory requirements. This commitment to reducing exposure also reflects the widespread recognition that surface treatment with Cr(VI) is critically important for several industries and that acceptable alternatives are not

available in the near-term. Potential workplace exposure to Cr(VI) has been progressively reduced in recent years as the effectiveness and implementation of RMM 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.

The surface treatment processes involving sealing after anodizing, chemical conversion coating, and pickling and etching are very similar in nature. Even so, individual operators may implement different RMMs over various timeframes for their own reasons, reflecting considerations such as (but not limited to) the layout (and age) of the facility, the scale, frequency and duration of operations, the levels of exposure (measured or anticipated), the number of operators potentially exposed, the type of articles, and/or the expenditure required.

9.0.1. Overview of uses and Exposure Scenarios

Tonnage information:

Assessed tonnage: <1 tonne/year based on:

- <1 tonne/year manufactured/imported [containing approximately 0.325 tonnes Cr(VI)]

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

Table 7. Overview of exposure scenarios and contributing scenarios

Identifiers	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
ES1 - F1		Formulation – Formulation of mixtures of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers - Formulation of mixtures of sodium chromate (ERC 2) - Delivery and storage of raw material (PROC 1) - Decanting and weighing of solids (PROC 8b) - Transfer to mixing vessel – solids (PROC 8b) - Mixing by dilution, dispersion (closed or open process) (PROC 2-5) - Transfer to small containers (including filtering) (PROC 9) - Cleaning of equipment (PROC 8b) - Maintenance of equipment (PROC 8a) - Storage of formulation (PROC 1) - Sampling (PROC 8b) - Waste management (PROC 8b)	< 1.0 [0.325 Cr(VI)]
ES2 - IW1		Use at industrial site - Use of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers - Use of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers (ERC 6b) - Delivery and storage of raw material (PROC 1) - Decanting of liquids (PROC 8b) - Decanting and weighing of solids (PROC 8b) - Mixing - liquids (PROC 5) - Mixing - solids (PROC 5) - Re-filling of baths for adjustment of concentration- liquids (PROC 8b) - Re-filling of baths for adjustment of concentration - solids (PROC 8b) - Use of sodium chromate for chemical conversion coating applications by aerospace companies and their suppliers (PROC 13)	< 1.0 [0.325 Cr(VI)]

Identifiers	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
		- Sealing after anodizing with sodium chromate in baths (PROC 13) - Pickling and Etching (PROC 13) - Maintenance of equipment (PROC 8a) -Surface treatment by brushing (small sized areas) (PROC 10) - 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) - End of Life (PROC 8a)	
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 sodium chromate for use in formulation and for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers after the sunset date in September 2017.

Sodium chromate has been included in Annex XIV to Regulation (EC) No 1907/2006 ('REACH') due to its intrinsic properties as being carcinogenic (Carc. 1B), mutagenic (Mut. 1B), and toxic to reproduction (Repr. 1B).

Following Regulation (EC) No 1907/2006, Article 62(4)(d), the CSR supporting an AfA needs to cover only those potential risks arising from the intrinsic properties specified in Annex XIV. Accordingly, only the potential human health risks related to the classification of sodium chromate as a carcinogenic, mutagenic and reproductive toxicant are considered in the current CSR. The dominating health effect resulting from the intrinsic hazardous properties of sodium chromate 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. Additionally, potential risk might relate to the reproductive hazard of sodium chromate, which is regarded as a threshold effect.

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 hexavalent chromium. During formulation and industrial surface treatment operations, prevention of releases of all products 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 formulation and surface operations are effectively prevented. Therefore any potential risk for carcinogenicity and/or

reproduction due to exposure to sodium chromate via the food chain is considered negligible. Dermal exposure potential is not expected for the general population.

Due to its low volatility, sodium chromate will not normally be present in air. Nevertheless, energetic processes can release sodium chromate into air. All workspaces with potential release to air are equipped with exhaust ventilation systems to remove residual particulates from a worker's 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 considered negligible.

Table 8. Type of risk characterisation required for the environment

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

Comments on assessment approach:

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

9.0.2.2. Man via environment

Scope and type of assessment

As discussed in 9.0.2.1., humans may potentially be exposed to sodium chromate 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 formulation and 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 37 "Predicted regional exposure concentrations (Regional PEC)") based on modelling with EUSES 2.1.2., and expressed as Cr(VI).

Table 9. 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
Inhalation: Systemic long-term	Quantitative	Reproduction: DNEL = 1.5E+01 µg Cr(VI)/kg bw/d
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 sodium chromate. 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 potential risk of lung cancer due to inhalation of hexavalent chromium;

(iii) the document on a reference dose-response relationship for Cr(VI) compounds (RAC/27/2013/06 Rev.1) states 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, no exposure via the oral route needs to be considered.

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

Sodium chromate is classified as toxic to reproduction (Repr. 1B) according to harmonised classification under the CLP Regulation. However, the derived inhalation DNEL for the general population is much higher than the estimated potential local and regional exposure to Cr(VI) resulting in RCR's < 0.01. Therefore, there is no additional risk for humans exposed via the environment for reproductive toxic effects due to inhalation of Cr(VI).

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 10. 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	Quantitative	Reproduction: DNEL = 3.0E+01 µg Cr(VI)/m³
	Systemic acute	Not needed	Not relevant

Route	Type of effect	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1)
	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	Qualitative	Reproduction: DNEL = 2.7E+01 µg Cr(VI)/kg bw/d
	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:

Sodium chromate has been included into Annex XIV to Regulation (EC) No 1907/2006 ('REACH') due to its intrinsic properties as being carcinogenic (Carc. 1B), mutagenic (Mut. 1B), and toxic to reproduction (Repr. 1B).

