CHEMICAL SAFETY REPORT

Legal name of applicants:	*Brenntag UK Limited;* *AD International BV;* *Henkel AG & Co. KGaA.*
Submitted by:	*Brenntag UK Limited.*
Substance:	*Sodium dichromate, EC No: 234-190-3, CAS No: 7789-12-0 (dihydrate), 10588-01-9 (anhydrous)*
Use title:	*Formulation of Mixtures* *Use of Sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites, sealings of anodic films*
Use number:	*1 and 2*

9. EXPOSURE ASSESSMENT (and related risk characterisation)

9.0. Introduction

This application is the culmination of extraordinary effort across industry over several years to share data and derive Exposure Scenarios that are reliable and representative of good practice across the industry.

The aerospace industry recognises that the use of such sector-specific Exposure Scenarios in an upstream application will facilitate assessment by RAC and SEAC and enforcement at Member State level. 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 Importantly, with reference to the specific provisions for authorisation set out in the REACH regulation, an upstream Application for Authorisation (AfA) is the only possible way to meet the needs of the aerospace Downstream Users (DU). An upstream AfA (e.g. by a manufacturer, importer or formulator) of a substance allows coverage of the entire supply chain where the relevant uses are already known.

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 in the aerospace sector (as explained in the AoA), the uses are well defined and uncertainty associated with the Exposure Scenarios is limited (this finding is supported by the data presented in the document). Minor differences in exposure conditions between facilities and companies occur occasionally and are described in the Exposure Scenarios. In such cases, exposure levels take account of the least stringent RMM/OC and greater release parameters to over-estimates the risk.

For the avoidance of any doubt, while the Exposure Scenarios represent good practice in the aerospace industry, it might be that there will be facilities that cannot demonstrate compliance with these Exposure Scenarios and will not be able to rely on this upstream authorisation.

This exposure assessment provides reliable estimates of current work place exposure levels across the EU. Occupational work place exposure to hexavalent chromium [Cr(VI)] is regulated in most European countries. National Occupational Exposure Limits (OELs) across Europe respect a range of 8 hour *Time Weighted Average* (TWA) values between 1 µg/m^3 and 50 µg/m^3. The US *Occupational Safety and Health Administration* (OSHA) OEL is at 5 µg/m^3. In 2014, France introduced a new OEL of 1 µg/m^3. This is one of the most stringent OEL currently in place anywhere in the World and industry has invested substantial research and investment to continually reduce exposure to this level. It is important to recognise that measurement data presented within the CSR are necessarily aggregated across several companies and a period of several years. They do not reflect the most stringent OELs since available measurement data were generally collected prior to the introduction of the French OEL and because there is no immediate regulatory imperative for facilities outside France to meet this limit. Nevertheless, 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; it represents a 'snap-shot' of workplace practices generally in place in and around 2013. It does not describe more recent or ongoing research, measures or initiatives to further drive down potential exposure.

Surface treatment including coating and plating operations are very similar in nature, as can be seen from the Exposure Scenarios developed based on input from operators across the European surface treatment industry. Even so, individual operators may implement different RMMs over various timeframes for their own reasons, reflecting considerations such as (but not limited to) the layout (and age) of the facility, the scale, frequency and duration of operations, the number of operators, the type of articles, and expenditure required.

9.0.1. Overview of uses and Exposure Scenarios

Tonnage information:

Assessed tonnage: 1300.0 tonnes/year based on:

- 1300.0 tonnes/year manufactured/imported [containing approximately 520 tonnes Cr(VI)]

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

Table 7. Overview of exposure scenarios and contributing scenarios

Identifiers	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
ES1 - F1		Formulation – Formulation of Mixtures - Formulation of Mixtures (ERC 2) - Delivery and storage of raw material (PROC 1) - Decanting and weighing of solids (PROC 8b) - Transfer to mixing vessel – aqueous solution (PROC 8a/8b) - Transfer to mixing vessel – solids (PROC 8b) - Mixing by dilution, dispersion (closed or open process) (PROC 2-5) - Transfer to small containers (including filtering) (PROC 9) - Cleaning of equipment (PROC 8b) - Maintenance of equipment (PROC 8a) - Storage of formulation (PROC 1) - Laboratory analysis (sampling, laboratory analysis) (PROC 15) - Waste management (PROC 8b)	1300.0 [520 Cr(VI)]
ES2 - IW1		Use at industrial site - Use of Sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloy, composites, sealings of anodic films - Surface treatment (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)	1300.0 [520 Cr(VI)]

Identifiers	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
		- Re-filling of baths- liquids (PROC 8b) - Re-filling of baths - solids (PROC 8b) - Surface treatment with Cr(VI) - loading of jigs (PROC 4) - Surface treatment with Cr(VI) - chemical pre-treatment (PROC 13) - Surface treatment with Cr(VI) - by dipping/immersion (PROC 2, 13) - Surface treatment with Cr(VI) - rinsing/drying (PROC 13) - Surface treatment with Cr(VI) - chemical post-treatment (PROC 13) - Surface treatment with Cr(VI) – cleaning and unloading of jigs (PROC 4) - Surface treatment with Cr(VI) - cleaning of equipment (PROC 8b) - Maintenance of equipment (PROC 8a) - Surface treatment with Cr(VI) - by rolling and brushing (PROC 10) - Surface treatment with Cr(VI) - by pen application (PROC 10) - Surface treatment in automatic spray tunnel (PROC 7) - Laboratory analysis (sampling, laboratory analysis) (PROC 15) - Machining operations on small to medium sized parts containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24) - Machining operations on small to medium sized surfaces containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24) - Machining operations in large work areas on parts containing Cr(VI) including cleaning (PROC 21, 24) - Machining operations in large work areas on surfaces containing Cr(VI) including cleaning (PROC 21, 24) - Machining operations on parts containing Cr(VI) in small work areas including cleaning (PROC 21, 24) - Machining operations on surfaces containing Cr(VI) in small work areas including cleaning (PROC 21, 24) - Storage of articles (PROC 1) - Waste management (PROC 8b) - End of Life (PROC 8a)	
Manufacture: M-#, Formulation: F-#, Industrial end use at site: IW-#, Professional end use: PW-#, Consumer end use: C-#, Service life (by workers in industrial site): SL-IW-#, Service life (by professional workers): SL-PW-#, Service life (by consumers): SL-C-#.)			

