CHEMICAL SAFETY REPORT

Use of potassium dichromate for sealing after anodizing applications by aerospace companies and their suppliers

Substance Name: potassium dichromate

EC Number: 231-906-6

CAS Number: 7778-50-9

Applicant's Identity: Haas Group International SCM Ltd

9. EXPOSURE ASSESSMENT (and related risk characterisation)

9.0. Introduction

The need for this application relates to the import of products containing potassium dichromate that are imported for use in the EU. These products are imported because they are specified for use as a final surface treatment to provide an anti-corrosive seal following anodising 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. 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-estimate the risk.

This exposure assessment provides reliable estimates of current work place exposure levels across the EU. Occupational work place exposure to hexavalent chromium [Cr(VI)] is regulated in most European countries. National Occupational Exposure Limits (OELs) across Europe respect a range of 8 hour *Time Weighted Average* (TWA) values between 1 $\mu g/m^3$ 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 OELs 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 practice across the industry is continually improving, driven by general awareness of workplace hygiene and increasingly stringent regulatory requirements. This commitment to reducing exposure also reflects the widespread recognition that surface treatment with Cr(VI) is critical for several industries and that alternatives are not available in the near-term. Potential workplace exposure to Cr(VI) has progressively reduced in recent years as the effectiveness and implementation of risk management measures has improved.

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

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

9.0.1. Overview of uses and Exposure Scenarios

Tonnage information:

Assessed tonnage: < 5 tonnes/year based on:

- < 5 tonnes/year imported [containing approximately 2 tonnes Cr(VI)]

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

Table 6. Overview of exposure scenarios and contributing scenarios

Identifiers	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
ES1 - IW1		Use at industrial site - Use of potassium dichromate for sealing after anodizing applications by aerospace companies and their suppliers - Use of potassium dichromate for sealing after anodizing 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) - Sealing after anodizing with potassium dichromate in baths (PROC 13) - 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)	< 5 [< 2 Cr(VI)]
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 potassium dichromate for use in sealing after anodizing applications by aerospace companies and their suppliers after the sunset date in September 2017.

Potassium dichromate has been included in Annex XIV to Regulation (EC) No 1907/2006 ('REACH') due to their 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 potassium dichromate as carcinogenic, mutagenic and reproductive toxicant are considered in the current CSR. The dominating health effect resulting from the intrinsic hazardous properties of potassium dichromate are 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 potassium dichromate, which are 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 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 surface operations are effectively prevented. Therefore any potential risk for carcinogenicity and/or reproduction due to exposure to potassium dichromate via the food chain is considered negligible. Dermal exposure potential is not expected for the general population.

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

Cr(VI) is neither directly nor indirectly released to soil and releases to soil are considered negligible.

Table 7. Type of risk characterisation required for the environment

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

Comments on assessment approach:

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

9.0.2.2. Man via environment

Scope and type of assessment

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

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

The regional concentrations are reported in section 10.2.1.1 (see Table 37 "Predicted regional exposure concentrations (Regional PEC)") based on modeling with EUSES 2.1.2., and expressed as Cr(VI).

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

Route of exposure and type of effects	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1)
Inhalation: Local long-term	Quantitative	Lung cancer: ELR = 2.9E−02 per 1 µg Cr(VI)/m³ for 70 years
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 potassium dichromate. 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 hence no exposure via the oral route needs to be considered.

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

Potassium dichromate 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 9. Type of risk characterisation required for workers

Route	Type of effect	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1)
Inhalation	Systemic long-term	Quantitative	Reproduction: DNEL = 3E+01 µg Cr(VI)/m³
	Systemic acute	Not needed	Not relevant
	Local long term	Quantitative	Lung cancer: ELR = 4.0E−03 per 1 µg Cr(VI)/m³ for 40 years
	Local acute	Not needed	Not relevant
Dermal	Systemic long term	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:

Potassium dichromate 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 potassium dichromate is lung cancer due to inhalation of dust and/or aerosols.

Potassium dichromate 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, potassium dichromate 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 industrial use is restricted to the lowest possible level.