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

Sodium chromate is classified as toxic to reproduction (Repr. 1B) according to harmonised classification under the CLP Regulation. However, the derived inhalation DNEL for workers is much higher than the highest estimated potential combined exposure to Cr(VI) in the following Exposure Scenarios (see section 10.1.1) resulting in an RCR < 0.1. Therefore, there is no additional risk of reproductive toxic effects due to inhalation of Cr(VI).

Furthermore, sodium chromate is classified as Skin Corr 1B (causes severe skin burns and eye damage) and as Skin Sens. 1 (may cause an allergic skin reaction).according to harmonised classification under the CLP Regulation. Therefore any dermal contact with the substance at the workplace has to be avoided by organizational measures and adequate dermal protection

Exposure estimates generated by ART 1.5 and measured exposure values are presented in this document in terms of hexavalent chromium [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 chemical safety report.

General information on risk management related to toxicological hazard:

Potential exposure of workers handling chromates during formulation and/or industrial use is restricted to the lowest possible level.

When handling solid sodium chromate personnel are required to wear 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, and adequate respiratory protection (e.g. half-face masks equipped with A2P3

filters[1]).

Aqueous solutions of sodium chromate are expected to entail only a low potential for generating mists, not requiring respiratory protective equipment (RPE). Nevertheless, 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), and goggles are mandatory for those tasks involving handling of the liquid formulation where skin exposure to sodium chromate (by full or splash contact) could occur (noting that various measures are in place to prevent such an occurrence). When the formation of aerosols is possible, adequate respiratory protection (e.g. half-mask equipped with A2P3 filters) is worn additionally to reduce inhalation exposures.

General information on risk management related to physicochemical hazard:

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

9.0.2.4. Consumers

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

9.1. Exposure scenario 1: Formulation – Formulation of mixtures of sodium chromate for the industrial uses covered by this application for authorization

Formulation of products containing sodium chromate in closed batch or batch process generally involves storage, decanting, weighing (if solid), transfer and charging of chemicals to a blend tank, mixing and/or reaction, transfer from the tank to packaging, maintenance and cleaning of equipment, transfer of waste and laboratory activities. Sodium chromate may or may not be a raw ingredient to the formulation. In some cases, sodium chromate is not a raw ingredient to the formulation but is formed during the mixing process[2].

Formulations are produced under controlled pre-dominantly closed conditions at ambient temperatures, with little potential for exposure of operators by inhalation. Under the conditions of use, the substance is non-volatile and aerosol exposure is unlikely.

Sodium chromate is a hazardous substances, therefore it is handled in a way as to eliminate or minimise the potential for worker exposure[3]. Personal protective equipment (PPE) and engineering controls (e.g. LEV) are used to limit potential dermal and inhalation exposure.

This scenario addresses formulation by stand-alone formulators. On-site formulation (i.e. mixing) at industrial sites is not included in this scenario but covered in the following industrial use scenario (see 9.2). Formulation in most cases is not a continuous but a batch process with limited potential exposure times. For workers, however, the exposure scenario assumes that the formulation tasks are conducted each day; therefore, exposure is effectively treated as a continuous process for the purpose of this assessment, resulting in an over-estimation of long-term inhalation exposure.

Environment contributing scenario(s):	
Formulation of mixtures of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers	ERC 2
Worker contributing scenario(s):	
Delivery and storage of raw material	PROC 1
Decanting and weighing of solids	PROC 8b
Transfer to mixing vessel – solids	PROC 8b
Mixing by dilution, dispersion (closed or open process)	PROC 2-5

[1] European standard EN 143 defines the classes of particle filters that can be attached to a face mask. A P3 filter is required to remove at least 99.95% of airborne particles at a filter penetration limit (at 95 L/min air flow)
[2] I.e. as a salt
[3] In accordance with Carcinogens Directive 90/394/EEC and Carcinogens and Mutagens Directive 2004/37/EC

Transfer to small containers (including filtering)	PROC 9
Cleaning of equipment	PROC 8b
Maintenance of equipment	PROC 8a
Storage of formulation	PROC 1
Sampling,	PROC 8b
Waste management	PROC 8b

Explanation on the approach taken for the ES

Occupational exposure estimates are based on measured data and/or on modelled estimates. Measurement data typically cover one task comprising several sub-tasks or sub-scenarios. For example, available measurement data covers all the sub-tasks (decanting and weighing, transfer, mixing and cleaning) involved in activities prior to during and following mixing (see worker contributing scenarios (WCS) 2-7). The measurement data is presented in the report at the end of final relevant WCS.

Where inhalation exposure has been estimated by modelling, the exposure model '*Advanced REACH Tool 1.5' or 'ART'*[4] has been used. 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 Cr(VI) in air), where available; such analysis indicates that ART is a reasonable but conservative tool for estimating exposure to airborne Cr(VI) in the scope of this assessment. Appropriate values for each model parameter have been selected in close cooperation with directly involved companies from the aerospace and aerospace suppliers, 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 were not available.

This detailed ES has been developed based on information provided by several 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. 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 (chronic) potential health effects, the duration of exposure per day as set out in the ES is expressed as *average* duration per day over a longer period (e.g. 2 hours each day are equal to 4 hours every second day). Therefore, it can be seen that the duration of exposure per day is not the same as the *maximum* allowed duration in any one day.