9.0.2. Introduction to the assessment

9.0.2.1. Environment

Scope and type of assessment

The current Chemical Safety Report (CSR) and the associated exposure scenarios (ES) are tailored to supporting the Application for Authorization (AfA) to continue use of sodium dichromate for use in formulation and surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloy, composites, sealings of anodic films after the sunset date in September 2017.

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

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

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

Measures to prevent or limit release of Cr(VI) to the environment are provided as best practice at facilities carrying out operations using hexavalent chromium. During formulation and industrial surface treatment operations, prevention of releases of all products to the aquatic environment is a matter of good practice. Treatment technology (on-site or off-site) to reduce Cr(VI) to trivalent chromium [Cr(III)] in wastewater is generally highly effective, such that residual concentrations of Cr(VI) in effluent are very low and often non-detectable, and may be considered negligible. .Solid and liquid waste containing Cr(VI) is collected and treated as hazardous waste where residual Cr(VI) can be effectively safely treated. In view of the risk management measures in place at the production facilities emissions to the aquatic environment associated with formulation and surface operations are effectively prevented. Therefore any potential risk for carcinogenicity and/or reproduction due to exposure to sodium dichromate via the food chain is considered negligible. Dermal exposure potential is not expected for the general population.

Due to its low volatility, sodium dichromate will not normally be present in air. Nevertheless, energetic processes can release sodium 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 8. Type of risk characterisation required for the environment

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

Comments on assessment approach:

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

9.0.2.2. Man via environment

Scope and type of assessment

As discussed in 9.0.2.1., humans may potentially be exposed to sodium 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 formulation and industrial use are estimated based on available emission data from companies or 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 9. Type of risk characterisation required for man via the environment

Route of exposure and type of effects	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1)
Inhalation: Local long-term	Quantitative	Lung cancer: ELR = 2.9E−02 per 1 µg Cr(VI)/m³ for 70 years
Inhalation: Systemic long-term	Quantitative	Reproduction: DNEL = 0.7E+01 µg Cr(VI)/m³
Oral: Local long-term	Not needed. Assume all inhaled material is respirable (worst case).	Intestinal cancer: ELR = 8.0E−04 per 1 µg Cr(VI)/kg bw/d for 70 years

Comments on assessment approach:

The risk assessment for humans exposed via the environment is restricted to inhalation of airborne residues of sodium 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).

Sodium 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 10. Type of risk characterisation required for workers

Route	Type of effect	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1)
Inhalation	Systemic long-term	Quantitative	Reproduction: DNEL = 3.0E+01 µg Cr(VI)/m³
	Systemic acute	Not needed	Not relevant
	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

Route	Type of effect	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1)
Eye	Local	Not needed	Not relevant

Comments on assessment approach related to toxicological hazard:

Sodium 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 sodium dichromate is lung cancer due to inhalation of dust and/or aerosols.

Sodium 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, sodium 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)].

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 worker handling the chromates during formulation industrial use is restricted to the lowest possible level.

When handling solid sodium 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 sodium 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 sodium 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.

[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)

General information on risk management related to physicochemical hazard:

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

9.0.2.4. Consumers

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

9.1. Exposure scenario 1: Formulation – Formulation of Mixtures

Formulation of sodium dichromate in closed batch or batch process generally involves storage, decanting, weighing (if solid), transfer and charging of chemicals to a blend tank, mixing and/or reaction, transfer from the tank to packaging, maintenance and cleaning of equipment, transfer of waste and laboratory activities.

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

Sodium dichromate is a hazardous substances, therefore is handled in a way as to eliminate or minimise the potential for worker exposure[21]. Personal protective equipment (PPE) and engineering controls (e.g. LEV) are used to limit potential dermal and inhalation exposure.

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

Environment contributing scenario(s):	
Formulation of Mixtures	ERC 2
Worker contributing scenario(s):	
Delivery and storage of raw material	PROC 1
Decanting and weighing of solids	PROC 8b
Transfer to mixing vessel - aqueous solution	PROC 8a/8b
Transfer to mixing vessel – solids	PROC 8b
Mixing by dilution, dispersion (closed or open process)	PROC 2-5
Transfer to small containers (including filtering)	PROC 9
Cleaning of equipment	PROC 8b
Maintenance of equipment	PROC 8a
Storage of formulation	PROC 1
Laboratory analysis (sampling, laboratory analysis)	PROC 15
Waste management	PROC 8b

Explanation on the approach taken for the ES

Occupational exposure estimates are based on measured data and/or on modelled data. Where inhalation exposure has been estimated by modelling, the exposure model '*Advanced REACH Tool 1.5' or 'ART'*[3] has been used. ART

[1] In accordance with Carcinogens Directive 90/394/EEC and Carcinogens and Mutagens Directive 2004/37/EC
[3] The use ART for workers exposure assessment under REACH is described in ECHA's updated Guidance on Information Requirements and chemical safety assessment R.14.

9.2. Exposure scenario 2: Use of Sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloy, composites, sealings of anodic films.

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

The main form of application is dipping or immersion of parts in a tank or through a series of tanks containing solutions in closed or open systems. Sometimes the solution containing hexavalent chromium is applied by brush or with a pen-stick, especially to small surfaces.