When handling solid potassium dichromate, 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 potassium dichromate 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 exposure to potassium dichromate (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.

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 potassium dichromate.

[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)

9.1. Exposure scenario 1: Use at industrial site - Use of potassium dichromate for sealing after anodizing applications by aerospace companies and their suppliers.

Potassium dichromate is used for sealing after anodizing in the post-treatment of various metal substrates. Potassium dichromate-based surface treatments are specified by aeronautics and aerospace companies because they provide superior corrosion resistance and inhibition and improved paint adhesion.

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 process of anodizing is briefly described below to fully explain the process and the need for a post-treatment anodize sealing. However, the AfA does not cover the use of chromates in the anodizing process.

Anodizing itself is an electrolytic oxidation process in which the surface of a metal is converted to form a layer or coating that has desirable protective or functional properties, including increased corrosion and wear resistance, as well as adhesion for subsequent processes. The oxide layer partly grows into the substrate and partly grows onto the surface.

The surface of the anodised metal is naturally porous and the micropores of 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 potassium dichromate solution. During the sealing, potassium dichromate 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.

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). 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 potassium dichromate for sealing after anodizing 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 – solids	PROC 8b
Sealing after anodizing with potassium dichromate in baths	PROC 13
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[2]. Inhalation exposure has been estimated using the exposure model '*Advanced REACH Tool 1.5' or 'ART'*[3]. 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 parameter~~s~~ have~~s~~ 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 potassium dichromate 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.

9.1.1. Environmental contributing scenario 1: Use of potassium dichromate for sealing after anodizing 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

[2] Only a limited number of measurement data specific to the sealing after anodizing process in baths (post-treatment process) are available
[3] 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.

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 potassium dichromate for the sealing after anodizing post-treatment of parts by aerospace companies and their suppliers described here, wastewater releases from the production facility are strictly controlled, i.e. there is only very low release of Cr(VI) to the aquatic environment, if 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 below detection limits.

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

9.1.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
▪ Daily use at site: <= 0.08 tonnes/day [as Cr(VI)]
▪ Annual use at a site: <= 0.2 tonnes/year [as Cr(VI)]
▪ Percentage of tonnage used at regional scale: = 33 %
Technical and organisational conditions and measures
▪ Air emission abatement: at least 99% efficiency. For operations where exposure potential is low [i.e. operations are infrequent using only small quantities of Cr(VI)] air emission abatement may not be required. ▪ Negligible discharge of Cr(VI) in wastewater from the site ▪ All solid and any liquid waste is collected and either the collected waste is directly forwarded to an external waste management company, or Cr(VI) in wastewater is reduced to Cr(III) on-site, or treated by vacuum evaporation. The treated wastewater is discharged to municipal sewage system. Any solid or slurry waste is either recycled or forwarded to an external waste management company (licenced contractor) for disposal as hazardous waste
Conditions and measures related to sewage treatment plant
▪ Not applicable – negligible discharge of Cr(VI) in wastewater from the site
Conditions and measures related to treatment of waste (including article waste)
▪ Collection of all solid and liquid waste, elimination of Cr(VI) from waste water, reuse disposal as hazardous waste by an external waste management company (licenced contractor)
Other conditions affecting environmental exposure
▪ When needed, exhaust air is passed through filters or wet scrubbers according to best available technique (minimum efficiency 99 %).

9.1.1.2. Releases

For the use of potassium dichromate for the sealing after anodizing post-treatment of parts for applications by aerospace companies and their suppliers activities, no specific air emission data (i.e. measurement of release to the atmosphere) were available. Facilities conducting these activities also have different other uses of chromium trioxide and chromates at the same facility and it is not possible to estimate the likely small contribution of sealing after anodizing 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 potassium dichromate 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 0.8 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 potassium dichromate in this use.