All sub-scenarios which are based on modelled values provide worst-case estimates using in general the highest exposure duration and the lowest level of personal protection reported. 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. Sodium chromate is contained within the preparation and the water used to rinse out the equipment is collected and recycled or disposed of in specialist facilities. Reductive treatment of any waste containing Cr(VI) 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: Formulation

9.1.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
▪ Daily use at site: <= 6.5E-03 tonnes/day [as Cr(VI)]
▪ Annual use at a site: <= 0.325 tonnes/year [as Cr(VI)] – largest formulator

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

▪ Percentage of tonnage used at regional scale: = 100 %
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 that is not re-used in the process 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, reduction of Cr(VI) in wastewater to Cr(III), reuse or 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 formulation of sodium chromate for surface treatment activities, no air emission data (i.e. measurement of release to the atmosphere) were available.

Significant loss of the substance as a gas or vapour will not occur under conditions of use because it contained in mixtures of low volatility (under the typical conditions of storage and use) and is not applied using energetic methods. The generation of airborne particles and aerosols containing Cr(VI) is expected to be minimal due to its use in liquid form and the release of the substance to the atmosphere as a particulate is also expected to be minimal as the substance itself is generally non-dust forming. However, due to the absence of measured emission data, the ERC 2 release factor of 2.5% was selected as initial release factor, even though it likely represents an unrealistic absolute "worst-case" assumption for the release of material.

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% for particulates is typical in industry for these air emission controls.

Therefore the final release factor for potential emissions to the atmosphere is set to 0.025%.

Table 11. Local releases to the environment

Release	Release factor estimation method	Explanation / Justification
Air	Release factor	**Initial release factor:** 2.5% **Final release factor:** 0.025% **Local release rate:** 2.0E-03 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 12. Exposure concentrations and risks for the environment

Protection target	Exposure concentration	Risk characterisation
Freshwater	Not relevant	-
Sediment (freshwater)	Not relevant	-
Marine water	Not relevant	-

Protection target	Exposure concentration	Risk characterisation
Sediment (marine water)	Not relevant	-
Predator (freshwater)	Not relevant	-
Predator (marine water)	Not relevant	-
Top predator (marine water)	Not relevant	-
Sewage treatment plant	Not relevant	-
Air	**Local PEC:** 6.19E-8 mg/m³	-
Agricultural soil	Not relevant	-
Predator (terrestrial)	Not relevant	-
Man via Environment – Inhalation	**Local PEC:** 6.19E-8 mg/m³	Based on the dose-response relationship derived by the RAC, considering a 70 year exposure time (24h/day, 7d/week), the following excess lifetime risk for the general population is derived based on the estimated exposure: 1.8E-3 per 1000 exposed.
Man via Environment - Oral	Not relevant	-

Conclusion on risk characterisation

The estimated exposure concentration of 6.19E-8 mg/m³ is used as worst-case estimate of $Plocal_{air,ann.}$ and used as the basis for risk characterisation for man via the environment.

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

1.8E-3 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)

Raw ingredients including sodium chromate or chromium trioxide flakes are delivered in sealed containers. The sodium chromate or chromium trioxide flakes are stored in a chemical storage room for dangerous substances; there is no potential for inhalation exposure to Cr(VI) under these conditions. In some cases, sodium chromate is not involved in this stage of the formulation process at all.

9.1.2.1. Conditions of use

	Method
Product (article) characteristics	
▪ Substance as such / in mixture ▪ Concentration of Cr(VI): < 53 % ▪ Concentration of Na_2CrO_4: < 33 %	Qualitative
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 1 hr ▪ 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

	Method
▪ Occupational Health and Safety Management System: Advanced	Qualitative
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No	Qualitative
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Qualitative
▪ Process temperature (for 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 13. Exposure concentrations and risks for workers

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

Conclusion on risk characterisation

As stated above, there is no potential for exposure under these conditions. The qualitatively determined exposure estimate of 0 µg Cr(VI)/m³ is used as the basis for risk characterisation.

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

Preparation for mixing, mixing, filling into small containers, cleaning and maintenance of equipment

Adequate measurement data for comparable substances in the CCST AfA covering all sub-tasks (decanting and weighing, transfer, mixing and cleaning) described in the following worker contributing scenarios (WCS) 2-7, are available. Exposure estimates based on this measurement data are provided at the end of WCS 7. The following WCS set out the operational conditions and risk management measures relevant for the different sub-scenarios.

Sodium chromate may or may not be a raw ingredient in the formulation process. As noted previously, in some cases it is not a raw ingredient but it is formed as a salt during the mixing process and, in such cases, exposure to sodium chromate will not occur during WCS2 to WCS3. Therefore, in these cases, exposure to sodium chromate will be lower than the measurement data, which covers exposure to Cr(VI) across the whole formulation process, where other Cr(VI) substances are present as raw ingredient.

9.1.3. Worker contributing scenario 2: Decanting and weighing of solids (PROC 8b)

Sodium chromate or chromium trioxide flakes may be decanted and weighed before transfer to the mixing vessel. Sodium chromate may or may not be involved in this stage of the formulation process. When sodium chromate is not a raw ingredient, there is no potential for inhalation exposure to sodium chromate in this activity.

9.1.3.1. Conditions of use

	Method
Product (article) characteristics	
▪ Substance as such ▪ Concentration of Cr(VI): < 53 % ▪ Concentration of Na_2CrO_4: < 33 %	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 1 hour	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measurement data
▪ Containment: No	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 [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *When handling solid, Cr(VI) containing substances, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature (for solids): ambient	Measurement data

9.1.3.2. Exposure and risks for workers

See end of WCS 7.

9.1.4. Worker contributing scenario 3: Transfer to mixing vessel - solids (PROC 8b)

Sodium chromate or chromium trioxide flakes are transferred to and filled into the mixing vessel. This is normally a manual process. Sodium chromate may or may not be involved in this stage of the formulation process. When sodium chromate is not a raw ingredient, there is no potential for inhalation exposure to sodium chromate in this activity.