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 and use of mist suppressants are technical means to minimize concentrations of Cr(VI) and other components of treatment solutions in the workplace air. Personal protective equipment 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 Sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloy, composites, sealings of anodic films	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 – liquids	PROC 8b
Re-filling of baths – solids	PROC 8b
Surface treatment with Cr(VI) - loading of jigs	PROC 4
Surface treatment with Cr(VI) - chemical pre-treatment	PROC 13
Surface treatment with Cr(VI) - by dipping/immersion	PROC 2, 13
Surface treatment with Cr(VI) - rinsing/drying	PROC 13
Surface treatment with Cr(VI) - chemical post-treatment	PROC 13
Surface treatment with Cr(VI) –cleaning and unloading of jigs	PROC 4
Surface treatment with Cr(VI) - cleaning of equipment	PROC 8b
Maintenance of equipment	PROC 8a
Surface treatment with Cr(VI) - by rolling and brushing	PROC 10
Surface treatment with Cr(VI) - by pen application	PROC 10
Surface treatment in automatic spray tunnel	PROC 7
Laboratory analysis (sampling, laboratory analysis)	PROC 15

Machining operations on small to medium sized parts containing Cr(VI) on an extracted bench/extraction booth including cleaning	PROC 21, 24
Machining operations on small to medium sized surfaces containing Cr(VI) on an extracted bench/extraction booth including cleaning	PROC 21, 24
Machining operations in large work areas on parts containing Cr(VI) including cleaning	PROC 21, 24
Machining operations in large work areas on surfaces containing Cr(VI) including cleaning	PROC 21, 24
Machining operations on parts containing Cr(VI) in small work areas including cleaning	PROC 21, 24
Machining operations on surfaces containing Cr(VI) in small work areas including cleaning	PROC 21, 24
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 measured data and/or on modelled data. Inhalation exposure has been estimated using the exposure model '*Advanced REACH Tool 1.5' or 'ART'*[7]. ART is a second tier model calibrated to assess exposure to inhalable dust, vapours, and mists; this Exposure Scenario is within the scope of ART. The figures obtained by modelling are considered to be worst-case estimates: supportive evidence for the conservative character of the modelled estimates is provided by comparison with relevant measured exposure data (measured concentrations of particulate residues of Cr(VI) in air), where available; such analysis indeed indicates that ART is a reasonable but conservative tool for estimating exposure of Cr(VI) in the scope of this assessment. Appropriate values for each model parameters haves been selected in close cooperation with directly involved companies from the aerospace and affiliated industries, as indicated elsewhere in this document. Where the sample size and sampling strategy is adequate (i.e. personal sampling data), the risk characterisation relies on the measured exposure values; in other cases the results of the exposure modelling were used as adequate measurement data was not available.

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

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

All sub-scenarios which are based on modelled values provide worst-case estimates using in general the highest exposure duration and the lowest level of personal protection reported. Furthermore in the scenarios a maximum level of the concentration of sodium 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.

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

9.2.1. Environmental contributing scenario 1: Use of Sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites, sealings of anodic films with sodium dichromate.

Hexavalent chromium releases to the environment are carefully controlled by industry and monitored by regulators. The volume of hexavalent chromium used depends on the scale of surface treatment operations.

Except in case of very low content of Cr(VI) during occasional release (e.g. infrequent surface treatment using small quantities of Cr(VI) where exposure potential is very low, air emissions relating to local exhaust ventilation (LEV) or extraction systems are filtered or passed through wet scrubbers to remove particulates prior to release to atmosphere. Information from facilities indicates that removal efficiency of at least 99% is typical for industry. Companies regularly monitor and report hexavalent chromium emissions as part of permit conditions. Releases are often beneath detection limits and extended sampling times are necessary to quantify releases. These measured data has therefore been used, in line with the applicable models and guidance, to determine the local concentration of hexavalent chromium in air, and exposure to man via the environment, as set out below.

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

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

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

9.2.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
▪ *See below*
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, and the treated 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, 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 %)

Point source emission data were provided for 5 sites. These data were used to estimate $Clocal_{air,ann}$, the estimated annual average concentration in air, 100 m from point source, for the assessment of Man via Environment according to the Technical Guidance document R. 16, 2012.

Where emission was reported in g/h, emission time per day and emission days per year was used to calculate the annual average daily emission (kg/d). Where the measured concentration (g/m^3) was reported, information on mass volume flow (m3/h) was used to determine emission per hour (g/h).

Measured concentrations below the detection limit were used applying a factor of 0.5 to the reported values. If the measurement reported the emission as Cr total, a factor of 0.5 as worst-case assumption was used to estimate Cr(VI) emission. In accordance with standard risk assessment procedures, measured concentration data below elevated detection concentrations (> 0.05 mg Cr(VI)/Nm^3) were not used as they do not allow realistic estimates that support meaningful risk assessment.

The $PECregional_{air,ann}$ was estimated in EUSES2.1.2. The following assumptions have been used for estimation:

Table 17. Parameters for estimating $PECregional_{air}$

Tonnage [as Cr(VI),9]	Release factor* (%)	Regional fraction** (%)
35	0.001	20

* The release factor was estimated using default from ERC6b (0.1%) and applying efficiency of air abatement of 99%.
** Percentage of tonnage used at regional scale

9.2.1.2. Exposure estimate for man via the environment - air

The air exposure concentrations are reported in the following table.

Table 18. Cr(VI) exposure concentrations in air, 100 meter from point source

No of Sites	Reporting Year	Range $Clocal_{air,ann}$ (mg/m^3)	Arithmetic Mean (mg/m3)	Geometric Mean (mg/m3)	90th Percentile (mg/m3)
5	2010-2012	2.03E-6 – 6.47E-8	1.02E-6	6.12E-7	1.86E-6

The 90th percentile value of 1.86E-6 mg Cr(VI)/m^3 is used as worst-case estimate of $Clocal_{air,ann.}$

The $PEClocal_{air,ann}$ of 1.86E-6 mg Cr(VI)/m^3 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:

5.39E-02 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)/m^3] might be an over-estimate.

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

Sodium dichromate is delivered either as dry powder in sealed bags or as aqueous solution in sealed containers and stored in a chemical storage room. There is no potential for exposure.

9.2.2.1. Conditions of use

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

9.2.2.2. Exposure and risks for workers

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

Table 19. Exposure concentrations and risks for workers

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

Conclusion on risk characterisation

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

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

9.2.3. 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 baths or for further pre-mixing.