Table 10. Local releases to the environment

Release	Release factor estimation method	Explanation / Justification
Air	Release factor	**Initial release factor:** 0.1% **Final release factor:** 0.001% **Local release rate:** 8E-6 kg/day

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

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

Table 11. Exposure concentrations and risks for the environment

Protection target	Exposure concentration	Risk characterisation
Freshwater	Not relevant	-
Sediment (freshwater)	Not relevant	-
Marine water	Not relevant	-
Sediment (marine water)	Not relevant	-
Predator (freshwater)	Not relevant	-
Predator (marine water)	Not relevant	-
Top predator (marine water)	Not relevant	-
Sewage treatment plant	Not relevant	-
Air	**Local PEC:** 1.523E-9 mg/m³	-
Agricultural soil	Not relevant	-
Predator (terrestrial)	Not relevant	-
Man via Environment – Inhalation	**Local PEC:** 1.523E-9 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: 4.52E-05 per 1000 exposed
Man via Environment - Oral	Not relevant	-

Conclusion on risk characterisation

The modelled $PEClocal_{air,ann}$ of 1.523E-9 mg Cr(VI)/m³ mg/m³ is estimated as sum of $Clocal_{air,ann}$ and $PECregional_{air}$ and used as the basis for risk characterisation for man via the environment.

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

4.52E-05 per 1000 exposed.

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

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

Potassium dichromate is delivered either as dry powder in sealed bags/containers or as an aqueous solution in sealed containers (concentration of Cr(VI) is <40% w/w) and stored in a chemical storage room. There is no potential for exposure.

9.1.2.1. Conditions of use

	Method
Product (article) characteristics	
▪ Substance as such/in a mixture ▪ Concentration of Cr(VI) : < 40%	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: Room temperature	Qualitative

9.1.2.2. Exposure and risks for workers

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

Table 12. Exposure concentrations and risks for workers

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0 µg/m^3**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived

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

Conclusion on risk characterisation

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

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

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

The aqueous solution may be decanted in (smaller) containers or mixing vessels for re-filling of the sealing bath or for further pre-mixing.

9.1.3.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: < 30%	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/2 weeks (reduction factor of 0.1 applied)	ART 1.5 ART 1.5 (extended) [4]
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Falling liquids	ART 1.5
▪ Situation: Transfer of liquid product with flow of 1–10 l/min	ART 1.5
▪ Containment level: Handling that reduces contact between product and adjacent air.	ART 1.5
▪ Loading type: Splash loading, where the liquid dispenser remains at the top of the reservoir and the liquid splashes freely	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5

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

	Method
▪ 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

9.1.3.2. Exposure and risks for workers

Table 13. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	3.1 µg/m³ (90th percentile value)	
Further adjusted for frequency	**0.31 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: 1.24 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.31 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure[5].

An excess lifetime risk of 1.24 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

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

[5] These include:

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

The solid potassium dichromate may be decanted and weighed for re-filling of baths or for further dilution. During this activity, the operators are wearing a half-face mask with P3 filter.

9.1.4.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5
▪ Powder weight fraction (Cr(VI): < 40%	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: < 15 min ▪ Frequency of activity: 1 time/2 weeks (reduction factor of 0.1 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 1 - 10 kg/min	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 hight: Drop height < 0.5 m	ART 1.5
▪ Containment level: Handling that reduces contact between product and adjacent air.	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: 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)

9.1.4.2. Exposure and risks for workers

Table 14. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	1.5 µg/m³ (90th percentile value)	
Further adjusted for frequency and RPE	**5.0E-3 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: 0.02 per 1000 exposed workers

<u>Conclusion on risk characterisation</u>

The modelled exposure estimate (ART 1.5) of 5.0E-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 0.02 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.

9.1.5. Worker contributing scenario 4: Mixing - liquids (PROC 5)

The aqueous solution may be pre-mixed before re-filling of sealing baths for concentration adjustment.

9.1.5.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: < 30%	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: < 20 min ▪ Frequency of activity: 1 time/2 weeks (reduction factor of 0.1 applied)	ART 1.5 ART 1.5 (extended)
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Activities with undisturbed surfaces (no aerosol formation)	ART 1.5
▪ Situation: Open surface < 0.1 m²	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5

	Method
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

9.1.5.2. Exposure and risks for workers

Table 15. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	0.76 µg/m³ (90th percentile value)	
Further adjusted for frequency	**0.076 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: 0.30 per 1000 exposed workers

__Conclusion on risk characterisation__

The modelled exposure estimate (ART 1.5) of 0.076 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 5).

