November 2022

CHEMICAL SAFETY REPORT

Non-confidential version

Legal name of applicant(s):	Boeing Distribution (UK) Inc. Wesco Aircraft EMEA Ltd MacDermid Performance Solutions UK Ltd Henkel Ltd		
Submitted by:	**Boeing Distribution (UK) Inc.**		
Substances:	Chromium trioxide (CT) (includes “Acids generated from chromium trioxide and their oligomers", when used in aqueous solutions)	EC 215-607-8	CAS 1333-82-0
Uses applied for:	Use 1: Anodising using chromium trioxide in aerospace and defence industry and its supply chains		

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Preliminary Remark

This Chemical Safety Report (CSR) has been prepared on behalf of the applicants by the Aerospace and Defence Chromates Reauthorisation (ADCR) Consortium.

Photos are for illustrative purposes only. PPE shown in the photos might be also driven by site-specific considerations and by exposures other than to chromates. PPE requirements are laid down in the Condition of Use tables.

Part A

1. SUMMARY OF RISK MANAGEMENT MEASURES

The risk management measures implemented for the use applied for are documented in detail in the exposure scenario in Chapter 9 of this CSR.

A succinct summary table of the risk management measures and operational conditions is submitted with this review report.

2. DECLARATION THAT RISK MANAGEMENT MEASURES ARE IMPLEMENTED

We declare that the risk management measures described in the exposure scenarios in Chapter 9 of this CSR are implemented at the site of the applicant.

3. DECLARATION THAT RISK MANAGEMENT MEASURES ARE COMMUNICATED

We declare that the risk management measures described in the exposure scenarios in Chapter 9 of this CSR are communicated via safety data sheets in the supply chain.

Part B

This review report uses the dose-response relationship established by RAC (see below). In this case, Chapters 1-8 of the CSR do not need to be provided as described in the ECHA document ‘How to apply for authorisation’ (ECHA, 2021). Relevant physico-chemical and environmental fate data used for modelling are taken from the literature as documented in section 9.1.2.

9 EXPOSURE ASSESSMENT (AND RELATED RISK CHARACTERISATION)

9.1 Introduction

9.1.1 Structure of this dossier “Anodising” and uses covered in this dossier

The Aerospace and Defence Chromates Reauthorisation (ADCR) Consortium on behalf of the applicants has developed several review reports. These applications cover all uses of soluble chromates considered to be relevant by the ADCR consortium members. Although formally they are upstream applications submitted by manufacturers, importers or formulators of chromate-containing chemical products, the applications are based on sector-specific data and detailed information obtained from actors throughout the supply chain.

The ADCR consortium developed the following dossiers with one use each:

- Formulation
- Pre-treatments: deoxidising, pickling, etching and/or desmutting
- Passivation of stainless steel
- Electroplating
- Anodising
- Chemical conversion coating
- Passivation of (non-Al) metallic coatings
- Inorganic finish stripping
- Anodise sealing
- Slurry coating
- Chromate rinsing after phosphating

This dossier “Anodising” contains a single use: “Anodising using chromium trioxide in aerospace and defence industry and its supply chains”.

9.1.2 Introduction to the assessment

9.1.2.1 Grouping approach for Cr(VI) compounds

As shown in Table 9-1 chromium trioxide (CT) has been included in Annex XIV of REACH (Entry No. 16) due to its carcinogenic and mutagenic properties as it is classified as carcinogenic (Cat. 1A) and mutagenic (Cat. 1B). As CT is mainly used as aqueous solution in the processes described below, this Application for Authorisation also covers Entry No. 17 of Annex XIV of REACH, which refers to acids generated from CT and their oligomers. **In the following, when referring to CT, this always also implies acids generated from CT and their oligomers.**

According to Article 62 (4)(d) of this Regulation, the chemical safety report (CSR) supporting an Application for Authorisation (AfA) needs to cover only those risks arising from the intrinsic properties specified in Annex XIV. Therefore, only the human health risks related to the classification of the chromate as mutagenic and carcinogenic substance are addressed in this CSR. This requires investigating the potential exposure of workers as well as exposure of humans via the environment.

Table 9-1: Substances considered for the assessment

Substance name	**CAS No.**	**EC No.**	**Annex XIV Entry No.**	**Intrinsic properties referred to in Art. 57**	**Formula**	**Mol. weight [g/mol]**	**Cr(VI) mol. weight fraction**
Cr(VI)	-	-	-		Cr^{6+}	52.00	1
Chromium trioxide [a] (CT)	1333-82-0	215-607-8	16	Muta. 1B Carc. 1A	CrO_3	99.99	0.52
Acids generated from chromium trioxide and their oligomers [a, b]	-	-	17	Carc. 1A			

[a] Chromium trioxide, when coming in contact with water forms chromic acid, dichromic acid and oligomers of chromic acid and dichromic acid, which are in the following referred as "Chromic acids and their oligomers". Chromium trioxide has been included in Annex XIV of REACH (Entry No. 16) due to its carcinogenic and mutagenic properties as it is classified as carcinogenic (Cat. 1A) and mutagenic (Cat. 1B). As chromium trioxide is mainly used as aqueous solution in the processes described below, this Application for Authorisation also covers Entry No. 17 of Annex XIV of REACH, which refers to "Acids generated from chromium trioxide and their oligomers". Differences between the substances (e.g., due to different forms: liquid, solid) with relevance to their hazards, exposure, alternatives etc. are considered in the assessment.

[b] Including chromic acid (CAS No.: 7738-94-5 | EC No.: 231-801-5), dichromic acid (CAS No.: 13530-68-2 | EC No.: 236-881-5) and oligomers of chromic acid and dichromic acid.

The carcinogenicity and mutagenicity toxicities of CT, its acids are driven by the chromium VI (Cr(VI)) ion released when the substances solubilise and dissociate. Since Cr(VI) is the relevant and common molecular entity generated from all these substances, all exposure assessments are performed for Cr(VI). Also, the exposure-risk relationships proposed by the Committee for Risk Assessment (RAC) express exposure as Cr(VI).

Human exposures (as well as environmental emissions) are expressed in units of Cr(VI) (converted by using substance-specific molecular weights) to allow for comparing and summing up of exposures and to support comparison with RAC's exposure-risk relationship.

9.1.2.2 Exposure-risk relationships (ERRs) for carcinogenic effects used for the assessment

The hazard evaluation follows recommendations given by RAC (ECHA, 2015)[1]:

For assessing carcinogenic risk, exposure-risk relationships are used to calculate excess cancer risks.

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[1] ECHA Website: https://echa.europa.eu/documents/10162/21961120/rac_35_09_1_c_dnel_cr-vi-_en.pdf/8964d39c-d94e-4abc-8c8e-4e2866041fc6; assessed in March 2021

As mutagenicity is a mode of action expected to contribute to carcinogenicity, the mutagenic risk is included in the assessment of carcinogenic risk, and low risks for mutagenicity are expected for exposures associated with low carcinogenic risks.

9.1.2.2.1 Exposure risk relationships (ERRs) for carcinogenic effects

ECHA published on December 4, 2013 the document "*Application for Authorisation: Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium*"[2] (ECHA, 2013), which states the opinion of RAC that hexavalent chromium is a non-threshold carcinogen. Consequently, demonstrating adequate control is not possible and the socioeconomic analysis (SEA) route is applicable. The exposure-risk relationships published in this document from ECHA (2013) are used to calculate excess cancer risks associated with the use(s) of Cr(VI) covered by this application. However, the resulting risk estimates likely overestimate the cancer risk. RAC states in its publication of the ERR (ECHA, 2013): "As the mechanistic evidence is suggestive of non-linearity, it is acknowledged that the excess risks in the low exposure range might be an overestimate".

The excess cancer risk characterisation for workers is solely based on inhalation exposure and the risk for lung cancer, as no information on the fraction of inhalable, but non-respirable particles is available, which prevents a differentiated consideration of inhalation and oral exposure of workers. This is also the standard procedure proposed by ECHA (2013), as ECHA states: *"In cases where the applicant only provides data for the exposure to the inhalable particulate fraction, as a default, it will be assumed that all particles were in the respirable size range".*

Therefore, it is assumed that all Cr(VI)-bearing particles are of respirable sizes, and thus no oral exposure routes are considered for worker inhalation. This is a conservative approach, since the potential lung cancer risk is at least an order of magnitude higher compared to the potential cancer risk for the digestive tract.

The following exposure-risk relationships are used for estimating excess lung cancer risks for workers (inhalation):

Table 9-2: Exposure-risk relationships for inhalation exposure of workers used for calculating cancer risks due to Cr(VI) exposure (from ECHA, 2013)

TWA Cr(VI) inhalation exposure concentration [µg/m^3]*	Excess lung cancer risk in workers [x 10^{-3}]
25	100
12.5	50
10	40
5	20
2.5	10

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[2] ECHA Website: https://echa.europa.eu/documents/10162/13579/rac_carcinogenicity_dose_response_crvi_en.pdf; assessed in March 2021

TWA Cr(VI) inhalation exposure concentration [µg/m^3]*	Excess lung cancer risk in workers [x 10^{-3}]
1	4
0.5	2
0.25	1
0.1	0.4
0.01	0.04

TWA: Time-weighted average, expressed in micrograms of Cr(VI) per cubic meter of air

* Based on a 40-year working life (8h/day, 5 days/week).

For the general population, oral (via drinking water and food) and inhalation exposure is considered following recommendations of RAC (RAC did not identify cancer risks after dermal exposure for workers or the general population). For inhalation exposure, RAC again is presenting an exposure-risk relationship for lung cancer, whereas for oral exposure the focus is on an increased risk for tumours of the small intestine (ECHA, 2013). As with the assessment of worker exposure, for inhalation exposure of the general population, it is assumed that all particles are in the respirable size range.

The following exposure-risk relationships are used to characterise risks of the general population after exposure (over 70 years) of humans via the environment.

Table 9-3: Exposure-risk relationships for inhalation exposure of general population used for calculating cancer risks due to Cr(VI) exposure (from ECHA, 2013)

Average Cr(VI) exposure concentration in ambient [µg/m^3]*	Excess lung cancer risk in the general population [x 10^{-3}]
10	290
5	145
2.5	72
1	29
0.5	14
0.25	7
0.1	2.9
0.01	0.29
0.001	0.029

Average Cr(VI) exposure concentration in ambient [µg/m^3]*	**Excess lung cancer risk in the general population [x 10^{-3}]**
0.0001	0.0029

* Based on an exposure for 70 years (24h/day, every day).

Table 9-4: **Exposure-risk relationships for oral exposure of general population used for calculating cancer risks due to Cr(VI) exposure of humans via environment (from ECHA, 2013)**

Constant average oral daily dose of Cr(VI) [µg/kg bw/day]*	**Excess small intestine cancer risk in the general population [x 10^{-4}]**
10	80
5	40
2.5	20
1	8
0.5	4
0.1	0.8

* Based on an exposure for 70 years (24h/day, every day)

9.1.2.3 Environment

<u>**Scope and type of assessment**</u>

CT is not listed in Annex XIV for endpoints related to concerns for the environment. Therefore, no environmental assessment has been performed.

9.1.2.4 Exposure of humans via the environment

9.1.2.4.1 Scope and type of assessment

The exposure of humans to Cr(VI) via the environment (HvE) as a result of wastewater and air emissions from the sites of the applicants and downstream users covered by this CSR is considered in section 9.2.3.1. With regard to oral exposure of humans via the environment, it has to be acknowledged that Cr(VI) is rapidly reduced to Cr(III) in many environmental compartments (ECB, 2005). Therefore, exposure to Cr(VI), estimated based on the release of Cr(VI) into environmental compartments may significantly overestimate human exposure via the environment. Moreover, several of the parameters necessary for environmental modelling (in particular the partition coefficients) are based on the log of the octanol-water partition coefficient (Kow) of a given substance. This parameter is of no relevance for inorganic substances such as Cr(VI), and therefore the calculated partition coefficients are not applicable.

Apart from that, there is only limited data on the presence of Cr(VI) in food. In the majority of cases, only total chromium was measured. According to a few studies, Cr(VI) generally amounts to less than 10% of total chromium (range 1.31-12.9%) (EFSA, 2014). Furthermore, some studies even indicate that foods of plant origin do not contain Cr(VI) at all and that the Cr(VI) levels measured are analytical artifacts (EFSA, 2014). The same may be the case with foods of animal origin. Based on these data, the EFSA-CONTAM Panel concluded 'that there is a lack of data on the presence of Cr(VI) in food' and 'decided to consider all the reported analytical results in food as Cr(III)' (EFSA, 2014). Furthermore, the CONTAM Panel concluded that it can be assumed 'that all the chromium ingested via food is in the trivalent form (i.e., Cr(III)), in contrast to drinking water where chromium may easily be present in the hexavalent state', primarily due to the use of strong oxidizing agents in the treatment of drinking water (EFSA, 2014). These considerations of the CONTAM Panel support the earlier evaluation of the EU Risk Assessment Report for chromates, in which the indirect oral exposure of humans via the environment was assessed only on the basis of exposure via (drinking) water and the consumption of fish (ECB, 2005). Therefore, same approach is followed here.

This assessment focuses primarily on the carcinogenicity of Cr(VI) released from the chromates as the most relevant endpoint and compares the exposure estimates with the exposure-risk relationship derived by the RAC for the general population, as shown below in in Table 9-5.

Table 9-5: Type of risk characterisation required for humans via the environment

Route of exposure and type of effects	**Endpoint considered and type of risk characterisation**	**Hazard conclusion** **DNEL/dose – response relationship**
Inhalation: Systemic Long Term	Carcinogenicity Quantitative	RAC dose-response relationship based on excess lung cancer risk (ECHA, 2013) For general population; based on 70 years of exposure; 24h/day: Exposure to 1 µg/m^3 Cr(VI) relates to an excess risk of 2.9×10^{-2} *
Oral: Systemic Long Term	Carcinogenicity Quantitative	RAC dose-response relationship based on excess cancer risk for tumours of the small intestine (ECHA, 2013) For general population; based on 70 years of exposure: Exposure to 1 µg Cr(VI) /kg bw/day relates to an excess risk of 8×10^{-4}

* The inhalation cancer risk characterisation for humans via the environment is solely considering risk for lung cancer, as no information on the fraction of inhalable, but non-respirable particles is available, which prevents a differentiated consideration of inhalation and oral exposure of humans via the environment).

9.1.2.4.2 Comments on assessment approach

In this section, we describe the approach to assess human exposure to Cr(VI) via the environment (HvE) resulting from the industrial use of chromates covered in this CSR (see Table 9-1). Exposure via ambient air and oral exposure (through drinking water intake and consumption of fish) has been assessed at local levels. No regional assessment has been carried out as it can be assumed that Cr(VI) from any source will be reduced to Cr(III) in most environmental situations and therefore the effects of Cr(VI) as such are likely to be limited to the area around the source, as described in the EU Risk Assessment Report for chromates (ECB, 2005). The approach to not perform a regional assessment for human Cr(VI) exposure via the environment as part of AfAs for chromate uses was also supported in compiled RAC and SEAC (Socio-economic Analysis Committee) opinions, as described for example in the *Opinion on an Application for Authorisation for Use of Sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites and sealings of anodic films* (ID 0043-02). This reference states that regional exposure of the general population is not considered relevant by RAC[3].

EUSES modelling of human exposure via the environment

The assessment of human Cr(VI) exposure via the environment is based on emission measurements in air and wastewater from representative sites, and distribution and exposure modelling are carried out with the European Union System for the Evaluation of Substances (EUSES) software (v. 2.1.2).

Release days

For the considered exposure pathways air, water, and fish, 365 release days are always assumed. This approach is considered justified, because:

- the air concentration (*annual average local "Predicted environmental concentration" (PEC) in air (total)*) and the concentration in fish (calculated from the bioconcentration factor in fish and from the *annual average local PEC in surface water (dissolved)*) are based on annual average PEC values, on which the number of release days has no impact.
- the Cr(VI) concentration in drinking water is based on the higher of the two values "*annual average local PEC in surface water (dissolved)"*, which is independent of the number of release days, as described above, and "*local PEC in pore water of agricultural soil"*, where fewer release days would lead to an intermittently higher PEC value. If the concentration in drinking water is based on the "*local PEC in pore water of agricultural soil"* and if this value is temporarily increased due to intermittent release (of sewage sludge to agricultural soil with temporarily higher Cr(VI) concentrations), the concentration in drinking water would be temporarily higher than under the assumption of 365 release days. This is a very unrealistic scenario since a spatial and temporal distance between pore water of agricultural soil and drinking water would compensate for variations in Cr(VI) drinking water concentrations due to intermittent release of Cr(VI) to wastewater. Furthermore, the use of an intermittently elevated drinking water concentration for the calculation of a lifelong cancer risk via drinking

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[3] RAC/SEAC "Opinion on an Application for Authorisation for Use of Sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites and sealings of anodic films", consolidated version, 2016; https://echa.europa.eu/documents/10162/658d42f4-93ac-b472-c721-ad5f0c22823c

water consumption would be an overestimation of the realistic risk and therefore, by considering 365 release days, a stable concentration in drinking water is calculated.

- in this latter case, the "*local PEC in pore water of agricultural soil*" is simply equated by EUSES software with the "*local concentration in groundwater*", which is taken as the concentration in drinking water (if the concentration is higher than the one derived from surface water; see above). As noted in the EUSES background report, equating the soil pore water concentration with the groundwater concentration 'is a worst-case assumption, neglecting transformation and dilution in deeper soil layers'. This conservatism would increase the unrealistic nature of intermittent release further and the use of an annual average exposure estimate is considered more adequate in the present context.

Sewage treatment plant (STP)

For sites where wastewater is sent to a biological sewage treatment plant (STP), we have adjusted the default distribution of Cr(VI) in the sewage treatment plant (STP) used in EUSES (99.9% in water and 0.1% in sludge) to 50% in water and 50% in sludge. This is based on the description given in the EU Risk Assessment Report (ECB, 2005) that during biological treatment 50% of Cr(VI) are released into the effluent and 50% are absorbed to sewage sludge. The application of sludge on agricultural soil (rate: 5000 kg/ha/year) and grassland (rate: 1000 kg/ha/year) was considered according to the EUSES standard setting unless there was information to the contrary.

Oral uptake via drinking water and fish

The intake of pollutants via drinking water and fish, as modelled in EUSES, is unreasonably conservative and therefore, specific reduction factors are applied for risk calculations in the environmental contributing scenario (see section 9.2.3.1). The arguments why the EUSES calculations are overly conservative for these pathways, and derivation of reduction factors are described below:

- Drinking water

  a) Local concentration in drinking water based on the local PEC in surface water ("*annual average local PEC in surface water (dissolved)")*:

  - The approach chosen is likely to "*overestimate the actual indirect exposure as the conversion of Cr (VI) to Cr (III) is expected to occur under the vast majority of environmental conditions* " (ECB, 2005). This reduction is not considered in the exposure values calculated in EUSES.

  - EUSES typically specifies a "purification factor" that accounts for removal processes from surface water in deriving the concentration in drinking water, e.g., by evaporation or adsorption to suspended solids. However, the latter is estimated by log Kow and not by specific distribution coefficients. This approach is not feasible for inorganic substances and therefore the estimate does not account for adsorption to suspended particles as a removal process before and during drinking water purification. Although these effects are difficult to quantify, the value of 50% (i.e., reduction by factor 2) for adsorption to sewage sludge as applied in the EU RAR (ECB, 2005) (as described above) can serve as an indicator of the degree of Cr(VI) adsorption to suspended solids in surface water.

- The local PEC in surface water is calculated for the mixing zone, neglecting the fact that for drinking water preparation additional water sources are added and dilution takes place.

b) Local concentration in drinking water based on the "*local PEC in pore water of agricultural soil*":

- The Cr(VI) concentration in groundwater is taken directly from the pore water concentration in the soil, which in turn is modelled from the Cr(VI) concentration in the soil. Cr(VI) reduction in soil is a well-known process and the EU Risk Assessment Report states that "*chromium (VI) is reduced to chromium (III) by organic matter and this process occurs reasonably readily in soils*" and assumes "*chromium present in soil following application is in the form of chromium (III)*" (ECB, 2005). This reduction is not considered in EUSES modelling.
- In addition, EUSES calculates the deposition (the main relevant pathway of groundwater contamination) for a circle around the source with a radius of 1000 m (RIVM, 2004), so that the resulting groundwater concentration only applies to the groundwater below this area.
- EUSES modelling of the concentration in groundwater is based on a simple algorithm that equates the concentration of a substance in groundwater with its concentration in the pore water of the soil (RIVM, 2004). These authors state, that "*this is a worst-case assumption, neglecting transformation and dilution in deeper soil layers*".
- Like for surface water, any additional dilution with other groundwater or surface water for drinking water preparation is not considered.

Overall, the conservatism of EUSES with respect to exposure to drinking water is classified as "worst case" by the software developers (RIVM, 2004).

Against the background of these substance-specific and model-inherent considerations, the estimate for local exposure via drinking water is regarded as unreasonable. The effects of all these issues are not quantifiable, but a general reduction of the local Cr(VI) concentration in drinking water, calculated in EUSES, by a factor of 5 due to the above factors, seems to be appropriate. Still, this is considered to result in a conservative exposure estimate.

- Fish

1) In EUSES, a default consumption of 115 g fish per day is used, which overestimates the realistic human daily intake of fish on a long-term basis. According to the food consumption data for humans in Europe, as accessible in the *PRIMo – Pesticide Residue Intake Model*[4] (v.3.1) of the

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[4] In the *PRIMo – Pesticide Residue Intake Model* (v.3.1) of the European Food Safety Authority (EFSA) food consumption data for individuals of different age groups in numerous European countries are listed. The model can be accessed via https://www.efsa.europa.eu/en/applications/pesticides/tools (accessed in November 2020).

European Food Safety Authority (EFSA), the maximum of the mean consumption of fish (and fish- and marine-/freshwater-products) is 29.3 g per day[5]. This amount is approximately 4-fold lower (factor 3.9) than the default consumption used in EUSES, most likely due to the fact that it reflects a long-term estimate (i.e., most people do not eat fish every single day).

2) It must be noted, that "*(p)eople do not consume 100% of their food products from the immediate vicinity of a point source. Therefore, the local assessment represents a situation which does not exist in reality*" (ECHA, 2016a).

From argument 1) (almost) a reduction factor of 4 can be assumed and although argument 2) is not scientifically verifiable, it certainly makes up more than a factor of 1.25. Thus, combining these two arguments, a **total reduction factor of 5** can be derived, which is assumed to be sufficiently conservative to also cover, for example, that some countries have not indicated long-term consumption quantities to EFSA (and are thus not represented in the PRIMo Model). Adding further to the conservatism, it must be noted that the value derived from the data in the PRIMo model relate to the consumption of '*fish, fish products and other marine and freshwater food product'* and therefore include food items that are unlikely to be sourced from the immediate vicinity of the site assessed.

Inhalation exposure

The following must be considered for local inhalation risks: The concentration in air and deposition are estimated in EUSES with the Operational Priority Substances (OPS) model that is embedded in EUSES (de Bruin et al., 2010; Toet and de Leeuw, 1992). When EUSES was developed, conservative input values were chosen (e.g., stack height of 10 m, no excess heat of the plume emitted compared to environmental temperature and an ideal point source). For a stack height of 10 m, the maximum concentration is modelled at a distance of 100 m from the source and this distance was set as the default distance for the local PECair in EUSES. The developers of the OPS model at the Dutch RIVM analysed the impact of these conservative default settings on the estimated concentration in air and on the total deposition. For example, they noted that '*[i]ncreasing the stack height from 10 to 50 m lowers the maximum concentration by a factor 40*' and – considering all factors – concluded that '*air concentration and total deposition used for risk assessment purposes are likely to be overestimated due to over-conservative default settings used in the standard scenario in EUSES*' (de Bruin et al., 2010). In the light of these findings, the inhalation risk estimates presented in this report are highly conservative.

Site-specific release fractions

Data for monitoring of Cr(VI) releases to water and air are available from several sites in Europe. Release fractions for Cr(VI) emissions to water, air and soil were derived from the site-specific emission data and tonnages of used chromates. These releases are generally governed by, and comply with,

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More detailed information on the model is under the following links:
https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2018.5147 and
https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/sp.efsa.2019.EN-1605

[5] The value was provided for Germany (general population) based on the daily intake (reported in the PRIMo model in g/kg bw and day), multiplied by the body weight (reported in kg). The value represents the maximum of the mean values reported for different countries and population groups (e.g., children, adults, general population).

local worker and environmental regulatory requirements.

Wastewater

Wastewater containing Cr(VI) may occur from bath solutions when treatment baths are renewed, rinsing water from rinsing tanks and from manual rinsing operations, cleaning water, liquids from secondary containment pits, wash water from wet scrubbers, and liquid waste from the laboratory. At all sites wastewater is collected and then treated by one or more of the following three options:

- Sending it to an external waste management company (licensed contractor) where it is treated as hazardous waste
- Recycling and evaporation in an on-site evaporation system; the residue is discharged as hazardous solid waste or liquid waste
- Discharge into a special treatment facility

The special treatment facility is in most cases located on-site but may also be external where the water is transferred via underground pipes. Typically, bath solutions are either disposed as hazardous waste by an external company or conveyed to the special treatment facility. Wastewater from the other sources listed above is usually either collected and mixed for treatment at the treatment facility or recycled and then sent to the evaporation system.

In the special treatment facility, the Cr(VI) in wastewater is reduced to Cr(III) by addition of a reducing agent (e.g., sodium metabisulphite, ferrous sulphate, or ferric chloride solutions) in excess of stoichiometry. Usually, reduction efficiency is measured by a redox probe. Following the reduction step, the wastewater pH is neutralized, and Cr(III) is precipitated. After monitoring of the Cr(VI) concentration in the reduced wastewater, the wastewater is usually mixed with other non-Cr(VI) containing waste solutions. The wastewater is then discharged to an external municipal wastewater/sewage treatment plant for further treatment prior to discharge to receiving waters (river, canal, or sea).

Air

Air from the Cr(VI) process baths is exhausted and treated through wet scrubbers or air filters prior to external release.

Soil

There is no direct release to soil, based on equipment and procedures in place.

Solid waste containing Cr(VI) may arise in the form of sludge from the treatment and rinsing baths, solid residue from the evaporation system for wastewater (at sites where this technique is performed), sludge from the reduction/neutralization process (at sites where this technique is performed), empty chemical containers, cleaning materials (e.g., rags, wipes), sorbents, used sandpaper, contaminated equipment (e.g., heaters, pumps), Cr(VI)-contaminated beads used for blasting and disposable PPE. Waste materials containing Cr(VI) are classified and treated as hazardous wastes according to EU and national regulations. Any solid or liquid waste is collected and forwarded to an external waste management company (licensed contractor) for disposal as hazardous waste.

Substance-specific input values

We have used the properties of CT for the input of substance-specific physico-chemical properties to model the behaviour of Cr(VI) with EUSES. The parameters of CT were selected because a comparative EUSES assessment with an example scenario, in which only the substance-specific physico-chemical properties of the eight chromates covered by the ADCR consortium were used, yielded the most conservative result with the CT parameters. The exposure of HvE via the combined exposure via air, drinking water and fish was slightly higher when using the CT parameters than when using the parameters of the other chromates (the physico-chemical properties of the seven other chromates used for EUSES modelling and the outcome of the comparative EUSES assessment is provided in Annex I of the CSR). Accordingly, we have used the **parameters of CT for EUSES modelling of the environmental behaviour of Cr(VI) released from all source chromates and sites** (irrespective of the chromate used at a particular site) for reasons of conservatism and consistency. However, it must be noted that these physico-chemical properties are only used as a surrogate for those of Cr(VI), as no physical properties exist for the Cr(VI) ion. For the environmental fate properties, in contrast, data are available for Cr(VI). Table 9-6 shows the physico-chemical properties of CT and the environmental fate properties of Cr(VI) required for EUSES modelling, as given in the EU Risk Assessment Report (ECB, 2005).

Table 9-6: Physico-chemical properties of CT and environmental fate properties of Cr(VI) required for EUSES modelling

Property	Description of key information	Value selected for EUSES modelling	Comment
Molecular weight	100 g/mol	100 g/mol	Refers to CT, value used in ECB (2005)
Melting /freezing point	196 °C	196 °C at 101.3 kPa	Refers to CT, value used in ECB (2005)
Boiling point	n/a decomposes at ~250 °C to Cr_2O_3 and O_2 (ECB, 2005)	250 °C	Refers to CT; value used in ECB (2005)
Vapour pressure	n/a: inorganic ionic compound	0.00001 Pa	N/A; dummy value entered
Log Kow	n/a: inorganic ionic compound	0	N/A; dummy value entered
Water solubility	Completely soluble in water, 1667 g/L at 20 °C, a 1% solution has a pH <1.	1667 g/L at 20 °C	Refers to CT; value used in ECB (2005)

Property	**Description of key information**	**Value selected for EUSES modelling**	**Comment**
Kp *suspended matter*		1100 L/kg	Refers to Cr(VI); value for acidic and alkaline conditions given in ECB (2005), mean value is used; see text below for details
Kp *sediment*		550 L/kg	Refers to Cr(VI); value for acidic and alkaline conditions given in ECB (2005), mean value is used; see text below for details
Kp *soil*		26 L/kg	Refers to Cr(VI); value for acidic and alkaline conditions given in ECB (2005), mean value is used; see text below for details
Bioconcentration factor fish	1 L/kg	1 L/kg	Refers to Cr(VI); value used in ECB (2005)

We derived the partition coefficients for Cr(VI) from Table 9-6 as follows (see Table 9-7). In the EU Risk Assessment Report (ECB, 2005), the Cr(VI) partition coefficients are given for suspended matter, sediment and soil under acidic and alkaline conditions. For EUSES modelling the mean value of the partition coefficients under acidic and alkaline conditions was used for each compartment because (a) it reflects the range of values and (b) the underlying data – especially for Kp suspended matter and Kp sediment - are not very well founded, which hinders a more reliable prediction of these parameters.