9.2.3.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: < 20%	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Falling liquids	ART 1.5
▪ Situation: Transfer of liquid product with flow of 10–100 l/min	ART 1.5
▪ Containment level: Open process.	ART 1.5
▪ Loading type: Splash loading, where the liquid dispenser remains at the top of the reservoir and the liquid splashes freely	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Medium level containment (99.00 % reduction)[8]	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

[8] Medium level containment can, e.g., be described as “Enclosed material transfer with the receiving vessel being docked or sealed to the source vessel” [Advanced REACH Tool (ART) version 1.5].

9.2.3.2. Exposure and risks for workers

Table 20. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.42 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 1.68 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of .0.42 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

An excess lifetime risk of 1.68 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

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

The solid sodium dichromate may be decanted and weighed for re-filling of baths or for further dilution.

9.2.4.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5
▪ 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	ART 1.5
▪ 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 10 - 100 kg	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

	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) *In most cases, this activity is conducted under LEV. However, this has not been considered in this exposure assessment.*	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *When handling solid chromates, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.2.4.2. Exposure and risks for workers

Table 21. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.5 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 2.0 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.5 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 2.0 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by

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

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

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

9.2.5.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: < 20%	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 15 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Activities with Agitated Surfaces	ART 1.5
▪ Situation: Open surface < 0.1 m²	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Low level containment (90.00 % reduction)[9]	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] Low level containment can, e.g., be described as "Physical containment or enclosure of the source of emission. The air within the enclosure is not actively ventilated or extracted. The enclosure is not opened during the activity" [Advanced REACH Tool (ART) version 1.5].

9.2.5.2. Exposure and risks for workers

Table 22. Exposure concentrations and risks for worker

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

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.11 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

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.

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

Before re-filling of baths, the solid sodium dichromate may be dissolved.

9.2.6.1. 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	ART 1.5
▪ 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 10 - 100 kg	ART 1.5
▪ Level of agitation: Low	ART 1.5
▪ Containment level: Handling that reduces contact between product and adjacent air.	ART 1.5

	Method
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Low level containment (90.00 % reduction)[10]	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *When handling solid chromates, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.2.6.2. Exposure and risks for workers

Table 23. Exposure concentrations and risks for worker

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

Conclusion on risk characterisation

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

The modelled exposure estimate (ART 1.5) of 0.17 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

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

9.2.7. Worker contributing scenario 6: Re-filling of baths- liquids (PROC 8b)

The sodium dichromate solution is transferred to and manually filled into the bath for adjustment of the concentration in the bath. This scenario covers as worst-case similar activities in which the adjustment is done automatically; or in which a complete emptying and re-filling of a bath is conducted - only rarely needed and not a manual process.

9.2.7.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: < 20%	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	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Falling liquids	ART 1.5
▪ Situation: Transfer of liquid product with flow of 10 –100 l/min	ART 1.5
▪ Containment level: Open process	ART 1.5
▪ Loading type: Splash loading, where the liquid dispenser remains at the top of the reservoir and the liquid splashes freely	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5

	Method
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.7.2. Exposure and risks for workers

Table 24. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.76 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 3.04 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.76 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 3.04 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.2.8. Worker contributing scenario 7: Re-filling of baths - solids (PROC 8b)

The solid sodium dichromate is transferred to and manually filled into bath for adjustment of the concentration in the bath.

9.2.8.1. 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

	Method
▪ Powder weight fraction [(Cr(VI)]: < 40%	ART 1.5
Activity emission potential	
▪ Duration of activity: < 10 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Falling powders	ART 1.5
▪ Situation: Transferring 10 – 100 kg/minute	ART 1.5
▪ Handling type: Careful transfer involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner e.g. careful weighing in laboratory	ART 1.5
▪ Drop height: Drop height < 0.5 m	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *When handling solid chromates, at least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.2.8.2. Exposure and risks for workers

Table 25. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.066 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime mortality risk up to age 89 is derived based on the estimated exposure: 0.26 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.066 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 0.26 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.

Surface treatment with Cr(VI) in baths or tanks

Surface treatment by dipping/immersion is conducted in sequential process steps within a series of tanks that contain treatment, cleaning and other related solutions. Tasks involved may include the loading of racks, hangers or jigs with the parts, chemical pre-treatment in baths, treatment with Cr(VI) in baths, chemical post-treatment in baths, cleaning, rinsing, drying of the treated parts and finally the unloading of the parts from racks, hangers or jigs. The movement of parts through the different baths may be an automatic process in which the movement of the jigs is controlled electronically, a semi-automatic process in which the parts are moved by the operator between the baths using an overhead hoist in a predetermined sequence, or a manual process, in which the worker starts himself the process and moves the parts manually or using hoists and tracks from tank to tank. The distance between the operators and the baths increases with increasing automation of the processes, so the exposure potential might decrease. On the other hand, the size of the baths of the automatic lines and the number of treated items might be larger compared to the manual systems, which may lead to an opposite effect on exposure potential. All baths containing hexavalent chromium or other hazardous substances are equipped with extract ventilation during the treatment process. Partially, baths are covered and/or mist suppressants are used.

Adequate measurement data covering all sub-tasks described in the following worker contributing scenarios (WCS) 8-15 are available. The exposure estimates based on this measurement data are provided at the end of WCS 15. The following WCS set out the operational conditions and risk management measures relevant for the different sub-scenarios.

9.2.9. Worker contributing scenario 8: Surface treatment with Cr(VI) - loading of jigs (PROC 4)

Jigs or hangers are manually loaded. Exposure to Cr(VI) cannot occur directly but through secondary sources (baths

in the same room).

9.2.9.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 20%	Measured data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 8 hours	Measured data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measured data
▪ Containment: No	Measured data
▪ Local exhaust ventilation: No	Measured data
▪ Occupational Health and Safety Management System: Advanced	Measured data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measured data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measured data
▪ Process temperature (for liquid): Room temperature	Measured data

9.2.9.2. Exposure and risks for workers

See end of WCS 15.