9.1.4.1. Conditions of use

	Method
Product (article) characteristics	
▪ Substance as such ▪ Concentration of Cr(VI): < 53 % ▪ Concentration of Na2CrO4: < 33 %	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 4 hours	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measurement data
▪ Containment: No	Measurement data

	Method
▪ 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 [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *When handling solid, Cr(VI) containing substances, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature (for solids): ambient	Measurement data

9.1.4.2. Exposure and risks for workers

See end of WCS 7.

9.1.5. Worker contributing scenario 4: Mixing by dilution, dispersion (closed or open process) (PROC 2 to PROC 5)

The mixing/blending of the preparation is performed within a mixing tank, often a closed or semi-closed system with automated mixing. During mixing, sodium chromate is formed.

9.1.5.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 1 %	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 8 hours	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measurement data
▪ Containment: No	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 ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measurement data

	Method
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature (for liquid): generally <= 40 °C; sometimes above	Measurement data

9.1.5.2. Exposure and risks for workers

See end of WCS 7.

9.1.6. Worker contributing scenario 5: Transfer to small containers (including filtering) (PROC 9)

Manual or automatic filling of formulation into specified containers or tanks.

9.1.6.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 1 %	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 8 hours	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measurement data
▪ Containment: No	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 ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature (for liquid): <= 40 °C	Measurement data

9.1.6.2. Exposure and risks for workers

See end of WCS 7.

9.1.7. Worker contributing scenario 6: Cleaning of equipment (PROC 8b)

Cleaning of equipment is not a separate task but conducted by those employees working in the mixing area as part of their normal working procedure.

9.1.7.1. Conditions of use

	Method
Product (article) characteristics	

	Method
▪ Concentration of Cr(VI) in mixture: < 1 %	Measurement data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 1 hour	Measurement data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	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 *In cases where exposure to solid, Cr(VI) containing substances may occur, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn; [Effectiveness Inhal: 96.67%]* ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measurement data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature (for liquid): <= 40 °C	Measurement data

9.1.7.2. Exposure and risks for workers

See end of WCS 7.

9.1.8. Worker contributing scenario 7: Maintenance of equipment (PROC 8a)

For the regular maintenance of formulation equipment, it is conservatively assumed that it will happen 30 minutes every day during the formulation process. There will be infrequent maintenance activities with longer duration but outside of the formulation process, so long-term exposure will be much lower than estimated in this scenario.

9.1.8.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 1 %	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: Basic general ventilation (1-3 air changes per hour)	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 [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *In cases exposure to airborne hexavalent chromium might occur, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn*	Measurement data

	Method
▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measurement data
▪ Process temperature (for liquids and solids): Room temperature	Measurement data

9.1.8.2. Exposure and risks for workers

See below.

9.1.3.2.-9.1.8.2. Combined assessment of exposure and risks for workers for WCS 2 - 7

Specific work place exposure monitoring data for the formulation of mixtures containing sodium chromate were not available. However, data were available for the formulation process of sodium and potassium dichromate. Around 30 personal sampling and static measurement data from 2007-2011 in three EU countries are available in the CCST AfA of for these substances. Because a sufficient number of data (>20) from personal sampling is available, the exposure assessment is based on these data (as suggested in the Technical Guidance document R.14). It is a conservative approach because the concentration of sodium chromate in the final solution is much lower than for both other substances, and because the frequency of exposure is also lower (batch process) than assumed for the data below (daily exposure). In addition, as noted above, exposure to sodium chromate is not possible until after the mixture is formed, as sodium chromate is a formed as an equilibrium product during formulation.

The individual company data have been comprehensively evaluated for the CCST AfA. 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).

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

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

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

Worker contributing scenario	PROC	Description	N*	Arithmetic Mean	Geometric Mean	90th Percentile	RCR
WCS – 2	PROC 8b	Decanting and weighing of solids					
WCS – 3	PROC 8b	Transfer to mixing vessel – solid					

WCS - 4	PROC 2 to 5	Mixing by dilution, dispersion (closed or open process)	**24**	**0.11 µg/m³**	**0.03 µg/m³**	**0.26 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 1.04 per 1000 exposed workers
WCS - 5	PROC 9	Transfer to small containers (including filtering)					
WCS - 6	PROC 8b	Cleaning of equipment					
WCS - 7	PROC 8a	Maintenance of equipment					

* N = number of measurements

Conclusion on risk characterisation

The 90th percentile value of the personal sampling data, collected for the CCST AfA and were adjusted for respiratory protection, of 0.26 µg Cr(VI)/m³ is used as the basis for risk characterisation as absolute worst case for this application.

An excess lifetime risk of 1.04 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate

9.1.9. Worker contributing scenario 8: Storage of formulation (PROC 1)

The final formulation is stored in containers. There is no potential for inhalation exposure.

9.1.9.1. Conditions of use

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

9.1.9.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (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 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 under these conditions. The qualitatively determined exposure estimate of 0 µg Cr(VI)/m³ is used as the basis for risk characterisation.

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

9.1.10. Worker contributing scenario 9: Sampling (PROC 8b)

9.1.10.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Very small (0.5 – 1 %)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 15 min	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
▪ Situation: Open surface 1 - 3 m² (as worst case)	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

	Method
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.1.10.2. Exposure and risks for workers

Table 15. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**1.4E-3 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 5.6E-3 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 1.4E-03 µg Cr(VI)/m³ is used as the basis for risk characterisation (absolute worst case, because in most circumstances, RPE with at least half-face mask and P3 filter is worn).

An excess lifetime risk of 5.6E-03 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate..

9.1.11. Worker contributing scenario 10: Waste management (PROC 8b)

Very low amounts of Cr(VI), if at all, is released from waste water 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 considered negligible and is not further assessed.