To assess the impact of the selected partition coefficients (under acidic or alkaline conditions), we conducted a sensitivity analysis with EUSES, where an exemplary exposure scenario (with no biological STP) was carried out using (a) the coefficients for acidic conditions, (b) the coefficients for alkaline conditions or (c) the calculated mean values. The outcome of the assessment was that the selected set of partition coefficients had close to no impact on the modelling result, as the variation of Cr(VI) exposure of HvE via the combined exposure routes air, drinking water and fish was lower than 2% (details are given in Annex II of this report).

Table 9-7: Partition coefficients for Cr(VI) for suspended matter, sediment and soil under acid and alkaline conditions, as given in ECB (2005)

Partition coefficient *	**Acid conditions (pH ≤ 5)**	**Alkaline conditions (pH ≥6)**	**Mean**
Kp *suspended matter*	2 000 L/kg	200 L/kg	1 100 L/kg
Kp *sediment*	1 000 L/kg	100 L/kg	550 L/kg

Partition coefficient *	**Acid conditions (pH ≤ 5)**	**Alkaline conditions (pH ≥6)**	**Mean**
Kp *soil*	50 L/kg	2 L/kg	26 L/kg

* All Kp values refer to partitioning between water and the solid phase indicated.

9.1.2.5 Workers

9.1.2.5.1 Scope and type of assessment

No professional or consumer uses are applied for in this application for authorisation, and such uses are therefore not part of this chemical safety report (CSR).

CT has been included in Annex XIV of the REACH Regulation for its carcinogenic properties. As regards this toxicological effect, the assessment is limited to the inhalation exposure pathway: indeed, according to RAC "there are no data to indicate that dermal exposure to Cr(VI) compounds presents a cancer risk to humans" (ECHA, 2013). Therefore, the quantitative occupational exposure estimation and risk characterisation for carcinogenic effects focuses on inhalation exposure of workers.

Table 9-8: Type of risk characterisation required for workers

Route of exposure and type of effects	**Endpoint considered and type of risk characterisation**	**Hazard conclusion** **DNEL/dose – response relationship**
Inhalation: Systemic Long Term	Carcinogenicity Quantitative	RAC dose-response relationship based on excess lifetime lung cancer risk (ECHA, 2013) For workers; based on 40 years of exposure; 8h/day; 5 days/week Exposure to 1 µg/m^3 Cr(VI) relates to an excess risk of 4x10^{-3} [a]

[a] The inhalation cancer risk characterisation for workers is solely based on inhalation exposure and the risk for lung cancer, as no information on the fraction of inhalable, but non-respirable particles is available, which prevents a differentiated consideration of inhalation and oral exposure of workers.

A qualitative risk characterisation with respect to the corrosive and skin sensitising properties of chromates such as CT is outside the scope of this CSR, as these chromates have been included in Annex XIV to Regulation (EC) No 1907/2006 (REACH) solely due to their carcinogenic and mutagenic properties. According to REACH, Article 62(4)(d), the CSR supporting an AfA needs to cover only those potential risks arising from the intrinsic properties specified in Annex XIV. The applicants duly apply and communicate risk management measures derived by the registrants of the chromates due to other substance properties related to human health concerns, which they communicated via the Safety Data Sheets (SDS).

9.1.2.5.2 Comments on assessment approach

General approach

The potential for exposure depends on the specific tasks identified for each use as described below in the respective sections. Based on the process characteristics and properties of chromates as non-volatile substances, all potential inhalation exposure will be due to aerosols/dusts containing Cr(VI). Potential dermal exposures arise from contact with Cr(VI) dissolved in liquids, or from dusts of solid Cr(VI)-containing products.

Inhalation exposure of workers is assessed via reliable and representative workplace air measurements. We have assigned exposed workers to "Similar Exposure Groups" (SEGs), which are defined for each use and comprise groups of workers performing similar tasks and, hence, are assumed to experience similar exposures. Measured data from members of the same SEG are pooled. On several occasions, workers might be engaged in more than one use in parallel (e.g., an operator surveying a line of baths, where several surface treatments are done). The respective chapters on the use-specific exposure assessment explain how measured exposures are assigned to specific uses. Generally, the measured full-shift time-weighted average concentration is assigned to all uses for which tasks were performed at the day of the measurement.

Measurement methods with varying sensitivity are applied. For values below the limit of quantification (LOQ), EN 689:2018 (Workplace exposure - Measurement of exposure by inhalation to chemical agents - Strategy for testing compliance with occupational exposure limit values) recommends statistical approaches to estimate the arithmetic or geometric mean in case of values below LOQ. However, due to the heterogeneity of our datasets (which come from different sites, with measurements performed by different service providers) these approaches are not feasible. Two other methods for treating such values, the use of LOQ/√2 or LOQ/2, are discussed in literature. The use of LOQ/2 is preferred for data sets with a geometric standard deviation >3 and the use of LOQ/√2 is preferred for data sets with a geometric standard deviation <3 (Morton and Lion, 2016; Succop et al., 2004). The resulting values of both methods likely overestimate mean values but are expected to have no influence on the 90th percentile of worker measurements considered in this CSR for exposure estimation. Since the use of LOQ/2 is a frequently used practical approach accepted by ECHA for the environmental part, we have used LOQ/2 for values <LOQ in the present exposure assessments (ECHA, 2016a; U.S. EPA, 2019).

Personal monitoring, with sampling heads in the worker's breathing zone and with sampling durations which allow to acquire sufficient analytical mass and interpret measured values as shift-average values are preferred. In limited, specific circumstances, values from **stationary (static) measurements** are helpful: incidentally exposed workers, i.e., workers not directly engaged with Cr(VI) (also called bystanders), but spending 10% or more of their working time in the same work hall as operators handling Cr(VI), might experience inhalation exposure. Such exposures can be estimated from stationary measurements, representing concentrations at some distance from the primary sources.

As the focus of the exposure assessment is on carcinogenic risks over a work life, the long-term average (chronic) exposure would be the most adequate measure. ECHA Guidance on Information Requirements and Chemical Safety Assessment, R.14: Occupational exposure assessment recommends use of the 90th percentile, without differentiating between health endpoints (ECHA, 2016b). We have followed the recommendation in the ECHA guidance to use the 90th percentile, although this is considered very conservative (as the data reflect measurement uncertainty as well as day-to-day (intra-individual) and inter-individual variation of exposure).

Biological monitoring data are not used in the assessment. Indeed, as regards biological indicators:

- The measure of chromium in erythrocytes is the only one which is specific to Cr(VI). However, the available literature data on the general population and on workers are insufficient to determine reference values and limit values for this indicator (ANSES, 2017). The German method provides a correlation between biomonitoring in erythrocytes and inhalation exposures but only for CrO_3 concentrations above 30 µg/m^3, which is above what is expected in these exposures (Greim, 2000). Additionally, it is expected that few sites apply biomonitoring in erythrocytes, as it is an invasive method using blood sampling and is thus difficult to apply to consistently use as a method of estimating exposure.
- Urinary biomonitoring does not allow a differentiation between Cr(III) and Cr(VI) (Drexler and Hartwig, 2009). France established a BLV (Biological Limit Value) by ANSES (French evaluation Authorities) in 2017, which can be used for workers but only under the following conditions: when the use is electroplating AND when the chrome products used are exclusively Cr(VI) compounds. Indeed, in case of mixed exposure to both Cr(VI) and Cr(III) compounds, the urine measurements need to be interpreted considering respective atmosphere measurements of Cr(VI) and Cr(III) compounds (if available). According to ANSES, the literature data available does not allow establishing a dose-response relationship between the urine measurements and the health effects (lung cancer, kidney toxicity, immunotoxicity) (ANSES, 2017). These constraints do not facilitate the implementation of this biomonitoring.
- Finally, chromium levels in biomonitoring studies are influenced by factors other than occupational exposure (geographical region, smoking status, intake from food and drinking water etc.), making the interpretation of the measurements as regards their relation to occupational exposures difficult.

Therefore, inhalation exposure measurements (ideally obtained by personal sampling) are preferred over biomonitoring in this case for exposure assessment.

Exposure modelling is applied for specific activities only, which cannot be adequately covered by measurements, such as:

- Activities of very short duration (e.g., laboratory workers handling Cr(VI) for a few minutes) might not allow direct measurements, considering the sensitivity of available methods.
- Infrequent activities, such as unscheduled maintenance activities, might not be included in occupational safety measurement programmes with the result that they are not covered by existing data.
- Activities using small amounts of mixtures with low concentrations of Cr(VI), such as use of touch-up pens.

Modelling is performed, where required, with Advanced REACH Tool (ART), version 1.5. Again, we have used the 90th percentile of the resulting distribution for risk assessment, according to (ECHA, 2016b).

Machining (e.g., drilling, grinding) of parts or blasting of surfaces, which were Cr(VI)-treated before might lead to Cr(VI) exposure via inhalation of fine dust particles that are generated. Such activities are included in the assessment if the surface treatment is expected to leave Cr(VI) on or near the surface.

Comments on assessment approach related to toxicological hazard:

There are no differences in the hazard profile compared to the initial applications regarding carcinogenic risks. Dose-response relationships for carcinogenic effects as proposed by RAC are used for risk characterisation.

Comments on assessment approach related to physicochemical hazard:

Physico-chemical hazards are not in the scope of this document.

General information on risk management related to toxicological hazard:

Information on risk management measures implemented and a comparison with obligations from previous applications for authorisation are provided in chapter 9.2.1.

General information on risk management related to physicochemical hazard:

Physico-chemical hazards are not in the scope of this document.

9.1.2.6 Consumers

Consumer uses are not subject of this review report.

9.2 Use 1: "Anodising using chromium trioxide in aerospace and defence industry and its supply chains"

9.2.1 Introduction

9.2.1.1 Relationship to previous application

This review report is for "**Use 1: Anodising using chromium trioxide in aerospace and defence industry and its supply chains**". It was prepared on behalf of the applicants by the Aerospace and Defence Chromates Reauthorisation (ADCR) consortium to cover uses of Chromium VI compounds in their supply chains. The review report is based on sector-specific knowledge provided by companies at various levels of the aerospace and defence industry and its supply chains. Compared to the initial applications (see Table 9-9), we narrowed the scope of this report in terms of the use definition, addressing only *Anodising using chromium trioxide in aerospace and defence industry and its supply chains*, to provide a more meaningful and specific description of use than the initial applications, which covered a wide range of surface treatments and substrates.

This chemical safety report covers the use of the one soluble Cr(VI) compound chromium trioxide (CT). The following table shows the initial applications to which this review report refers.

Table 9-9: Overview of initial applications

Application ID/ authorisation number	Substance	CAS #	EC #	Applicants	Use name
0032-04 REACH/20/18/14, REACH/20/18/16, REACH/20/18/18	Chromium trioxide	1333-82-0	215-607-8	Various applicants (CTAC consortium)	Surface treatment for applications in the aeronautics and aerospace industries, unrelated to functional chrome plating or functional chrome plating with decorative character
0032-05 REACH/20/18/21, REACH/20/18/23, REACH/20/18/25	Chromium trioxide	1333-82-0	215-607-8	Various applicants (CTAC consortium)	Surface treatment (except passivation of tin-plated steel (ETP)) for applications in various industry sectors namely architectural, automotive, metal manufacturing and finishing, and general engineering (unrelated to functional chrome plating or functional chrome plating with decorative character)

With the initial authorisation the European Commission issued several obligations and RAC/SEAC provided recommendations in their joint opinion on initial applications 0032-04 (REACH/20/18/14, REACH/20/18/16, REACH/20/18/18) and 0032-05 (REACH/20/18/21, REACH/20/18/23, REACH/20/18/25). The table below outlines how the applicants (authorisation holder; AH), together with downstream users (DUs) represented by the ADCR consortium, reacted to these tasks.

Table 9-10 describes the comparison between the initial and the current applications in a concise way, while the individual exposure scenarios describe in more detail the measures already implemented.

Table 9-10: Obligations in EC Implementing decisions

Initial application	Current application
AH shall develop specific exposure scenarios for representative processes, operations, and individual tasks, describing risk management measures and operational conditions applied and containing information on the exposure levels. This obligation applies to 0032-04 and 0032-05	The consortium responsible for the initial application developed specific exposure scenarios and made them available to the DUs. Starting from that, we further developed and refined the exposure scenarios provided in section 9.2.3 of this report, together with the risk management measures described there, considering the narrower scope of use.
The AHs and DUs shall implement monitoring programmes for air monitoring of occupational exposure representative for the tasks undertaken and shall implement monitoring programmes for chromium (VI) emissions to wastewater and air from local exhaust ventilation. This obligation applies to 0032-04 and 0032-05 (with the requirement for at least annual monitoring of occupational exposure and of environmental wastewater and air emissions)	Monitoring programmes are implemented by the DUs, and data from these programmes were used for developing exposure assessments of workers and of humans via the environment.
The AHs and DUs shall regularly review the effectiveness of the risk management measures and operational conditions in place and introduce measures to further reduce exposure and emissions. This obligation applies to 0032-04 and 0032-05	Sites regularly review the effectiveness of risk management measures and operational conditions in place.
The AHs and the DUs ensure that there is no chromium (VI) above the detectable level present in articles for supply to the general public. This obligation applies only to 0032-05, not to 0032-04	No articles treated by anodising are supplied to the general public
If an authorisation holder submits a review report, it shall include a detailed guidance on how to select and apply risk management measures and a refined assessment of the exposure to chromium (VI) of humans via the environment (HvE), as well as of the resulting risks. This assessment shall be performed using a higher-tier exposure assessment model going beyond the default assumptions of the Guidance on Information Requirements and Chemical Safety Assessment and of the European Union System for the Evaluation of Substances (EUSES) model and making use of site-specific emission information. All reasonably foreseeable routes of exposure of humans via the environment, including the oral route, shall be included in the assessment.	Detailed information on the adequate RMMs for each activity are included in the exposure scenarios of this review report. The assessment of exposure of HvE is performed based on measured emission data from various sites. Inhalation exposure from emissions to air and oral exposure from emissions to wastewater is considered.

This obligation applies to 0032-04 and 0032-05	

Enforcement activities by Member State Enforcement Authorities

So far, we are not aware of any enforcement activity with relation to the use described here.

9.2.1.2 Overview of use and exposure scenarios

9.2.1.2.1 Deviations from the exposure scenarios and contributing scenarios in the original submission

The exposure scenarios (ES) and contributing scenarios of this review report deviate from those included in the original submission in the following ways:

1) This review report has a much narrower scope than the initial applications to provide more meaningful use descriptions. The use covered by this review report is limited to *Anodising using chromium trioxide in aerospace and defence industry and its supply chains* while the initial applications 0032-04 (REACH/20/18/14, REACH/20/18/16, REACH/20/18/18) and 0032-05 (REACH/20/18/21, REACH/20/18/23, REACH/20/18/25) each cover a multitude of surface treatments and substrates.

2) In this review report we have identified similar exposure groups (SEGs) of workers for the uses considered here, and the SEGs are described in separate worker contributing scenarios (in order to respond adequately to the EC Implementing decision and RAC/SEAC recommendations to *develop specific exposure scenarios for representative processes, operations and individual tasks*, as described in Table 9-11). Each contributing scenario covers the relevant processes and individual tasks performed by the respective group of workers in relation to the use and describes the operating conditions (OCs) and risk management measures (RMMs) for the individual tasks involving Cr(VI) exposure. The Cr(VI) exposure from these activities is quantified by personal air measurements. In this way, Cr(VI) inhalation exposures from all relevant tasks performed by a SEG during its daily work are considered and combined for risk assessment.

   In the initial applications, no SEGs were determined. Instead, for a general worker, separate tasks with potential Cr(VI) exposure were described in each individual worker contributing scenario. For this, either Cr(VI) exposure was modelled for each task based on standard assumptions for the conditions of use, or, where available, monitoring data were considered for combinations of worker contributing scenarios.

3) In the environmental contributing scenario of this review report, the assessment of humans via the environment is considered via the inhalation route and the oral route. Environmental monitoring data for releases to air and wastewater serve as a basis for EUSES modelling of human exposure via several environmental compartments (ambient air, drinking water, fish). In the initial applications, only the inhalation route was considered for EUSES modelling and emissions to wastewater were described as negligible and, thus, not considered.

Due to differences in the structure of the current and initial applications, in especially due to the assignment of tasks to SEGs, a direct comparison is not easy to perform. Table 9-11 provides an overview on major differences between the review report and the initial applications. In the first column, the PROCs assigned to different SEGs are shown. The PROCs from the initial applications corresponding to these tasks are listed in the second column. Deviations between the consideration of PROCs are described as remarks in the third column.

Table 9-11: Activities and descriptors in current and initial applications

Current application	Initial applications [b]	Remarks
ECS 1 – Anodising – use at industrial site leading to inclusion (of Cr(VI) or the reaction products) into/onto article ERC 5	ERC 6b – Other surface treatment	For this use, ERC 5 is considered more appropriate, as it cannot be excluded that small amounts of Cr(VI) remain in/on the surface
WCS 1 – Line operators [a] PROC 9, PROC 10, PROC 13, PROC 28	PROC 2, 13 – Surface treatment by dipping/immersion PROC 8b – Cleaning of equipment PROC 10 – Surface treatment by rolling/brushing/pen stick PROC 13 – Rinsing/drying PROC 15 – Laboratory analysis (sampling, laboratory analysis)	For surface treatment by dipping/immersion only PROC 13 is regarded appropriate in the current application, PROC 2 is not considered adequate For cleaning PROC 28 is regarded more appropriate in the current application For sampling PROC 9 is regarded more appropriate in the current application, PROC 15 is not considered adequate
WCS 2 – Storage area workers [a] PROC 5, PROC 8b, PROC 28	PROC 5 – Mixing of solids/liquids PROC 8b – Re-filling of baths – solids/liquids PROC 8b – Decanting of liquids PROC 8b – Decanting and weighing of solids PROC 8b – Cleaning of equipment PROC 8b – Waste management	For cleaning PROC 28 is regarded more appropriate in the current application
WCS 3 – Laboratory technicians [a] PROC 15	PROC 15 – Laboratory analysis (sampling, laboratory analysis)	
WCS 4 – Maintenance and/ or cleaning workers [a] PROC 28	PROC 8a – Maintenance of equipment	For maintenance and cleaning PROC 28 is regarded more appropriate in the current application
WCS 5 – Machinists [a]	PROC 21, 24 – Machining operations	

PROC 21, PROC 24		
WCS 6 – Incidentally exposed workers (no Cr(VI)-related activities) [a] PROC 0		Not considered in initial application
Not considered relevant in this review report, as not related to Cr(VI) exposure	PROC 1 – Delivery and storage of raw material PROC 1 – Storage of articles PROC 4 – Un-/loading and cleaning of jigs PROC 8a – End of Life PROC 26 – Drying/curing	No exposure is expected from these processes in the current application; cleaning of jigs is covered in WCS 1 and 2 under cleaning of equipment (PROC 28)
Not considered relevant in this review report, as these activities are not part of the use described in this review report (but may be relevant for other surface treatments)	PROC 7 – Surface treatment by spraying PROC 13 – Chemical pre-/post-treatment	Not relevant for the scope of this use

[a] For descriptions of tasks assigned to the individual PROCs see worker contributing scenarios in sections 9.2.3.2 to 9.2.3.7.

[b] Since this application is based on several initial applications and the PROC descriptions sometimes vary between the different applications or are used in several variants in some cases the original PROC description is not given in this table but a summary description of the PROC(s) it is assigned to is.

The exposure scenarios and contributing scenario of this review report are shown below in Table 9-12.

9.2.1.2.2 Scope of use – supply chain considerations

This CSR covers the use of CT for anodising in the aerospace and defence industry and its supply chains. This use is performed in the European Economic Area (EEA) and in the United Kingdom (UK) in exclusively industrial settings in the following levels of the supply chain:

- Original Equipment Manufacturer (OEM)
- Downstream user – Build-to-print manufacturer (BtP)
- Downstream user – Design-to-build manufacturer (DtB), and
- Maintenance, Repair and Overhaul (MRO) companies and Ministries of Defence (MoDs, undertaking military maintenance, repair and overhaul work)

Due to the different levels in the supply chain, to which the individual companies may be associated, and the variation in the size of the sites, the conditions under which the use is carried out can be variable. The conditions of use cover small sites and repair shops with rare and infrequent applications up to large sites with high throughput, and thus, a low to high level of automation for specific activities. This variability was also observed in extensive consultation processes during the preparation of this review report.

The use of CT for anodising typically involves one environmental contributing scenario for the use of this chromate at an industrial site.

Table 9-12 lists all the exposure scenarios (ES) and contributing scenarios assessed in this CSR.

Table 9-12: Overview of exposure scenarios and their contributing scenarios

ES number	**ES Title**	**Environmental release category (ERC)/ Process category (PROC)**
ES1-IW1	Anodising **–** use at industrial site	
Environmental contributing scenario(s)		
ECS 1	Anodising - use at industrial site leading to inclusion (of Cr(VI) or the reaction products) into/onto article	ERC 5
Worker contributing scenario(s)		
WCS 1	Line operators	PROC 9, PROC 10, PROC 13, PROC 28
WCS 2	Storage area workers	PROC 5, PROC 8b, PROC 28
WCS 3	Laboratory technicians	PROC 15
WCS 4	Maintenance and/or cleaning workers	PROC 28
WCS 5	Machinists	PROC 21, PROC 24
WCS 6	Incidentally exposed workers	PROC 0
Exposure scenario for industrial end use at site: ES1-IW1		

9.2.1.2.3 Relationship between uses

Anodising with CT is usually combined with pre-treatment(s) (e.g., deoxidising, etching, pickling or desmutting) and one post-treatment which is anodise sealing. The pre-treatments can involve the use of chromates or may be Cr(VI)-free. Inorganic finish stripping can also be required in case of defective finishing or as part of rework processes.

For the combination with deoxidising/etching/pickling/desmutting, inorganic finish stripping or anodise sealing with chromates, all details on these processes are described in the respective CSR (see ADCR dossiers “Pre-treatments: deoxidising, pickling, etching and/or desmutting”, “Inorganic finish stripping”, and “Anodise sealing”).

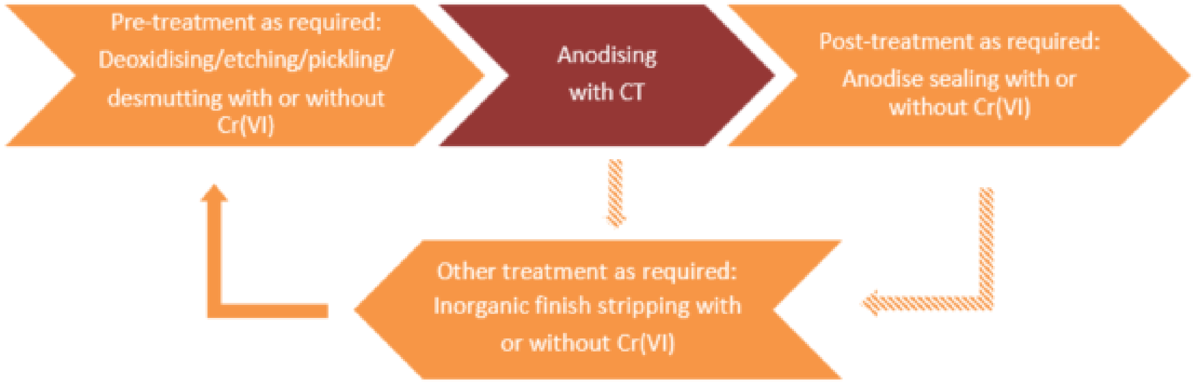

Figure 9-1: **Schematic presentation of treatment steps**

9.2.2 Detailed information on use

9.2.2.1 Process description

Anodising with CT, also called Chromic Acid Anodising (CAA), is used to improve wear resistance, ensure corrosion protection and/or improve adhesive properties for subsequent painting, adhesive bonding or adhesive repair. Anodising is a chemical electrolytical process. The metallic parts to be treated act as the anode and the respective cathode is inert. The current passes through the metallic parts in an electrolyte which consists of an acidic solution containing CT. An anodic oxide layer is formed on the surface of the parts creating pores uniformly distributed. The anodic film formation is mainly driven by the applied voltage but also by the temperature and the immersion duration. The thickness of the anodic coating layer formed on the surface is typically in a range between 0.5 to 18 µm. The oxide layer formed is normally porous, so a sealing process is often needed to achieve corrosion resistance. In case adhesion properties are required (for instance for a subsequent painting step), sealing may not be performed before the painting operations are carried out.

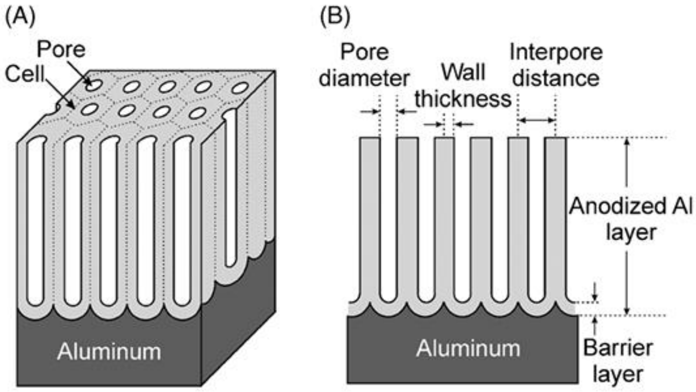

Figure 9-2: **Idealized structure of anodic porous alumina (A) and a cross-sectional view of the anodized layer (B) (Sulka G., 2008)**

Cr(VI) is partly trapped in the oxide layer and remains in the surface layer. As a consequence, subsequent machining activities on treated parts are included in this assessment as Cr(VI) dust may be generated during machining activities.

The key functionalities of Cr(VI) for anodising are detailed in the Analysis of Alternatives (AoA) report.

Anodising is a chemical, electrolytical process which is mostly carried out by immersion of parts in treatment baths. Typically, the treatment baths for anodising are positioned in a large hall where baths for other immersion processes are also present; some of these baths might also involve the use of Cr(VI) for pre- or post-treatment processes or they may be unrelated to the present use. The immersion tanks can be placed individually or within a line of several immersion tanks. Usually anodising baths and anodise sealing baths are located in the same line. Most of the time, at least one rinsing tank with water is positioned after an immersion tank, for rinsing off the anodising solution from the parts.

Figure 9-3: Anodising bath

Selective anodising can also be performed when limited, selective areas of large, complex metallic assemblies need anodising to either restore a previously anodised surface or to fulfil an original specification requirement. This local treatment is done using a swab/electrode. When anodising, the tool used acts as the cathode and the part to be treated becomes the anode. The anodised coating is formed on a localised area of the metallic surface in the presence of the electrolyte.

Figure 9-4: Anodising electrode

Anodising	CT

Substrate(s)

Several metallic substrates can be processed by anodising such as titanium, magnesium, niobium, zirconium, hafnium, tantalum and aluminium. It should be noted however that aluminium represents the very large majority of the treated substrates (> 95%).

9.2.2.2 Teams and employees involved

For the present assessment, we have identified the following similar exposure groups (SEGs) for tasks with potential Cr(VI) exposure related to anodising:

- Line operators
- Storage area workers
- Laboratory technicians
- Maintenance and/or cleaning workers
- Machinists
- Incidentally exposed workers (without direct Cr(VI)-related activities)

9.2.2.3 Technical and organisational risk management measures

All sites that perform anodising within the ADCR supply chains are specialised industrial sites being active in the EEA or the UK. They have rigorous internal safety, health, and environment (SHE) organisational plans. The sites adhere to best practices to reduce workplace exposures and environmental emissions to as low as technically and practically feasible and use automated processes to the extent possible. The feasibility and the degree of automation can vary between different sites and depend, among other factors, on the size of the site and the frequency with which the use in question is carried out.

9.2.2.3.1 Workers

At all sites, risk management measures in accordance with Article 5 of Directive 2004/37/EC are implemented as appropriate.

9.2.2.3.1.1 Technical measures

The technical measures implemented at the sites include:

- Chemical treatment baths are equipped with LEV, as described in the respective worker contributing scenarios in sections 9.2.3.2 to 9.2.3.7.

Efficiency of LEV

LEV systems are designed and installed for the specific baths to remove contaminants from the workers' breathing zone through exhaust extraction.

The efficiency of the installed LEV system depends on the exhaust air flow rate of the system per time unit. The sites follow the manufacturer requirements as well as recommendations from national guidelines, where applicable, and perform preventative maintenance of equipment to maintain the stated efficiencies of the LEV systems.