9.2.10. Worker contributing scenario 9: Surface treatment with Cr(VI) - chemical pre-treatment (PROC 13)

Parts are dipped into pre-treatment baths, either automatically or manually.

9.2.10.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 20%	Measured data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 8 hours	Measured data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measured data
▪ Containment: No	Measured data

	Method
▪ Local exhaust ventilation: Yes, if Cr(VI) or other dangerous substances are used in the pre-treatment	Measured data
▪ Occupational Health and Safety Management System: Advanced	Measured data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measured data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measured data
▪ Process temperature (for liquid): Above room temperature	Measured data

9.2.10.2. Exposure and risks for workers

See end of WCS 15.

9.2.11. Worker contributing scenario 10: Surface treatment with Cr(VI) - by dipping/immersion (PROC 2, PROC 13)

Parts are dipped into hexavalent chromate containing bath, either automatically or manually. The residence time in the bath depends on the required thickness of the final coating.

9.2.11.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 20%	Measured data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 8 hours	Measured data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measured data
▪ Containment: No	Measured data
▪ Local exhaust ventilation: Yes	Measured data
▪ Occupational Health and Safety Management System: Advanced	Measured data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles]	Measured data

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

9.2.11.2. Exposure and risks for workers

See end of WCS 15.

9.2.12. Worker contributing scenario 11: Surface treatment with Cr(VI) - rinsing/drying (PROC 13)

Parts are washed, rinsed and dried, either automatically or manually.

9.2.12.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 20%	Measured data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 8 hours	Measured data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measured data
▪ Containment: No	Measured data
▪ Local exhaust ventilation: No	Measured data
▪ Occupational Health and Safety Management System: Advanced	Measured data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measured data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measured data
▪ Process temperature (for liquid): <= 40 °C	Measured data

9.2.12.2. Exposure and risks for workers

See end of WCS 15.

9.2.13. Worker contributing scenario 12: Surface treatment with Cr(VI) - chemical post-treatment (PROC 13)

Parts may be chemically post-treated in baths, either automatically or manually.

9.2.13.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: <20%	Measured data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 8 hours	Measured data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measured data
▪ Containment: No	Measured data
▪ Local exhaust ventilation: Yes, if Cr(VI) or other dangerous substances are used in post-treatment	Measured data
▪ Occupational Health and Safety Management System: Advanced	Measured data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measured data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measured data
▪ Process temperature (for liquid): <= 40 °C	Measured data

9.2.13.2. Exposure and risks for workers

See end of WCS 15.

9.2.14. Worker contributing scenario 13: Surface treatment with Cr(VI) – cleaning and unloading of jigs (PROC 4)

After surface treatment, parts are cleaned and unloaded from jigs or hangers.

9.2.14.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 20%	Measured data

	Method
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 8 hours	Measured data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measured data
▪ Containment: No	Measured data
▪ Local exhaust ventilation: No	Measured data
▪ Occupational Health and Safety Management System: Advanced	Measured data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measured data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measured data
▪ Process temperature (for liquid): <= 40 °C	Measured data

9.2.14.2. Exposure and risks for workers

See end of WCS 15.

9.2.15. Worker contributing scenario 14: Surface treatment with Cr(VI) - cleaning of equipment (PROC 8b)

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

9.2.15.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 20%	Measured data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 1 hour	Measured data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measured data
▪ Containment: No	Measured data
▪ Local exhaust ventilation: No	Measured data
▪ Occupational Health and Safety Management System: Advanced	Measured data
Conditions and measures related to personal protection, hygiene and health evaluation	

	Method
▪ 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.*	Measured data
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measured data
▪ Process temperature (for liquid): <= 40 °C	Measured data

9.2.15.2. Exposure and risks for workers

See end of WCS 15

9.2.16. Worker contributing scenario 15: Maintenance of equipment (PROC 8a)

For the regular maintenance of the baths and related equipment (e.g. LEV, rectifier, pumps, panels etc.), it is conservatively assumed that it will happen 60 minutes every day. Regular maintenance is conducted when the bath solutions are at ambient temperature and no aerosol formation can be expected. Therefore, the results of the air measurements provided below, which have been conducted during the surface treatment process, represent a worst-case estimate for the regular maintenance activities. If maintenance is needed during the process, often RPE is used. This scenario also covers infrequent maintenance activities with longer duration.

9.2.16.1. Conditions of use

	Method
Product (article) characteristics	
▪ Concentration of Cr(VI) in mixture: < 20%	Measured data
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: < 1 hour	Measured data
Technical and organisational conditions and measures	
▪ General ventilation: Basic general ventilation (1-3 air changes per hour)	Measured data
▪ Local exhaust ventilation: No	Measured data
▪ Occupational Health and Safety Management System: Advanced	Measured data
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	Measured data

	Method
Other conditions affecting workers exposure	
▪ Place of use: Indoor	Measured data
▪ Process temperature (for liquids and solids): Room temperature	Measured data

9.2.16.2. Exposure and risks for workers

See below.

9.2.9.2.-9.2.16.2. Combined assessment of exposure and risks for workers for WCS 8 - 15

More than 400 personal sampling and static measurement data from 2000-2013 in six EU countries are available. Because a sufficient number (>80) of data from personal sampling is available, the exposure assessment is based on these data (as suggested in the Technical Guidance document R.14).

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

The estimation below therefore considers already the effectiveness of local exhaust ventilation (reflected by the measured values).

The values reported below include an estimate of the effectiveness of respiratory protection.

In general, however, respiratory protection is not worn during surface treatment activities and the data therefore rather represent external, measured exposure results.

In the few cases in which respiratory protection was used, the effectiveness of respiratory protection was assessed using the company information on type of mask and filter used and the protection factors (APFs) provided by the *German BG rule "BGR/GUV-R190"* from December 2011 or alternatively, if available, the APF provided by the manufacturer of the respiratory protection equipment. Respiratory protection is always worn in situations in which exposure to sodium dichromate in solid state could occur. Partially, however, respiratory protection is also used when work is conducted close to the chromate emission source (chromate containing baths). In a minority of cases, depending on the level of reporting provided with the data, the duration for which respiratory protection had been used clearly could be assigned to the measurement results and the measured values then have been adjusted accordingly. In most of the cases, however, this was not possible and the values used for exposure estimation provide an overestimate of inhaled dose (i.e. the measured values were not adjusted to account for use of respiratory protection in these cases).