Other process waste (empty bags or containers) is stored in closed containers which further are collected by licensed waste management companies for treatment, incineration and disposal of incineration residues to contaminated landfill. Process waste containing sodium chromate might be generated from cleaning activities of the mixing vessel.

For the purpose of this exposure assessment it is assumed that this activity is conducted one time per week on average.

9.1.11.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Paste, slurry or clearly (soaked) wet powder	ART 1.5
▪ Dustiness: Firm granules, flakes or pellets	ART 1.5
▪ Powder weight fraction [Cr(VI)]: Small (1 – 5%)	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) [5]
▪ Activity class: Handling of contaminated solid objects or paste	ART 1.5
▪ Situation: Handling of objects with visible contamination (object covered with fugitive dust from surrounding dusty activities)	ART 1.5
▪ Handling type: 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 waste transfer activities with potential to exposure to airborne hexavalent chromium at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

[5] 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, we have extended the ART model by incorporating both parameters in the calculation of the final exposure estimate, where appropriate.

9.1.11.2. 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		
ART model output	0.22 µg/m³ (90th percentile value)	
Further adjusted for frequency and RPE	**1.47E-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 5.88E-3 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 1.47E-03 µg Cr(VI)/m³ is used as the basis for risk characterisation. The estimate is based on several conservative assumptions[6] regarding exposure.

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

An excess lifetime risk of 5.88E-03 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.

[6] These include:

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

9.2. Exposure scenario 2: Use of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers

Sodium chromate is used in the surface treatment of various metal substrates; chromium coatings are used to enhance corrosion protection on these metal surfaces. The surface treatment involves chemical and/or electrolytic process to impart a protective chromium coating. The coating itself contains no or very low residual levels of hexavalent chromium. Typical processes include, conversion coating, sealing after anodizing, pickling and etching.

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. 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 brush, especially to small localised areas.

Sodium chromate is used for sealing after anodizing in the post-treatment of various metal substrates. The surfaces of substrates after anodizing are naturally porous. The anodised coating cannot provide the required corrosion resistance without further treatment; a post-treatment sealing is necessary for a broad variety of sectors and applications.

The anodized surface have to be closed in a post-treatment sealing step to provide the requisite long-term corrosion resistance. The sealing after anodizing step is performed with a sodium chromate solution. During the sealing, sodium chromate and hydroxides precipitate in the pores of the anodized oxide layer and are hydrated. By this process, the pores are closed and an adequate wear resistance and corrosion resistance is provided to the surface. The sealing step needs to be carefully controlled so as not to cause poor adhesion of the subsequent paint coatings that are applied to most anodized and sealed parts.

Sealing is often performed in a hot aqueous chromate solution (typically > 95°C but below the solution's boiling point) and 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. Sometimes the solution containing hexavalent chromium is applied by brush or with a pen-stick, especially to small surfaces.

Etching and pickling is the removal of material selectively to reveal a surface or the surface properties and the removal of oxides or other compounds from a metal surface by chemical or electrochemical action and is not a stand-alone process but part of a process chain. 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. Sometimes the solution containing hexavalent chromium is applied by brush, especially to small surfaces.

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. Local exhaust ventilation (LEV), 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 (e.g., protective clothing, goggles, gloves, respirators) 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) and its proper use is enforced. 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 sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers	ERC6b
Worker contributing scenario(s):	
Delivery and storage of raw material	PROC 1
Decanting of liquids	PROC 8b
Decanting and weighing of solids	PROC 8b
Mixing – liquids	PROC 5

Mixing – solids	PROC 5
Re-filling of baths for adjustment of concentration– liquids	PROC 8b
Re-filling of baths for adjustment of concentration – solids	PROC 8b
Use of sodium chromate for chemical conversion coating applications by aerospace companies and their suppliers	PROC 13
Sealing after anodizing with sodium chromate in baths	PROC 13
Pickling and Etching	PROC 13
Surface treatment by brushing (small sized areas)	PROC 10
Maintenance of equipment	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
End of Life	PROC 8a

Subsequent service life exposure scenario(s):

Included

Explanation on the approach taken for the ES

Occupational exposure estimates are based on modelled data supported by measurement data, if available[7]. Inhalation exposure has been estimated using the exposure model '*Advanced REACH Tool 1.5' or 'ART'*[8]. 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 haves 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.

This detailed Exposure Scenario has been developed based on information provided by multiple companies involved in this activity. Companies provided details of the conditions under which the activity was carried out as well as the duration and frequency of each task.

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

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

[7] Only a limited number of measurement data specific to the sealing after anodizing process in baths (post-treatment process) and for the application by brushing (low exposure potential) are available.
[8] The use of ART for workers exposure assessment under REACH is described in ECHA's updated Guidance on Information Requirements and Chemical Safety Assessment R.14.

9.2.1. Environmental contributing scenario 1: Use of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers.

Hexavalent chromium 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 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. Companies regularly monitor and report hexavalent chromium emissions as part of permit conditions. Releases are often beneath detection limits

For the applications in the use of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching by aerospace companies and their suppliers described here, the production facility is strictly separated from the wastewater stream, i.e. there is only very low release of Cr(VI) to the aquatic environment, if at all. Water in scrubbers or filters is generally recycled and occasionally replaced, with resulting material being treated as a waste.

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

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

9.2.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
▪ Daily use at site: <= 2E-04 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 %).

9.2.1.2. Releases

For the use of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching applications by aerospace companies and their suppliers, 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 sodium chromate surface treatment 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 sodium chromate 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 [as Cr(VI)]; this is considered very conservative with respect to information provided by industry regarding annual tonnage used per site and the total tonnage of sodium chromate in this use.