9.2.2.3.1.2 Organisational measures

The following organisational measures to reduce workplace exposure are implemented at all sites:

- Annual monitoring programmes are implemented for air monitoring of occupational exposure to Cr(VI), which are representative of the range of tasks undertaken where exposure to Cr(VI) is possible, including tasks involving process and maintenance operations (requirement for CT).
- The effectiveness of the risk management measures and operational conditions in place are regularly reviewed and, as applicable, measures are introduced to further reduce exposure and emissions.
- LEV systems are inspected and maintained according to the manufacturer´s specification.
- Standard procedures are available for use and maintenance of respiratory protective equipment (RPE) (including procedures for fit testing of RPE masks which are applied in accordance with relevant standards).
- The provision of PPE for the workers is organised by a designated responsible person.
- The conditions of the PPE are checked regularly.
- A program of PPE management is implemented on site which includes PPE selection, training for correct wearing/removal of the PPE, storage of PPE, cleaning or renewal and distribution of the PPE, communication via workplace signage or working instructions at the workplace.
- Training on chemical risks is periodically done for workers handling chemicals. Safety Data Sheets and instructions for hazardous chemicals handling are available.
- Training at the workplace is given periodically and work instructions are available on how to carry out specific tasks through standard operating procedures.
- Cleaning of company supplied uniforms is organised by the site, or contaminated clothes are renewed.
- In the production area reducing chemicals are available, which are suitable to remove Cr(VI) from the skin (e.g., ascorbic acid, formation of Cr(III), which can be washed off easily).
- Small splashes or amounts are taken up with wipes. Wipes are disposed of as solid waste.
- Chemical products are stored in a designated area.
- Effective cleaning practices are implemented in the vicinity of the tanks, where machining activities take place, and where solid chromates are handled.
- At some sites, water in rinsing tanks is recirculated and regularly tested for conductivity. When a certain conductivity limit is exceeded, the rinse water is treated as wastewater and renewed in the rinsing tanks. This prevents elevated Cr(VI) concentrations from being present in the rinsing tanks in the working area.

9.2.2.3.1.3 Personal Protective Equipment

For all tasks with potential direct Cr(VI) exposure, standard operating procedures are available at the sites, wherein the appropriate PPE to be worn is specified (selected based on risks and in accordance with the exposure scenarios). The following PPE is applied for activities where exposure to Cr(VI) is possible, in order to control Cr(VI) exposures:

- Chemical protective clothing, where necessary (plus coveralls or aprons for specific tasks)
- Suitable eye protection as per relevant risk assessment
- Chemical resistant gloves
- Respiratory protection, worn during all tasks not performed under an LEV for which industrial hygiene exposure assessment confirms RPE use is required

Use of Assigned Protection Factors (APFs) throughout this CSR

The European Standard EN 529 – "Respiratory protective devices. Recommendations for selection, use, care and maintenance" provides guidance on the selection and use of RPE. It also lists "Assigned protection factors" as recommended in various European countries. RPE is described according to the types of device that will be in use rather than APF values to be met. Since APFs vary numerically between countries and no generally accepted factors exist, a conservative approach is taken in this review report, when APFs are used to calculate workers exposure. Where an APF is cited for a type of RPE, this will correspond to the lowest APF value for that type of RPE over all countries listed in the Table to Annex V.

The specific PPE for each task is described in detail in the worker contributing scenarios in sections 9.2.3.2 to 9.2.3.7.

9.2.2.3.2 Environment

9.2.2.3.2.1 Emissions to air

The following technical and organisational measures are implemented to reduce environmental air emissions to the maximum extent possible:

- All chemical treatment baths are equipped with LEV systems. The local exhaust air is collected and released via exhaust stacks.
- The local exhaust air from treatment baths treated in wet scrubbers or by air filters before it is released to the environment.
- Wash water in the wet scrubber is regularly exchanged when a certain threshold value of either conductivity, pH or Cr(VI) concentration is exceeded. Regular replacement of the wash water helps to ensure that the cleaning performance of the wet scrubber does not decrease.
- At least annual monitoring programmes for Cr(VI) emissions to air from LEV systems are implemented and the effectiveness of the risk management measures and operational conditions in place are regularly reviewed.

Efficiency of air emission abatement technology

- Wet scrubbers are regularly checked by measuring conductivity, pH, or Cr(VI) concentration ensuring proper function.

- The usual way to check the performance of air filters is to measure pressure loss.
- The efficiency of the wet scrubbers or air filters can also be checked by comparative measurements with and without the use of the wet scrubber/filter or between the duct inlet and outlet. At sites where such measurements are performed, very high efficiencies for air abatement can be demonstrated. As an example, such measured values from one site show a purification of the exhaust air from Cr(VI) concentrations in the range of several mg/m^3 (before the filter) to a concentration below the detection limit of the measurement method used (after the filter).

9.2.2.3.2.2 Emissions to wastewater

Cr(VI)-containing wastewater is gathered and either sent to an external waste management company (licensed contractor), or treated onsite in a reduction facility and/or evaporated in an on-site evaporation system (the residue is discharged as hazardous solid waste or liquid waste) and/or recycled or discharged in accordance with regulatory requirements.

For the reduction of environmental emissions to wastewater to the maximum extent possible, the technical and organisational measures implemented at the sites include:

- Wastewater is sent to a reduction facility (typically on-site), where Cr(VI) in wastewater is reduced to Cr(III) by addition of a reducing agent (e.g., sodium bisulfite or ferrous sulfate). After the reduction process, Cr(III) is precipitated and separated from the wastewater by a filter press (the filter cake is disposed as waste), and the treated wastewater is, either evaporated, reused on site, or discharged to a wastewater treatment plant (WWTP) or municipal sewage treatment plant (STP) (in accordance with local regulatory requirements).
- Regular monitoring programmes for Cr(VI) emissions to wastewater are implemented and the effectiveness of the risk management measures (i.e., the efficiency of the wastewater reduction) and operational conditions in place are regularly reviewed.

9.2.2.3.2.3 Emissions to soil

The following technical and organisational measures are implemented to prevent environmental emissions to soil:

- The indoor and outdoor surfaces where chemicals are handled are sealed. Chemicals and solid waste containing Cr(VI) are stored in closed containers, either inside or outside.
- Treatment baths are surrounded by a secondary containment pit and the solution collected in the containment pit is treated or disposed of as hazardous waste.

9.2.2.3.3 Solid waste

Solid waste generated at the sites may include the filter cake from the filter press (only contains Cr(III)), solid residues from the evaporation system for wastewater, and Cr(VI) contaminated waste from activities related to the surface treatment process (e.g., empty chemical containers and bags, filters, waste from cleaning activities, sorbents, brushes, used sandpaper, abrasive material from blasting, contaminated equipment and PPE).

The filter cake containing Cr(III) is collected and stored in containers and forwarded to an external waste management company (licensed contractor) for disposal as waste.

The solid residues from the evaporation system for wastewater are collected and discharged as hazardous solid waste by an external waste management company (licensed contractor).

The Cr(VI)-contaminated solid waste such as contaminated wipes, rags and PPE (e.g., gloves, overalls, aprons), contaminated equipment or empty chemical containers (canisters, bags, drums) are usually disposed as hazardous waste unless they are cleaned prior to their disposal (if they are cleaned, they are disposed as non-hazardous solid waste). This hazardous solid waste is stored in closed drums and containers and forwarded to an external waste management company (licensed contractor) for disposal.

9.2.2.4 Tonnages and mass balance considerations

9.2.2.4.1 Tonnages

Assessed tonnage: up to 1040 kg Cr(VI)/year per site based on:

0 to 2000 kg CT used per year per site

9.2.2.4.2 Mass balance considerations

Consumption during process

During the treatment process, part of the Cr(VI) introduced in the bath is trapped in the anodic oxide layer which is formed on the treated part. Chromate-containing baths are kept for long periods and consumed chromate is replenished.

For local application, ready-to-use solution is used in quantity needed for the surface to be treated.

Amount of Cr(VI) released to wastewater

Only a minor share of the total amount of Cr(VI) used at the site goes into wastewater, but the Cr(VI) concentration in wastewater prior to reduction is not measured at the sites. During the reduction step Cr(VI) is converted to Cr(III) and after precipitation collected in a filter press. As the concentration of Cr(III) in the filter cake is not measured, the amount of chromium leaving the process via the filter cake cannot be assessed.

The residual Cr(VI) in wastewater after reduction, which is released to an external STP or WWTP, is between 0 and 3.32 kg per year (as described in Annex III).

Amount of Cr(VI) discharged as waste

Cr(VI) in solid waste occurs only in the form of solid residues from the wastewater evaporation system (at sites where this technique is performed) and as contaminated objects such as empty chemical containers/bags, filters, equipment, sorbents, brushes, used sandpaper, abrasive material from blasting, cleaning materials and PPE; the quantities of Cr(VI) are negligible and not quantifiable. Some sites discharge (part of) their Cr(VI) wastewater as liquid waste by sending it to an external waste management company (licensed contractor). These quantities are highly variable and not consistently quantifiable.

Amount of Cr(VI) released via fugitive emissions

No measurement data is available for fugitive emissions. However, due to the low vapour pressure of the chromates and as the baths are at most sites covered with a lid when not in use, such emissions are expected to be low. When the baths are running, air emissions occur at higher temperatures, which are extracted by the LEV.

Amount of Cr(VI) released to the atmosphere

The exhaust air from treatment baths which is released via exhaust stacks is between 0.000077 and 3.05 kg per year (as described below in Annex III). The exhaust air is treated in wet scrubbers or by air filters before release. The wash water from wet scrubbers is released to the wastewater reduction plant and thus the Cr(VI) fraction washed off in a wet scrubber contributes to the Cr(VI) fraction released to wastewater.

9.2.3 Exposure scenario 1 for Use 1: "Anodising using chromium trioxide in aerospace and defence industry and its supply chains"

Market sector: -

Sector of use: Other: Aerospace and defence industry and its supply chains

Article categories: not relevant

Environment contributing scenario(s): ERC 5

Worker/Consumer contributing scenario(s): PROC 0, PROC 5, PROC 8b, PROC 9, PROC 10, PROC 13, PROC 15, PROC 21, PROC 24, PROC 28

Subsequent service life exposure scenario(s): not relevant (see below)

Description of the activities and technical processes covered in the exposure scenario:

Anodising using CT by immersion and local application (see detailed use information in section 9.2.2).

Explanation on the approach taken for the ES:

We established the exposure scenario based on sector-specific information provided by sites performing these activities.

Exposure from service life of treated articles:

Anodising is performed on the surface of metallic parts of various size, that are most of the time either sealed or painted afterwards with or without Cr(VI).

Although Cr(VI) may be partly reduced during the anodising process (redox reaction with the metal oxide layer formed at the surface), it cannot be excluded that Cr(VI) remains in the pores formed at the surface to some extent. However, concentrations are expected to be well below 0.1% (w/w), which is the concentration above which notifications of Candidate List substances in articles according to REACH Art. 33 (ECHA, 2017) are required. Furthermore, as subsequent sealing, painting or bonding operations are usually performed, Cr(VI) from anodising will remain trapped in the capillaries of the surface layer. Therefore, exposure from parts treated by anodising is negligible. In consequence, no service life scenario for use of parts treated by anodising is required.

9.2.3.1 Environmental contributing scenario 1

As CT is not listed in REACH Annex XIV due to environmental effects, no environmental exposure assessment is performed here. However, we assessed the exposure of humans via the environment in the following sections.

9.2.3.1.1 Conditions of use

Table 9-13: Conditions of use – environmental contributing scenario 1

Product (article) characteristics
Product A: Solid CT (flakes or powder), pure substance (100%) or mixture (50-100%); **52% Cr(VI)**
Product B: Aqueous solution of CT as purchased (1-10% CT (w/w)); **max. 5.2% (w/w) Cr(VI)**
Product C: Mixture containing CT, used to perform local anodising (<5% CT (w/w)); **max. 2.6% (w/w) Cr(VI)**
Amount used, frequency and duration of use (or from service life)
Product A: Solid CT (flakes or powder), used to prepare aqueous bath solutions ▪ Daily use at site: up to 2.85 kg/day [as Cr(VI)] ▪ Annual use at a site: up to 1040 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Product B: Aqueous solution of CT as purchased, used to prepare aqueous bath solutions ▪ Daily use at site: up to 0.41 kg/day [as Cr(VI)] ▪ Annual use at a site: up to 150 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Product C: Mixture containing CT, used to perform local anodising ▪ Daily use at site: up to 0.00041 kg/day [as Cr(VI)] ▪ Annual use at a site: up to 0.15 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Technical and organisational conditions and measures
All products: ▪ **Technical measures** o Air - Chemical treatment baths are equipped with LEV - Exhaust air is treated in wet scrubbers or by air filters before it is released via stack(s)[6] o Wastewater - Wastewater occurs from bath solutions (depending on the site and the Cr(VI) concentration), water from drag-out tanks, rinsing water, cleaning water, liquid from

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[6] 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.

- secondary containment pits, water from wet scrubbers, and liquid hazardous waste from the laboratory - Cr(VI)-containing wastewater is gathered and, either directly sent to an external company certified for disposing of liquid hazardous waste, recycled after evaporation in an on-site evaporation system (the residue is discharged as hazardous solid waste or liquid waste), and/or treated on-site in a reduction facility, where Cr(VI) in wastewater is reduced to Cr(III) by addition of a reduction agent (e.g., sodium bisulfite or ferrous sulfate), followed by neutralisation and precipitation of Cr(III) - Reduced wastewater is sent to a wastewater treatment plant (WWTP) or municipal sewage treatment plant (STP) (depending on local regulatory requirements) ○ Soil - The indoor and outdoor surfaces where chemicals are handled are sealed and if chemicals and solid waste containing Cr(VI) are stored outside, then it is only in closed containers - Tanks are surrounded by secondary containment pits, and liquids collected in the pit are sent to the wastewater collection tank ▪ **Organisational conditions and measures** ○ Air - Cr(VI) air emission measurements are at least annually performed at identified exhaust stack(s) where the process emissions are released ○ Wastewater - Reduction of Cr(VI) in wastewater is controlled regularly by Cr(VI) measurements - Batches of reduced wastewater are discharged only after confirmation of Cr(VI) reduction to a concentration below the permitting limit (in accordance with the local regulatory requirements)
Conditions and measures related to sewage treatment plant
All products: ▪ Biological (municipal) STP: Standard STP or on-site treatment plant (removal rate: 50% to sludge assumed, see description in section 9.1.2.4) ▪ Sludge application to agricultural soil: in most cases not; however, as it is not ascertained in all cases, for a conservative assessment sludge application is assumed ▪ Discharge rate STP: 2 000 m^3/day (by model default if no site-specific data available) ▪ Dilution factor for receiving water body: 10 (by model default if no site-specific data available)
Conditions and measures related to treatment of waste (including article waste)
All products: ▪ Filter cake from the wastewater reduction plant only contains Cr(III) (since, even if the reduction

were incomplete, residual Cr(VI) is readily soluble in water and would be found in the water phase) and is forwarded to an external waste management company (licensed contractor) for disposal as waste. ▪ Other solid hazardous waste contaminated with Cr(VI) such as contaminated wipes, rags and PPE, contaminated equipment or empty chemical containers (canisters, bags, drums) or other abrasive material from blasting are usually also disposed as hazardous waste unless they are cleaned prior to their disposal (if they are cleaned, they are disposed as non-hazardous solid waste). This hazardous solid waste is stored in closed drums and containers and forwarded to an external waste management company (licensed contractor) for disposal as hazardous waste.
Other conditions affecting environmental exposure
All products: ▪ Process temperature of the treatment baths (from 25 to 50 °C)
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
▪ None

The use of CT for anodising in the aerospace and defence industry and its supply chains is carried out at small to large sites. The sites operate between 8 and 24h per day, on 5-7 days per week and up to 365 production days per year. Some plants have one or several annual shutdowns (of the whole plant or of individual baths/lines), while other sites are continuously running.

Air emissions

The anodising process is carried out in treatment baths at temperatures between 25 and 50 °C and with Cr(VI) concentrations of up to 5.2% (a detailed description is given in section 9.2.3.2). At some sites, baths operating at higher temperatures are covered with lids to reduce evaporation and air emissions when the bath is not in use. Cr(VI) emissions to air generated during the treatment process are captured by LEV systems connected to the treatment baths. The exhaust air is then either treated in a wet scrubber (Figure 9-5 a + b) or by air filters. In stacks receiving exhaust air from baths with higher Cr(VI) concentrations and/or elevated temperatures Cr(VI) emissions to the environment are typically monitored in regular intervals at the sites. However, in stacks receiving only exhaust air from baths with lower Cr(VI) concentrations and/or low temperatures Cr(VI) emissions to the environment are not monitored at some sites.

Exhaust air from dedicated decanting and weighing stations (e.g., in the storage area), where the raw material is aliquoted, may also contribute to the air emissions of a site. However, due to the low frequency of such aliquoting processes, these emissions are negligible.

It must be noted that, in many cases, the monitored exhaust stack(s) also receive Cr(VI) emissions from other sources, usually from other Cr(VI) containing treatment baths located in the same line or process area as the treatment bath(s) for anodising.

Figure 9-5: **Wet scrubber (a + b)**

Wastewater emissions

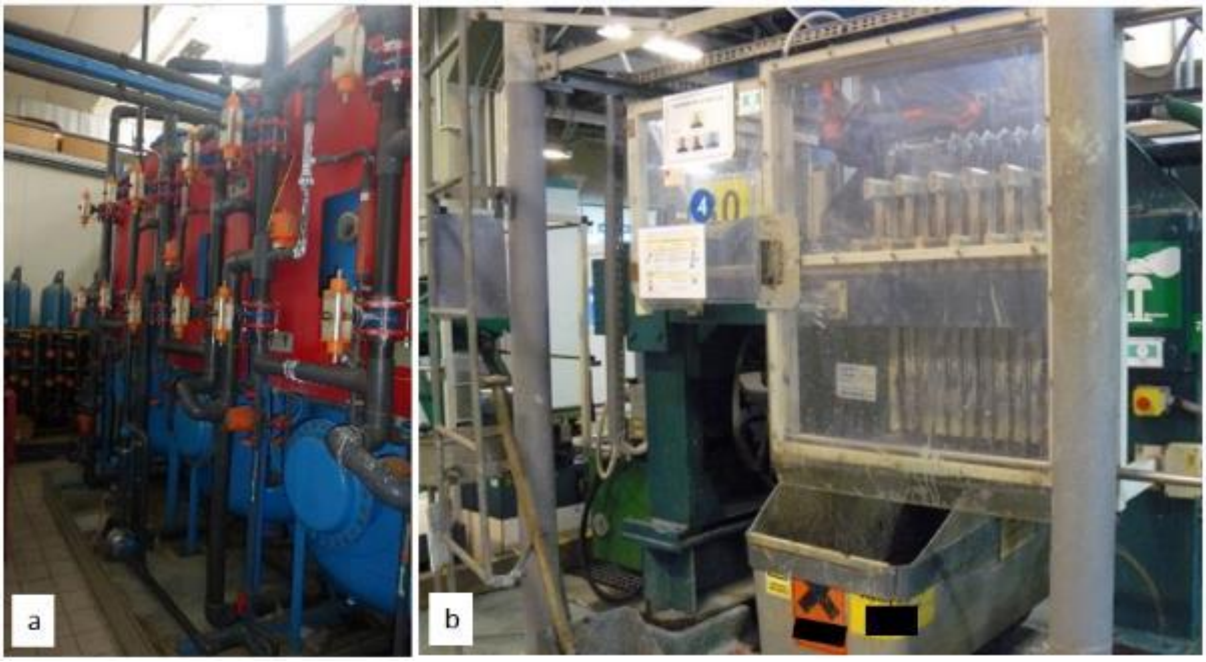
Cr(VI) containing wastewater can arise from the following sources:

- bath solutions (depending on the site and the Cr(VI) concentration) when they are renewed
- rinsing water from rinsing tanks
- cleaning water (e.g., from bath cleaning, cleaning of empty chemical containers, general/workplace cleaning, cleaning of equipment)
- liquid from secondary containment pits
- water from wet scrubbers
- liquid hazardous waste from samples processed in the laboratory

At some sites, the bath solutions may also be collected and sent to an external waste management company (licensed contractor) (depending on the site and the Cr(VI) concentration). At sites where wastewater is recycled after evaporation in an on-site evaporation system, the residue is discharged as hazardous solid waste or liquid waste. All other wastewater is sent to an on-site reduction plant, where Cr(VI) in wastewater is reduced to Cr(III) by addition of a reduction agent (e.g., sodium bisulfite or ferrous sulfate) in excess, to ensure Cr(VI) reduction to a concentration below the permitting limit. Afterwards the wastewater is neutralised, and Cr(III) is precipitated (Figure 9-6 a). The precipitated Cr(III) is then separated from the wastewater by a filter press (Figure 9-6 b) and the filter cake is disposed by a certified waste handling company. In the reduced wastewater the Cr(VI) content is usually measured with a photometric method to confirm sufficient reduction in accordance with the permitted limit before the wastewater is sent either to an external wastewater treatment plant

(WWTP) or municipal sewage water treatment plant (STP). In addition to the photometric determination of Cr(VI) in wastewater on-site, the Cr(VI) concentration in reduced wastewater is at many sites also determined in regular intervals by external laboratories, whereby often more sensitive analytical methods are used, allowing the detection of very low Cr(VI) concentrations in wastewater.

For the present assessment, we included both the monitoring data from on-site assessments with the photometric method as well as measurements carried out by external laboratories. Similarly as described above for the air emissions, also for wastewater, usually diverse sources contribute to the Cr(VI) emissions.



[redacted]

[redacted]

Figure 9-6: **Water deionisation tanks for wastewater treatment (a) and filter press for separation of the filter cake (b)**

Soil emissions

There is no direct release to soil, based on equipment and procedures in place.

9.2.3.1.2 Releases

The release fractions to water and air are calculated from the annual amount of Cr(VI) used at the sites and the amounts of Cr(VI) emitted to water and air. The site-specific release fractions are used as input for EUSES modelling of the environmental concentrations.

In case the emissions originated from several Cr(VI) sources (e.g., exhaust air measurement of a stack through which the exhaust air of five Cr(VI) baths for different applications is released, or collected wastewater emissions of ten different Cr(VI) baths), we calculated environmental concentrations based on the share of the emission relevant for anodising. This share was determined by dividing the

Cr(VI) amount used for anodising by the total Cr(VI) amount contributing to the measured emission (i.e., used for all uses contributing to the measured emission).

Twenty-one sites performing anodising with CT provided site-specific emission data for environmental emission modelling. Among these 21 sites, 16 are located in seven different countries in the EEA and five sites are located in the UK. Most of these sites perform additional surface treatments with Cr(VI) that contribute to air and water emissions (if any).

Table 9-14 shows ranges of release fractions and total emissions from the sites. These release fractions served as input for EUSES modelling of human exposure via the environment. Note that the calculated release fractions to wastewater refer to the emissions after the on-site reduction step.

We point out that **these results represent the overall releases of the sites, among which in each case only a certain share is generated by anodising**. The calculation of the share of exposure from anodising (as described above) is performed after the EUSES calculation. Site-specific information on releases, on wastewater (application of sewage sludge to agricultural soil/grassland, dilution in the treatment plant and in the receiving water) and on the share of anodising in the overall emission are given in Annex III of this CSR.

Table 9-14: Local releases to the environment

Release route	Release fraction [a]	Release [kg/year] [a]	Explanation/Justification
Air [b]	4.93E-07 - 9.30E-03 90th percentile: 5.54E-03	0.0001 – 43.1 90th percentile: 6.57	Measured release (site-specific data)
Water [b]	0 – 5.60E-02 90th percentile: 9.15E-03	0 – 4.86 90th percentile: 3.12	Measured release (site-specific data)
Soil	0	0	No release to soil

[a] The indicated ranges of release fractions to wastewater, air and soil are based on recent release data and tonnages provided by sites that are representative to cover the whole release spectrum relevant for this use.

[b] For values <LOQ a value corresponding to LOQ/2 was used, as described in ECHA´s Guidance on Information Requirements and Chemical Safety Assessment. Chapter R.16: Environmental exposure assessment (ECHA, 2016a). For wastewater emissions this is very likely an overestimation, since the upstream redox process leads to the almost complete conversion of Cr(VI) into Cr(III).

One large site (site 5) has a high air emission (43.1 kg/year) which is at least one order of magnitude higher than air emissions from other sites while the release fraction to air (9.30E-03) is comparable to the other sites. Thus, the air emission of this site is much higher than the 90th percentile over the releases from all sites. However, as only a small fraction of the air emission of this site is related to anodising, the total risk from environmental emissions from this site related to anodising is well within the range of total risk from all sites (see below).

Two sites (site 17 and site 1) have high water emission (3.57 and 4.86 kg/year respectively) which is at least one order of magnitude higher than water emissions from other sites. This is explained by their high release fractions to water (5.60E-02 and 1.16E-02 respectively) which are higher than those of all other sites (range from 0 to 5.60E-02). Thus, the water releases of these two sites is much higher than the 90th percentile over the releases from all sites. However, as only a small fraction of the water emission is related to anodising for site 1 and as only a small quantity of Cr(VI) is used at site 17 (<70 kg/y), the total risk from environmental emissions for these two sites related to anodising are well within the range of total risk from all sites (see below).

It has to be noted that six out of the 21 sites have no Cr(VI) emissions to water as all contaminated water is gathered and sent to an external waste management company (licensed contractor) for disposal.

The assumed release to soil is zero for all sites based on equipment and procedures in place.

Releases to waste

Solid wastes are disposed of as described above by certified companies specialised in hazardous waste disposal. No emissions from solid wastes are expected.

Release fraction to waste from the process: 0

9.2.3.1.3 Exposure and risks for the environment and humans via the environment

The calculated exposure concentrations for humans via the environment (on a local scale) per site are shown in Annex III. The EUSES modelling protocols can be provided upon request. The calculation of the share of exposure and risk specifically for the individual use is performed after the EUSES calculation.

The calculation of the share of exposure and risk from anodising is shown below in Table 9-15. Note that even for sites without emission to wastewater EUSES calculates oral exposure via deposition from air.

Table 9-15: Excess cancer risk estimates for humans via the environment (general population, local assessment) attributed to anodising

	Inhalation			Oral			
Site	**Local Cr(VI) PEC in air [µg/m^3]**	**Excess lung cancer risk [1/(µg/m^3)] [a]**	**Inhalation risk**	**Oral exposure (water and fish) [µg Cr(VI)/kg x d]**	**Excess cancer risk for tumours of the small intestine [1/(µg/kg bw/day)] [b]**	**Oral risk**	**Combined risk**
Site 1	4.85E-04	2.90E-02	1.41E-05	4.77E-05	8.00E-04	3.82E-08	1.41E-05
Site 2	1.83E-05	2.90E-02	5.31E-07	3.20E-04	8.00E-04	2.56E-07	7.87E-07
Site 3	2.51E-06	2.90E-02	7.27E-08	4.88E-05	8.00E-04	3.90E-08	1.12E-07
Site 4	2.33E-03	2.90E-02	6.75E-05	1.50E-02	8.00E-04	1.20E-05	7.95E-05
Site 5	5.48E-04	2.90E-02	1.59E-05	1.36E-05	8.00E-04	1.09E-08	1.59E-05
Site 6	1.63E-04	2.90E-02	4.72E-06	1.07E-05	8.00E-04	8.55E-09	4.73E-06
Site 7	3.86E-04	2.90E-02	1.12E-05	9.58E-06	8.00E-04	7.66E-09	1.12E-05
Site 8	5.19E-06	2.90E-02	1.51E-07	1.36E-07	8.00E-04	1.09E-10	1.51E-07
Site 9	8.32E-05	2.90E-02	2.41E-06	2.06E-06	8.00E-04	1.65E-09	2.41E-06
Site 10	2.51E-04	2.90E-02	7.28E-06	6.31E-06	8.00E-04	5.05E-09	7.29E-06
Site 11	5.57E-04	2.90E-02	1.62E-05	1.38E-05	8.00E-04	1.10E-08	1.62E-05
Site 12	2.66E-06	2.90E-02	7.70E-08	6.60E-08	8.00E-04	5.28E-11	7.71E-08
Site 13	5.85E-08	2.90E-02	1.70E-09	5.14E-06	8.00E-04	4.12E-09	5.81E-09
Site 14	3.77E-06	2.90E-02	1.09E-07	2.01E-06	8.00E-04	1.61E-09	1.11E-07
Site 15	5.78E-04	2.90E-02	1.68E-05	1.44E-05	8.00E-04	1.15E-08	1.68E-05
Site 16	7.22E-06	2.90E-02	2.09E-07	2.05E-07	8.00E-04	1.64E-10	2.09E-07
Site 17	1.47E-05	2.90E-02	4.26E-07	5.83E-04	8.00E-04	4.66E-07	8.93E-07
Site 18	1.14E-03	2.90E-02	3.30E-05	1.26E-04	8.00E-04	1.00E-07	3.31E-05

	Inhalation			**Oral**			
Site	**Local Cr(VI) PEC in air [µg/m^3]**	**Excess lung cancer risk [1/(µg/m^3)]** [a]	**Inhalation risk**	**Oral exposure (water and fish) [µg Cr(VI)/kg x d]**	**Excess cancer risk for tumours of the small intestine [1/(µg/kg bw/day)]** [b]	**Oral risk**	**Combined risk**
Site 19	1.03E-03	2.90E-02	2.98E-05	2.26E-03	8.00E-04	1.81E-06	3.16E-05
Site 20	3.65E-04	2.90E-02	1.06E-05	9.03E-06	8.00E-04	7.23E-09	1.06E-05
Site 21	3.74E-06	2.90E-02	1.08E-07	4.68E-05	8.00E-04	3.75E-08	1.46E-07
MIN	5.85E-08		1.70E-09	6.60E-08		5.28E-11	5.81E-09
MAX	2.33E-03		6.75E-05	1.50E-02		1.20E-05	7.95E-05
Median	1.63E-04		4.72E-06	1.36E-05		1.09E-08	4.73E-06
AM	3.80E-04		1.10E-05	8.83E-04		7.07E-07	1.17E-05
90th percentile	**1.03E-03**		**2.98E-05**	**5.83E-04**		**4.66E-07**	**3.16E-05**

[a] RAC dose-response relationship based on excess lifetime lung cancer risk (ECHA, 2013): Exposure to 1 µg/m^3 Cr(VI) relates to an excess risk of 2.9x10^{-2} for the general population, based on 70 years of exposure; 24h/day.

