October 2022

CHEMICAL SAFETY REPORT

Non-confidential Version

Legal name of applicant(s):	Wesco Aircraft EMEA Ltd MacDermid Performance Solutions UK Ltd Boeing Distribution (UK) Inc. 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: Electroplating 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

Not applicable - as the applicants are not using the substance for this use (upstream application).

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 “Electroplating” 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:

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

This dossier “Electroplating” contains a single use: “Electroplating using chromium trioxide in the 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 CT 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 of CT and 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. 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
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

Scope and type of assessment

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 sections 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 most 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). The same approach is therefore 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 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 2.9x10^{-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 8x10^{-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 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 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.

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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

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 taken into account 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 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

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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).

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).

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, 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, contaminated equipment (e.g., heaters, pumps) 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)
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
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 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. As a general rule, 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 in light of parallel 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, taking into account 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).

Comments on assessment approach related to toxicological hazard:

There are no differences in the hazard profile compared to the initial application with regard to 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 the previous application 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: “Electroplating using chromium trioxide in aerospace and defence supply chains”

9.2.1 Introduction

9.2.1.1 Relationship to previous application

This review report is for “**Use 1: Electroplating 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 application (see Table 9-9), we narrowed the scope of this report in terms of the application sectors, addressing only *Electroplating 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 application.

This chemical safety report covers the solely use of the soluble Cr(VI) compound chromium trioxide (CT) whereas other existing applications also cover the use of sodium dichromate and potassium dichromate. The following table shows the initial application to which this review report refers.

Table 9-9: Overview of initial application

Application ID/ authorisation number	Substance	CAS #	EC #	Applicants	Use name
0032-02/ REACH/20/18/7, REACH/20/18/9, REACH/20/18/11	Chromium trioxide	1333-82-0	215-607-8	Various applicants (CTAC consortium)	Functional chrome plating

With the initial authorisation the European Commission issued several obligations and RAC/SEAC provided recommendations in their joint opinion on the initial application 0032-02 (REACH/20/18/7, REACH/20/18/9, REACH/20/18/11). 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 application in a concise way, while the individual exposure scenarios describe in more detail the measures already implemented.

Table 9-10: Obligations in EC Implementing decision

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.	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 annual monitoring programmes for air monitoring of occupational exposure representative for the tasks undertaken where exposure to chromium is possible, including tasks involving process and maintenance workers and shall implement annual monitoring programmes for chromium (VI) emissions to wastewater and air from local exhaust ventilation.	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 to introduce measures to further reduce exposure and emissions.	Sites regularly review the effectiveness of risk management measures and operational conditions in place.
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.

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 application to provide a more meaningful use description. The use covered by this review report is limited to *Electroplating using chromium trioxide in aerospace and defence supply chains* while the initial application 0032-02 (REACH/20/18/7, REACH/20/18/9, REACH/20/18/11) covered a multitude of application sectors.

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 (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 application, 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 application, 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 application, 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 application. In the first column, the PROCs assigned to different SEGs are shown. The PROCs from the initial application 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 application

Current application	Initial application	Remarks
ECS 1 – Electroplating – use at industrial site **not** leading to inclusion (of Cr(VI)) into/onto article ERC 6b	ERC 6b – Functional chrome plating	
WCS 1 – Line operators [a] PROC 9, PROC 13, PROC 28	PROC 2, 13 – Functional chrome plating - by dipping/immersion PROC 8b – Functional chrome plating - cleaning of equipment PROC 13 – Functional chrome plating - rinsing/drying	For surface treatment by dipping/immersion only PROC 13 is regarded appropriate in the current application, PROC 2 is not considered adequate

	PROC 15 – Laboratory analysis (sampling, laboratory analysis)	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 - solids/liquids PROC 8b – Re-filling of baths – solids/liquids PROC 8b – Decanting - liquids PROC 8b – Decanting and weighing of solids PROC 8b – Functional chrome plating - 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 – 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 4 – Functional chrome plating -loading of jigs PROC 4 - Functional chrome plating - cleaning and unloading of jigs PROC 1 – Storage of articles PROC 8a – End of Life	No exposure is considered from these processes in the current application; cleaning of jigs is covered in WCS 1 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 13 – Functional chrome plating - 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 9.2.3.6.