Table 17. 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

9.2.1.3. 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 18. Exposure concentrations and risks for the environment

Protection target	Exposure concentration	Risk characterisation
Freshwater	Not relevant	-
Sediment (freshwater)	Not relevant	-
Marine water	Not relevant	-
Sediment (marine water)	Not relevant	-
Predator (freshwater)	Not relevant	-
Predator (marine water)	Not relevant	-
Top predator (marine water)	Not relevant	-
Sewage treatment plant	Not relevant	-
Air	**Local PEC:** 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	-

Conclusion on risk characterisation

The modelled PEClocal$_{air,ann}$ of 3.808E-10 mg Cr(VI)/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.

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

Sodium chromate flakes or formulations containing sodium chromate are delivered in either sealed bags, drums or containers, or as an aqueous solution in sealed containers and stored in a chemical storage room. There is no potential for exposure.

9.2.2.1. Conditions of use

	Method
Product (article) characteristics	
▪ Substance as such/in a mixture ▪ Concentration of Cr(VI) : <33 %	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	
▪ Place of use: Indoor	Qualitative
▪ Process temperature (for liquids and solids): Room temperature	Qualitative

9.2.2.2. Exposure and risks for workers

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

Table 19. Exposure concentrations and risks for workers

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

Route of exposure and type of effects	Exposure concentration	Risk characterisation
		exposure: 0 per 1000 exposed workers

Conclusion on risk characterisation

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

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

9.2.3. Worker contributing scenario 2: Decanting of liquids (PROC 8b)

The aqueous solution containing sodium chromate may be decanted in (smaller) containers or mixing vessels for re-filling of baths or for further pre-mixing.

9.2.3.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: 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	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: Falling liquids	ART 1.5
▪ Situation: Transfer of liquid product with flow of 1–10 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: 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

	Method
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.3.2. 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	0.31 µg/m³ (90th percentile value)	
Further adjusted for frequency	**0.062 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 0.248 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.062 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 6).

An excess lifetime risk of 0.248 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.

9.2.4. Worker contributing scenario 3: Decanting and weighing of solids (PROC 8b)

The solid sodium chromate (concentration of Cr(VI) in pure sodium chromate is around 33%) or the solid chromate containing formulation may be decanted and weighed for re-filling of baths or for further dilution.

9.2.4.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5

	Method
▪ Powder weight fraction (Cr(VI): < Substantial (10 – 50%)	ART 1.5
▪ Dustiness: Low (inhalable fraction: ≤ 100 mg/kg)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	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: Transfer of powders, granules or pelletised material	ART 1.5
▪ Situation: Movement and agitation of 1 - 10 kg	ART 1.5
▪ Handling type: Careful transfer 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
▪ Drop high: < 0.5 m	ART 1.5
▪ Containment level: Handling that reduces contact between product and adjacent air.	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) *In most cases, this activity is conducted under LEV. However, this has not been considered in this exposure assessment.*	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%] *When handling solid chromates, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.2.4.2. 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	2.2 µg/m³ (90th percentile value)	
Further adjusted for frequency and RPE	**1.47E-2 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 5.88E-2 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 1.47E-02 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 6).

An excess lifetime risk of 5.88E-02 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.

9.2.5. Worker contributing scenario 4: Mixing - solids (PROC 5)

Before re-filling of baths for adjustment of concentration, the solid sodium chromate or the solid chromate containing formulation may be dissolved.

9.2.5.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5
▪ Dustiness: Low (inhalable fraction: ≤ 100 mg/kg)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5
▪ Powder weight fraction (Cr(VI): < Substantial (10 - 50%)	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: Movement and agitation of powders, granules or pelletised material	ART 1.5
▪ Situation: Movement and agitation of 1 - 10 kg/min	ART 1.5

	Method
▪ Containment level: Handling that reduces contact between product and adjacent air.	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%] *When handling solid chromates, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.2.5.2. 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	7.4 µg/m³ (90th percentile value)	
Further adjusted for frequency and RPE	**0.049 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 0.196 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.049 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 6).

An excess lifetime risk of 0.196 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.

9.2.6. Worker contributing scenario 5: Re-filling of baths for adjustment of concentration - liquids (PROC 8b)

The solution containing sodium chromate is transferred to and manually filled into the bath for adjustment of the concentration in the bath. This scenario covers as worst-case similar activities in which the adjustment is done automatically; or in which a complete emptying and re-filling of a bath is conducted – which is only rarely.

9.2.6.1. 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: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: <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
▪ 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

	Method
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.6.2. 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	0.11 µg/m³ (90th percentile value)	
Further adjusted for frequency	**0.022 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-2 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.022 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 6).

An excess lifetime risk of 8.8E-02 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.

9.2.7. Worker contributing scenario 6: Re-filling of baths for adjustment of concentration-solids (PROC 8b)

The solid sodium chromate or the formulation containing solid sodium chromate is transferred to and manually filled into bath for adjustment of the concentration in the bath.

9.2.7.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5
▪ Dustiness: Low (inhalable fraction: ≤ 100 mg/kg)	ART 1.5

	Method
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5
▪ Powder weight fraction [(Cr(VI)]: Substantial (10 - 50%)	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
▪ Activity class: Falling powders	ART 1.5
▪ Situation: Transferring 10 – 100 kg/minute	ART 1.5
▪ Handling type: Careful transfer involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner e.g. careful weighing in laboratory	ART 1.5
▪ Drop height: Drop height < 0.5 m	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: 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: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *When handling solid chromates, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.2.7.2. 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	0.74 µg/m³ (90th percentile value)	
Further adjusted for frequency and RPE	**4.93E-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 1.97E-2 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 4.93E-03 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 6).