[b] RAC dose-response relationship based on excess cancer risk for tumours of the small intestine (ECHA, 2013): Exposure to 1 µg/kg bw/day Cr(VI) relates to an excess risk of 8x10^{-4} for the general population, based on 70 years of exposure; daily exposure.

Anodising	CT

For the use anodising, the 90th percentile for the local PEC in air is 1.03E-03 µg/m^3 and the 90th percentile for the inhalation risk is 2.98E-05. The 90th percentile for oral exposure is 5.83E-04 µg Cr(VI)/kg per day and the 90th percentile for the oral risk is 4.66E-07. **The 90th percentile for the combined risk of humans via inhalation and oral exposure is 3.16E-05.** Risks span a range of several orders of magnitude, mainly caused by differences in the size of the sites and amounts of substances used.

Note that the modelling of local air concentrations with EUSES is generally acknowledged as being overly conservative, as described in detail in section 9.1.2.4.2.

Conclusion on risk characterisation:

Carcinogenicity

Combined risks of cancer by inhalation and by the oral route from the local assessment result in an excess cancer risk of **3.16E-05 (90th percentile; range from 5.81E-09 to 7.95E-05)**. These theoretical cancer risks are based on a conservative, linear ERR. Further, due to the overly conservative nature of the predictions of the EUSES model for the local air concentrations the risk level can be considered as overestimated.

Based on the gathered information and considering the implemented RMM we conclude that risk of exposure is minimised.

Comparison of outcome with initial applications

The assessment of exposure of humans via the environment in this review report is based on measured data for emission to air and wastewater. For this assessment combined exposure of humans via the inhalation (air) and the oral (uptake of water and fish) route is considered.

Total exposure of humans via the environment via inhalation (90th percentile for local PEC in air = 1.03E-03 µg/m^3) and oral exposure (90th percentile for oral exposure from fish and drinking water = 5.83E-04 µg/kg per day) results in an estimated excess cancer risk of 3.16E-05 (90th percentile for combined risk).

In the initial applications only the inhalation route was considered for the assessment of human exposure via the environment. The following exposure was estimated:

Application ID	Chromate	90th percentile of PEClocal air,ann [µg/m^3]	Excess lung cancer risk
0032-04	CT	0.00325	9.43E-05
0032-05	CT	0.00325	9.43E-05

The excess lung cancer risk in the initial applications is 9.43E-05 for CT. This risk is slightly higher than the combined risk of 3.16E-05 as estimated in the present assessment.

9.2.3.2 Worker contributing scenario 1 – Line operators

Line operators for anodising are usually involved in numerous activities related to the anodising process. Most of their working time they spend in a hall where the anodising tanks are located and where the immersion process takes place, on activities either with direct or indirect Cr(VI) exposure. Typical activities with possible Cr(VI) exposure performed by line operators are:

Main tasks

- Task 1: Anodising via immersion or dipping, followed by rinsing and drying of parts (PROC 13)
- Task 2: Sampling of treatment baths (PROC 9)
- Task 3: Diverse cleaning activities – Cleaning of workplace, equipment, jigs (PROC 28)
- Task 4: Selective (swab) anodising (PROC 9, PROC 10)

Secondary tasks

- Task 5: Bath make-up and addition, including decanting of substances and mixing them with water (PROC 5, PROC 8b)
- Task 6: Bath emptying and cleaning (PROC 28)
- Task 7: Waste management – Cleaning of empty chemical containers/bags (PROC 28)
- Task 8: Waste management – Handling of solid waste (PROC 8b)
- Task 9: Aliquot chemicals – Decanting of liquids (PROC 8b)
- Task 10: Aliquot chemicals – Measuring and weighing of solids (PROC 8b)

As tasks 5 to 10 are main tasks performed by the storage area workers, they are described in detail in the relevant worker contributing scenario (section 9.2.3.3).

Line operators might also be engaged in other activities not related to uses of Cr(VI) (e.g., loading/unloading of jigs or activities on non-Cr(VI) baths), and thus not be directly exposed. However, they may still experience indirect exposure when they perform tasks in the vicinity of running baths.

In the following sections, the conditions of use for each task with potential direct Cr(VI) exposure are specified and the individual activities are described in more detail.

9.2.3.2.1 Conditions of use

Table 9-16 summarises the conditions of use for the activities with direct Cr(VI) exposure related to anodising carried out by line operators.

Table 9-16: Conditions of use – worker contributing scenario 1 – Line operators

Product (article) characteristics
Product 1: Aqueous solution of CT for Tasks 1 to 3 ▪ Concentration of substance in mixture for bath applications: up to 5.2% (w/w) Cr(VI) (based on ranges of CT (2.8-10% (w/w)) in the aqueous solution in the anodising bath) ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Product 2: Mixture containing CT for Task 4 ▪ Concentration of substance in mixture for selective (swab) anodising: max. 2.6% (w/w) Cr(VI) (based on CT concentration (up to 5% (w/w)) in the electrolyte solution used for selective anodising) ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)

Amount used (or contained in articles), frequency and duration of use/exposure

Task 1: Surface treatment by dipping/immersion
- Duration of activity: <10-140 min/shift (time spent close to the bath)
- Frequency of task: <1-240 days/year (<1-5 days/week, 48 weeks/year)

Task 2: Sampling of treatment baths
- Amount: 5-300 mL Sample
- Duration of activity: 1-20 min/shift
- Frequency of task: 12-240 days/year (<1-5 days/week, 48 weeks/year)

Task 3: Cleaning of workplace, equipment, jigs
- Duration of activity: 5-45 min/shift (with low frequency of 1x/month up to 180 min)
- Frequency of task: 24-240 days/year (1 day/2 weeks up to every day, 48 weeks/year)

Task 4: Selective (swab) anodising
- Amount used per application: 100 mL
- Duration of activity: 3-20 min/shift
- Frequency of task: 12-96 days/year (once/month to 2 days/week, 48 weeks/year)

Technical and organisational conditions and measures

Task 1: Surface treatment by dipping/immersion
- LEV: yes
- Ventilation rate of general ventilation system: natural ventilation
- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Task 2: Sampling of treatment baths
- LEV: yes
- Ventilation rate of general ventilation system: natural ventilation
- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Task 3: Cleaning of workplace, equipment, jigs
- LEV: no
- Ventilation rate of general ventilation system: natural ventilation
- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Task 4: Selective (swab) anodising
- LEV: yes
- Ventilation rate of general ventilation system: natural ventilation
- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Conditions and measures related to personal protection, hygiene, and health evaluation

Gloves

Chemical resistant gloves are worn during all tasks (Tasks 1 to 4), except for Task 1 on an automatic or semi-automatic line.

All gloves used for the handling of chemicals are tested according to EN 374. A variety of materials are suited for protection against CT.

The following materials have a breakthrough time ≥8h for aqueous CT solutions (10% CT)[a]:

- Natural rubber/Natural latex (0.5 mm)
- Polychloroprene (0.5 mm)
- Nitrile rubber/Nitrile latex (0.35 mm)
- Butyl rubber (0.5 mm)
- Fluorocarbon rubber (0.4 mm)
- Polyvinyl chloride (0.5 mm)

Type of gloves to be used for specific tasks is laid down in work instructions for the tasks.

Respiratory protection equipment

RPE is worn during all tasks not performed under an LEV for which industrial hygiene exposure assessment confirms RPE use is required.

The following types of RPE are used according to EN 529:2005 [b]:

- Half mask FFP3 (APF 10), half mask with P3 filter (APF 10), half mask with P3 combination filter (APF 10) or
- Full mask with P3 filter (APF 20), full mask with P3 combination filter (APF 20)

Type of RPE to be used for specific tasks is laid down in work instructions for the tasks.

Protective clothes

Chemical protective clothing must be worn during Tasks 1, 3 and 4. For all cleaning activities performed with a hose the workers wear an apron and waterproof boots.

Type of protective clothes to be used for specific tasks is laid down in work instructions for the tasks.

Eye protection

Suitable eye protection (as per relevant risk assessment) must be worn during all tasks (Tasks 1 to 4).

Type of eye protection to be used for specific tasks is laid down in work instructions for the tasks.

Other conditions affecting workers' exposure

Task 1: Surface treatment by dipping/immersion

- Place of use: indoors – any size workroom
- Temperature: up to 50 °C (range 25-50 °C)
- Situation: Activities with open liquid surfaces or open reservoirs
- Open surface: typically 0.1-3 m^2 and rarely up to 6 m^2
- Agitation: yes (not in every case)
- Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)

Task 2: Sampling of treatment baths

- Place of use: indoors – any size workroom

▪ Temperature: up to 50 °C (range 25-50 °C) ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m) ▪ Activity class: Activities with relatively undisturbed surfaces (no aerosol formation) ▪ Open surface: typically 0.1-3 m^2 and rarely up to 6 m^2
Task 3: Cleaning of workplace, equipment, jigs ▪ Place of use: indoors – any size workroom ▪ Temperature: room temperature ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)
Task 4: Selective (swab) anodising ▪ Place of use: indoors – any size workroom ▪ Temperature: room temperature ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m) ▪ Activity class: Spreading of liquid products ▪ Situation: Spreading of liquids at surfaces or work pieces <0.1 m^2/hour
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
▪ None

[a] https://www.dguv.de/ifa/gestis/gestis-stoffdatenbank/index.jsp ; accessed 8 December 2020

[b] For selection of APF see Annex V of this report.

9.2.3.2.2 Exposure and risks for workers

Between individual sites, the number of line operators working on anodising is variable, depending on the size of the site, the organisation of the treatment process (one individual bath vs. several baths organised in one or several lines, automatic vs. manual process) and the throughput and distribution of work. Also, the number of work shifts varies from site to site; one to three shifts per day are run at the sites. The shift duration is usually 8h but may also be up to 12h, depending on the organisation of the site and national law.

Usually, one to three line operators work per shift on lines where anodising is performed. Anodising is commonly not a full-time activity of the line operators. The remaining part of their shift they spend on other activities related to the line, e.g., pre- and/or post-treatment, which is performed with or without Cr(VI). However, relevant contributions from other Cr(VI)-related activities cannot be assumed for the majority of workers.

At some sites, also supervisors or process engineers who accompany the line operators may perform the tasks listed for line operators (spending a relevant part of their working time at the line). For those sites, the number of workers counted for line operators also includes these supervisors and process engineers.

We describe below in detail the relevant activities with direct Cr(VI) exposure for line operators and the working conditions.

Task 1: Surface treatment by dipping/immersion

The process of anodising is mostly carried out by immersion of metallic parts into a treatment bath. The parts are typically hung on or wired up to a grid, hook, or a jig (depending on the size and shape of the parts) and then immersed in the process bath. Often, when the parts are hung on a grid or wired up, the grid is also immersed in the bath.

Depending on the automation level of the process at the respective site, the line operator either

- manually transports the jig to the bath and hangs it in the bath, or
- moves it to the bath and immerses it by means of a crane, which he manoeuvres in short distance to the bath using a control device (semi-automated process), or,
- in the case of an automated process, he controls a pre-programmed, crane-controlled immersion process from a monitor located at some distance from the bath in a separate control area/room (Figure 9-7).

The degree of automation for this process is highly dependent on the frequency of this application in the respective site (high throughput applications processes are more likely to be semi-automated or automated), but the geometry and weight of the part also plays a decisive role in how far the process can be automated. All chemical treatment baths are equipped with LEV which is running while the bath is in use.

The immersion baths typically have a size between 1 and 15 m^3, but it can reach 20 m^3 at some sites. The Cr(VI) concentration in the bath ranges from 1.5 to 5.2 % (w/w) and the process temperature is between 25 and 50 °C.

The immersion process is typically performed between <1 (at sites with frequencies of one time/week or less) and 70 times per week, with a frequency ranging from <1 to 14 times per shift. The duration of the immersion process is between 30 and 120 min, but in case of an automated process, the line operator is not in the proximity of the bath during the treatment process. During a manual or semi-manual process, the line operator will only be close to the bath for up to 10 min of the immersion process, in between he will leave the bath area. Based on this, the time spent close to the bath ranges between 10 and 140 min per shift (max 14x/shift for 10 min).

In some cases, prior to the immersion process, the parts need preparatory work (e.g., grit blasting in case of MRO activities). These activities are described in the dedicated worker contributing scenario (see section 9.2.3.6). In other cases, after anodising, inorganic finish stripping needs to be performed in case of quality problems (non-conformity observed after the treatment process or for MRO activities). The part is then stripped and subjected to a second anodising process to restart the treatment over.

After the anodising bath, the parts are usually rinsed by immersion into one or two drag-out and/or rinsing tanks or by using a spray, a water-air gun or a hose for parts with geometric constraints (e.g., blind holes, recesses). In case of an automatic line, the parts may also be automatically rinsed with water steam while they are lifted by crane from the anodising bath, before they are immersed into a rinsing tank. The number of rinsing steps after the treatment process is variable from site to site and can depend on the Cr(VI) concentration in the treatment tank and on the wastewater treatment system of the site. The rinsed parts are then dried at room temperature, with compressed air, or in a dryer (temperature ca. 40 °C). Depending on the customer requirements, the treated part may need to be sealed as a final step. The anodise sealing process can involve again Cr(VI) or not.

When the anodising baths are not in use, they are usually cooled down to room temperature and covered with a lid to reduce the indirect Cr(VI) exposure for the workers in the vicinity.

Whenever the line operator is close to the treatment baths during the immersion process (including rinsing), he wears eye protection (as per relevant risk assessment), chemical resistant gloves, and a chemical protective clothing, as specified above in Table 9-16.

Figure 9-7: **Automatic line with control area in front of automatic line (at the monitor)**

<u>Task 2: Sampling of treatment baths</u>

The treatment baths are sampled at regular intervals to determine the Cr(VI) concentration and potentially also other parameters of the treatment solution. Typically, the line operator takes a sample volume of 5-300 mL and performs sampling by one of the following techniques:

- Immersion of a sampling bottle or a vessel of typically 50-300 mL by hand into the treatment bath and filling it with up to 300 mL of bath solution. Then the vessel is closed and rinsed several times in the rinsing bath(s) (located after the treatment bath), before being transported to the laboratory. When using this technique, the line operator takes care that the glove itself does not come into contact with the bath solution.
- The sampling bottle is attached to a metal or plastic rod and is immersed.
- A specific plastic sampling rod or a pipette is used with which a sample can be drawn up and transferred into a sample bottle (Figure 9-8).
- The sample is taken from a sampling tap installed at the bath. For this, the line operator holds a bottle under the tap and briefly opens and closes the tap to drain the required volume of solution from the bath.

The process of sampling and rinsing the sampling bottle/device takes up to 20 min (typically 1-3 min). The concentration of the sampled anodising bath is identical to the one described for the immersion process (i.e., up to 5.2% Cr(VI)), the concentrations of the rinsing baths are much lower. The sampling can be carried out at temperatures between 25 and 50 °C and the LEV is running during this activity. The frequency of sampling is variable between different sites, depending on the frequency in which the immersion process is carried out and bath make-ups or additions are necessary at the respective site, ranging between 10x/week (5 days/week, twice per day) and less than once per month.

During sampling, the line operator wears eye protection (as per relevant risk assessment) and chemical resistant gloves, and RPE (when sampling needs to be performed at a bath without a running LEV system and industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-16.

At some sites it may be the case that the sampling process as described above might not be carried out by the line operator but by the storage area worker (see section 9.2.3.3) or the laboratory technician (see section 9.2.3.4).

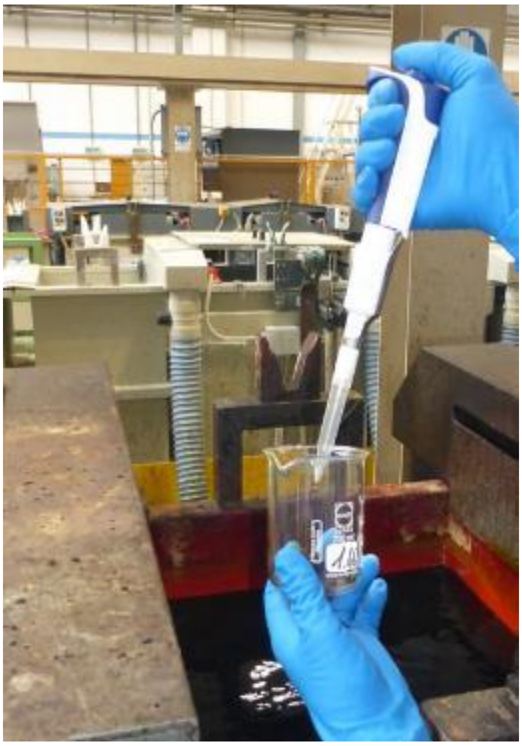


Figure 9-8: **Sampling with a pipette for smaller volumes**

Task 3: Cleaning of workplace, equipment, jigs

General cleaning activities are regularly integrated in the daily routine and sporadic cleaning tasks are part of the responsibilities of line operators.

A typical regular cleaning activity performed at most sites is the cleaning of the floor around the bath at the end of a treatment sequence for the shift or working day. For this, the worker either rinses the floor around the baths with a hose, (the rinse water drains into the tank pits below the baths; see

Figure 9-9), or he wipes the floor with a wiper mop (the cleaning water he disposes of in the on-site reduction plant).

Regular cleaning of external tank surfaces or of equipment such as jigs, hooks, or containers used for bath additions/make-ups is typically performed by rinsing the equipment in the rinsing tanks or wiping the contaminated surfaces with paper towels or rags.

At some sites, where the treatment baths are surrounded by walkways and rinsing water from walkway cleaning is collected in drains in the basement (from where the water is sent to the wastewater collection tank(s)), it is regularly (1x/month) necessary to clean the basement (e.g., with a hose). Usually the entire basement (below numerous lines and tanks) is cleaned by 1-3 workers. This cleaning work usually takes up to three hours.

Sporadic cleaning is, for instance, necessary when splashes occur from the immersion process, which the line operator rinses with water and/or wipes up with paper towels or rags, which are disposed of as hazardous solid waste. Another cleaning activity which occurs occasionally is when the baths are refilled with chemicals and some dust may deposit on the edges of the bath, which are then either removed, e.g., by wet cleaning with a rag, a hose, or vacuum cleaning (waste managed as solid hazardous waste).

For the present assessment, a regular general cleaning of the workplace, including equipment and jigs (if necessary), is considered as an integrated duty in the daily routine. Accordingly, line operators perform workplace cleaning from three times per day (1x/shift) to at least once every two weeks, i.e., up to 240 days per year, with a total duration of 5 to 45 min per day where cleaning is performed. This scenario constitutes a reasonable worst-case, which also covers spontaneous cleaning whenever this may be necessary. As described above, for larger cleaning tasks of low frequency (such as basement cleaning, performed 1x/month), the duration may be up to 180 min. The cleaning is carried out at room temperature, and the line operators may come into contact with splashes of the treatment bath which contain a maximum of 5.2% Cr(VI) (the maximum concentration described for the immersion process above) or splashes of cleaning water from wiping solid dust (maximum Cr(VI) concentration in the cleaning water considered equal to that in the treatment baths). If cleaning is carried out with a hose the line operators may come into contact with aerosols formed from cleaning water and bath solution or cleaning water and solid chromate from bath solution dried on the floor or tanks. Cleaning with the hose results in rapid dilution of the bath solution of substance dried on the floor. Since any potential dust circulation is prevented by wet cleaning or vacuum cleaning negligible risk of dust exposure during cleaning activities exists. Technically it is impossible to have a suitable LEV installed wherever cleaning could occur and thus, cleaning is not performed under use of an LEV.

For all these general cleaning activities the line operator wears eye protection (as per relevant risk assessment), chemical protective clothing (for all cleaning activities performed with a hose he also wears an apron and waterproof boots), chemical resistant gloves, and RPE (if not performed under an LEV and industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-16.


[redacted]

Figure 9-9: Hose for cleaning the edges of the tanks and the walkways surrounding the baths

Task 4: Selective (swab) anodising

Selective (swab) anodising may be required as localized treatment or as repair process when damage to the anodised layer is caused during manipulation or other internal processes. After assembly with other components, re-immersion or disassembly of the parts is generally impossible. Therefore, the swab process is required to locally touch up the areas that need it. The surfaces to be treated can be small scratches or slightly larger surfaces that have been prepared by localised polishing; they generally do not exceed 1 cm².

Usually, the line operator performs selective (swab) anodising by one of the following techniques:

- The surface to be treated is cleaned and prepared. Depending on the surface of the part, line operator can use either abrasive cloth, powered tool, cutter, scraper, sanding mat (under wet condition to reduce the emission of dust) or chemical mixture.
- The anodising solution is applied using a graphite or platinized titanium electrode, wrapped in a cotton bag. The anode is dipped in the solution, the cotton bag soaks up the solution, and the electrode is then applied to the surface of the part to carry out the electrolysis.
- The electrode is applied to the part and wetted with the solution using a squeeze bottle.
- The treatment is carried out using a stick connected to a pump that delivers the solution according to the flow required. This technique allows local anodising without any electrolyte flow or leakage.

For each of these techniques, the swab/electrode is connected to a rectifier that delivers the required voltage. For the first two techniques, the line operator prepares either in a beaker or in a bottle up to

100 mL of the anodising solution (ready-to-use product). For the third technique, the solution is transferred into bottles with specific caps which are connected to a pump delivering the solution as needed.

The selective (swab) anodising takes up to 20 min (typically 3-10 min), including the solution preparation. The Cr(VI) concentration in the electrolyte solution is up to 2.6% Cr(VI). This treatment is carried out in a galvanic area workstation or in a dedicated room, at room temperatures and a LEV system (articulated extraction arm or fixed LEV) is used during this activity. The frequency of selective anodising and number of parts to treat per batch is variable between different sites. Touch-up can be required from once per month to twice a week, with maximum ten parts per batch (typically 2-3 parts).

During selective (swab) anodising, the line operator wears eye protection (as per relevant risk assessment), chemical protective clothing, chemical resistant gloves, and RPE (if not performed under an LEV and industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-16.

Selective (swab) anodising is carried out by some of the line operators who have been trained for swab plating. Each of these operators carrying out local anodising also performs immersion treatments in parallel. None of these operators is solely dedicated to this task.

9.2.3.2.2.1 Inhalation exposure

Measured inhalation exposure concentration

In total, 115 personal and 35 stationary measurements covering exposure from anodising are available for this SEG. Four personal measurements were excluded from further analysis because they were below an unreasonably high LOQ (i.e., <19.6 µg/m^3, <14.3 µg/m^3 for two short-term measurements and <2 µg/m^3 for two long-term measurements). Two additional personal measurements taken at one site showing high exposure values (2.8 and 2.2 µg/m^3) were excluded, as, according to the reporting by the site, the monitored operators smoked certain cigarette brands where “significant levels of Cr(VI) have been found within the tobacco” of these cigarettes, which they considered as a potential source for higher Cr(VI) exposure. Since these two measurements were repeated four weeks later showing much lower exposure values (both <0.7 µg/m^3) of the workers performing the same activities (anodising with CT and other immersion activities with Cr(VI)), we excluded the initial measurements from further analyses, as the source of exposure was apparently unrelated to the tasks performed and was ruled out in the second measurements.

Of the remaining 109 personal monitoring data, 92 are long-term (≥2h)[7], shift-representative and 17 are short-term (<2h) measurements. The personal monitoring data come from 23 sites of nine countries in the EEA (85 measurements, including 11 short-term measurements) and from seven sites in the UK (24 measurements, including six short-term measurements). About 64% of the data (70 values) are <LOQ and 36% (39 values) are >LOQ.

Among the 35 stationary measurements, 34 are long-term (≥2h) and one is a short-term (<2h) measurement. Of the 35 stationary data, 25 values come from ten sites located in seven EEA countries

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[7] All long-term measurements (≥2h) are considered as shift-representative measurements and used as such as 8h TWA exposure values; no recalculation has been performed. Measurements <2h were not used to calculate 8h TWA exposure values.

and ten values come from four sites in the UK. Twenty-three stationary measurements (66%) are <LOQ and 12 values (34%) are >LOQ.

A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex IV of this report. The individual measurements can be provided upon request. An overview of the available data for line operators is given in Table 9-17.

Table 9-17: Overview of available inhalation exposure measurements for WCS 1 – Line operators

	N	>LOQ	<LOQ
Personal			
- Long-term (≥2h)	92	36	56
- Short-term (<2h)	17	3	14
Stationary			
- Long-term (≥2h)	34	12	22
- Short-term (<2h)	1	-	1

<u>Personal measurements – long-term</u>

Long-term personal measurements were taken for operators working at lines where anodising with CT is performed. However, during many of the measurements, the line operators also had (potential) Cr(VI) exposure from other uses (e.g., deoxidising, pickling/etching, inorganic finish stripping, passivation of (non-Al) metallic coatings, conversion coating, anodise sealing) with CT and/or other chromates. In addition, the workers may also have carried out Cr(VI) treatments for other industrial sectors (i.e., non- aerospace and defence relevant sectors). During the personal measurements, the line operators were mainly engaged in performing and controlling the immersion process for anodising (Task 1) and other dipping processes with or without Cr(VI) (e.g., the uses described before). Also, during numerous measurements, the workers were hanging parts on racks, or unhanging them, performing masking activities, cleaning the workplace or equipment (Task 3) and sometimes performing sampling of the treatment baths (Task 2). Furthermore, seven measurements reported a bath make-up or addition (secondary task of line operators), including at least in five cases also the substance weighing/measuring.

The arithmetic mean (AM) over the total of long-term personal measurements is 0.318 µg/m^3 and the 90th percentile is 0.591 µg/m^3 (Table 9-18).

These data cover the anodising process on manual, semi-manual or automatic lines. Twenty of the measurements (22%) were taken from operators only working at automatic lines, all other values include work on manual and/or semi-manual lines or no information is available on the type of line. The AM over the long-term personal measurements on automatic lines is 0.264 µg/m^3 and the 90th percentile is 0.580 µg/m^3, very similar to the values obtained from the total long-term personal measurements. Therefore, all exposure values related to automatic, semi-automatic, and manual processes are considered jointly in this assessment.

The seven measurements during which bath make-up or addition (partly in combination with measuring/weighing of the substance) were performed show exposure values in the range of 0.0035 - 0.4 µg/m^3 with an AM of 0.113 µg/m^3 and are therefore within the range of all long-term measurements for line operators: no clear exposure effect of handling the pure substance during part of the measurement is discernible.

Of the total of long-term personal measurements, 12 values (13%) were taken while the workers performed only activities related to anodising, but not to any other Cr(VI) use (according to the information provided by the sites). The AM over these single-use personal measurements is 0.159 µg/m^3 and the 90th percentile of these measurements is 0.360 µg/m^3, which is lower than the 90th percentile of the measurements covering activities related to anodising in combination with other Cr(VI) uses. However, it is not possible to conclude from this whether exposure from anodising is lower than exposure from other Cr(VI) uses, because it is not clear from the available information on the measured values whether workers spent as much or less time on Cr(VI) activities during these 12 measurements than during measurements that also covered other Cr(VI) uses. It should also be noted that none of these measurements involved bath additions.

Personal measurements – short term

Of the 17 short-term measurements, six values cover specifically the sampling activity (Task 2) and six only the selective (swab) anodising (Task 4). The AM of the 19 short-term exposure values is 0.235 µg/m^3 and the 90th percentile of these measurements is 0.719 µg/m^3.

Looking specifically at the six measurements covering only selective (swab) anodising, all the results are below the LoQ, the AM is 0.089 µg/m^3, which is well below the AM of long-term personal measurements. It is not clear from the available information whether this activity was specifically performed under a LEV, but it is reported that RPE (half-mask respirator FFP3) was worn during all six measurements.

Despite the low measurement durations and the resulting higher LOQs, the AM of the 17 short-term measurements is below the 90th percentile of the long-term measurements, suggesting that exposure from the individual activities such as sampling or selective (swab) anodising does not differ substantially from the shift-average exposure of operators working at lines where anodising is performed.

Stationary measurements

The AM of the 34 long-term stationary measurements available for anodising is 0.358 µg/m^3. Nineteen of these measurements can be clearly assigned to anodising activity only. For the other measurements, it is unclear from the data description adjacent to which tank of the process line (including Cr(VI) chemical bath) the device was positioned. For these 15 values, the result is affected to all Cr(VI) uses performed on the process line (including anodising) or in some cases to all uses performed on site.

The 90th percentile of the anodising specific 19 measurements (0.540 µg/m^3) is comparable to the 90th percentile of the shift average measurements from personal monitoring of line operators (0.591 µg/m^3), suggesting that exposure of line operators performing anodising is close to the background exposure level of anodising lines.

One short-term measurement was sampled 1 meter from the working table where a worker performed selective (swab) anodising. The result was below the LOQ (<0.143 µg/m^3; 50 min).

Table 9-18 shows the summary statistics of workplace measurements for line operators. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. All measurements are from 2015 through 021.

Table 9-18: Summary statistics of inhalation exposure measurements for WCS 1 – Line operators

Personal – long-term (measurement period 2015-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	92	100	0.318	0.640	0.100	0.591
Automatic process	20	22	0.264	0.433	0.100	0.580
Only this use covered by the measurement	12	13	0.159	0.163	0.077	0.360

Personal – short-term (measurement period 2015-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	17	100	0.235	0.283	0.105	0.719
Only covering selective swab anodising process	6	35	0.089	n.a.	n.a.	n.a.

Stationary (measurement period 2015-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	35	100				
- Long-term	34	97	0.358	0.467	0.217	0.784
Only this use covered by the measurement	19	54	0.252	0.278	0.166	0.540
- Short-term	1	3	n.a. [a]	n.a.	n.a.	n.a.