An excess lifetime risk of 0.3 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

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

Before re-filling of baths for concentration adjustment, the solid potassium dichromate may be dissolved in water. Operators are wearing a half-face mask with P3 filter.

9.1.6.1. 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): < 40%	ART 1.5
Activity emission potential	
▪ Duration of activity: < 15 min ▪ Frequency of activity: 1 time/2 weeks (reduction factor of 0.1 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
▪ Level of agitation: Low	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)	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)

9.1.6.2. Exposure and risks for workers

Table 16. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	4.9 µg/m³ (90th percentile value)	
Further adjusted for frequency and RPE	**0.016 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: 0.065 per 1000 exposed workers

<u>Conclusion on risk characterisation</u>

The modelled exposure estimate (ART 1.5) of 0.016 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 5).

An excess lifetime risk of 0.065 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

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

The potassium dichromate solutions are transferred to and manually filled into the bath for adjustment of the concentration in the bath. This scenario covers, as worst-case, activities associated with a complete emptying and re-filling of a bath; in practice, however, such a complete refill is only rarely needed (around one time per year).

9.1.7.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: < 30%	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/2 weeks (reduction factor of 0.1 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

	Method
▪ Situation: Transfer of liquid product with flow of 10 –100 l/min	ART 1.5
▪ Containment level: Open process	ART 1.5
▪ Loading type: Splash loading, where the liquid dispenser remains at the top of the reservoir and the liquid splashes freely	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ 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

9.1.7.2. Exposure and risks for workers

Table 17. Exposure concentrations and risks for worker

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

<u>Measurement data</u>

One measurement as personal sampling result is available for this activity. The measured Cr(VI) exposure value is reported as 0.4 µg Cr(VI)/m³ (not 8h TWA).

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.11 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 5).

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

9.1.8. Worker contributing scenario 7: Re-filling of baths for adjustment of concentration - solids (PROC 8b)

The solid potassium dichromate is transferred to and manually filled into the bath(s) for adjustment of the concentration in the bath(s). This scenario covers, as worst-case, activities associated with a complete emptying and re-filling of a bath; in practice, however, such a complete refill is only rarely needed (around one time per year).

9.1.8.1. 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)]: < 40%	ART 1.5
Activity emission potential	
▪ Duration of activity: < 10 min ▪ Frequency of activity: 1 time/2 weeks (reduction factor of 0.1 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 1 – 10 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

	Method
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)

9.1.8.2. Exposure and risks for workers

Table 18. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	0.33 µg/m³ (90^{th} percentile value)	
Further adjusted for frequency	**1.1E-3 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 4.4E-3 per 1000 exposed workers

<u>Conclusion on risk characterisation</u>

The modelled exposure estimate (ART 1.5) of 1.1E-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 4.4E-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.

9.1.9. Worker contributing scenario 8: Sealing after anodizing with potassium dichromate in baths (PROC 13)

Potassium dichromate is a component of a sealing treatment bath. This sealing surface treatment is made on aluminium parts. As noted before, 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 a post-treatement 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.

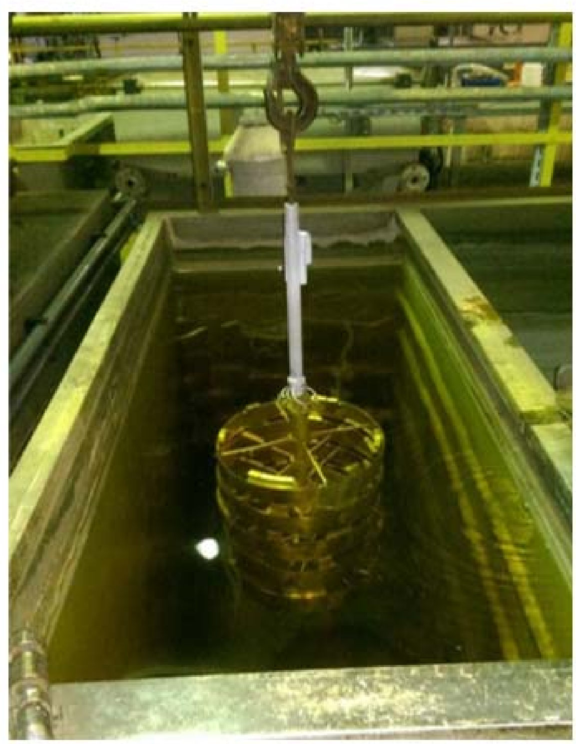
Articles and tools are placed in the bath through the upper opened surface of the tank, and immersed in the treatment solution. The opened surface of the tank might be covered during the process which is conducted at just below 100°C. The stainless steel bath tank is equipped with temperature controller and with extract ventilation during the treatment process. Cr(VI) concentration in the sealing bath is below 5%.