An excess lifetime risk of 1.97E-02 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.

9.2.8. Worker contributing scenario 7: Use of sodium chromate for chemical conversion coating applications by aerospace companies and their suppliers (PROC 13)

Use of sodium chromate for chemical conversion coating applications in the aeronautics and aerospace industries 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 immerged. 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.

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.

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

9.2.8.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Very small (0.5 - 1%)	ART 1.5
▪ Process temperature: Above temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 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
▪ 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

9.2.8.2. 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	5.8E-3 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: 0.023 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 5.8E-3µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

An excess lifetime lung cancer risk of 0.023 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.

9.2.9. Worker contributing scenario 8: Sealing after anodizing with sodium chromate in baths (PROC 13)

Sodium Chromate is a component of a sealing treatment bath. This sealing surface treatment is made on aluminium parts. The sealing process, which is an electroless process, is applied after CAA (Chromic Acid Anodizing) treatment which is not covered by this AfA. Therefore it is a post-treatment process. The sealing treatment provides corrosion resistance for unpainted or partially painted parts. The weight of articles treated per sealing bath is from few grams up to several kg, and the parts that are sealed have a variable geometry.

The sealing surface treatment is performed by immersion of the articles in the bath. Potential exposure to Cr(VI) might occur when the operators is near the bath tank (e.g. during bath preparation, parts immersion, parts lifting and all others tasks near the sealing line in the workshop).

Lifting tools (hoist and tracks) are used to move articles to and from the sealing bath. The hoist may be operated as either a manual or an automatic process. Titanium tools are used to maintain articles immersed in the bath.

Articles and tools are placed in the bath through the upper opened surface of the tank, and immersed in the treatment solution. The opened surface of the tank might be covered during the process which is conducted at just below 100°C. The stainless steel bath tank is equipped with temperature controller and with extract ventilation during the treatment process. Cr(VI) concentration in the sealing bath is below 1%.

The duration of the sealing process is around 0.5 hours.

Finally, articles and tools are removed from the bath using the lifting tools, drained above the bath during few seconds and then rinsed in adjacent demineralized water tanks. Before the parts are finally removed from the tools, articles are dried in a heating tank at hot temperature.

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.

9.2.9.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Very small (0.5 - 1%)	ART 1.5
▪ Process temperature: Hot processes (below 100°C)	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	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
▪ 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 ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.9.2. Exposure and risks for workers

Table 26. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	5.8E-3 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: 0.023 per 1000 exposed workers

Measurement data

Data for the sealing after anodizing process in baths are available for one site for comparable substances but in higher concentrations. Personal sampling was conducted in 2014. The result of this measurement was below the LOD (< 0.5 µg/m³).

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 5.8E-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 (see footnote 6).

An excess lifetime lung cancer risk of 0.023 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.

9.2.10. Worker contributing scenario 9: Pickling and Etching (PROC 13)

Etching and pickling is the removal of material to reveal a surface or the surface properties and the removal of oxides or other compounds from a metal surface by chemical or electrochemical action. The pickling/etching process is a pre-treatment process.

Sodium Chromate is a component of a pickling/etching treatment bath. This pickling/etching surface treatment is made on titanium/titanium alloys and corrosion resistant steel and nickel alloys. The weight of articles treated per pickling/etching bath is from few grams up to several kg, and the parts that are treated have a variable geometry.

The pickling/etching surface treatment is performed by immersion of the articles in the bath. Potential exposure to Cr(VI) might occur when the operators is near the bath tank (e.g. during bath preparation, parts immersion, parts lifting and all others tasks near the pickling/etching line in the workshop).

Lifting tools (hoist and tracks) are used to move articles to and from the pickling/etching bath. The hoist may be operated as either a manual or an automatic process.

Articles and tools are placed in the bath through the upper opened surface of the tank, and immersed in the treatment solution. The opened surface of the tank might be covered during the process. The bath tank is equipped with extract ventilation during the treatment process. Cr(VI) concentration in the pickling/etching bath is below 5 %.

The duration of the pickling/etching process is depending on the layer to be removed but potential operator exposure is less than 30 minutes.

Finally, articles and tools are removed from the bath using the lifting tools, drained above the bath during few seconds and then rinsed in adjacent demineralized water tanks.

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.

9.2.10.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Small (1 - 5%)	ART 1.5
▪ Process temperature: Hot processes	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 30 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: 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 ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.10.2. Exposure and risks for workers

Table 27. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	0.012 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: 0.048 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.012 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

An excess lifetime lung cancer risk of 0.048 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.

9.2.11. Worker contributing scenario 10: Surface treatment by brushing (small sized areas) (PROC 10)

Small sized areas may be treated by brushing with a small pencil containing small amounts of sodium chromate. 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.

9.2.11.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Very small (0.5 - 1%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Spreading of liquid products	ART 1.5
▪ Situation: Spreading of liquids at surfaces or work pieces < 0.1 m² / hour	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5

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

9.2.11.2. Exposure and risks for workers

Table 28. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.057 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.23 per 1000 exposed workers

Measurement data

Data for the touch-up application are available for comparable substances but in higher concentrations for two sites. Personal sampling was conducted in 2012 and 2015, respectively. The results of these measurements were below the LOD (< 1.0 and < 0.7 µg/m³).

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.057 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 6).

An excess lifetime risk of 0.23 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.

9.2.12. Worker contributing scenario 11: 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, sealing after anodizing and etching/pickling processes (i.e. assuming a background concentration of Cr(VI) within the work area equivalent to that present during surface treatment processes, even if no surface treatment takes place) and that LEV is off. Adequate PPE is always worn (protective clothing, chemical-resistant gloves, goggles). The highest exposure estimate calculated for these processes (for the etching/pickling application, see WCS 9) has been used for assessment.