It is important to mention that the exposure data do not represent exposure to sodium dichromate alone but, in most cases, include also exposure to other chromates, and to chromium trioxide as the main emission source. However, because it was not possible to separate the respective contribution of each emission source, the values below provide Cr(VI) exposure estimates from all emission sources as worst case estimate for sodium dichromate exposure.

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

Table 26. Exposure concentrations and risks for workers – inhalation, local, long-term

Worker contributing scenario	PROC	Description	N*	Arithmetic Mean	Geometric Mean	90th Percentile	RCR
WCS - 8	PROC 4	Loading of jigs					Based on the dose-response relationship

WCS - 9	PROC 13	Chemical pre-treatment	87	0.69 µg/m³	0.45 µg/m³	1.26 µg/m³	derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 5.04 per 1000 exposed workers
WCS - 10	PROC 13	Surface treatment by dipping/immersion					
ECS – 11	PROC 13	Rinsing/drying					
WCS - 12	PROC 13	Chemical post-treatment					
WCS - 13	PROC 4	Cleaning and unloading of jigs					
WCS - 14	PROC 8b	Cleaning of equipment					
WCS - 15	PROC8a	Maintenance of equipment					

* N = number of measurements

Conclusion on risk characterisation

The 90th percentile value of the personal sampling data partially adjusted for respiratory protection of 1.26 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case).

An excess lifetime risk of 5.04 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship.

9.2.17. Worker contributing scenario 16: Surface treatment with Cr(VI) - by rolling and brushing (PROC 10)

Small areas may be treated with sodium dichromate using a brush.

9.2.17.1. 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	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Spreading of liquid products	ART 1.5
▪ Situation: Spreading of liquids at surfaces or work pieces < 0.1 m² / hour	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	

	Method
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.17.2. Exposure and risks for workers

Table 27. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.23 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.92 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.23 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 0.92 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.2.18. Worker contributing scenario 17: Surface treatment with Cr(VI) - by pen application (PROC 10)

Very small areas are treated using a pen stick containing sodium dichromate in small amounts. The pen-stick is designed specifically to minimize worker exposure during small maintenance activities.

9.2.18.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: very small (0.5 - 1%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Medium	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Spreading of liquid products	ART 1.5
▪ Situation: Spreading of liquids at surfaces or work pieces < 0.1 m² / hour	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
▪ Dispersion	
▪ Work area: Indoors/outdoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
▪ Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.18.2. Exposure and risks for workers

Table 28. Exposure concentrations and risks for worker

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

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.017 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

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

9.2.19. Worker contributing scenario 18: Surface treatment in automatic spray tunnel (PROC 7)

Spraying with no or low compressed air use occurs in spraying tunnels of different length. The metal subject to spraying runs through the spray line, comes out of the tunnel wet and is subsequently dried in an oven outside the spraying line. The aqueous solution is pumped through enclosed pipelines to the spray processing line. The bottom, the top, and the sides of a tunnel are generally confined with the exception of a long narrow slot for the suspension fitting. The transporting devices typically consist of a suspension arrangement where items are hung upside down to be moved through the tunnel. The sides of the tunnel have maintenance openings, which are not opened during spraying. Enclosures at the entrance and outlet of the tunnel are not opened during the activity but have openings wide enough for the component parts. Two washing areas to deposit remaining aqueous fog are situated between the entrance and the outlet of the spraying tunnel. A negative pressure has to be kept within the enclosure, e.g. by use of an exhaust device.

Effective housekeeping practices include regularly cleaning as well as preventive maintenance of machinery and control measures to repel spill and reduce personal cloud.

9.2.19.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Extremely small (0.1 – 0.5%)	ART 1.5
▪ Process temperature: Room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5

	Method
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 480 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: No	ART 1.5
▪ Activity class: Surface spraying of liquids	ART 1.5
▪ Situation: High application rate (> 3 l/minute)	ART 1.5
▪ Spray direction: In any direction (including upwards)	ART 1.5
▪ Spray technique: Spraying with no or low compressed air use	ART 1.5
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: 300m^3	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Medium level containment (99.00 % reduction)[11]	ART 1.5
▪ Secondary: Other enclosing hoods (90.00 % reduction)	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.19.2. Exposure and risks for workers

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

[11] Medium level containment can, e.g., be described as “Enclosed material transfer with the receiving vessel being docked or sealed to the source vessel” [Advanced REACH Tool (ART) version 1.5].

Table 29. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.4 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 1.6 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.4 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

An excess lifetime risk of 1.6 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.2.20. Worker contributing scenario 19: Laboratory analysis (sampling, laboratory analysis) (PROC 15)

9.2.20.1. Conditions of use

9.2.20.1.1. Sub-activity: Drawing of sample and transfer to the laboratory

One or more samples are drawn at the bath(s) and then transferred in a closed flask to the laboratory.

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: < 20%	ART 1.5
▪ Process temperature: Above room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 30 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Activities with relatively undisturbed surfaces (no aerosol formation)	ART 1.5
▪ Situation: Open surface 1 - 3 m²	ART 1.5
Surface contamination	

	Method
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.20.1.2. Sub-activity: Laboratory analysis

The sample(s) will be diluted and then analysed**.**

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Liquid	ART 1.5
▪ Concentration of Cr(VI) in mixture: Minor (5 - 10%)	ART 1.5
▪ Process temperature: Above room temperature	ART 1.5
▪ Vapour pressure of substance: < 0.01 Pa	ART 1.5
▪ Viscosity: Low	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Activities with relatively 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
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5

	Method
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: No ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5

9.2.20.2. Exposure and risks for workers

Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.65 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 2.6 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.65 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 2.6 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

9.2.21. Worker contributing scenario 20: 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 covers also machining operations with a longer duration of activity but with a higher level of respiratory protection, e.g. by using a half-face mask with P3 filter (APF 30) or a full face mask with P3 filter (APF 400).