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

n.a. = not assessed; the statistical parameter was only determined if at least three (for AM) or ten (for SD, Median and 90th percentile) values were available.

[a] The value is 0.0715 µg/m^3.

Risk characterisation is based on the complete set of long-term personal measurements. Table 9-19 shows the resulting long-term inhalation exposure concentration for line operators used for risk assessment, based on the 90th percentile of personal sampling values.

As stated above, partial exposure from sources and processes not related to the use of anodising may have contributed to some of the exposure values assigned to this use. However, the 90th percentile of the single-use measurements is lower than the 90th percentile of the total of the long-term measurements. Therefore in a conservative way, 100% of the shift average exposure value (90th percentile of all long-term measurements) is assigned to this use.

Typically, one or three operators work per shift and one to three shifts are operating per site, depending on the size and organisation of the site. This leads to a theoretical range of one to nine workers engaged per site per day. In the following we assume that as a conservative average, **five line operators** per day are engaged in this use per site. For sites where the work is distributed among a higher number of workers, a higher number of people would have to be considered, but their long-term average individual exposure concentration would be lower.

RPE is sometimes worn for specific, short-term activities only (e.g., during selective (swab) anodising as described for the short-term measurements), but usually not for immersion (Task 1) because LEV is in place. Therefore, no RPE is considered in the exposure assessment, which constitutes a further conservative element of the assessment.

Table 9-19: Measured inhalation exposure concentration for WCS 1 – Line operators

Type of measurement	Number of measurements	Exposure value (8h TWA) [a] [μg/m³]	Assigned protection factor (APF) for RPE [b]	Exposure value corrected for RPE [μg/m³]	Long-term exposure [c] [μg/m³]
Personal	92	0.591	1	0.591	0.591

All exposure values rounded to three significant figures for presentation, but unrounded values were used for calculation of exposure.

[a] Based on 90th percentile of measurements.

[b] No RPE is considered, see text above

[c] No frequency/duration correction factor was applied (see text above).

9.2.3.2.2.2 Risk characterisation

Risk for carcinogenicity

Table 9-20 shows the risk characterisation for carcinogenicity for line operators. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for line operators and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-20: Risk characterisation for carcinogenicity for WCS 1 – Line operators

Route of exposure and type of effects	Long-term exposure [μg/m³]	Risk characterisation: Excess lifetime lung cancer risk * [1/μg/m³]	Excess lifetime cancer risk (ELCR)
Inhalation: Systemic Long Term	0.591	4.00E-03	2.36E-03

All values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

Anodising	CT

* RAC dose-response relationship based on excess lifetime lung cancer risk (ECHA, 2013): Exposure to 1 µg/m^3 Cr(VI) relates to an excess risk of 4x10^{-3} for workers, based on 40 years of exposure; 8h/day; 5 days/week.

Conclusion on risk characterisation:

Carcinogenicity

The Excess life-time cancer risk for line operators is 2.36E-03.

This risk estimate can be considered as conservative, because:

- it is based on a conservative exposure-risk relationship (ERR),
- it uses the 90th percentile of the reported long-term measurements,
- these measurements were not corrected for their duration but assumed to be shift representative values,
- and no correction for wearing RPE was applied although workers may wear RPE under certain conditions for some short-term activities (such as cleaning, sampling or selective (swab) anodising).

As described above, it is considered for the assessment that **five line operators** per day and site work on the line(s) where anodising is performed.

Based on the gathered information and considering the implemented RMM we conclude that risk of exposure is minimised.

Comparison of outcome with initial applications

Inhalation exposure

In the initial applications, long-term inhalation exposure was determined by personal monitoring of workers typically performing the following activities:

- Loading of jigs (PROC 4); no LEV
- Chemical pre-treatment (PROC 13); LEV was used
- Dipping/immersion (PROC 2, PROC 13); LEV was used
- Rinsing/drying (PROC 13); no LEV
- Chemical post-treatment (PROC 13); LEV was used
- Cleaning and unloading of jigs (PROC 4); no LEV
- Cleaning of equipment (PROC 8b); no LEV
- Maintenance of equipment (PROC 8a) (regular maintenance); no LEV

This task list is broadly comparable with the activities carried out by the SEG line operators in the present assessment. During measurements included in the present assessment, mostly immersion processes and some cleaning of workplace/equipment were performed.

Initial assessment				**Present assessment**	
Application ID	**Chromate**	**Inhalation, long-term exposure, 90th Perc. [µg/m^3]**	**Excess lifetime lung cancer risk [1/µg/m^3]**	**Inhalation, long-term exposure, 90th Perc. [µg/m^3]**	**Excess lifetime lung cancer risk [1/µg/m^3]**

0032-04	CT	1.25	5.00E-03	0.591	2.36E-03
0032-05	CT	1.25	5.00E-03		

As shown in the table above, the excess lifetime lung cancer risk for line operators in the present assessment (2.36E-03) is by factor 2 lower than the risk calculated in the initial applications. The current assessment is based on a broader database and supported by additional data (short-term and stationary measurements).

Sampling

In the initial applications, inhalation exposure from sampling was modelled with ART 1.5 as part of two sub-activities:

- Sub-activity 1: Drawing of sample and transfer to the laboratory (<30 min)
- Sub-activity 2: Laboratory analysis (<60 min)

Modelling assumed that sampling was performed under a capturing hood (90% efficiency), without RPE. The Cr(VI) concentrations in the samples were up to 50% for CT.

For the present assessment, the laboratory analysis of samples is not considered as this activity is exempted from authorisation (see explanation in section 9.2.3.4). Sampling is covered by some shift average measurements (12) and a few short-term measurements performed on line operators, the exposure during sampling is considered to be within the 90th percentile of shift average personal measurements.

As shown in the table below, the excess lifetime lung cancer risk based on modelled inhalation exposure was up to 2.76E-03 µg/m^3 in the initial applications. The excess lifetime lung cancer risk for shift average measurements (including sampling activities) in the present assessment is with 2.36E-03 slightly lower than the risk calculated in the initial applications, but since the measurements cover multiple Cr(VI) tasks it can be assumed that the exposure from only the sampling activity is much lower.

Initial assessment				**Present assessment**	
Application ID	**Chromate**	**Inhalation exposure, 90th Perc. [µg/m^3]**	**Excess lifetime lung cancer risk [1/µg/m^3]**	**Inhalation exposure, 90th Perc. [µg/m^3]**	**Excess lifetime lung cancer risk [1/µg/m^3]**
0032-04	CT	0.69	2.76E-03	included above (0.591)	included above (2.36E-03)
0032-05	CT	0.69	2.76E-03		

Selective (swab) anodising

The inhalation exposure from touch-up by brushing was modelled with ART 1.5 in the initial application for CT.

Modelling for CT assumed that the touch-up was performed without LEV or RPE. The Cr(VI) concentrations was up to 5% for brushing.

For the present assessment, as exposure from short-term measurements covering specifically selective (swab) anodising process is below long-term personal measurements, in a conservative way, 100% of the shift average exposure value (90th percentile of all long-term measurements) can be assigned to this task.

Initial assessment				Present assessment	
Application ID	**Chromate**	**Inhalation exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**	**Inhalation, long-term exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**
WCS 21 – Touch-up by brushing (PROC 10)				included above (0.591)	included above (2.36E-03)
0032-04	CT	0.69	2.76E-03		
0032-05	CT	0.69	2.76E-03		

As shown in the table above, the excess lifetime lung cancer risk based on modelled inhalation exposure was 2.76E-03 µg/m^3 in the initial applications. The excess lifetime lung cancer risk calculated from shift average measurements in the present assessment is below with 2.36E-03. Moreover, considering the low duration and frequency in which this task is performed plus the short-term results available for this task, it can be assumed that the exposure from the selective (swab) anodising activity alone is much lower.

9.2.3.3 Worker contributing scenario 2 – Storage area workers

The SEG defined as "storage area workers" comprises workers who perform several relevant activities related to anodising with potential for Cr(VI) exposure, but who may have different names at diverse sites (e.g., chemical lab department worker, chemical operator, ...). Storage area workers are involved in several activities related to anodising with potential for Cr(VI) exposure, but these tasks account only for a small fraction of their working time and mostly they are occupied with activities not related to anodising and without Cr(VI) exposure.

The storage area workers are responsible for ordering, storing, transporting, delivering, and managing the chemicals used at a site. They spend a considerable part of their working time on transport and handling of chemicals in closed containers, where no opportunity for Cr(VI) exposure exists. Typical tasks with potential Cr(VI) exposure are:

Main tasks

- Task 1: Aliquot chemicals – Decanting of liquids (PROC 8b)
- Task 2: Aliquot chemicals – Measuring and weighing of solids (PROC 8b)
- Task 3: Waste management – Cleaning of empty chemical containers/bags (PROC 28)
- Task 4: Waste management – Handling of solid waste (PROC 8b)
- Task 5: Bath make-up or addition, including decanting of substances and mixing them with water (PROC 5, PROC 8b)
- Task 6: Bath emptying and cleaning (PROC 28)

Secondary task

- Task 7: Sampling of treatment baths (PROC 9)

As task 7 is a main task performed by line operators, it has already been described in detail in the worker contributing scenario for line operators (see section 9.2.3.2).

In addition to the tasks listed above, the storage area workers may also perform and control the wastewater and sludge treatment at sites where wastewater is treated on-site, but at some sites, this can also be the responsibility of the laboratory technicians. The treatment of wastewater and sludge typically includes refilling of reducing agents, sampling of reduced wastewater, analysis of the Cr(VI) content in the wastewater samples (e.g., by means of a photometric quick test; for verification that the Cr(VI) content in the wastewater is below a threshold value under which release to the external WWTP or STP is permitted), dewatering and removal of the sewage sludge (containing only Cr(III)) and cleaning of the sludge press. However, as the duration the worker spends close to non-reduced wastewater is negligible and the reduced wastewater typically only contains traces of Cr(VI) (<0.3 mg/L), wastewater treatment is not considered a relevant task with Cr(VI) exposure in this CSR. Exposure from wastewater and sludge treatment is expected to be covered by the exposure assessment performed for the above listed tasks.

The activities related to the use with potential direct exposure to Cr(VI) and the working conditions are described below in detail and are supported by worker air monitoring data covering one or more of these tasks.

9.2.3.3.1 Conditions of use

Table 9-21 summarises the conditions of use for the activities with Cr(VI) exposure related to anodising carried out by storage area workers. In this table only the conditions of use for Tasks 1 to 6 are described, the use conditions for Task 7 are given in the worker contributing scenario for line operators, in Table 9-16.

Table 9-21: Conditions of use – worker contributing scenario 2 – Storage area workers

Product (article) characteristics
Product 1: Solid CT (flakes or powder) for Task 2, Task 3 and Task 5 ▪ Substance product type: Powders, granules, or pelletised material ▪ Dustiness: Flakes or powder ▪ Moisture content: Dry product (<5 % moisture content) ▪ Weight fraction: Pure material (100%) or mixture (mixture may be used, 50-100%) ▪ Concentration in pure substance: 52% Cr(VI)
Product 2: Aqueous solution of CT for Task 1, Task 3, Task 4 and Task 5 ▪ Concentration of substance in mixture: max. 5.2% (w/w) Cr(VI) (based on ranges of CT (1-10% (w/w)) in supplied aqueous solution used for bath make-up or addition) ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Product 3: Aqueous solution of CT for Task 4 and Task 6 ▪ Concentration of substance in mixture for bath applications: up to 5.2% (w/w) Cr(VI) (based on ranges of CT (2.8-10% (w/w)) in the aqueous solution in the anodising bath) ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Amount used (or contained in articles), frequency and duration of use/exposure

Task 1: Aliquot chemicals – Decanting of liquids ▪ Amount per aliquot: <1 up to 92 kg Cr(VI); corresponding to up to 1600 L of product 2 (density 1.1) ▪ Duration of activity: 5-10 min (for large quantities aliquoting may take up to 60 min) ▪ Frequency of task: 2-12 days/year (2 days/year to 1 day/month)
Task 2: Aliquot chemicals – Measuring and weighing of solids ▪ Amount per aliquot: <1 up to 188 kg Cr(VI) corresponding to up to 360 kg of product 1 ▪ Duration of activity: 5-10 min (for large quantities weighing may take up to 60 min) ▪ Frequency of task: <1-48 days/year (<1 day/year up to 1 day/week, 48 weeks/ year)
Task 3: Waste management – Cleaning of empty chemical containers/bags ▪ Duration of activity: <1-10 min ▪ Frequency of task: <1-48 days/year (<1 days/year up to 1 day/week, 48 weeks/year)
Task 4: Waste management – Handling of solid waste ▪ Duration of activity: 2-10 min (exposure duration) ▪ Frequency of task: 2-240 days/year (2 days/year up to 5 days/week, 48 weeks/year)
Task 5: Bath make-up or addition ▪ Amount: <1 up to 188 kg Cr(VI) (bath make up); <1 up to 26 kg Cr(VI) (bath addition) ▪ Duration of activity: 5-120 min ▪ Frequency of task: <1-4 days/year (bath make-up) or <1-48 days/year (bath addition)
Task 6: Bath cleaning ▪ Duration of activity: 30-120 min (close to bath) ▪ Frequency of task: <1-4 days/year (between once every 2 years up to 4x/year)
Technical and organisational conditions and measures
Task 1: Aliquot chemicals – Decanting of liquids ▪ LEV: yes/no; depending on the site ▪ Ventilation rate of general ventilation system: natural ventilation ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 2: Aliquot chemicals – Measuring and weighing of solids ▪ LEV: yes/no; depending on the site ▪ Ventilation rate of general ventilation system: natural ventilation ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 3: Waste management – Cleaning of empty chemical containers/bags ▪ LEV: no ▪ Ventilation rate of general ventilation system: natural ventilation ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 4: Waste management – Handling of solid waste ▪ LEV: no; use of LEV during handling of solid waste is often technically impossible ▪ Ventilation rate of general ventilation system: natural ventilation

- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Task 5: Bath make-up or addition

- LEV: yes
- Ventilation rate of general ventilation system: natural ventilation
- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Task 6: Bath cleaning

- LEV: yes/no; depending on the site
- Ventilation rate of general ventilation system: natural ventilation
- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Conditions and measures related to personal protection, hygiene, and health evaluation

Gloves

Chemical resistant gloves are worn during all tasks. All gloves used for the handling of chemicals are tested according to EN 374. A variety of materials are suited for protection against CT.

The following materials have a breakthrough time ≥8h for aqueous CT solutions (10% CT)[a]:

- Natural rubber/Natural latex (0.5 mm)
- Polychloroprene (0.5 mm)
- Nitrile rubber/Nitrile latex (0.35 mm)
- Butyl rubber (0.5 mm)
- Fluorocarbon rubber (0.4 mm)
- Polyvinyl chloride (0.5 mm)

The following materials have a breakthrough time ≥8h for aqueous CT solutions (50% CT) [a]:

- Fluorocarbon rubber (0.4 mm)

The following materials have a breakthrough time ≥2h for aqueous CT solutions (50% CT) [a]:

- Polychloroprene (0.5 mm)
- Butyl rubber (0.5 mm)
- Polyvinyl chloride (0.5 mm)

The following material has a breakthrough time ≥4h for solid CT:

- Butyl rubber (0.7 mm)

Type of gloves to be used for specific activities is laid down in work instructions for the activities.

Respiratory protection equipment

RPE is worn during Task 2 and 6. During Task 1, and Tasks 3 to 5 RPE is worn if not performed under an LEV and if industrial hygiene exposure assessment confirms that RPE use is required. The following types of RPE are used according to EN 529:2005 [b]:

- Half mask FFP3 (APF 10), half mask with P3 filter (APF 10), half mask with P3 combination filter (APF 10) or
- Full mask with P3 filter (APF 20), full mask with P3 combination filter (APF 20)

Type of RPE to be used for specific tasks is laid down in work instructions for the tasks.

Protective clothes

Chemical protective clothing must be worn during all tasks. For all cleaning activities performed with a hose (may occur in tasks 3 and 6) the workers wear an apron and waterproof boots.

Type of protective clothes to be used for specific tasks is laid down in work instructions for the tasks.

Eye protection

Suitable eye protection (as per relevant risk assessment) is worn during all tasks.

Type of eye protection to be used for specific tasks is laid down in work instructions for the tasks.

Other conditions affecting workers’ exposure

Task 1: Aliquot chemicals – Decanting of liquids

- Place of use: indoors – any size workroom
- Temperature: room temperature
- Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)
- Activity class: Falling liquids
- Situation: Transfer of liquid product with flow of 1–10 L/min
- Containment of the process: Handling that reduces contact between product and adjacent air

Task 2: Aliquot chemicals – Measuring and weighing of solids

- Place of use: indoors – any size workroom
- Temperature: room temperature
- Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)
- Activity class: Movement and agitation of powders, granules, or pelletised material
- Situation: Transferring 1-10 kg/min
- Containment of the process: Handling that reduces contact between product and adjacent air

Task 3: Waste management – Cleaning of empty chemical containers/bags

- Place of use: indoors – any size workroom
- Temperature: room temperature
- Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)
- Activity class: Handling of contaminated solid objects or paste

Task 4: Waste management – Handling of solid waste

- Place of use: indoors – any size workroom
- Temperature: room temperature
- Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)

- Activity class: Handling of contaminated solid objects or paste (worst case assumption, see section details in 9.2.3.3.2)
- 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

Task 5: Bath make-up or addition

- Place of use: indoors – any size workroom
- Temperature: room temperature
- Situation: Activities with open liquid surfaces or open reservoirs
- Open surface: typically 0.1-3 m^2 and rarely up to 6 m^2
- Activity class: Movement and agitation of powders, granules or pelletised material or falling liquids
- Situation: Transfer of 1-100 kg/min or transfer of liquid product with flow of 10-100 L/min
- Containment of the process: Handling that reduces contact between product and adjacent air
- Agitation: no (not in every case)
- Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)

Task 6: Bath cleaning

- Place of use: indoors – any size workroom
- Temperature: room temperature or elevated temperature (up to 50 °C)
- Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)

Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply

- None

[a] https://www.dguv.de/ifa/gestis/gestis-stoffdatenbank/index.jsp; accessed 8 December 2020.

[b] For selection of APF see Annex V of this report.

9.2.3.3.2 Exposure and risks for workers

The work system at a site can be divided in one to three shifts per day, with typically one or two workers per shift (up to seven workers per shift at some sites). The shift duration is usually 8h but may also be up to 12h, depending on the organisation of the site and national law.

We describe in detail below the relevant activities with direct Cr(VI) exposure for storage area workers and the working conditions.

Task 1 and Task 2: Aliquot chemicals – Decanting of liquids and measuring or weighing of solids

The aliquoting of chemicals needed for bath make-ups and additions is performed by the storage area workers either in the storage area (Figure 9-10 a), in the laboratory or close to the treatment bath. All measuring and weighing processes for solid chromates are carried out at a dedicated place, either under a fume hood, or at a station equipped with an LEV. At sites where this is technically not possible, the storage area workers wear RPE during the measuring and weighing process if industrial hygiene exposure assessment confirms RPE use is required.

Task 1: To aliquot liquids, the storage area worker either carefully pours the required volume of the product into a graduated container or transfers it via a small hand pump (Figure 9-10 b). The measured volume per aliquot is at maximum 1600 L chromate solution (92 kg Cr(VI); for a make-up of a large bath) but usually <50 L chromate (<3 kg Cr(VI); for bath additions), depending on the required Cr(VI) concentration in the bath and the tank volume. Then the storage area worker closes the storage container and the measurement vessel with lids. In case the chemical is measured in a measurement canister that cannot be closed, he transfers the measured liquid into a bottle which he then closes with a lid. The empty measurement vessel is rinsed with water and the rinse water is gathered in the wastewater collection tank.

Task 2: For weighing solids, the worker opens the lid of a container with the solid substance (flakes or powder) and transfers the required quantity of the substance with a shovel into a measuring container or bag (Figure 9-10 c + d). The amount of substance to be weighed is at maximum 360 kg chromate per aliquot (188 kg Cr(VI); for a make-up of a large bath) and <50 kg chromate (<26 kg Cr(VI); for bath additions), depending on the required Cr(VI) concentration in the bath and the tank volume. Typically, during or after measuring, the storage area worker weighs the container or bag with the measured chemical on a scale to precisely adjust the required quantity. After this is achieved, the worker closes the container with the raw material and the container or bag with the weighed amount of substance. Whenever possible, entire containers or bags are used for bath make-ups and additives; aliquoting is then not required.

Figure 9-10: **Storage room for chemicals (a), measuring of liquid chromate (b), measuring, and weighing of solid chromate (c + d) in a dedicated area**

Tasks 1+2: The closed containers, bags or bottles containing the aliquoted chemical are transported to the treatment bath where they are used for a bath make-up or addition (Figure 9-11). In cases where large quantities of chromates are required, the measuring of the solution or solid product is typically carried out at the bath.

The aliquoting procedure of either solids or liquids takes each approximately 5-10 min. In case large quantities are measured, the procedure may take up to 60 min. Weighing of solids is typically performed up to 48 times per year and aliquoting of liquids typically up to once a month, in each case as often as bath make-ups or additions are necessary. During aliquoting, the storage area worker wears eye protection (as per relevant risk assessment), chemical protective clothing, and chemical resistant gloves. At least in cases where it is technically impossible to aliquot within a fume hood or at a station equipped with an LEV, they also wear RPE (if industrial hygiene exposure assessment confirms RPE use is required), as described above in Table 9-21.

At some sites, the storage area is equipped with an automatic filling station for solid substances. An automatic filling station is a closed system and requires no manual intervention by the workers. For plants equipped with such a system, the measured values recorded below represent a conservative exposure assessment.

The tasks of aliquoting chemicals as described above are at some sites not carried out by the storage area workers but by the line operators (secondary task of line operators; see section 9.2.3.2).

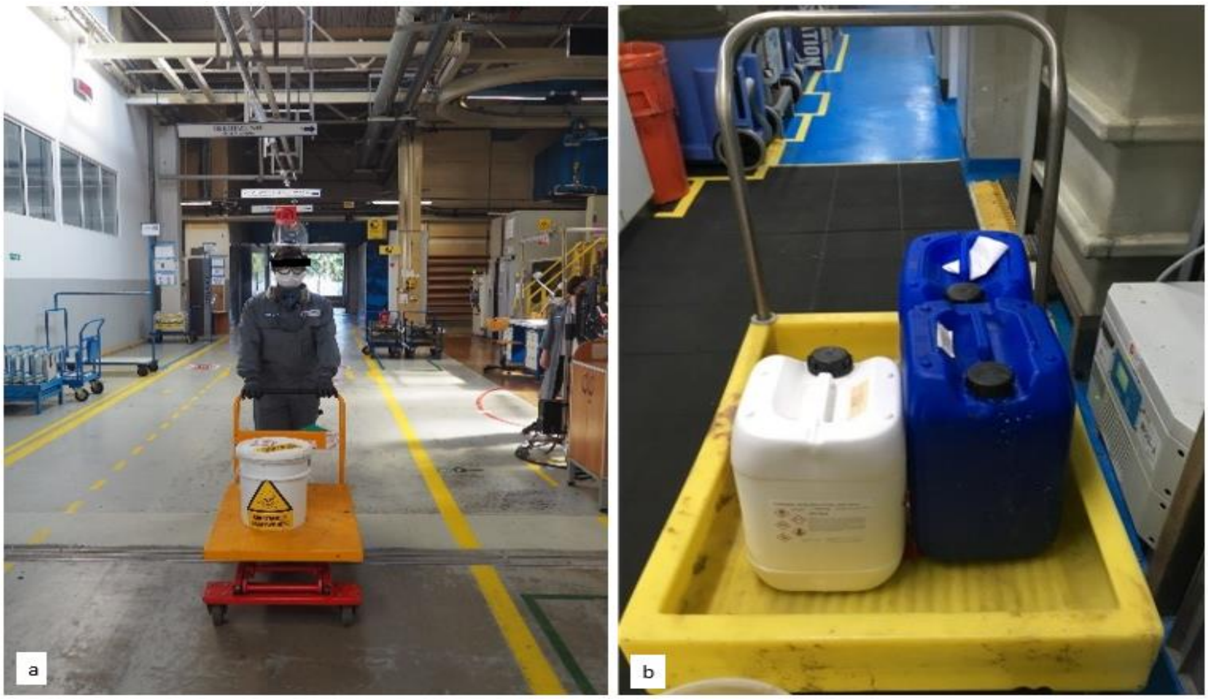
[redacted]

Figure 9-11: **Transport of solid (a) and liquid (b) chemicals to the treatment bath(s)**

Task 3: Waste management – Cleaning of empty chemical containers/bags

At sites where the containers in which the raw materials are delivered are rinsed and then disposed of as non-hazardous solid waste (see description below on Task 4), the cleaning of the containers is usually carried out by storage area worker. For this, he typically immerses the containers in the rinsing bath and then carefully rinses them with a water hose above the rinsing bath until the wash water is clear. At some sites, he directly rinses the containers (without immersion prior to rinsing) above the drainage channel, so that the wastewater is drained to the on-site-wastewater treatment plant. When rinsing, the worker takes care not to splash the water out of the container.

Cleaning of chemical containers only occurs rarely, up to 48 times per year (at maximum as often as bath additions/make-ups are necessary (see frequency described below), depending on the amount of chemical used per site for bath make up and the packaging size of the chromate used in the respective site). The storage area worker usually needs up to 10 min for one cleaning event of empty chemical containers/bags. As the rinsing baths are typically not equipped with LEV and it is practically impossible to rinse the empty chemical containers and bags at a place equipped with LEV, no LEV is used for this activity, but general ventilation is available at the workplace.

During cleaning of empty chemical containers/bags, the worker wears eye protection (as per relevant risk assessment), chemical protective clothing (for cleaning with a hose he also wears an apron and waterproof boots), chemical resistant gloves and RPE (if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-21.

At some sites, the task of cleaning empty chemical containers is not carried out by the storage area workers but by the line operators (secondary task of line operators; see section 9.2.3.2).

Task 4: Waste management – Handling of solid waste

The hazardous solid waste generated from this use, especially from the anodising and cleaning activities (empty uncleaned bags and containers, contaminated wipes, rags, brushes, PPE, sorbents, contaminated equipment, used sandpapers, abrasive material from blasting, filter cartridges) is disposed of in a waste container, typically by the worker who generates the waste (Figure 9-12 a). In cases where there is a considerable amount of moisture in the waste, the worker may add a special sorbent to the waste to absorb the moisture. During the handling of empty bags, filters, and other process waste, the operator proceeds in accordance with appropriate standard operating procedures to reduce as low as possible the release of dust in the air during these operations.

At most sites, the waste container holds a waste bag in which the waste is collected. The waste container is placed e.g., near the anodising baths, in the storage area and/or in the laboratory, at a dedicated station and the container is closed when it is not in use (see Figure 9-12 b).

When the waste bag is full, the storage area worker will seal the waste bag and either remove it from the waste container and transport it to the storage area, or leave the sealed waste bag in the storage container and transport both to the storage area. The waste remains in the storage area until it is sent to an external waste management company (licensed contractor) for disposal as hazardous waste. This activity is assumed to take place between 2x/year and 1x/day at the end of a shift (the frequency may vary from site to site depending on the frequency at which the use is performed, and the amount of waste handled, as well as on the contribution of waste from other sources). The duration of the transport can be variable depending on the organization of the site, but the exposure duration (sealing of waste container/bag and transport to storage area/container) is maximum 10 min per day.

When handling solid waste, the worker wears eye protection (as per relevant risk assessment), chemical protective clothing, chemical resistant gloves and RPE (if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-21.

At some sites, the handling of solid waste is not carried out by the storage area workers but by the line operators (secondary task of line operators; see section 9.2.3.2) or by the maintenance workers (secondary task of maintenance workers; see section 9.2.3.5).

[redacted]

Figure 9-12: **Operator discarding solid waste contaminated with Cr(VI) into a drum for hazardous waste (a); closed hazardous waste drum (b)**

<u>Task 5: Bath make-up or addition</u>

For bath make-up or addition, the storage area worker uses the appropriate amount of chemical (either pure solid substance or a liquid mixture containing CT) which he already aliquoted into a closed container, bottle, or bag (see description for Task 1 and 2 above; see Figure 9-13 a). Then he either mixes the aliquoted amount of chemical in a bucket with water and stirs it with a metal rod to prepare a homogenised pre-mixture (in case of solid chemical), or he pours it as it is (solid or liquid) in the treatment bath (Figure 9-13 b + c).

At some sites, bath make-up or addition is performed by first slightly moistening the solid to prevent dust formation, then transferring it to a fine-pored basket located on the bath. By adding water to the basket, a solution is then formed which runs directly into the bath.

For make-ups where high amounts of chromates are required, the storage area worker transfers the product directly from the original chemical container into the bath/basket, without it being aliquoted beforehand.

At some sites, the liquid is pumped from the container (e.g., IBC) and transferred into the bath (via a connected pipe or a stick placed in the container). The operator carefully handles empty containers after liquid transfer or empty bags after solid transfers, and manage them as hazardous solid waste (as described in Task 4).

In case of bath make-up, the bath is either empty or filled by up to approximately 1/3 with water before the storage area worker slowly pours the chromate/mixture into the bath, taking care to pour at a minimum distance from the bottom of the bath or the water surface to avoid dust and/or splashing, and then tops it up with water. For bath addition, the bath is already filled with treatment solution and the storage area worker only adds some chromate to adjust the Cr(VI) concentration in the bath (after the bath solution was sampled and the amount of chromate to be added to achieve the required chromate concentration was determined). Also here, the storage area worker slowly pours the chemical at a minimum distance from the surface of the bath solution to avoid dust and/or splashes.