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.

Sealing bath



Rinsing bath

9.1.9.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Small (1 - 5%)	ART 1.5
▪ Process temperature: Hot processes (below 100ºC)	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 > 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

9.1.9.2. Exposure and risks for workers

Table 19. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	0.023 µg/m³ (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.09 per 1000 exposed workers

Measurement data

Data for the sealing after anodizing process in baths are available for one site where 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 0.023 µg/m³ Cr(VI) is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure.

An excess lifetime lung cancer risk of 0.09 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.10. Worker contributing scenario 9: Maintenance of equipment (PROC 8a)

Workers 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 sealing after anodizing processes (i.e. assuming a background concentration of Cr(VI) within the work area equivalent to that present during sealing (see WCS5), even if no sealing takes place) and that LEV is off. Adequate PPE is always worn (protective clothing, chemical-resistant gloves, goggles).

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

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: 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

9.1.10.2. Exposure and risks for workers

Table 20. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	0.23 µg/m³ (90th percentile value)	
Further adjusted for frequency	**2.3E-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: 9.2E-2 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 2.3E-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 9.2E-02 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

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

9.1.11.1. Conditions of use

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

	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/2 weeks (reduction factor of 0.1 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 > 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

9.1.11.2. Exposure and risks for workers

Table 21. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	5.7E-3 µg/m³ (90^{th} percentile value)	
Further adjusted for frequency	**5.7E-4 µg/m³**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 2.3E-3 per 1000 exposed workers

<u>Conclusion on risk characterisation</u>

The modelled exposure estimate (ART 1.5) of 5.7E-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 2.3E-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.

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

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

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

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

9.1.12.1. Conditions of use

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

9.1.12.2. Exposure and risks for workers

Table 22. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	0.38 µg/m³ (90th percentile value)	
Further adjusted for RPE	**0.013 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.05 per 1000 exposed workers

<u>Conclusion on risk characterisation</u>

The modelled exposure estimate (ART 1.5) of 0.013 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 5).

An excess lifetime risk of 0.05 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.1.13. Worker contributing scenario 12: Machining operations in large work areas on parts containing Cr(VI) including cleaning (PROC 21, 24)

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

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

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

9.1.13.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 0.1 %	ART 1.5
▪ 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 -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)

9.1.13.2. Exposure and risks for workers

Table 23. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	0.83 µg/m³ (90th percentile value)	
Further adjusted for RPE	**0.028 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.11 per 1000 exposed workers

__Conclusion on risk characterisation__

The modelled exposure estimate (ART 1.5) of 0.028 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 5).

An excess lifetime risk of 0.11 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

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

Parts are drilled, riveted or cut in comparable small work areas (e.g. inside wing tanks). 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 (i.e. 0.5 % concentration in the product would lead to an increase of the exposure estimate by a factor of 5). If needed, OCs and RMMs could be adjusted for that different situation.

9.1.14.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 0.1 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 30 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Small workrooms only	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 400] [Effectiveness Inhal: 99.75%] *Full face mask with P3 filter (APF 400 according to German BG rule 190) is worn if workplace monitoring data do not confirm negligible exposure clearly below 1 µg/m³ (e.g. < 0.1 µg/m³)* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles]	ART 1.5 (extended)

9.1.14.2. Exposure and risks for workers

Table 24. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
ART model output	32 µg/m³ (90th percentile value)	
Further adjusted for RPE	**0.08 µg/m³**	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: 0.32 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.08 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 5).