This scenario also covers infrequent maintenance activities with longer duration and depending of the exposure potential, RPE is worn additionally.

9.2.12.1. 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	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

9.2.12.2. Exposure and risks for workers

Table 29. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output in WCS 9	0.012 µg/m³ (90th percentile value)	
Further adjusted for duration and frequency	**2.4E-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: 9.6E-3 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 2.4E-03 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 9.6E-03 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

9.2.13. Worker contributing scenario 12: 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. As worst case, sampling at the pickling/etching bath(s) has been used.

9.2.13.1. 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	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)
▪ 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	

	Method
▪ 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 ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.13.2. Exposure and risks for workers

Table 30. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	5.7E-3 µg/m³ (90th percentile value)	
Further adjusted for frequency	**1.14E-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: 4.56E-3 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 1.14E-04 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 4.56E-03 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.

9.2.14. Worker contributing scenario 13: Machining operations on small to medium sized parts containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24)

During assembly, maintenance and/or repair, small to medium sized solid parts are drilled, 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.

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.

9.2.14.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: <0.1%	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ 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

	Method
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 -face 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)* ▪ 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)

9.2.14.2. Exposure and risks for workers

Table 31. 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	**1.27E-2 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: 5.07E-2 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 1.27E-02 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 lung cancer risk of 5.07E-02 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.

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

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.

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.

9.2.15.1. 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: < 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/vacuum cleaning (90.00 % reduction)	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)* ▪ 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)

9.2.15.2. Exposure and risks for workers

Table 32. 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	**2.77E-2 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 2.77E-02 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 6).

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.

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

Parts are drilled, riveted, 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.

9.2.16.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 0.1 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5

	Method
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: 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%%] *At least 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)

9.2.16.2. Exposure and risks for workers

Table 33. 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 6).

An excess lifetime lung cancer risk of 0.32 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.

9.2.17. Worker contributing scenario 16: Storage of articles (PROC 1)

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

9.2.17.1. Conditions of use

	Method
Product (article) characteristics	
• Concentration of substance 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

9.2.17.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (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 derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0 per 1000 exposed workers

Conclusion on risk characterisation

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

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

9.2.18. Worker contributing scenario 17: Waste management (PROC 8b)

Very low amounts of Cr(VI), if at all, is released from waste water 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 considered negligible and is not further assessed.

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

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

9.2.18.1. 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)]:Substantial (10 – 50%)	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)
▪ 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
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 ▪ 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] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.18.2. Exposure and risks for workers

Table 34. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	0.37 µg/m³ (90th percentile value)	
Further adjusted for frequency	**0.074 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: 0.296 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.074 µg Cr(VI)/m³ is used as the basis for risk characterisation. The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

An excess lifetime risk of 0.296 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.

9.2.19. Worker contributing scenario 28: End of Life (PROC 8a)

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

All Aircraft parts must, as part of aviation requirement [AMC 145.A.42; AMC M.A. 504 (d)(2) and AMC M.A. 504 (e)] to avoid suspect unapproved parts, be destroyed to avoid reuse. Defence products typically go through a process of demilitarization to ensure control against inappropriate re-use or disposal.

The coating itself contains no or very low residual levels of hexavalent chromium.

10. RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

10.1. Human health

10.1.1. Workers

In the formulation process, there is no further combined potential exposure apart from what already has been shown in the respective sub-scenarios. Even in the case that one worker would conduct all activities, estimated combined potential exposure would remain below 0.3 µg Cr(VI)/m³.

Workers in the use of sodium chromate for sealing after anodizing, chemical conversion coating, pickling and etching 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.

For all activities, exposure estimates have been prepared by modelling supported by measurement data, where available. By design, the exposure modelling used provided worst-case estimates in order to be assuredly conservative and to apply across a broad range of activities and situations. Accordingly, modelling may provide results that are so over-conservative as to be rather unrealistic, depending on the basic assumptions of the model and the specificity, the quality and the currency of the underlying model database.

Furthermore, taking into account the various details of processes carried on and risk management measures applied by different companies, each of the sub-scenarios represents a worst-case scenario by using the lowest level of OCs and RMMs reported for that one specific activity. Summing exposure estimates across sub-scenarios further amplifies the impact of conservative or worst-case assumptions across activities, resulting in potentially substantial over-estimates of potential exposure. As a clear example, summing up all exposure estimates from the worker sub-scenarios in section 9.2. would result in an unrealistic individual exposure duration.

A theoretically possible combination of sub-scenarios is the combination of WCS 2-9 and 12, activities in relation to the different application in baths. The combined exposure estimate (as the 90th percentile value of model-based exposure distribution) of these activities would be 0.18 µg/m³.

A further possible combination of activities would be the machining activities (WCS 13-15). The combined exposure estimate (as the 90th percentile value of model-based exposure distribution) of these activities would be 0.12 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 and sometimes provides unrealistic estimates. 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 0.18 µg/m³ for all 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 0.72 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

10.1.2. Consumer

Not relevant as there is no consumer use.

10.2. Environment (combined for all emission sources)

10.2.1. All uses (regional scale)

10.2.1.1. Regional exposure

Environment

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

The PEC regional have been estimated with EUSES.

Table 35. 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	3.319E-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 risk characterisation ratios are presented in the table below. The exposure concentration via inhalation is equal to the PEC air.

Table 36. Regional exposure to man via the environment

Route	Regional exposure	Risk characterisation
Inhalation	3.319E-18 mg/m³	Based on the dose-response relationship derived by the RAC, considering a 70 year exposure time (24h/day, 7d/week), the following excess lifetime risk for the general population is derived based on the estimated exposure: 9.63E-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.