The exposure scenarios and contributing scenarios 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 electroplating 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 also was observed in extensive consultation processes during the preparation of this review report.

The use of CT for electroplating typically involves one environmental contributing scenario for the use of these chromates at an industrial site.

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

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

ES number	ES Title	Environmental release category (ERC)/ Process category (PROC)
ES1-IW1	Electroplating **–** use at industrial site	
Environmental contributing scenario(s)		
ECS 1	Electroplating - use at industrial site **not** leading to inclusion (of Cr(VI)) into/onto article	ERC 6b
Worker contributing scenario(s)		
WCS 1	Line operators	PROC9, PROC 13, PROC 28
WCS 2	Storage area workers	PROC 5, PROC 8b, PROC 28
WCS 3	Laboratory technicians	PROC 15
WCS 4	Maintenance workers	PROC 28
WCS 5	Incidentally exposed workers	PROC 0
Exposure scenario for industrial end use at site: ES1-IW1		

9.2.1.2.3 Relationship between uses

As shown in Figure 9-1, electroplating with CT is usually combined with pre-treatments (e.g., degreasing, etching) and post-treatments. The pre-treatments (e.g., pickling/etching, degreasing) can involve chromates or not, except for alkaline cleaning which is solely performed Cr(VI)-free. In some cases, parts may be etched in the electroplating baths (reverse etching, without removing the parts) rather than in a separate pre-treatment bath. After electroplating, parts may undergo a post-treatment, which can contain (Cr(VI), e.g., impregnation with resins or primers) or is Cr(VI) free (e.g., heating or application of an additional coating/impregnation). In cases of defective finishing or as part of rework processes, chemical or electrochemical removal of the Cr(0) layer of electroplated parts is performed under acidic or alkaline conditions containing no Cr(VI). Additionally, mechanical removal of the electroplated coating may also be performed. For the combination with deoxidising/pickling/etching/desmutting with CT or sodium dichromate, all details on these pre-treatment processes are described in the CSR on Pre-treatments (see ADCR dossier “Pre-treatments”).

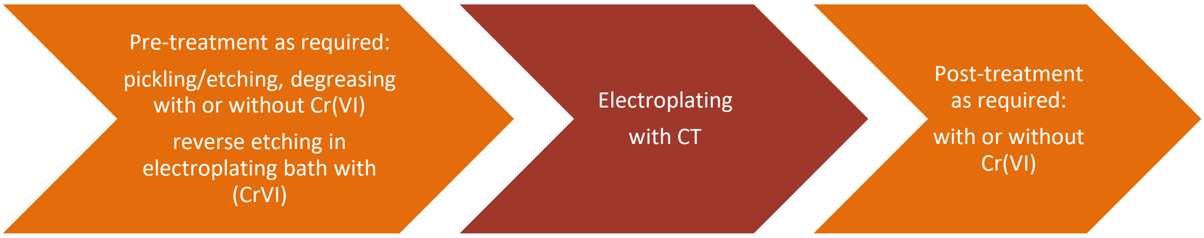


Figure 9-1: **Schematic presentation of treatment steps**

9.2.2 Detailed information on use

9.2.2.1 Process description

Electroplating is a surface treatment process by which the part to be treated is coated coherently based on electrochemical deposition (electrolysis). During the process, the part to be treated, which serves as a cathode, is immersed into an electrolyte containing CT as well as additives and an anode (e.g., inert material or block of metal) (Figure 9-2). While an external electric current is applied, the Cr(VI) in the chromate ions of the electrolyte is reduced and deposited forming a suitable adhered metallic chrome coating that protects the substrate (increased hardness as well as wear, abrasion, and corrosion resistance).