Homogenous dilution of the chromate in the bath is often supported by permanent bath internal circulation or agitation. The LEV, with which all chemical treatment baths are equipped, is running during make-ups and additions.

During bath make-up and addition, the maximum Cr(VI) concentration is up to 52% when the raw material is handled and the storage area workers use up to 188 kg Cr(VI) for bath make-up and up to 26 kg Cr(VI) for bath addition. Both tasks are carried out at room temperature. For bath make-up the whole process of mixing, transfer to the bath, pouring it in the bath and then filling the bath up with water takes up to several hours. However, the operator may leave the bath in between (e.g., during filling of the bath), so that the exposure duration is at maximum 120 min per make-up. Make-up is typically carried out only four times per year or less. Bath addition only takes up to 10 min and is also necessary at a maximum of 48 times per year (once per week). Typically, when a site performs very frequent bath additions (e.g., 1x/week), bath make-ups are rarely or never required.

For both, bath make-up and addition, the storage area worker wears eye protection (as per relevant risk assessment), chemical protective clothing, chemical resistant gloves, and RPE (if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-21.

At some sites, it may be the case that bath make-up or addition is not carried out by the storage area workers but by the line operators (secondary task of line operators; see section 9.2.3.2).

[redacted]

Figure 9-13: **Operator transfers a bucket with solid chromate to the tank (a); operator carefully pours the chromate into the bath for bath make-up or addition (b + c)**

Task 6: Bath cleaning

The cleaning of the baths is carried out during a bath renewal. For this purpose, the storage area worker drains the old bath solution by gravity or by means of a pump and, depending on the site's wastewater management system and the concentration of the bath solution, either pumps it into an Intermediate Bulk Container (IBC) (see Figure 9-14 a), in which case it is later disposed of externally as a liquid hazardous waste[8], or it is pumped to the on-site wastewater treatment plant, where it is reduced and neutralized (see a detailed description of the wastewater treatment process in section 9.2.2.3.2.2).

When the bath is drained, at some sites the storage area worker rinses it thoroughly with a hose and removes potential solid deposits in the bath with the water jet or wet and dry vacuum cleaner (Figure 9-14 b-d). The rinse water is pumped out and treated as wastewater. The water collected with the wet and dry vacuum cleaner is transferred to a special container and sent to an external company for treatment. The electrodes may also need to be cleaned by mechanical action. When the bath is cleaned, it is ready for refilling (see description for bath make-up above). During the whole cleaning process the storage area worker usually spends up to 120 min at the bath, but during the draining process (which may take several hours at some sites) the worker may temporarily be away from the bath. Depending on the size of the plant and the number of anodising baths, bath cleaning is necessary up to four times per year. During the cleaning process, the treatment solutions and the rinsing water are in most events at room temperature, but sometimes they may be at elevated temperature (up to 50 °C). Depending on the site organisation, the LEV may be deactivated to perform the cleaning.

For the bath cleaning the storage area worker wears eye protection (as per relevant risk assessment), chemical protective clothing (for cleaning with a hose he also wears an apron and waterproof boots; in case he enters the treatment bath he wears a chemical protective coverall), chemical resistant gloves, and a RPE (at least at sites where the LEV is not running during bath cleaning and if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-21.

At some sites it may be the case that bath cleaning is not carried out by the storage area workers but by the line operators (secondary task of line operators; see section 9.2.3.2) or by an external service provider.

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[8] At some sites, an external service provider pumps the contents of the IBC into a tank truck. Due to the low frequency of this activity (maximum 4x per year), the short duration in which the worker connects and disconnects the tank nozzle (approx. 5 min per event) and as the transfer is exclusively performed via closed lines this activity is not considered for a separate group of workers. It is expected that the exposure coming from this activity is covered by the number of workers, duration and frequency considered for the bath cleaning performed by the storage area workers.

Figure 9-14: **Bath emptying by transfer of old bath solution into an IBC (a) and bath cleaning with a hose and wet and dry vacuum cleaner (b, c, d)**

9.2.3.3.2.1 Inhalation exposure

Measured inhalation exposure concentration

In total, 51 personal measurements covering exposure from anodising are available for this SEG. One personal long-term measurement values was excluded from further analysis because it was below an unreasonably high LOQ (i.e., <2 µg/m^3).

Of the remaining 50 personal monitoring data, 26 are long-term (≥2h)[9], shift-representative and 24 are short-term (<2h) measurements. No stationary measurements are available for storage area workers.

The personal monitoring data come from 12 sites of eight countries in the EEA (44 measurements) and from three sites in the UK (six measurements). 50% of the data (25 values, including 13 short-term measurements) are <LOQ and 50% (25 values, including 11 short-term measurements) are >LOQ.

A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex IV of this report. The individual measurements can be provided upon request. An overview of the available data for storage area workers is given in Table 9-22.

Table 9-22: Overview of available inhalation exposure measurements for WCS 2 – Storage area workers

	n	**>LOQ**	**<LOQ**
Personal			
- Long-term (≥2h)	26	14	12
- Short-term (<2h)	24	11	13

<u>Personal measurements – long-term</u>

Long-term personal measurements were taken for storage area workers performing tasks related to anodising. However, during most of the measurements the storage area workers also had potential Cr(VI) exposure from other uses (e.g., deoxidising, pickling/etching, inorganic finish stripping, passivation of (non-Al) metallic coatings, conversion coating, anodise sealing) with CT and/or other chromates, as storage area workers are typically responsible for providing chemicals for all baths operating at a site. During the personal measurements, the storage area workers mainly performed decanting of liquids (Task 1), measuring/weighing of solids (Task 2), bath make-ups or additions (Task 5), bath cleaning (Task 6), logistic activities related to chemical storage (transport, ordering) and activities related to wastewater or sludge treatment. Cleaning of chemical containers (Task 3) and handling of solid waste (Task 4) are not explicitly recorded for the long-term measurements data, but it can be assumed that exposure from these activities is covered by the available shift average exposure values as these are typical activities performed on a regular basis by storage area workers.

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[9] All long-term measurements (≥2h) are considered as shift-representative measurements and used as such as 8h TWA exposure values; no recalculation has been performed. Measurements <2h were not used to calculate 8h TWA exposure values.

The AM of all long-term personal measurements is 0.394 µg/m^3, the 90th percentile is 0.950 µg/m^3. For long-term exposure values of measurements covering activities involving the handling of solids (from which exposure to dust may arise) such weighing/measuring of solids and bath make-ups/additions (among other activities; in total nine long-term measurements) the AM is 0.433 µg/m^3, slightly above the AM of all long-term personal measurements, which indicates that these activities are well represented by the worker exposure measurements. For seven of the measurements, it is reported that the workers wore RPE (at least reusable half mask – particle filter) during parts of the measurement period, during which they performed specific activities (such as weighing of solid CT), but for the other measurements no information is documented on the use of RPE.

Only two of the long-term measurements were taken while the worker performed activities only related to anodising, but not to any other Cr(VI) use (according to the information provided by the sites). The first measurement was carried out for 336 min during which the worker performed a bath make-up using 1600 L of chromic acid solution. The exposure value was below the LOQ (<0.9 µg/m^3). The second measurement was carried out for 182 min during which the worker transported solid CT to the chemical treatment bath for anodising, weighted a certain amount of solid CT, and performed a bath addition using 15 kg of CT. The exposure value was again below the LOQ (<0.056 µg/m^3) and is at the lower end of the exposure values for long-term measurements of storage area workers. These two measurements show that the activity of bath make-ups/additions only contributes to a low extent to the shift-average exposure of storage area workers.

Nine of the long-term measurements cover activities related to wastewater/sludge treatment (e.g., neutralization of Cr(VI) in sewage, packing of dried sludge) as the only potential Cr(VI) exposure source. The values of these measurements are within a range of 0.01 – 0.9 µg/m^3.

Personal measurements – short term

The 24 short-term measurements cover all relevant tasks performed by storage area workers except Task 1 (decanting of liquids) and Task 3 (Cleaning of empty chemical containers/bags):

- Task 2: Measuring and weighing of solids (four values; 0.072-172 µg/m^3, 7-105 min; two of these measurements also cover bath make-up/addition)
- Task 4: Handling of solid waste (seven values, 0.0425 and 0.54 µg/m^3, 10-105 min)
- Task 5: Bath make-up or addition, including decanting of substances and mixing them with water (nine values, 0.072-79.1 µg/m^3, 4-105 min; two values also cover measuring/weighing of solids)
- Task 6: Bath emptying and cleaning (one value, 0.77 µg/m^3, 75 min)
- Wastewater treatment (five values, 0.09-6 µg/m^3, 10-45 min)

Note that some of the measurements cover more than one task and are thus listed above more than once.

Twenty-two of the 24 short-term measurements are within a range of 0.0425 - 6 µg/m^3. The other two measurements differ from the other results by their high value: 172 µg/m^3 and 79.1 µg/m^3 (with respectively 7 min duration for measuring/weighing of solids and 28 min duration for measuring/weighing of solids and bath addition). The 8h TWA[10] values calculated from these measurements are 2.508 µg/m^3 and 4.614 µg/m^3 respectively, considering 473 and 452 min non-exposure time[11]. It was clearly stated that RPE was worn during both measurements. During the first one, a supplied-air respirator with an APF factor of 40 was used leading to an exposure value of 0.0627 µg/m^3 and for the second one a full mask with P3 with an APF factor of 20 was worn leading to an exposure value of 0.231 µg/m^3. These two exposure values corrected for RPE are below the 90th percentile of the long-term measurements, suggesting that exposure from these two individual activities of measuring/weighing of solids and bath make-up or addition using a RPE are covered by the shift-average exposure of operators.

Regarding the 22 other short-term measurements, 8h TWA values were calculated using respective sampling durations (assuming that the remaining shift is without Cr(VI) exposure). The highest value obtained is 0.207 µg/m^3, well below the AM of long-term personal measurements. This suggests that no increased exposure is to be expected from the relevant tasks listed above.

In addition, workers wear respiratory protection for such short-term activities for which industrial hygiene exposure assessment confirms RPE use is required. Use of RPE is documented for many of the short-term measurements listed above, i.e., measuring/weighing of solids, bath make-up/additions, bath cleaning, handling of solid waste.

Table 9-23 shows the summary statistics of workplace measurements for storage area workers. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. All measurements are from 2016 through 2021.

Table 9-23: Summary statistics of inhalation exposure measurements for WCS 2 – Storage area workers

Personal – long-term (measurement period 2016-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	26	100	0.394	0.637	0.140	0.950
- Only this use covered by the measurement	2	8	n.a. [a]	n.a.	n.a.	n.a.
Personal – short-term (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	24	100	11.70	37.69	0.47	6.00

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

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[10] TWAs are calculated by assuming that the remaining time of the 8h shift, during which the measurement was not performed, is non-exposure time.

[11] 172 µg/m^3 x (7 min/480 min) = 2.508 µg/m^3 / 79.1 µg/m^3 x (28 min/480 min) = 4.614 µg/m^3

n.a. = not assessed; the statistical parameter was only determined if at least three (for AM) or ten (for SD, Median and 90th percentile) values were available.

[a] The individual values are 0.45 and 0.028 µg/m³.

All personal long-term measurements of storage area workers performing tasks related to anodising are included in the assessment of inhalation exposure. Table 9-24 shows the resulting long-term inhalation exposure concentration for storage area workers used for risk assessment, based on the 90th percentile of personal sampling values.

As stated above, partial exposure from sources and processes not related to the use of anodising may have contributed to most of the exposure values assigned to this use. Considering that, storage area workers typically spend only a minor part of their working time on activities related to anodising (rounded up to 2.0%[12]), we assign 2.0% of the shift average exposure value (90th percentile of all long-term measurements) to this use.

Typically, one or two workers per shift are engaged, with one to three shifts per site. On average, we assume that **four storage area workers per day** are engaged per site and that **each worker spends a maximum of 2% of his working time on activities related to anodising**. Consequently, the long-term exposure concentration is corrected by a factor of 0.02. For sites where the work is distributed among a higher number of workers, a higher number of people would have to be considered, but their long-term average individual exposure concentration would be lower.

RPE is worn during short-term activities for which industrial hygiene exposure assessment requires it. As these activities usually only account for shorter periods of the shift average measurements, no RPE is considered in the exposure assessment, which constitutes a further conservative element of the assessment.

Table 9-24: Measured inhalation exposure concentration for WCS 2 – Storage area workers

Type of measurement	Number of measurements	Exposure value (8h TWA) [a] [µg/m³]	Assigned protection factor (APF) for RPE [b]	Exposure value corrected for RPE [µg/m³]	Long-term exposure [c] [µg/m³]
Personal	26	0.950	1.00	0.950	0.019

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

[a] Based on 90th percentile of measurements.

[b] No RPE is considered; RPE is only worn during some measurements for specific, short-term activities only (with measurements performed outside the mask), see text above.

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[12] Considering the maximum durations (exposure time) and frequencies of all main tasks performed by storage area workers as described in section 9.2.3.3.2 and considering 1920h working time per year for one worker (8h per day, 240 days per year), the exposure time related to anodising accounts for 6.46% of his shift ((60 min 12x/year (Task 1) + 60 min 48x/year (Task 2) + 10 min 48x/year (Task 3) + 10 min 240x/year (Task 4) + 120 min 4x/year (Task 5) + 120 min 4x/year (Task 6)) = 7440 min/y = 124h/y; 124h/1920h = 6.46% assuming that one worker performs all activities; if the activities are divided between four workers the percentage is 1.61% per worker, conservatively rounded up to 2%.

[c] The frequency/duration correction factor of 0.02 was applied for storage area workers: each of the four storage area workers spend up to 2% of his shift on activities related to anodising with Cr(VI).

9.2.3.3.2.2 Risk characterisation

Risk for carcinogenicity

Table 9-25 shows the risk characterisation for carcinogenicity for storage area workers. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for storage area workers and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-25: Risk characterisation for carcinogenicity for WCS 2 – Storage area workers

Route of exposure and type of effects	Long-term exposure [µg/m^3]	Risk characterisation: Excess lifetime lung cancer risk * [1/µg/m^3]	Excess lifetime cancer risk (ELCR)
Inhalation: Systemic Long Term	0.0190	4.00E-03	7.60-05

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

* RAC dose-response relationship based on excess lifetime lung cancer risk (ECHA, 2013): Exposure to 1 µg/m^3 Cr(VI) relates to an excess risk of $4x10^{-3}$ for workers, based on 40 years of exposure; 8h/day; 5 days/week.

Conclusion on risk characterisation:

Carcinogenicity

The Excess life-time cancer risk for storage area workers is 7.60E-05.

This risk estimate can be considered as conservative, because:

- it is based on a conservative ERR,
- it uses the 90th percentile of the reported long-term measurements,
- these measurements were not corrected for their duration but assumed to be shift representative values,
- and no correction for wearing RPE was applied although workers typically wear RPE for exposure-relevant tasks (as shown by the short-term measurements, such as weighing/measuring of solids and bath make-ups/additions).

As described above, it is considered for the assessment that **four storage area workers** per day and site perform all tasks assigned to this SEG related to anodising.

Based on the gathered information and considering the implemented RMM we conclude that risk of exposure is minimised.

Comparison of outcome with initial applications

Inhalation exposure

The tasks considered in the present assessment typically performed by the storage area workers were described in the initial applications as separate tasks that were not assigned to a specific SEG and were not aggregated in their exposure. These separate tasks were modelled with ART 1.5 in the initial applications and no typical frequencies were specified. Consequently, we can only compare the modelling results for individual tasks with the shift-average inhalation exposure values measured for the storage area workers in the current assessment.

As shown in the table below, the excess lifetime lung cancer risks based on inhalation exposure modelling in the initial applications were between 1.00E-04 and 6.00E-03 for the individual activities performed by the storage area workers. RPE with an assigned protection factor (APF) of 30 was considered for all activities where solid chromates are handled.

In the present assessment, the excess lifetime lung cancer risk based on shift-average inhalation exposure value is **7.60E-05**, covering all individual tasks and considering durations and frequencies in which these tasks are performed in relation to anodising. In contrast to the modelling approach in the initial applications, **use of RPE is not considered in the present assessment** based on shift-average values, although it is used during exposure-relevant tasks. This constitutes a very conservative approach.

Initial assessment				**Present assessment**	
Application ID	**Chromate**	**Inhalation exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**	**Inhalation, long-term exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**
Decanting of liquids (PROC 8b) <60 min, up to 50% Cr(VI), containment (99%), no RPE				0.0190	7.60E-05
0032-04	CT	0.69	2.76E-03		
0032-05	CT	0.69	2.76E-03		
Decanting and weighing of solids (PROC 8b) <60 min, up to 50% Cr(VI), no containment/LEV, RPE (APF 30)					
0032-04	CT	1.5	6.00E-03		
0032-05	CT	1.5	6.00E-03		
Mixing of liquids (PROC 5) <60 min, up to 50% Cr(VI), containment (90%), no RPE					
0032-04	CT	0.69	2.76E-03		
0032-05	CT	0.69	2.76E-03		
Mixing of solids (PROC 5) <60 min, up to 50% Cr(VI), containment (90%), RPE (APF 30)					
0032-04	CT	0.5	2.00E-03		
0032-05	CT	0.5	2.00E-03		
Re-filling of baths – liquids (PROC 8b) <60 min, up to 50% Cr(VI), fixed capturing hood (90%), no RPE					
0032-04	CT	1.1	4.40E-03		

0032-05	CT	1.1	4.40E-03		
Re-filling of baths – solids (PROC 8b) <10 min, up to 50% Cr(VI), fixed capturing hood (90%), RPE (APF 30)					
0032-04	CT	0.025	1.00E-04		
0032-05	CT	0.025	1.00E-04		
Waste management (PROC 8b) 30 min, up to 50% Cr(VI), containment (90%), RPE (APF 30)					
0032-04	CT	0.22	8.80E-04		
0032-05	CT	0.22	8.80E-04		

9.2.3.4 Worker contributing scenario 3 – Laboratory technicians

Usually, there is a group of one to five laboratory technicians per site (depending e.g., on the size of the site). Laboratory technicians may be involved in activities related to anodising with potential for Cr(VI) exposure, but these tasks only account for a small fraction of their time and most of their work is not related to anodising.

Typical activities with possible Cr(VI) exposure performed by laboratory technicians are:

Main task

- Task 1: Laboratory analysis of treatment bath sample (PROC 15)

Secondary task

- Task 2: Sampling of treatment baths (PROC 9)

Moreover, at some sites, the laboratory technicians are also responsible for the sampling and analysis of wastewater after the reduction process at the reduction facility, while at other sites this task is performed by the storage area workers. In the wastewater samples, the Cr(VI) content is determined by means of a photometric rapid test, to verify that the Cr(VI) content in the wastewater is below a regulatory limit concentration under which release to the external WWTP or STP is permitted. As the reduced wastewater usually contains only traces of Cr(VI) (<0.3 mg/L), the sampling and analysis of wastewater is not considered a relevant activity with Cr(VI) exposure in this CSR.

As the handling of substances in laboratories for quality control purposes under controlled conditions and in amounts below 1 t/year falls under the exemption for authorisation for the use of substances in scientific research and development[13] according to REACH Art. 56(3), no exposure assessment is performed for the laboratory analysis of treatment bath samples.

The activity of sampling the treatment bath typically consumes a small fraction of the lab technician's time. This task is described in detail in the worker contributing scenario for line operators (main task for line operators, see section 9.2.3.2).

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[13] Q&A Reference number: ID 0585; https://echa.europa.eu/de/support/qas-support/browse/-/qa/70Qx/view/ids/585-1442-1443-1498-1565; assessed in March 2021

9.2.3.5 Worker contributing scenario 4 – Maintenance and/or cleaning workers

Maintenance and/or cleaning workers may be involved in activities related to anodising with potential for Cr(VI) exposure, but these tasks constitute only a small fraction of their time and most of their work is not related to anodising.

The activities with potential Cr(VI) exposure performed by maintenance and/or cleaning workers are summarized for the present assessment as the following tasks:

Main task

- Task 1: Maintenance and cleaning of equipment (PROC 28)

Secondary task

- Task 2: Waste management – Handling of solid waste (PROC 8b)

Typical activities during maintenance and cleaning of equipment related to the use with potential direct exposure to Cr(VI) as well as the working conditions are described below in detail and are supported by worker air monitoring data covering maintenance activities.

Since task 2 is a typical main task performed by storage area workers, it is described in detail in the worker contributing scenario for storage area workers (see section 9.2.3.3).

9.2.3.5.1 Conditions of use

Table 9-26 summarises the conditions of use for maintenance and cleaning activities with Cr(VI) exposure related to anodising carried out by maintenance workers.

Table 9-26: Conditions of use – worker contributing scenario 4 – Maintenance and/or cleaning workers

Product (article) characteristics
Product: Aqueous solution of CT ▪ Concentration of substance in mixture for bath applications: up to 5.2% (w/w) Cr(VI) (based on ranges of CT (2.8-10% (w/w)) in the aqueous solution in the anodising bath) ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Amount used (or contained in articles), frequency and duration of use/exposure
Task 1: Maintenance and cleaning of equipment ▪ Duration of activity: up to 240 min (at some sites, specific maintenance activities are performed for 480 min once per year) ▪ Frequency of task: 48 days/year (once per week, 48 weeks per year)
Technical and organisational conditions and measures
Task 1: Maintenance and cleaning of equipment ▪ LEV: yes/no (depends on the place where maintenance takes place) ▪ Ventilation rate of general ventilation system: natural ventilation

- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Conditions and measures related to personal protection, hygiene, and health evaluation

Gloves

Chemical resistant gloves are worn during all activities with possible exposure to Cr(VI). All gloves used for the handling of chemicals are tested according to EN 374. A variety of materials are suited for protection against CT.

The following materials have a breakthrough time ≥8h for aqueous CT solutions (10% CT) [a]:

- Natural rubber/Natural latex (0.5 mm)
- Polychloroprene (0.5 mm)
- Nitrile rubber/Nitrile latex (0.35 mm)
- Butyl rubber (0.5 mm)
- Fluorocarbon rubber (0.4 mm)
- Polyvinyl chloride (0.5 mm)

Type of gloves to be used for specific activities is laid down in work instructions for the activities.

Respiratory protection equipment

RPE is worn during all tasks not performed under an LEV for which industrial hygiene exposure assessment confirms RPE use is required.

The following types of RPE are used according to EN 529:2005 [b]:

- Half mask FFP3 (APF 10), half mask with P3 filter (APF 10), half mask with P3 combination filter (APF 10) or
- Full mask with P3 filter (APF 20), full mask with P3 combination filter (APF 20)

Type of RPE to be used for specific tasks is laid down in work instructions for the tasks.

Protective clothes

Chemical protective clothing must be worn during activities with possible Cr(VI) exposure.

Type of protective clothes to be used for specific activities is laid down in work instructions for the activities.

Eye protection

Suitable eye protection (as per relevant risk assessment) is worn during Task 1.

Type of eye protection to be used for specific activities is laid down in work instructions for the activities.

Other conditions affecting workers' exposure

Task 1: Maintenance and cleaning of equipment

- Place of use: indoors – any size workroom
- Temperature: typically at room temperature

- Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m) - Activity class and subclass: Handling of contaminated objects
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
- None

[a] https://www.dguv.de/ifa/gestis/gestis-stoffdatenbank/index.jsp; accessed 8 December 2020.

[b] For selection of APF see Annex V of this report.

9.2.3.5.2 Exposure and risks for workers

At each site, a group of maintenance and/or cleaning workers is engaged the size of which can vary largely (depending, e.g., on the size of the site). At some sites, the maintenance workers are subcontracted service providers. The work system at a site is divided in one to three shifts per day, with one to five workers per shift. However, these workers are only infrequently engaged in activities related to Cr(VI) exposure and it can be assumed that only one worker per shift is dealing with Cr(VI)-related activities (see below). The shift duration is usually 8h but may also be up to 12h, depending on the organisation of the site and national law.

We describe below in detail relevant activities of maintenance and cleaning with direct Cr(VI) exposure for maintenance and/or cleaning workers and the working conditions.

Task 1: Maintenance and cleaning of equipment

Typical maintenance tasks comprise for example maintenance or replacement of pipes, pumps, sensors, filters, rectifiers, scrubbers, and machining equipment, repair of electrical installations such as heating and mixing equipment installed in the treatment baths, pumps and valves, joints of baths/hydraulic installations and LEV systems (exemplarily, the replacement of a filter is shown in Figure 9-15). Some of these activities can be performed in situ but in cases where this is not possible, the part needs to be dismantled for repair either in the workshop or externally by a specialized company. Prior to maintenance cases, either the line operators or the maintenance workers clean the part to be maintained/repaired. During maintenance/repair, additional cleaning by the maintenance worker in situ and/or in the workshop may be necessary.

The repair of heaters in the anodising bath is described in the following as a typical maintenance case and is considered a representative worst case for other maintenance activities related to the use.

When a heater in a treatment bath must be replaced, the treatment bath is cooled down to room temperature, emptied and the heater and bath are cleaned by the storage area worker (see description for bath cleaning in section 9.2.3.3) in preparation for the maintenance work. Then the maintenance worker enters the empty bath and either repairs the heater in situ, if this is possible, or he removes the heater and transports it to the workshop for repair (exemplarily, cleaning and repair of equipment in a cleaned treatment bath is shown in Figure 9-16 a + b). In the workshop, when the heater is being repaired, additional cleaning may be necessary, either by wiping the heater with e.g., a cloth or by rinsing it with water over a collection vessel (the liquid waste is fed to the on-site reduction unit). After repair, the maintenance worker brings the heater back to the treatment bath and reinstalls it. In total, including dismantling, repair, and re-installation, such a maintenance case takes about 240 min.

The duration and frequency of maintenance activities can be highly variable between different sites, with frequencies between one and 48 times per year and durations typically between 5 and 240 min per maintenance case. At some sites, specific maintenance activities are performed for 480 min once per year. For the present exposure assessment, we consider a frequency of 48 times per year and a duration of 240 min per maintenance/cleaning event as a worst-case estimate.

Maintenance activities are typically performed at room temperature. The maximum Cr(VI) concentration in the treatment bath at which maintenance may be necessary is 5.2% Cr(VI). During maintenance in and at the treatment bath, the LEV of the bath is running and when contaminated parts are handled in the workshop a mobile LEV is used wherever this is technically and practically possible. For maintenance activities performed in the workshop, the maintenance worker wears eye protection (as per relevant risk assessment), and chemical resistant gloves. For activities with potential Cr(VI) exposure (e.g., during cleaning and when entering the treatment bath), he additionally wears chemical protective clothing and RPE (if Industrial Hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-26.

Figure 9-15: Maintenance of equipment - Filter change

Figure 9-16: Cleaning of equipment (a + b)

9.2.3.5.2.1 Inhalation exposure

Measured inhalation exposure concentration

For maintenance and/or cleaning workers, 21 personal measurements covering exposure from anodising are available. One personal long-term measurement value was excluded from further analysis as it was below an unreasonably high LOQ (i.e., <2 µg/m^3). The remaining 20 values are 12 long-term (≥2h)[14] measurements, and eight short-term (<2h) measurement values. No stationary measurements are available for maintenance and/or cleaning workers.

It is stated by the sites providing monitoring data that maintenance tasks are hard to schedule for days on which monitoring is performed (as monitoring campaigns usually need be planned months in advance and as, per definition, repair activities are difficult to predict). Due to this, monitoring data on maintenance tasks were rather difficult to collect, which is reflected in the comparably low number of

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[14] All long-term measurements (≥2h) are considered as shift-representative measurements and used as such as 8h TWA exposure values; no recalculation has been performed. Measurements <2h were not used to calculate 8h TWA exposure values.

measurements. Furthermore, the maintenance activities performed during the measurements usually cannot be assigned to a single use but relate to all uses performed at one site, which makes it difficult to discern between exposures from different galvanic Cr(VI) uses. Considering these restrictions, all measurement data for maintenance and/or cleaning workers available for diverse Cr(VI) uses performed in galvanic areas (i.e., the galvanic Cr(VI) uses covered by ADCR) are pooled for the exposure assessment of maintenance and/or cleaning workers. Since the same types of tasks are carried out under comparable conditions of intervention, we consider it reasonable to not distinguish between exposure from maintenance activities related to different uses. Some of these measurements cover maintenance activities not only related to galvanic but also to spraying uses (i.e., slurry coating and/or use of primer), as multiple tasks including maintenance on galvanic- and spraying-related equipment were performed during these measurements. More than one chromate is used at many of the sites providing these measurements and measurements are often not assignable to a single chromate. Therefore, stratification according to substance is not reasonable.

In total, 34 personal monitoring values are available, but two values were excluded from the analysis: the one value described above plus one long-term measurement from a worker who experienced high exposure due to inappropriate individual behaviour, resulting in an increased exposure value (6.94 µg/m^3). Of the remaining 32 personal measurements, 17 long-term, shift-representative and 15 short-term personal measurements are available.

The pooled personal monitoring data come from 13 sites in four countries in the EEA (27 measurements) and from three sites in the UK (five measurements). About 44% of the data (14 values, including seven short-term measurements) are <LOQ and 56% (18 values, including eight short-term measurements) are >LOQ. A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex IV of this report. The individual measurements can be provided upon request. An overview of the available data for maintenance and/or cleaning workers is given in Table 9-27.