The Cr(VI) weight fraction of the part is assumed to be < 0.1 %. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way[12] (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.

9.2.21.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 0.1 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 180 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Equipment level: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood /Vacuum cleaner (HEPA filter with at least 99.00 % reduction)	ART 1.5 (extended)
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 10] [Effectiveness Inhal: 90%] *At least half or quarter mask with P2 filter (APF 10 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)

[12] The exposure model ART applies a linear relationship

9.2.21.2. Exposure and risks for workers

Table 30. Exposure concentrations and risks for worker

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

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.11 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

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.

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

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

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

The Cr(VI) content of the surface is assumed to be < 3 %. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way (i.e. a 10% concentration on the surface would lead to an increase of the exposure estimate by a factor of more than 3). If needed, OCs and RMMs could be adjusted for that different situation.

9.2.22.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 3 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5

	Method
Activity emission potential	
▪ Duration of activity: < 180 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Equipment level: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Fixed capturing hood /Vacuum cleaner (HEPA filter with at least 99.00 % reduction)	ART 1.5 (extended)
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67 %] *At least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn if workplace monitoring data do not confirm negligible exposure clearly below 1 µg/m³ (e.g. < 0.1 µg/m³)* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles]	ART 1.5 (extended)

9.2.22.2. Exposure and risks for workers

Table 31. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**1.13 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime mortality risk up to age 89 is derived based on the estimated exposure: 4.52 per 1000 exposed workers

Measured Data for WCS 21:

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

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

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

   The measured values indicate that the estimated exposure from the ART model (based on the solid material *stone* as metal is currently not an available option in ART*)*, which resulted in an exposure estimate of 1.13 µg Cr(VI)/m³ and which accounted for respiratory protection overestimated exposure for this situation by a factor of around 500.

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

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

   The measured values indicate that the estimated exposure from the ART model (based on the solid material *stone* as metal is currently not an available option in ART), which resulted in an exposure estimate of 1.13 µg Cr(VI)/m³ likely produced a considerable overestimation of exposure.

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 1.13 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 4.52 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship.

9.2.23. Worker contributing scenario 22: Machining operations in large work areas on

parts containing Cr(VI) including cleaning (PROC 21, 24)

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

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

The Cr(VI) weight fraction of the part is assumed 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.

9.2.23.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 0.1 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Large workrooms only	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Wetting at the point of release/on-tool extraction/vacuum cleaning (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 10] [Effectiveness Inhal: 90%] *At least half or quarter mask with P2 filter (APF 10 according to German BG rule 190) is worn if workplace monitoring data do not confirm negligible exposure clearly below 1 µg/m³ (e.g. < 0.1 µg/m³)* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles]	ART 1.5 (extended)

9.2.23.2. Exposure and risks for workers

Table 32. Exposure concentrations and risks for worker

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

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.20 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

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

9.2.24. Worker contributing scenario 23: Machining operations in large work areas on surfaces containing Cr(VI) including cleaning (PROC 21, 24)

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

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

The Cr(VI) content of the surface is assumed to be < 3 %. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way (i.e. a 10% concentration on the surface would lead to an increase of the exposure estimate by a factor of more than 3). If needed, OCs and RMMs could be adjusted for that different situation.

9.2.24.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 3 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5

	Method
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Large workrooms only	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Wetting at the point of release/on-tool extraction/vacuum cleaning (90.00 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *At least half-mask with P3 filter (APF 30 according to German BG rule 190) is worn* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.2.24.2. Exposure and risks for workers

Table 33. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**2.03 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 8.12 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 2.03 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 8.12 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship.

Measured Data for WCS 22 and 23:

Personal sampling data are available representing a mixture of activities described in WCS 22 and 23. The small sample size (n = 7) does not allow for using the measured data as the basis for exposure estimation. However, the measured value is presented as supportive evidence for the appropriateness of model estimates:

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

The measured values indicate that the ART model (based on the solid material *stone* as metal currently is not an available option in ART), which resulted in an exposure estimate of 0.20 and 2.03 µg Cr(VI)/m³ respectively, likely produced an overestimation of exposure for machining activities on the surface of parts.

9.2.25. Worker contributing scenario 24: 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.

9.2.25.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 0.1 %	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5
Activity emission potential	
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Small workrooms only	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 400] [Effectiveness Inhal: 99.75%] *Full face mask with P3 filter (APF 400 according to German BG rule 190) is worn if workplace monitoring data do not confirm negligible exposure clearly below 1 µg/m³ (e.g. < 0.1 µg/m³)* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles]	ART 1.5 (extended)

9.2.25.2. Exposure and risks for workers

Table 34. Exposure concentrations and risks for worker

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

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.16 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

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

9.2.26. Worker contributing scenario 25: Machining operations on surfaces containing Cr(VI) in small work areas including cleaning (PROC 21, 24)

Small surfaces are fettled, edged, abraded or sanded in comparable small work areas (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) content of the surface is assumed to be < 3 %. In case of lower or higher Cr(VI) content, estimated exposure would be reduced or increased in a linear way (i.e. a 10 % concentration on the surface would lead to an increase of the exposure estimate by a factor of more than 3). If needed, OCs and RMMs could be adjusted for that different situation.

9.2.26.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Solid object	ART 1.5
▪ Solid weight fraction: < 3%	ART 1.5
▪ Solid material: Stone (as worst-case for metal)	ART 1.5
▪ Moisture content: Dry product (<5 % moisture content)	ART 1.5
Activity emission potential	

	Method
▪ Duration of activity: < 60 min	ART 1.5
▪ Primary emission source located in the breathing zone of the worker: Yes	ART 1.5
▪ Activity class: Fracturing and abrasion of solid objects	ART 1.5
▪ Situation: Mechanical treatment / abrasion of small sized surfaces	ART 1.5
▪ Containment level: Open process	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Small workrooms only	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: No localized controls (0.0 % reduction)	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 1000] [Effectiveness Inhal: 99.9%] *Full-face mask with P3 filter and air supply (APF 1000 according to German BG rule 190) is worn* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.2.26.2. Exposure and risks for workers

Table 35. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**1.9 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 7.6 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 1.9 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case).