Cr(VI) is reduced in this process to Cr(0) and no Cr(VI) is incorporated into or onto the surface layer. As a consequence, subsequent machining activities on treated parts are not further included in this assessment.

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

Electroplating is an electrolytic process which is in most cases carried out by immersion of parts in treatment baths. Typically, the treatment baths for electroplating 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) although they may be unrelated to the present use. The immersion tanks can be placed individually or within a line of several immersion tanks. Usually, at least one rinsing tank with water is positioned after an immersion tank, for rinsing off the electroplating solution from the part(s).

Figure 9-2: **Treatment bath for electroplating with anode**

Substrate(s)

A variety of substrates are electroplated. Often the components are made of steel or stainless steel. However, also aluminium, copper, cast iron, and different alloys (e.g., brass, Al-Ni-Bronze) can be used as substrate.

Differences between chromates

Only CT is used for electroplating in the aerospace and defence industry and its supply chains.

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 electroplating:

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

9.2.2.3 Technical and organisational risk management measures

All sites that perform electroplating 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 possibility for 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 9.2.3.6.

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.
- 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 wear/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.
- 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 activities)
- 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 devices 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 9.2.3.6.

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 is 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.
- Regular 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 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), treated on-site 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 local 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 reused, evaporated, or discharged to an external wastewater treatment plant (WWTP) or municipal sewage treatment plant (STP) or directly to the receiving water (depending on 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, 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. Further, lead chromate is formed in the anode sludge of the galvanic baths. During bath renewal, it is retrieved and disposed of by an external waste management company (licensed contractor).

9.2.2.4 Tonnages and mass balance considerations

9.2.2.4.1 Tonnages

Assessed tonnage: up to 20,800 kg Cr(VI)/year per site, based on 300 to 40,000 kg CT used per site per year.

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 consumed, as it is needed to build the chromium coated layer of on the component. Cr(VI) is reduced to Cr(0) in this process. Chromate-containing baths are kept for long periods and consumed chromate is replenished.

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 STP or WWTP, is between 0 and 7.2 kg per year (as described in Annex-III).

Amount of Cr(VI) discharged as waste

Cr(VI) in solid waste occurs 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, masking material, sorbents, cleaning materials and PPE; the quantities of Cr(VI) are negligible and not quantifiable. Further, lead chromate is formed in the anode sludge. It is disposed of by an external waste management company (licensed contractor). Also, 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 CT and as baths are usually 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 amount of Cr(VI) emitted via exhaust air from treatment baths is between 0.000014 and 12.9 kg Cr(VI) 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: “Electroplating using chromium trioxide in the 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 6b

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

Subsequent service life exposure scenario(s): not relevant

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

Electroplating using CT by immersion (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.

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), pure substance (100%); **52% Cr(VI)**
Product B: Aqueous solution of CT as purchased (up to 50% (w/w)); **max. 26% (w/w) Cr(VI)**
Amount used, frequency and duration of use (or from service life)
Product A: Solid CT (flakes), used to prepare aqueous bath solutions ▪ Daily use at site: up to 50 kg/day [as Cr(VI)] ▪ Annual use at a site: up to 18,000 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 8 kg/day [as Cr(VI)] ▪ Annual use at a site: up to 2800 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**
  - Air
    - Chemical treatment baths are equipped with LEV and
    - Exhaust air is treated in wet scrubbers or by air filters before it is released via exhaust stack(s)
  - Wastewater
    - Wastewater occurs from bath solutions (depending on the site and the Cr(VI) concentration), water from rinsing tanks, cleaning water, liquid from secondary containment pits, water from wet scrubbers, and liquid hazardous waste from the laboratory
    - Cr(VI)-containing wastewater is gathered and either 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 an external 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, which collect splashes and wash water and direct it to the wastewater collection tank
- **Organisational conditions and measures**
  - Air
    - Cr(VI) air emission measurements are performed regularly 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)
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) 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. Lead chromate formed in the anode sludge is disposed of by an external waste management company (licensed contractor).
Other conditions affecting environmental exposure
All products: ▪ Process temperature of the treatment baths (room temperature - 70 °C)
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
▪ None