Table 9-27: Overview of available inhalation exposure measurements for WCS 4 – Maintenance and/or cleaning workers

	n	**>LOQ**	**<LOQ**
Personal – related to anodising			
- Long-term (≥2h)	12	6	6
- Short-term (<2h)	8	2	6
Personal – related to any Cr(VI) use			
- Long-term (≥2h)	17	10	7
- Short-term (<2h)	15	8	7

<u>Personal measurements – related to anodising (long-term and short-term measurements)</u>

The 12 long-term personal measurements were taken for workers performing maintenance activities related to anodising. The AM for these measurements is 0.277 µg/m^3 and the 90th percentile is 0.958 µg/m^3). None of these measurements is exclusively related to this use, they all cover activities related to multiple Cr(VI) uses (e.g., deoxidising, pickling/etching, inorganic finish stripping, conversion coating, , passivation of (non-Al) metallic coatings, anodise sealing). Activities performed during the measurements include general inspections, maintenance and cleaning throughout the site and specific tasks such as replacement of heaters, repair of pipes or dampers in the baths, cleaning and repair of wet scrubbers, removal of anodes from treatment baths or refilling of chemicals for the wastewater treatment plant. For two measurements (covering the removal of anodes from a treatment bath for the first one and infrequent maintenance activities without further details for the second one), it was reported that RPE was used. No information on the use of RPE is documented for the other measurements.

Also, eight short-term personal measurements were performed on operators working on maintenance activities related to anodising. The AM for these measurements is 0.132 µg/m^3 and the 90th percentile is 0.413 µg/m^3). None of these measurements is exclusively related to anodising, all measurements cover additional activities related to Cr(VI) uses (e.g., pickling/etching, inorganic finish stripping, conversion coating, anodise sealing). During these measurements the workers performed regular maintenance of the baths and related equipment and RPE was worn in all cases (e.g., reusable half mask – particle filter or full face mask in case of splashes).

As described above, the measurements usually cover activities from multiple uses as the maintenance activities performed during the measurements cannot be assigned to a single use but usually relate to all uses performed at one site. Therefore, the pooled monitoring data from all Cr(VI) uses are considered and discussed for the exposure assessment.

Personal measurements – related to any Cr(VI) use (long-term measurements)

The AM of the total long-term measurements is 0.721 µg/m^3 and the 90th percentile is 1.92 µg/m^3 for the pooled personal monitoring data. The exposure values cover general inspections, maintenance and cleaning throughout the site and specific activities such as replacement of heaters, repair of pipes, pumps, or dampers in the baths, cleaning, and replacement of demisters of the air purification systems, cleaning and repair of wet scrubbers, removal of anodes from treatment baths or refilling of chemicals for the wastewater treatment plant. The activities reported for the pooled long-term measurements show a large overlap with the activities reported for the monitoring data covering maintenance activities related to anodising, which further supports the total long-term measurements to be considered for the assessment.

The AM and the 90th percentile of the pooled personal monitoring data are by factor 2 higher than the AM and 90th percentile of the monitoring data related to anodising, suggesting that it may be a conservative approach to consider the 90th percentile of the pooled monitoring data for the exposure assessment of maintenance and/or cleaning workers for anodising.

Beside the two measurements mentioned above, during which anodes were removed from a treatment bath and infrequent maintenance activities were performed, use of RPE (Reusable half mask – particle filter) was documented for two additional measurements (“maintenance of equipment” was performed in one case and “cleaning of equipment” in the second case).

Personal measurements – related to any Cr(VI) use (short-term measurements)

For the total of 15 short-term measurements the AM is 0.325 µg/m^3 and the 90th percentile is 0.870 µg/m^3. During these measurements the workers performed regular maintenance of the baths and related equipment such as LEV, rectifier, pumps, panels and sensors, inspection and cleaning of wet scrubbers, or aspiration of extraction filters above treatment baths with a vacuum cleaner.

For all short-term measurements it is documented that RPE (e.g., reusable half mask – particle filter, or half mask – gas filter FFABEK1P3RD) is used, e.g., during line breakdowns or during maintenance of equipment.

Also, for the pooled short-term personal monitoring data, the 90th percentile is approximately by factor 2 higher than the 90th percentile of the short-term monitoring data related to anodising.

Table 9-28 shows the summary statistics of workplace measurements for maintenance and/or cleaning workers. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. All measurements are from 2018 through 2021.

Table 9-28: Summary statistics of inhalation exposure measurements for WCS 4 – Maintenance and/or cleaning workers

Personal – related to any Cr(VI) use (measurement period 2018-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Long-term	17	100	0.721	1.28	0.240	1.92
Short-term	15	100	0.325	0.399	0.170	0.870
Personal – related to anodising (measurement period 2018-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Long-term	12	60	0.277	0.379	0.0378	0.958
Short-term	8	40	0.132	n.a.	n.a.	n.a. (MAX = 1.0)

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

n.a. = not assessed; the statistical parameter was only determined if at least three (for AM) or ten (for SD, Median and 90th percentile) values were available.

All personal long-term measurements of maintenance and/or cleaning workers performing tasks related to any galvanic Cr(VI) use are included in the assessment of inhalation exposure. Table 9-29 shows the resulting long-term inhalation exposure concentration for maintenance workers used for risk assessment, based on the 90th percentile of personal sampling values.

As stated above, exposure from sources and processes not related to the use of anodising contributed to most of the exposure values. Considering that maintenance workers typically spend only a minor part of their working time on activities related to anodising (at maximum 5%[15]), we assign 5% of the shift average exposure value (90th percentile of all long-term measurements) to this use. We further assume that one worker per shift (**three maintenance and/or cleaning workers per day**) is engaged

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[15] Considering the durations of all main tasks performed by maintenance and/or cleaning workers as described in section 9.2.3.5.2 and assuming conservatively 48 maintenance activities per year, with a duration of 4h each, the exposure time related to anodising accounts for (48 x 4h = 192h; 192h/(1920h working time per year) = 10%. If tasks are divided between three workers, this would consume 3.3% of their working time, which is conservatively rounded to 5%).

with activities potentially leading to Cr(VI) exposure (**each worker spending a maximum of 5% of his working time on activities related to anodising**). Consequently, the long-term exposure concentration is corrected by a factor of 0.05. For sites where the work is distributed among a higher number of workers, a higher number of people would have to be considered, but their long-term average individual exposure concentration would be lower.

RPE may be worn during specific maintenance and/or cleaning activities as its use was documented for all short-term measurements. However, it is assumed that RPE was worn during certain short periods of the shift average measurements. Therefore, no RPE is considered in the exposure assessment, which constitutes a further conservative element of the assessment.

Table 9-29: Measured inhalation exposure concentration for WCS 4 – Maintenance and/or cleaning workers

Type of measurement	Number of measurements	Exposure value (8h TWA) [a] [µg/m³]	Assigned protection factor (APF) for RPE [b]	Exposure value corrected for RPE [µg/m³]	Long-term exposure [c] [µg/m³]
Personal	17	1.92	1	1.92	0.0960

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

[a] Based on 90th percentile of measurements.

[b] No RPE is considered; RPE is only worn during some measurements for specific, short-term activities only (with measurements performed outside the mask), see text above.

[c] The frequency/duration correction factor of 0.05 was applied for maintenance and/or cleaning activities related to anodising: each of the three maintenance workers spends up to 5% of his shift on activities related to anodising with Cr(VI).

9.2.3.5.2.2 Risk characterisation

Risk for carcinogenicity

Table 9-30 shows the risk characterisation for carcinogenicity for maintenance and/or cleaning workers. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for maintenance and/or cleaning workers and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-30: Risk characterisation for carcinogenicity for WCS 4 – Maintenance and/or cleaning workers

Route of exposure and type of effects	Long-term exposure [µg/m^3]	Risk characterisation: Excess lifetime lung cancer risk * [1/µg/m^3]	Excess lifetime cancer risk (ELCR)
Inhalation: Systemic Long Term	0.0960	4.00E-03	3.84-04

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

* RAC dose-response relationship based on excess lifetime lung cancer risk (ECHA, 2013): Exposure to 1 µg/m^3 Cr(VI) relates to an excess risk of 4x10^{-3} for workers, based on 40 years of exposure; 8h/day; 5 days/week.

Conclusion on risk characterisation:

Carcinogenicity

The Excess life-time cancer risk for maintenance and/or cleaning workers is 3.84E-04.

This risk estimate can be considered as conservative, because:

- it is based on a conservative ERR,
- it uses the 90th percentile of the reported long-term measurements,
- these measurements were not corrected for their duration but assumed to be shift representative values, and
- no correction for wearing RPE was applied although workers may wear RPE under certain conditions for some activities (such as removal of anodes from treatment baths).

As described above, it is considered for the assessment that **three maintenance and/or cleaning workers** per day and site perform all maintenance and/ or cleaning activities related to anodising.

Based on the gathered information and considering the implemented RMM we conclude that risk of exposure is minimised.

Comparison of outcome with initial applications

Inhalation exposure

Maintenance of equipment (PROC 8a)

In the initial applications, regular maintenance of equipment at the baths (e.g., change of LEV or pump) is covered by personal monitoring of workers who also perform the surface treatment by dipping/immersion. As these measured values also cover such treatment activities and other tasks that are usually carried out by line operators (see the comparison with initial applications in section 9.2.3.2.2.2), this value is not suitable for a direct comparison.

Infrequent maintenance activities (PROC 8a)

In addition to such regular maintenance and cleaning activities, infrequent maintenance activities are considered as a separate task in the applications 0032-04 and 0032-05. For such activities inhalation exposure was estimated by modelling with ART 1.5. It was assumed for modelling that filter changes were performed 1x per month for 240 min. For this activity handling of solids/powders with a Cr(VI) weight fraction of up to 10% was considered, without use of LEV but with RPE (APF 30).

As shown in the table below, the excess lifetime lung cancer risk based on inhalation exposure modelling was 1.00E-03 in the initial applications. In the present assessment, inhalation exposure from maintenance and cleaning of equipment is evaluated by personal monitoring of maintenance and/or cleaning workers performing typical maintenance tasks.

The excess lifetime lung cancer risk for the present assessment is with **3.84E-04** lower than the risk calculated in the initial applications. However, actually measured exposures in the breathing zone of workers are much lower than those modelled. As we did not consider RPE in our risk calculations although it may be used for specific maintenance tasks, this is a conservative risk estimate.

Initial assessment				**Present assessment**	
Application ID	**Chromate**	**Inhalation, long-term exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**	**Inhalation, long-term exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**
0032-04	CT	0.25	1.00E-03	0.0960	3.84E-04
0032-05	CT	0.25	1.00E-03		

9.2.3.6 Worker contributing scenario 5 – Machinists

Machinists are involved in several activities related to the mechanical treatment of metallic parts. However, machining on anodised parts is only carried out at some sites (according to current information ca. 25%) performing this use.

Moreover, at sites where machining is carried out on parts that have been treated with anodising, machining of these parts accounts for only a small share of the working time of the machinists. Most of their working time is not related to anodising.

The activities with potential Cr(VI) exposure performed by machinists are summarized for the present assessment as the following task:

Main tasks

- Task 1: Machining operations on anodised parts included cleaning (PROC 21, 24)

Typical machining activities on anodised parts related to the use with potential direct exposure to Cr(VI) as well as the working conditions are described below in detail and are supported by worker air monitoring data covering machining activities.

9.2.3.6.1 Conditions of use

Table 9-31 summarises the conditions of use for the activities with potential direct Cr(VI) exposure related to machining activities on anodised parts carried out by machinists.

Table 9-31: Conditions of use – worker contributing scenario 5 – Machinists

Product (article) characteristics
Product: Part treated by anodising with CT ▪ Product type: Solid object ▪ Solid material: Metal ▪ Moisture content: Dry product (<5% moisture content)
Amount used (or contained in articles), frequency and duration of use/exposure
Task 1: Machining operations on anodised metallic parts ▪ Duration of activity: up to 180 min (at few sites infrequent long-term activities of up to 600 min per shift on 2 days per year are reported) ▪ Frequency of task: <1-240 days/year (<1-5 days/week, 48 weeks/year)
Technical and organisational conditions and measures
Task 1: Machining operations on anodised metallic parts including cleaning ▪ LEV: no/yes (depends on the place where machining takes place and whether exposure to dust is possible) ▪ Ventilation rate of general ventilation system: natural ventilation ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Conditions and measures related to personal protection, hygiene, and health evaluation
Gloves As it is expected that any residual Cr(VI) contained in coating particles released by machining cannot be absorbed through the skin, no gloves are required for protection against Cr(VI). However, although gloves are not required to protect against Cr(VI), the PPE for each machining activity is determined by each site with an overall EH&S risk assessment for potential mechanical injury.
Respiratory protection equipment RPE is worn during all tasks not performed under an LEV for which industrial hygiene exposure assessment confirms RPE use is required. The following types of RPE are used according to EN 529:2005 [b]: ▪ Half mask FFP3 (APF 10), half mask with P3 filter (APF 10), half mask with P3 combination filter (APF 10) or ▪ Full mask with P3 filter (APF 20), full mask with P3 combination filter (APF 20) Type of RPE to be used for specific tasks is laid down in work instructions for the tasks.
Protective clothes A protective suit is worn during all activities related to Task 1. Type of protective clothes to be used for specific tasks is laid down in work instructions for the tasks.

Eye protection Suitable eye protection (as per relevant risk assessment) must be worn during all activities related to Task 1. Type of eye protection to be used for specific tasks is laid down in work instructions for the tasks.
Other conditions affecting workers' exposure
Task 1: Machining operations on anodised parts including cleaning ▪ Place of use: indoors – any size workroom ▪ Temperature: room temperature ▪ Activity Class: Fracturing and abrasion of solid objects ▪ Situation: Mechanical treatment/abrasion of small sized surfaces ▪ Containment level: Open or partially enclosed processes ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
▪ *None*

[a] https://www.dguv.de/ifa/gestis/gestis-stoffdatenbank/index.jsp ; accessed 8 December 2020

[b] For selection of APF see Annex V of this report.

9.2.3.6.2 Exposure and risks for workers

At sites where machining after anodising is performed, usually one to 15 machinists are engaged (depending, e.g., on the size of the site). However, machining of these parts accounts on average only for 40% of their working time. Most of their time they spend on activities not related to this use, with and without Cr(VI) exposure. The work system at a site can be divided in one or two shifts per day, with one to eight workers per shift. The shift duration is usually 8h but may also be up to 12h, depending on the organisation of the site and national law.

We describe below in detail relevant machining activities performed by machinists on anodised parts and the working conditions.

Task 1: Machining operations on anodised parts including cleaning

The machinists are responsible for operations of all types of mechanical metal processing. Machining may be required for production, maintenance, and repair activities when parts need to be reworked or resized to meet dimensional accuracy, special surface characteristics or textures defined in the customer specifications.

The aim of these treatments is the removal of material or the chromic anodise treatment from a workpiece. Different types of machining might be necessary: milling, drilling, cutting, edging, grinding, grating, honing, reaming, deburring, pressing, abrading and sanding. All these manual mechanical treatments (excluding blasting processes) are called machining. During these machining processes, the part or its surface is mechanically pierced or abraded, resulting in the release of dust. Some activities, such as grating, do not generate dust as coarse shavings are taken off the surface.

Machining can be performed in small to large work areas (e.g., in a machine shop or in a large workshop on an aircraft assembly unit), on partially enclosed machines or on special workbenches. When machining is required to be carried out directly on an aircraft or on an assembled unit, the machining activity is carried out *in situ*. Transportable parts are typically machined on partially enclosed machines, workstations, work benches or manually operated lathes. Whenever technically possible, machining activities with dust release and/or potential for worker inhalation exposure to Cr(VI) are conducted under the use of an LEV (e.g., at a dedicated work bench equipped with LEV or in a fixed capturing hood) or using a vacuum cleaner with HEPA filter. If this is not technically possible and industrial hygiene exposure assessment confirms RPE use is required, the worker wears RPE.

In case of some MRO activities, the removing of the coating is achieved by blasting. This operation is performed in a closed system with no expected Cr(VI) exposure.

Machining can be performed under dry or wet conditions depending on the technique used. The water or fluid used for wet machining reduces the dispersion of emitted particles. After treatment, the parts may be rinsed and dried.

In addition to carrying out the mechanical work, the machinists are generally also responsible for cleaning the machines and tools and managing the waste generated. These activities are included in this task because they are conducted under the same operational conditions and risk management measures as the machining activities. A typical cleaning operation consists of cleaning and disposing of waste particles generated during the machining process. Also, after activities where coarser surface shavings are removed without releasing dust, the workers clean the working area with a vacuum cleaner at the end of the shift or in between. All process fluids are collected and sent to an external waste management company.

The duration and frequency of machining activities can be highly variable between different sites. At some sites, machining activities on parts treated with anodising are only performed at maximum 2x/year but then with a duration of 20-600 min, at other sites they are performed more frequently, for 10 to 180 min per shift.

During machining activities, a fixed or mobile LEV is used wherever this is technically and practically possible. Machinists wear eye protection (as per relevant risk assessment), a protective suit, and RPE (if not performed under an LEV and industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-31.

9.2.3.6.2.1 Inhalation exposure

Measured inhalation exposure concentration

In total, 25 personal and four stationary measurements covering exposure from machining activities on anodised parts are available for this SEG.

Among the 25 personal monitoring data, 20 are long-term (≥2h) [16], shift-representative and five are short-term (<2h) measurements. Among the four stationary measurements, three are long-term (≥2h), shift-representative and one is a short-term (<2h) measurement.

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[16] All long-term measurements (≥2h) are considered as shift-representative measurements and used as such as 8h TWA exposure values; no recalculation has been performed. Measurements <2h were not used to calculate 8h TWA exposure values.

The personal monitoring data come from five sites of four countries in the EEA (20 measurements) and from two sites in the UK (five measurements). 80% of the data (20 values, including three short-term measurements) are <LOQ and 20% (five values, including two short-term measurements) are >LOQ. Regarding stationary data, they all come from two sites located in two EEA countries and all are >LOQ.

As previously mentioned in the case of some MRO activities, removing of coating can be achieved using blasting tools. This operation is performed in a closed system and thus no Cr(VI) exposure is expected. This is confirmed by six long-term personal monitoring data from one EEA site where only grit-blasting or sand-blasting activities were performed. All results are below a reasonable LOQ (<0.02 to <0.111 µg/m^3), which confirms that Cr(VI) exposure related to this specific activity is very low.

A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex IV of this report. The individual measurements can be provided upon request. An overview of the available data for machinists is given in Table 9-32.

Table 9-32: Overview of available inhalation exposure measurements for WCS 5 – Machinists

	n	>LOQ	<LOQ
Personal			
- Long-term (≥2h)	20	3	17
- Short-term (<2h)	5	2	3
Stationary			
- Long-term (≥2h)	3	3	0
- Short-term (<2h)	1	1	0

Personal measurements – long-term

Long-term personal measurements were taken for operators performing machining on parts with Cr(VI)-treated surfaces. However during most of the measurements, several types of coatings are machined. Parts could have been anodised or treated by other processes (e.g., passivation of (non-Al) metallic coatings, conversion coating, anodise sealing) with CT and/or other chromates. In some cases, it is not known which parts were machined during the measurement period, or which finishes were initially applied on the parts, and in other cases, machining was performed on parts with different types of finishing coatings.

The AM of all long-term personal measurements is 0.158 µg/m^3 and the 90th percentile is 0.513 µg/m^3. During the long-term personal measurements, the workers performed diverse machining activities such as deburring, milling, drilling, polishing or boring. Some tasks are performed with machines (such as milling, drilling, or boring), other tasks are carried out manually (e.g., manual grinding).

One long-term measurement explicitly covers manual grinding, the result was below the LOQ (<0.02 µg/m3). During this measurement, RPE was worn (half mask with filters P3). This very low value suggests that no increased exposure is to be expected from this operation, but no conclusion can be driven from one single measurement.

Only one of the long-term measurement was taken while the worker worked on parts only treated by anodising, but not with any other Cr(VI) use (according to the information provided by the site). The measurement was carried out for 198 min during which the worker used hand tools and deburring tools on parts that had undergone anodise treatment. The exposure value was below the LOQ (<1 µg/m3).

Personal measurements – short term

The five short-term measurements are within a range of 0.0212 – 0.5 µg/m^3, the AM is 0.296 µg/m^3.

Two of these short-term measurements were taken while the worker performed activities only related to anodising, but not to any other Cr(VI) use (according to the information provided by the sites). The first measurement was carried out for 94 min during which the worker deburred parts using a partially enclosed machine. The second measurement was carried out for 47 min during which the worker machined parts in a lapping machine. Both exposure values were below the LOQ (<1 µg/m^3) corresponding to the upper value of the range.

Stationary measurements

Three long-term stationary measurements are available for workplaces where machining of anodised parts was performed in addition to many other tasks (e.g., immersion, primer application, touch-up). All these three values were taken at the same site. The individual values are 0.173, 0.767 and 4.09 µg/m^3. The latter value is well above the others. No specific explanation is available to explain such a difference. It is reported that during the measurements, primers application and sanding may also have been performed (the details of the tasks performed during the measurement are not available). Therefore, we assume that either the activities carried out during the measurement involved more Cr(VI) activities than only machining would include or that a problem occurred during this measurement, as the two other measurements performed the same year covering the same tasks (still without details) are available and showed much lower exposure. Anyway without further information, this value is considered in this assessment and presented in the following tables.

The short-term measurement was performed in a sanding room during which a large component (approx. 2.5 m^2) was sanded down to the base material using a multi-hole eccentric sander (0.14 µg/m^3; 85 min). Apart from anodised surfaces the worker also worked on surfaces treated with primers.

Table 9-33 shows the summary statistics of workplace measurements for machinists. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. All measurements are from 2017 through 2021.

Table 9-33: Summary statistics of inhalation exposure measurements for WCS 5 – Machinists

Personal – long-term (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	20	100	0.158	0.295	0.046	0.513
Personal – short-term (measurements performed in 2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**

Total	5	100	0.296	n.a.	n.a.	n.a. (MAX = 0.5)
Stationary – (measurement period 2019-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	4	100				
- Long-term	3	75	1.677 [a]	n.a.	n.a.	n.a.
- Short-term	1	25	n.a. [b]	n.a.	n.a.	n.a.

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

n.a. = not assessed; the statistical parameter was only determined if at least three (for AM) or ten (for SD, Median and 90th percentile) values were available.

[a] The individual values are 0.173, 0.767 and 4.09 µg/m3.

[b] The value is 0.14 µg/m^3.

All personal long-term measurements of machinists performing tasks related to anodising are included in the assessment of inhalation exposure.

Table 9-34 shows the resulting long-term inhalation exposure concentration for machinists used for this risk assessment, based on the 90th percentile of personal sampling values.

As stated above, partial exposure from sources and processes not related to the use anodising may have contributed to all exposure values assigned to this use. Considering that machinists typically spend only a minor part of their working time on activities related to anodising (at maximum 40%[17]), we assign 40% of the shift average exposure value (90th percentile of all long-term measurements) to this use.

Typically, two or four machinists per shift are engaged, with one to two shifts per site. They usually spend only a minor part of their time on this use, often limited to a few days per week. On average, we assume that **five machinists per day** are engaged per site and that **each worker spends a maximum of 40% of his working time on activities related to anodising**. Consequently, the long-term exposure concentration is corrected by a factor of 0.4.

For sites where the work is distributed among a higher number of workers, a higher number of people would have to be considered, but their long-term average individual exposure concentration would be lower.

RPE may be worn during specific machining activities but this usually only accounts for shorter periods of the shift average measurements. Therefore, no RPE is considered in the exposure assessment, which constitutes a further conservative element of the assessment.

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[17] Considering the durations of all main tasks performed by machinists as described in section 9.2.3.6.2 and assuming conservatively relevant machining activities daily for 180 min per shift, the exposure time related to anodising accounts for 37.5% (180 min/480 min = 37.5%), conservatively rounded up to 40%.

Table 9-34: Measured inhalation exposure concentration for WCS 5 – Machinists

Type of measurement	Number of measurements	Exposure value (8h TWA) [a] [µg/m^3]	Assigned protection factor (APF) for RPE [b]	Exposure value corrected for RPE [µg/m^3]	Long-term exposure [c] [µg/m^3]
Personal	20	0.513	1	0.513	0.205

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

[a] Based on 90th percentile of measurements.

[b] No RPE is considered; RPE is only worn during some measurements for specific, short-term activities only (with measurements performed outside the mask), see text above.

[c] The frequency/duration correction factor of 0.4 was applied for machining activities related to anodising, see text.

9.2.3.6.2.1 Risk characterisation

Risk for carcinogenicity

Table 9-35 shows the risk characterisation for carcinogenicity for machinists. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for machinists and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-35: Risk characterisation for carcinogenicity for WCS 5 – Machinists

Route of exposure and type of effects	Long-term exposure [µg/m^3]	Risk characterisation: Excess lifetime lung cancer risk * [1/µg/m^3]	Excess lifetime cancer risk (ELCR)
Inhalation: Systemic Long Term	0.205	4.00E-03	8.21E-04

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

* RAC dose-response relationship based on excess lifetime lung cancer risk (ECHA, 2013): Exposure to 1 µg/m^3 Cr(VI) relates to an excess risk of 4x10^{-3} for workers, based on 40 years of exposure; 8h/day; 5 days/week.

Conclusion on risk characterisation:

Carcinogenicity

The Excess life-time cancer risk for maintenance and/or cleaning workers is 8.21E-04.

This risk estimate can be considered as conservative, because:

- it is based on a conservative ERR,
- it uses the 90th percentile of the reported long-term measurements,
- these measurements were not corrected for their duration but assumed to be shift representative values, and

- no correction for wearing RPE was applied although workers may wear RPE under certain conditions for some activities.

As described above, it is considered for the assessment that **five machinists** per day and site perform all machining activities related to anodising.

Based on the gathered information and considering the implemented RMM we conclude that risk of exposure is minimised.

Comparison of outcome with initial applications

Inhalation exposure

The tasks considered in the present assessment to be typically performed by the machinists were described in the initial applications as separate tasks. These separate tasks were modelled with ART 1.5 in the initial applications and no typical frequencies were specified. Consequently, we can only compare the modelling results for individual tasks with the shift-average inhalation exposure values measured for the machinists in the current assessment. As shown in the table below, the excess lifetime lung cancer risk based on inhalation exposure modelling in the initial applications was between 8.12E-03 and 4.40E-04 for machining.

In the present assessment, the excess lifetime lung cancer risk based on shift-average inhalation exposure value is with **8.21E-04** in the range of the initial applications.

However, actually measured exposures in the breathing zone of workers are much lower than those modelled. As we did not consider RPE in our risk calculations the measured exposure concentrations overestimate the risks.

Initial assessment				**Present assessment**	
Application ID	**Chromate**	**Inhalation exposure, 90th Perc. [µg/m^3]**	**Excess lifetime lung cancer risk [1/µg/m^3]**	**Inhalation, long-term exposure, 90th Perc. [µg/m^3]**	**Excess lifetime lung cancer risk [1/µg/m^3]**
Machining operations on small to medium sized parts containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24) <180 min, <0.1% Cr(VI), LEV (99%), APF 10				0.205	8.21E-04
0032-04	CT	0.11	4.40E-04		
0032-05	CT	0.11	4.40E-04		
Machining operations on small to medium sized surfaces containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24) <180 min, <3% Cr(VI), LEV (99%), APF 30					
0032-04	CT	1.13	4.52E-03		
0032-05	CT	1.13	4.52E-03		

Machining operations in large work areas on parts containing Cr(VI) including cleaning (PROC 21, 24) <60 min, <0.1% Cr(VI), LEV (90%), APF 10					
0032-04	CT	0.20	8.00E-04		
0032-05	CT	0.20	8.00E-04		
Machining operations in large work areas on surfaces containing Cr(VI) including cleaning (PROC 21, 24) <60 min, <3% Cr(VI), LEV (90%), APF 30					
0032-04	CT	2.03	8.12E-03		
0032-05	CT	2.03	8.12E-03		
Machining operations on parts containing Cr(VI) in small work areas including cleaning (PROC 21, 24) <60 min, <0.1% Cr(VI), no LEV, APF 400					
0032-04	CT	0.16	6.40E-04		
0032-05	CT	0.16	6.40E-04		
Machining operations on surfaces containing Cr(VI) in small work areas including cleaning (PROC 21, 24) <60 min, <3% Cr(VI), no LEV, APF 1000					
0032-04	CT	1.90	7.60E-03		
0032-05	CT	1.90	7.60E-03		

9.2.3.7 Worker contributing scenario 6 – Incidentally exposed workers

Incidentally exposed workers are defined as workers who spend a relevant part (10% or more) of their working time in the work area where the treatment baths for anodising are located, but do not carry out tasks with direct Cr(VI) exposure potential themselves. These workers may incidentally be exposed from such activities due to inhalation background exposure in the work area. Their tasks are required to be performed in this work area, as they are essential activities related to either the anodising process or to other processes necessary to be carried out in the same workplace. The activities performed by incidentally exposed workers are summarized for the present assessment as the following task:

- Task 1: Activities with indirect Cr(VI) exposure (PROC 0)

In the following sections, we specify the conditions of use under which indirect exposure these workers can occur, and we describe typical activities they perform while indirectly exposed.

9.2.3.7.1 Conditions of use

Table 9-36 summarises the conditions of use for various tasks performed by incidentally exposed workers working in the hall and in the vicinity of the bath(s) where anodising is carried out, from which the workers are incidentally exposed.