For the risk characterisation (excess lifetime cancer risk), the reader is referred to the Socio-Economic Analysis (SEA).

Measured Data for WCS 24 and 25:

Personal sampling data representing a mixture of activities described in WCS 24 and 25 are available. The small sample size (n = 11) does not allow for using the measured data as the basis for exposure estimation. However, the measured value is presented as supportive evidence for the appropriateness of model estimates:

Measured exposure (personal sampling, taking respiratory protection into account, arithmetic mean): **0.28 µg Cr(VI)/m³**, (90th percentile 0.18 µg/m³).

The measured values indicate that the ART model (based on the solid material *stone* as metal currently is not an available option in ART), which resulted in an exposure estimate of 0.475 and 1.9 µg Cr(VI)/m³ respectively, likely produced an overestimation of exposure in both WCS.

9.2.27. Worker contributing scenario 26: Storage of articles (PROC 1)

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

9.2.27.1. Conditions of use

	Method
Product (article) characteristics	
• Concentration of substance in article: Non detectable or residual (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

	Method
Conditions and measures related to personal protection, hygiene and health evaluation	
• Respiratory Protection: No	Qualitative
Other conditions affecting workers exposure	
• Place of use: Indoor/outdoors	Qualitative
• Process temperature (for solids): ambient	Qualitative

9.2.27.2. 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/m^3**	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0 per 1000 exposed workers

Conclusion on risk characterisation

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

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

9.2.28. Worker contributing scenario 27: Waste management (PROC 8b)

Very low amounts of Cr(VI), if at all, is released from waste water treatment systems, where residual Cr(VI) is reduced to Cr(III); the resulting Cr(III) is then precipitated and disposed to landfill by licensed waste management companies.

Other process waste (empty bags, containers, filters, waste from cleaning activities) 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 (e.g. empty bags) to the storage area.

9.2.28.1. Conditions of use

	Method
Product (article) characteristics/substance emission potential	
▪ Substance product type: Powders, granules or pelletised material	ART 1.5
▪ Dustiness: Fine Dust	ART 1.5
▪ Moisture content: Dry product (< 5 % moisture content)	ART 1.5
▪ Powder weight fraction [Cr(VI)]: < 40%	ART 1.5

	Method
Activity emission potential	
▪ Duration of activity: < 30 min	ART 1.5
▪ Activity class: Handling of contaminated solid objects or paste	ART 1.5
▪ Situation: Handling of objects with visible contamination (object covered with fugitive dust from surrounding dusty activities)	ART 1.5
▪ Handling type: Careful handling, involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner.	ART 1.5
Surface contamination	
▪ Process fully enclosed? No	ART 1.5
▪ Effective housekeeping practices in place? Yes	ART 1.5
Dispersion	
▪ Work area: Indoors	ART 1.5
▪ Room size: Any size workroom	ART 1.5
Technical and organisational conditions and measures – localised controls	
▪ Primary: Low level containment (90.00 % reduction)[13]	ART 1.5
▪ Secondary: No localized controls (0.0 % reduction)	ART 1.5
▪ Ventilation rate: Only good natural ventilation	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory Protection: Yes [Respirator with APF 30] [Effectiveness Inhal: 96.67%] *During waste transfer activities with potential to exposure to airborne hexavalent chromium at least half-mask with A2P3 filter (APF 30 according to German BG rule 190) is worn* ▪ Dermal Protection: Yes [Protective clothing, chemical-resistant, impermeable gloves (e.g. nitrile rubber gloves with a minimum layer thickness of 0.11 mm and a break through time of at least 480 min), goggles] *The RMM and OC specified above represent good industry practice for this task. DUs may adapt or improve RMM and OC selection in order to most appropriately and efficiently control worker exposure and maintain compliance with national regulations.*	ART 1.5 (extended)

9.2.28.2. Exposure and risks for workers

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

Table 36. Exposure concentrations and risks for worker

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	**0.22 µg/m³** (ART 1.5 prediction, 90th percentile value)	Based on the dose-response relationship derived by the RAC, considering a 40 year working life (8h/day, 5d/week), the following excess lifetime risk up to age 89 is derived based on the estimated exposure: 0.88 per 1000 exposed workers

Conclusion on risk characterisation

The modelled exposure estimate (ART 1.5) of 0.22 µg Cr(VI)/m³ is used as the basis for risk characterisation. The estimate is based on several conservative assumptions regarding exposure (see footnote 6).

An excess lifetime risk of 0.88 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship. As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks inferred in the low exposure range [i.e. below an exposure concentration of 1 µg Cr(VI)/m³] might be an over-estimate.

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

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

10. RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

10.1. Human health

10.1.1. Workers

In the formulation process, there is no further combined potential exposure apart from what already has been shown in the respective sub-scenarios. Even in the case that one worker would conduct all activities (except laboratory work), estimated combined potential exposure would remain below 0.5 µg Cr(VI)/m³.

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

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

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

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

Nevertheless, several possible combinations of sub-scenarios representing the highest possible combined exposure estimate (as the 90th percentile value of the data or model-based exposure distribution) have been evaluated and adjusted to an 8 hour working day.

As a result and for use in the SEA, a maximum individual exposure value of 2 µg Cr(VI)/m³ is seen as a reasonable basis for calculation.

In this case, an excess lifetime risk of 8 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship.

10.1.2. Consumer

Not relevant as there is no consumer use.

10.2. Environment (combined for all emission sources)

10.2.1. All uses (regional scale)

10.2.1.1. Regional exposure

Environment

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

The PEC regional have been estimated with EUSES.

Table 37. 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	4.93E-14 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 38. Regional exposure to man via the environment

Route	Regional exposure	Risk characterisation
Inhalation	4.93E-14 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: 1.43E-9 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.