The use of CT for electroplating in the aerospace and defence industry and its supply chains is carried out in small to large sites. The sites operate between 8 and 24 h 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

Electroplating is carried out in treatment baths at temperatures ranging from room temperature up to 70 °C and with Cr(VI) concentrations of up to 28% (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) air emissions 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 9-3) or by air filters.

Exhaust air from dedicated measuring 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.

The air monitoring data included in the present assessment mainly comprise air emissions from treatment baths with higher temperatures/Cr(VI) concentrations and/or which are frequently used. Emissions from baths with lower temperatures/Cr(VI) concentrations and/or infrequent use are comparably 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 electroplating.

Figure 9-3: **Wet scrubber (a + b)**

Wastewater emissions

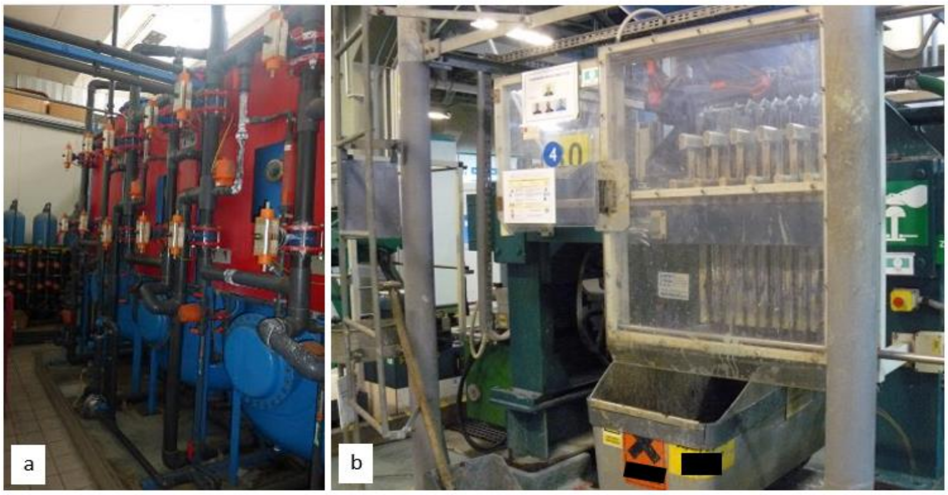
Cr(VI) containing wastewater can arise from the following sources:

- 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)
- water from wet scrubbers
- liquid hazardous waste from samples processed in the laboratory
- liquid from secondary containment pits.

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 and evaporated 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 9-4 a). The precipitated

Cr(III) is then separated from the wastewater by a filter press (Figure 9-4 b) and the filter cake is disposed by an external waste management company (licensed contractor). 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 released either to an internal or 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 have 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 9-4: **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 electroplating. This share was determined by dividing the Cr(VI) amount used for electroplating 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 electroplating with CT provided site-specific emission data for environmental emission modelling. Eighteen are located in seven different countries in the EEA and two sites are located in the UK. The location of one further site is unknown as the data come from an anonymous Art. 66 notification. Some, but not all these sites perform additional surface treatments with Cr(VI) that contribute to environmental emissions.

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 only a certain share is generated by electroplating at those sites with several uses. The calculation of the share of exposure from electroplating (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 electroplating of 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]	6.73E-09 – 5.54E-03 90th percentile: 3.48E-03	0.0001 – 12.9 90th percentile: 7.27	Measured release (site-specific data of representative sites)
Water [b]	0 - 4.88E-03 90th percentile: 5.31E-04	0 – 7.27 90th percentile: 1.12	Measured release (site-specific data of representative sites)
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).