An excess lifetime risk of 0.32 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

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

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

9.1.15.1. Conditions of use

	Method
Product (article) characteristics	
• Concentration of substance in article: Non detectable or very low	Qualitative
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: < 8 hours	Qualitative
Technical and organisational conditions and measures	
• General ventilation: Basic general ventilation (1-3 air changes per hour)	Qualitative
• Local exhaust ventilation: No	Qualitative
• Occupational Health and Safety Management System: Advanced	Qualitative
Conditions and measures related to personal protection, hygiene and health evaluation	
• Respiratory Protection: No	Qualitative
Other conditions affecting workers exposure	
• Place of use: Indoor/outdoors	Qualitative
• Process temperature (for solids): ambient	Qualitative

9.1.15.2. Exposure and risks for workers

The exposure concentrations and 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.

9.1.16. Worker contributing scenario 15: 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 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.

9.1.16.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5
▪ Dustiness: Firm granules, flakes or pellets	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
▪ Powder weight fraction [Cr(VI)]: < 40%	ART 1.5
Activity emission potential	
▪ Duration of activity: < 15 min ▪ Frequency of activity: 1 time/2 weeks (reduction factor of 0.1 applied)	ART 1.5 ART 1.5
▪ Activity class: Handling of contaminated solid objects or paste	ART 1.5
▪ Situation: Handling of objects with limited residual dust (thin layer visible)	ART 1.5
▪ Handling type: Careful handling, involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner.	ART 1.5
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

9.1.16.2. Exposure and risks for workers

Table 25. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term		
	0.49 µg/m³ (90th percentile value)	
	0.049 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: 0.196 per 1000 exposed workers

<u>**Conclusion on risk characterisation**</u>

The modelled exposure estimate (ART 1.5) of 0.049 µg Cr(VI)/m³ is used as the basis for risk characterisation. The estimate is based on several conservative assumptions regarding exposure (see footnote 5).

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.

9.1.17. Worker contributing scenario 16: End of Life (PROC 8a)

At the end of life, serospace components are collected in designated, secure boxes and sent to a licensed scrap dealer 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. All other parts, at end of life, are collected and sent to a licensed scrap dealer or waste contractor who treats the metals according to EU and national requirements.

10. RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

10.1. Human health

10.1.1. Workers

Workers in the use of potassium dichromate for sealing after anodizing applications by aerospace companies and their suppliers process 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 nature, the exposure models used provide worst-case estimates in order to be assuredly conservative and to apply across a broad range of activities and situations. Accordingly, 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 9.1. would result in an unrealistic individual exposure duration.

A possible combination of sub-scenarios is the combination of WCSs 2, 4, 6, 8, and 10 or WCSs 3, 5, 7, 8 and 10 (combined exposure activities in relation to the sealing application in baths). The combined exposure estimates (as the 90th percentile value of model-based exposure distribution) of these activities would be 0.52 µg/m³ and 0.046 µg/m³, respectively.

A further possible combination of activities would be the machining activities (WCS 11-13). The combined exposure estimate (as the 90th percentile value of model-based exposure distribution) of these activities would be 0.121 µg/m³. In general, and as mentioned in the respective CSR WCSs, the ART 1.5 model does not have a specific assessment option for metallic objects but only for stone. The model is therefore not ideal, however, it is conservative 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 0.52 µg/m³ for all sealing bath related activities, in which the same workers could be involved, reasonably representing worst-case combined exposure.

In this case,, an excess lifetime lung cancer risk of 2.08 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

<u>Environment</u>

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 26. Predicted regional exposure concentrations (Regional PEC)

Protection target	Regional PEC	Risk characterisation
Freshwater	Not relevant	Not relevant
Sediment (freshwater)	Not relevant	Not relevant
Marine water	Not relevant	Not relevant
Sediment (marine water)	Not relevant	Not relevant
Air	3.735E-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 27. Regional exposure to man via the environment

Route	Regional exposure	Risk characterisation
Inhalation	3.735E-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: 1.08E-13 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.