Table 9-36: Conditions of use – worker contributing scenario 6 – Incidentally exposed workers

Product (article) characteristics
Product 1: Aqueous solution of CT ▪ Concentration of substance in mixture for bath applications: up to 5.2% (w/w) Cr(VI) (based on ranges of CT (2.8-10% (w/w)) in the aqueous solution in the anodising bath) ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Amount used (or contained in articles), frequency and duration of use/exposure
Task 1: Activities with indirect Cr(VI) exposure ▪ Duration of activity: up to 480 min ▪ Frequency of task: 240 days/year
Technical and organisational conditions and measures
Task 1: Activities with indirect Cr(VI) exposure ▪ Ventilation rate of general ventilation system: natural ventilation ▪ Process temperature: room temperature ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Conditions and measures related to personal protection, hygiene, and health evaluation
Task 1: Activities with indirect Cr(VI) exposure ▪ Standard PPE (not intended for protection against chromates) as described in work instructions for the tasks
Other conditions affecting workers exposure
Task 1: Activities with indirect Cr(VI) exposure ▪ Place of use: indoors – any size workroom ▪ Primary emission source proximity: The primary emission source is usually in the far field (>1 m)
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
▪ *None*

9.2.3.7.2 Exposure and risks for workers

The number of incidentally exposed workers for the anodising process can be highly variable, depending on the size of the site, the organisation of process lines (e.g., numerous lines in one hall vs.

one line per hall) and the organisation of work. Typically, there are between zero to 15 incidentally exposed workers per site (zero to five per shift). It has to be noted that in compliance with Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work (EU, 2013), wherever a carcinogen or mutagen is used, the sites keep the number of workers exposed or potentially to be exposed as low as possible and only essential activities are carried out in the vicinity of the treatment bath(s). During activities performed by operators involving solid CT (e.g., bath addition, see WCS1) these workers (i.e., incidentally exposed workers) keep large distances from these activities.

The work system at a site can be divided in one to three shifts per day. The shift duration is usually 8h but may also be up to 12h, depending on the organisation of the site and national law.

Usually, at least three different uses with Cr(VI) are carried out in one work area, such that only one third of the worker exposure for incidentally exposed workers arises from anodising.

Considering:

- the typical number of incidentally exposed workers per site (zero to 15) and
- that only 1/3 of the exposure during this time comes from the use under consideration,

it is estimated that between zero and five incidentally exposed workers are to be considered per site for the use anodising. For risk characterisation, an average of six workers (working part of their shift in the hall where anodising is performed, 240 days per year, being indirectly exposed to Cr(VI) during 50% of their working time) per site is assumed.

We describe below the potential activities that can be performed by incidentally exposed workers and the working conditions under which indirect Cr(VI) exposure from anodising may occur. Workers may also be incidentally exposed from additional Cr(VI) uses performed in the same hall as anodising (e.g., anodise sealing).

Task 1: Activities without direct Cr(VI) exposure

The tasks of incidentally exposed workers of anodising can be very diverse, but at many sites, workers who are not working directly with Cr(VI) sources may regularly carry out activities near the treatment bath(s), including, but not limited to the following:

- line operations at other process baths (not using Cr(VI))
- supervision of processes
- quality assessment of parts
- un-/jigging of parts and cleaning of jigs (Figure 9-17)
- un-/masking of parts
- transportation of closed chemical containers
- machining activities (on parts, where no Cr(VI) exposure is possible)

[redacted] [redacted]

Figure 9-17: Workers responsible for un-/jigging

During all tasks performed by incidentally exposed workers at the same location as the treatment bath(s) for anodising, the workers wear standard PPE, as specified above in Table 9-36.

Depending on the organisation of the site, some of the above-mentioned activities may also be performed by line operators.

9.2.3.7.2.1 Inhalation exposure

Measured inhalation exposure concentration

In total, 18 personal and eight stationary measurements are available for incidentally exposed workers in galvanic departments. Two personal long-term measurements were excluded from further analysis due to unreasonably high LOQs (i.e., above 1 µg/m^3).

Of the remaining 16 personal monitoring data, 15 are long-term (≥2h) [18], shift-representative and one is a short-term (<2h) measurement.

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[18] All long-term measurements (≥2h) are considered as shift-representative measurements and used as such as 8h TWA exposure values; no recalculation has been performed. Measurements <2h were not used to calculate 8h TWA exposure values.

The personal monitoring data come from five sites in five countries in the EEA (eight measurements) and from two sites in the UK (eight measurements). Approximately 63% of the data (ten values, including the one short-term measurement) are <LOQ and 37% (six values) are >LOQ.

A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex IV of this report. The individual measurements can be provided upon request. An overview of the available data for incidentally exposed workers is given in Table 9-37.

Table 9-37: Overview of available inhalation exposure measurements for WCS 6 – Incidentally exposed workers

	n	>LOQ	<LOQ
Personal			
- Long-term (≥2h)	15	6	9
- Short-term (<2h)	1	0	1
Stationary			
- Long-term (≥2h)	8	0	8

Personal measurements – long-term

Long-term personal measurements were taken in the hall where immersion processes in baths containing Cr(VI) were performed, e.g., in the area where un-/jigging or masking are carried out or in the control area. Eleven of these measurements cover exposure from anodising in combination with exposure from other Cr(VI) uses, but none of them relates exclusively to exposure from anodising.

As we expect incidental exposure to be comparable between diverse Cr(VI) uses, the monitoring data for all Cr(VI) immersion uses were pooled regardless of whether they also cover incidental exposure from anodising or only from other Cr(VI) uses. The AM over the total of long-term personal measurements is 0.316 $\mu g/m^3$, the median is 0.290 $\mu g/m^3$ and the 90th percentile is 0.500 $\mu g/m^3$.

Personal measurements – short term

The short-term measurement has an exposure value of 1.0 $\mu g/m^3$ and was taken in a hall where passivation of stainless steel and electroplating (both with Cr(VI)) were performed.

Stationary measurements

The eight stationary monitoring data are long-term measurements. The AM over of these measurements is 0.0564 $\mu g/m^3$. The measurements were taken in halls where in most cases multiple immersion uses were performed, (e.g., anodising, conversion coating and passivation of (non-Al) metallic coatings), positioned e.g., in the un-/jigging area, in the area where finished parts are stored or in the broader vicinity of treatment baths with or without Cr(VI). During two measurements also machining activities and touch-ups with brush or pen stick were carried out in approximately 2 m distance to where the static sampling device was positioned. Two of the static measurements cover incidental exposure from anodising in combination with chemical conversion coating (both 0.085 $\mu g/m^3$). None of the measurement exclusively covers incidental exposure from anodising.

Table 9-38 shows the summary statistics of workplace measurements for incidentally exposed workers. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. All measurements are from 2018 through 2021.

Table 9-38: Summary statistics of inhalation exposure measurements for WCS 6 – Incidentally exposed workers

Personal (measurement period 2018-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Long-term	15	94	0.316	0.254	0.290	0.500
Short-term	1	6	n.a. [a]			
Stationary – (measurement period 2018-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Long-term - total	8	100	0.0564	n.a.	n.a.	n.a.

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

n.a. = not assessed; the statistical parameter was only determined if at least three (for AM) or ten (for SD, Median and 90th percentile) values were available.

[a] The value is 1.0 µg/m³

All personal long-term measurements of incidentally exposed workers operating in halls where Cr(VI) uses were performed are included in the assessment of inhalation exposure. Table 9-39 shows the resulting long-term inhalation exposure concentration for incidentally exposed workers used for risk assessment, based on the 90th percentile of personal sampling values.

As stated above, partial exposure from sources and processes not related to the use of anodising may have contributed to all exposure values assigned to this use. It was estimated above that for risk characterisation, an average of **six workers** (exposed for 50% of their shifts) needs to be considered per site.

Table 9-39: Measured inhalation exposure concentration for WCS 6 – Incidentally exposed workers

Type of measurement	**Number of measurements**	**Exposure value (8h TWA) [a] [µg/m³]**	**Assigned protection factor (APF) for RPE [b]**	**Exposure value corrected for RPE [µg/m³]**	**Long-term exposure [c] [µg/m³]**
Personal	15	0.500	1	0.500	0.250

All exposure values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

[a] Based on 90th percentile of measurements.

[b] No RPE is considered.

[c] Workers are assumed to be exposed during 50% of their shift and thus a reduction factor of 2 was applied.

9.2.3.7.2.2 Risk characterisation

Risk for carcinogenicity

Table 9-40 shows the risk characterisation for carcinogenicity for incidentally exposed workers. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for incidentally exposed workers and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-40: Risk characterisation for carcinogenicity for WCS 6 – Incidentally exposed workers

Route of exposure and type of effects	Long-term exposure [µg/m^3]	Risk characterisation: Excess lifetime lung cancer risk * [1/µg/m^3]	Excess lifetime cancer risk (ELCR)
Inhalation: Systemic Long Term	0.250	4.00E-03	1.00E-03

All values rounded to three significant figures for presentation, but unrounded values used for calculation of exposure.

* RAC dose-response relationship based on excess lifetime lung cancer risk (ECHA, 2013): Exposure to 1 µg/m^3 Cr(VI) relates to an excess risk of 4×10^{-3} for workers, based on 40 years of exposure; 8h/day; 5 days/week.

Conclusion on risk characterisation:

Carcinogenicity

The Excess life-time cancer risk for incidentally exposed workers is 1.00E-03.

This risk estimate can be considered as conservative, because:

- it is based on a conservative ERR,
- it uses the 90th percentile of the reported long-term measurements,
- these measurements were not corrected for their duration but assumed to be shift representative values.

As described above, it is considered for the assessment that on average **six workers (exposed for 50% of their shifts)** might be incidentally exposed at a site where this use is performed.

Based on the gathered information and considering the implemented RMM we conclude that risk of exposure is minimised.

Comparison of outcome with initial application

Exposure of incidentally exposed workers was not considered in previous applications.

10 RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

10.1 Human health (related to combined, shift-long exposure)

10.1.1 Workers

Efforts were undertaken to clearly identify and describe groups of workers exposed to chromates. These SEGs (Similar Exposure Groups) typically perform more than one task. Exposure data provided cover the various activities performed during the work routine of these workers and are used to describe long-term exposure. Therefore, the combined exposure from performing several tasks is already covered in the exposure assessment.

The situation where workers are exposed due to activities related to other uses with Cr(VI) are discussed in the respective worker contributing scenarios.

10.1.2 Consumers

No consumer uses are addressed in this CSR.

10.2 Environment (combined for all emission sources)

10.2.1 All uses (regional scale) – regional assessment

In accordance with RAC's conclusions (see e.g., the RAC/SEAC "Opinion on an Application for Authorisation for Use of Sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites and sealings of anodic films"[19]), no regional assessment has been carried out as it can be assumed that Cr(VI) from any source will be reduced to Cr(III) in most environmental situations and therefore the effects of Cr(VI) as such are likely to be limited to the area around the source, as described in the EU Risk Assessment Report for chromates (ECB, 2005). Therefore, combined exposures from various sources on the regional scale do not need to be considered.

On the local scale all relevant exposures from the emission source to air and wastewater are assessed (see section 9.2.3.1).

10.2.2 Local exposure due to all wide dispersive uses

There are no wide dispersive uses covered in this CSR.

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[19] RAC/SEAC, consolidated version, 2016; https://echa.europa.eu/documents/10162/658d42f4-93ac-b472-c721-ad5f0c22823c

10.2.3 Local exposure due to combined uses at a site

The assessment of exposure of humans via the environment was performed using site-specific emission data for all substances used for this use, taking into account the relative amounts consumed for this use. Therefore, the total releases at a specific site from all uses performed at the site are higher in cases, where several uses are performed in parallel. The total releases per site are between 0.0000876 and 43.1 kg/year to air (compared to 0.000077-3.055 kg/year for anodising only) and between 0 and 4.86 kg/year to water (compared to 0-3.32 kg/year for anodising only), as summarised in Table 9-14 and as shown in detail in Annex III (Table Annex III-1) of this CSR.

11 Annexes

11.1 Annex I – Comparative assessment of physico-chemical input parameters for EUSES modelling

In the following tables the physico-chemical properties of the four chromates covered by the ADCR consortium other than chromium trioxide (CT) are shown. The physico-chemical properties of CT are given in section 9.1.2.4.

With these physico-chemical properties as input parameters we carried out a comparative EUSES assessment with an example scenario in which only the substance-specific physico-chemical properties of the five chromates covered by the ADCR consortium were exchanged.

Physico-chemical properties of the other chromates covered by the ADCR consortium

Physico-chemical properties of sodium dichromate (SD), required for EUSES modelling

Property	Description of key information	Value selected for EUSES modelling	Comment
CAS	10588-01-9		
Molecular weight	262 g/mol	262 g/mol	Refers to SD; value used in ECB (2005)
Melting/freezing point	Becomes anhydrous at 100 °C (ECB, 2005), salt melts at ca. 357 °C	357 °C at 101.3 kPa	Refers to SD; value used in ECB (2005)
Boiling point	decomposes above 400 °C (ECB, 2005)	400 °C	Refers to SD; value used in ECB (2005)
Vapour pressure	n/a: inorganic ionic compound	0.00001 Pa	n/a; dummy value entered
Log Kow	n/a: inorganic ionic compound	0	n/a; dummy value entered
Water solubility	2355 g/L at 20 °C; (a 1% solution has a pH ~4)	2355 g/L at 20°C	Refers to SD; value used in ECB (2005)

Physico-chemical properties of sodium chromate (SC), required for EUSES modelling

Property	Description of key information	Value selected for EUSES modelling	Comment
CAS	7775-11-3		
Molecular weight	161.99 g/mol	161.99 g/mol	Refers to SC, value used in ECB (2005); Registration dossier
Melting/freezing point	decahydrate loses H2O and melts at ~20°C; anhydrous salt melts at ~762 °C (acc. to ECB, 2005); 792 °C (acc. to registration dossier)	500 °C (highest value possible for EUSES)	Refers to SC, value used in ECB (2005); Registration dossier
Boiling point	n/a; inorganic compound	500 °C (highest value possible for EUSES)	
Vapour pressure	n/a: inorganic ionic compound	0.00001 Pa	n/a; dummy value entered
Log Kow	n/a: inorganic ionic compound	0	n/a; dummy value entered
Water solubility	~530 g/l at 20 °C (the aqueous solution is alkaline (pH 9))	530 g/L at 20°C	Refers to SC, value used in ECB (2005)

Physico-chemical properties of potassium dichromate (PD) required for EUSES modelling

Property	Description of key information	Value selected for EUSES modelling	Comment
CAS	7778-50-9		
Molecular weight	294.22 g/mol	294.22 g/mol	Refers to PD, value used in ECB (2005)
Melting/freezing point	~398°C	398	Refers to PD, value used in ECB (2005)
Boiling point	n/a decomposes above 500 °C	500	Refers to PD, value used in ECB (2005)

Property	Description of key information	Value selected for EUSES modelling	Comment
Vapour pressure	n/a: inorganic ionic compound	0.00001 Pa	n/a; dummy value entered
Log Kow	n/a: inorganic ionic compound	0	n/a; dummy value entered
Water solubility	~115 g/L at 20 °C (a 10% solution has a pH ~3.5)	115 g/L at 20 °C	Refers to PD, value used in ECB (2005)

Physico-chemical properties of dichromium trischromate (DtC) required for EUSES modelling

Property	Description of key information	Value selected for EUSES modelling	Comment
CAS	24613-89-6		
Molecular weight	451.97 g/mol	451.97 g/mol	Refers to DtC, value used in SVHC support document (ECHA, 2011)
Melting/freezing point	The substance melts above 300 °C	300	Refers to DtC, value used in SVHC support document (ECHA, 2011)
Boiling point	n/a	300	Refers to DtC, value used in SVHC support document (ECHA, 2011)
Vapour pressure	n/a: inorganic ionic compound	0.00001 Pa	n/a; dummy value entered
Log Kow	n/a: inorganic ionic compound	0	n/a; dummy value entered
Water solubility	96.6 g/L at 20 °C	96.6 g/L	Refers to DtC, value used in SVHC support document (ECHA, 2011)

Comparative EUSES assessment with an example scenario

The outcome of the comparative EUSES assessment is shown in the Table below. The test was carried out using the partition coefficients determined under alkaline conditions and no use of a biological STP was assumed. As can be seen from the table, the modelling results are largely identical, except for the daily dose through intake of drinking water, which is slightly higher based on CT data. Although the difference is very small, we used CT data for EUSES modelling of Cr(VI) exposure for all sites for reasons of conservatism.

Outcome of the comparative EUSES assessment of the impact of the physico-chemical properties of the five different chromates on the concentrations in the considered Cr(VI) uptake media drinking water, fish, and air

Anodising CT

Chromate	Daily dose through intake of drinking water [mg/kg/day]	Daily dose through intake of fish [mg/kg/day]	Daily dose through intake of air [mg/kg/day]	Sum of daily dose through intake of drinking water, fish, and air [mg/kg/day]
SD	1.77E-07	1.02E-08	1.74E-07	3.61E-07
CT	**3.41E-07**	1.02E-08	1.74E-07	**5.25E-07**
SC	1.77E-07	1.02E-08	1.74E-07	3.61E-07
PD	1.77E-07	1.02E-08	1.74E-07	3.61E-07
DtC	1.77E-07	1.02E-08	1.74E-07	3.61E-07

11.2 Annex II – EUSES sensitivity analysis of impact of partition coefficients

We assessed the impact of the selected partition coefficients (under acidic or alkaline conditions) in a sensitivity analysis with EUSES. We carried out an exemplary exposure scenario (with no biological STP) using (a) the coefficients for acidic conditions, (b) the coefficients for alkaline conditions or (c) the calculated mean values. The outcome of the assessment is shown in the table below. From the table it becomes obvious that the variation of Cr(VI) exposure of HvE via the combined exposure routes air, drinking water and fish was lower than 2%. Accordingly, it can be concluded that the selected set of partition coefficients had close to no impact on the modelling result.

Outcome of the comparative EUSES assessment of the impact of the partition coefficients on the concentrations in the considered Cr(VI) uptake media drinking water, fish, and air

Set of partition coefficients used	Daily dose through intake of drinking water [mg/kg/day]	Daily dose through intake of fish [mg/kg/day]	Daily dose through intake of air [mg/kg/day]	Sum of daily dose through intake of drinking water, fish, and air [mg/kg/day]	Variation of sum of daily dose through intake of drinking water, fish, and air from calculation with mean partition coefficients [%]
Mean values	1.74E-07	1.00E-08	1.74E-07	3.58E-07	0%
Acid	1.72E-07	9.89E-09	1.74E-07	3.56E-07	0.59%
Alkaline	1.77E-07	1.02E-08	1.74E-07	3.61E-07	- 0.89%

11.3 Annex III – EUSES input data and release fractions derived from environmental monitoring data of representative sites

The table below shows site-specific information on releases, on wastewater (biological treatment, dilution in the treatment plant and in the receiving water) and on the share of anodising of the overall emission. The Cr(VI) amounts used by the sites shown in Annex III-1 for anodising range from <1 to 1040 kg/year.

Note that one site reported the air emission only as total chromium (Cr total); in this case, the emission value was conservatively taken as Cr(VI). Still, the air emission from this site is comparably low.

Table Annex III-1 – EUSES input data and release fractions derived from environmental monitoring data of representative sites

Site	Fraction of tonnage released to air	Release to air [kg/year]	Fraction of tonnage released to water	Release to water [kg/year]	Share of air emission relevant for this use	Share of water emission relevant for this use	STP discharge rate $[m^3/day]$	Application of sewage sludge to agricultural soil/grassland	Dilution factor receiving water
Site 1	1.52E-03	0.634	1.16E-02	4.86	1.000	0.303	386230	assume yes [d]	2.2 [g]
Site 2	2.53E-03	0.040	5.89E-03	0.09	0.594	0.594	2000 [a]	assume yes [d]	10 [c]
Site 3	2.04E-04	0.547	5.31E-04	1.42	0.006	0.006	2000 [a]	assume yes [d]	1000 [b]
Site 4	3.31E-03	3.636	2.84E-03	3.12	0.840	0.840	2000 [a]	assume yes [d]	10 [c]
Site 5	9.30E-03	43.100	0.00E+00	0.00	0.017	0.017	-	-	-
Site 6	4.41E-04	0.299	8.36E-06	0.01	0.714	0.714	2077	no	4.3 [f]
Site 7	4.88E-03	7.270	6.72E-06	0.01	0.070	0.070	2000 [a]	no	10 [c]
Site 8	1.10E-04	0.007	0.00E+00	0.00	1.000	1.000	-	-	-
Site 9	1.20E-03	0.001	0.00E+00	0.00	0.351	0.351	-	-	-
Site 10	1.76E-04	0.374	8.89E-05	0.19	0.884	0.884	275000	no	2.7 [e]
Site 11	5.21E-03	1.008	0.00E+00	0.00	0.726	0.726	-	-	-
Site 12	3.54E-04	0.149	0.00E+00	0.00	0.024	0.024	-	-	-

Anodising CT

Site	Fraction of tonnage released to air	Release to air [kg/year]	Fraction of tonnage released to water	Release to water [kg/year]	Share of air emission relevant for this use	Share of water emission relevant for this use	STP discharge rate [m^3/day]	Application of sewage sludge to agricultural soil/grassland	Dilution factor receiving water
Site 13	4.93E-07	0.000	5.77E-06	0.00	0.876	0.876	2000 [a]	assume yes [d]	10 [c]
Site 14	1.25E-04 [h]	0.134 [h]	8.50E-06	0.01	0.037	0.037	2000 [a]	assume yes [d]	10 [c]
Site 15	2.00E-03	4.480	1.79E-08	0.00	0.170	0.170	2000 [a]	assume yes [d]	10 [c]
Site 16	2.25E-05	0.013	8.70E-09	0.00	0.733	0.733	2000 [a]	assume yes [d]	10 [c]
Site 17	3.26E-04	0.021	5.60E-02	3.57	0.931	0.931	2000 [a]	assume yes [d]	10 [c]
Site 18	5.54E-03	6.570	6.32E-05	0.08	0.228	0.228	2000 [a]	assume yes [d]	10 [c]
Site 19	8.73E-03	1.571	2.61E-03	0.47	0.857	0.833	2000 [a]	assume yes [d]	10 [c]
Site 20	3.48E-03	1.064	0.00E+00	0.00	0.451	0.451	-	-	-
Site 21	5.49E-03	0.259	9.15E-03	0.43	0.019	0.019	2000 [a]	assume yes [d]	10 [c]
MIN	4.93E-07	0.0000876	0.00E+00	0.00	0.00603	0.00603			
MAX	9.30E-03	43.1	5.60E-02	4.86	1.000	1.000			
Median	1.52E-03	0.374	8.36E-06	0.00910	0.594	0.451			
AM	2.62E-03	3.39	4.23E-03	0.679	0.501	0.467			
90th percentile	**5.54E-03**	**6.57**	**9.15E-03**	**3.12**	**0.931**	**0.884**			

[a] No site-specific information is available for the STP discharge rate and thus the EUSES default of 2000 m3/day was used.

[b] According to site-specific data, the receiving water has a minimum flow rate of 500 000 – 5 000000 [redacted] m^3/day; a maximum dilution factor of 1000 is used for EUSES calculation.

[c] No site-specific information is available for the flow rate of the receiving water and thus the EUSES default of 18 000 m3/day was used.

[d] Application of STP sludge to agricultural soil/grassland is considered since no information to the contrary is available.

[e] According to site-specific data, a minimum flow rate of the receiving water of 100 000 – 1 000 000 [redacted] m^3/day and a treatment plant discharge of 100 000 – 1 000 000 [redacted] m^3/day results in a dilution factor of 2.7.

[f] According to site-specific data, a minimum flow rate of the receiving water of 1 000 – 10 000 [redacted] m^3/day and a treatment plant discharge of 1 000 – 10 000 [redacted] m^3/day results in a dilution factor of 4.3

[g] According to site-specific data, a minimum flow rate of the receiving water of 100 000 – 1 000 000 [redacted] m^3/day and a treatment plant discharge of 100 000 – 1 000 000 [redacted] m^3/day results in a dilution factor of 2.2

[h] For emissions to air only total chromium was measured at this site, this value was conservatively taken as Cr(VI).

In the following table the exposure concentrations for humans via the environment (on a local scale) are shown. Note that the exposure concentrations are based on the **overall releases of the sites, of which only a certain share is generated by anodising**.

Table Annex III-2: Exposure concentrations for humans via the environment – on local scale (based on total emissions from site)

	Inhalation	**Oral (drinking water and fish)**		
Site	**Local Cr(VI) PEC in air [µg/m^3]**	**Drinking water * [µg Cr(VI)/kg x d]**	**Fish * [µg Cr(VI)/kg x d]**	**Oral exposure (water and fish) [µg Cr(VI)/kg x d]**
Site 1	4.85E-04	1.55E-04	2.50E-06	1.58E-04
Site 2	3.08E-05	5.36E-04	2.08E-06	5.38E-04
Site 3	4.16E-04	8.10E-03	3.24E-07	8.10E-03
Site 4	2.77E-03	1.78E-02	6.90E-05	1.79E-02
Site 5	3.28E-02	8.12E-04	2.28E-07	8.12E-04
Site 6	2.28E-04	1.42E-05	8.14E-07	1.50E-05
Site 7	5.53E-03	1.37E-04	2.66E-07	1.37E-04
Site 8	5.19E-06	1.29E-07	7.22E-09	1.36E-07
Site 9	2.37E-04	5.86E-06	8.78E-09	5.87E-06
Site 10	2.84E-04	7.02E-06	1.20E-07	7.14E-06
Site 11	7.67E-04	1.90E-05	1.24E-08	1.90E-05
Site 12	1.13E-04	2.80E-06	7.94E-09	2.81E-06
Site 13	6.68E-08	5.84E-06	3.00E-08	5.87E-06
Site 14	1.02E-04	5.42E-05	2.10E-07	5.44E-05
Site 15	3.41E-03	8.46E-05	3.10E-08	8.46E-05
Site 16	9.85E-06	2.72E-07	7.36E-09	2.79E-07
Site 17	1.58E-05	6.24E-04	2.44E-06	6.26E-04
Site 18	5.00E-03	5.50E-04	1.70E-06	5.52E-04
Site 19	1.20E-03	2.70E-03	1.04E-05	2.71E-03
Site 20	8.09E-04	2.00E-05	1.26E-08	2.00E-05
Site 21	1.97E-04	2.46E-03	9.56E-06	2.47E-03
MIN	6.68E-08	1.29E-07	7.22E-09	1.36E-07
MAX	3.28E-02	1.78E-02	6.90E-05	1.79E-02
Median	2.84E-04	8.46E-05	2.28E-07	8.46E-05
AM	2.59E-03	1.62E-03	4.75E-06	1.63E-03
90th percentile	**5.00E-03**	**2.70E-03**	**9.56E-06**	**2.71E-03**

* See explanations on oral uptake via drinking water and fish in CSR section 9.1.2.4.2.

Remarks on measured exposure:
The 90th percentiles of the local exposure concentrations based on the **overall releases of the sites** are 5.00E-03 µg/m^3 for the PEC in air and 2.71E-03 µg Cr(VI)/kg per day for oral exposure via drinking water and fish. Note that for the exposure via drinking water and fish a reduction factor of 5 was applied, as described in section 9.1.2.4.2 of the CSR.

11.4 Annex IV – Inhalation exposure measurements for workers

For inhalation exposure measurements, diverse analytical methods were used. Frequently reported analytical methods are NIOSH 7600 (VIS), NIOSH 7605 2003, ion chromatography, OSHA 215, UV/VIS spectrometry, IFA 6665: 2014-10 with ion chromatography or UV/VIS Spectroscopy, ISO 16740 PN-87/Z-04126/03.

According to the diversity of analytical methods used, the reported LOQs are heterogeneous, ranging from 0.01 µg/m^3 to 10 µg/m^3.

Available Information on methods and LOQs for individual measurements are documented in a separate excel file.

11.5 Annex V – Respiratory protection –Assigned protection factors (APF)

The European Standard EN 529 – “Respiratory protective devices. Recommendations for selection, use, care and maintenance” provides guidance on the selection and use of RPE. It also lists “Assigned protection factors” as recommended in various European countries. As can be seen in the Table below, APFs vary numerically between countries and no generally accepted factors exist. In a conservative approach in this review report we use the lowest value per device over all countries listed in the Table. As it is not always possible to differentiate between companies using combined gas-particle or pure particle filters P3, the same APF (20) is used for full masks with combined gas particle filter Gas X P3 and with particle filter P3.

Assigned protection factors according to EN 529 and APFs used for assessment.

Type	**Specific EU norm**	**Example**	**APFs as used in some countries according to EN 529**						**APF used in this report**
			Fin	D	I	S	UK	FR[1]	
Filtering half mask FFP3 (non-reusable)	EN 149		20	30	30	20	20	10	**10**
Half mask with particle filter P3	EN 140 (mask) EN 143 (filter)		-	30	30	-	20	10	**10**
Half mask with combined gas-particle filter Gas X P3	EN 405		-	30	-	-	10	-	**10**
Full mask (all types) with particle filter P3	EN 136 (mask) EN 143 (filter)		500	400	400	500	40	30	**20**
Full mask (all types) with combined gas-particle filter Gas X P3	EN 136 (mask) EN 143 (filter)		-	400	-	-	20	-	**20**
Powered filtering device incorporating a hood or a helmet (PAPR,	EN 12941		200	100	200	200	40	40	**40**

powered & supplied air respiratory protection) TH3										
Powered filtering device incorporating a full mask TM3	EN 12942		1000	500	400	1000	40	60 (120 L/min) 100 (160 L/min)	**40**
fresh air hose breathing apparatus - full mask or hood or helmet	EN 138		500	1000	400	500	40	-	**40**
Supplied-air respirator (SAR) Continuous flow compressed airline breathing apparatus 4A/4B	EN 14594		-	-	-	-	-	250	**40**
Compressed air line breathing apparatus with demand valve - Apparatus with a full face mask	EN 14593-1		1000	1000	400	1000	40	-	**40**

[1] Source: INRS guidance ED6106

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