Site-specific releases to air and wastewater vary largely. One major reason is that sites differ vastly in their size and the amount of CT used (see below). 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 (see Annex III).

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 from electroplating 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 electroplating

Site	Local Cr(VI) PEC in air [µg/m^3]	Excess lung cancer risk [1/(µg/m3)] [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
1	2.83E-04	2.90E-02	8.20E-06	5.50E-03	8.00E-04	4.40E-06	**1.26E-05** [c]
2	6.20E-03	2.90E-02	1.80E-04	1.62E-04	8.00E-04	1.30E-07	**1.80E-04** [c]
3	5.08E-03	2.90E-02	1.47E-04	1.26E-04	8.00E-04	1.01E-07	**1.48E-04** [c]
4	8.37E-05	2.90E-02	2.43E-06	2.07E-06	8.00E-04	1.66E-09	2.43E-06
5	9.79E-03	2.90E-02	2.84E-04	2.42E-04	8.00E-04	1.94E-07	**2.84E-04** [c]
6	2.82E-05	2.90E-02	8.18E-07	7.10E-07	8.00E-04	5.68E-10	8.19E-07
7	3.09E-06	2.90E-02	8.96E-08	1.32E-07	8.00E-04	1.06E-10	8.97E-08
8	7.79E-05	2.90E-02	2.26E-06	1.94E-06	8.00E-04	1.55E-09	2.26E-06
9	1.55E-05	2.90E-02	4.49E-07	8.94E-07	8.00E-04	7.16E-10	4.50E-07
10	1.05E-06	2.90E-02	3.06E-08	2.74E-07	8.00E-04	2.20E-10	3.08E-08
11	8.77E-05	2.90E-02	2.54E-06	4.68E-05	8.00E-04	3.74E-08	2.58E-06
12	9.33E-05	2.90E-02	2.71E-06	4.88E-06	8.00E-04	3.90E-09	2.71E-06
13	6.55E-04	2.90E-02	1.90E-05	1.62E-05	8.00E-04	1.30E-08	1.90E-05
14	2.06E-05	2.90E-02	5.97E-07	1.08E-06	8.00E-04	8.67E-10	5.98E-07
15	2.00E-04	2.90E-02	5.79E-06	9.22E-06	8.00E-04	7.38E-09	**5.80E-06** [c]
16	9.45E-05	2.90E-02	2.74E-06	1.80E-04	8.00E-04	1.44E-07	2.88E-06
17	3.19E-03	2.90E-02	9.24E-05	3.52E-04	8.00E-04	2.81E-07	9.27E-05

Site	Local Cr(VI) PEC in air [µg/m^3]	Excess lung cancer risk [1/(µg/m3)] [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
18	2.97E-05	2.90E-02	8.61E-07	1.44E-04	8.00E-04	1.15E-07	**9.76E-07** [c]
19	1.07E-08	2.90E-02	3.10E-10	1.70E-03	8.00E-04	1.36E-06	**1.36E-06** [c]
20	3.34E-04	2.90E-02	9.69E-06	8.27E-06	8.00E-04	6.62E-09	**9.69E-06** [c]
21	3.65E-04	2.90E-02	1.06E-05	9.03E-06	8.00E-04	7.22E-09	1.06E-05
MIN	1.07E-08		3.10E-10	1.32E-07		1.06E-10	3.08E-08
MAX	9.79E-03		2.84E-04	5.50E-03		4.40E-06	2.84E-04
90th percentile	5.08E-03		1.47E-04	3.52E-04		2.81E-07	1.48E-04
Median	9.33E-05		2.71E-06	9.22E-06		7.38E-09	2.71E-06
AM	1.27E-03		3.68E-05	4.05E-04		3.24E-07	3.71E-05
90th percentile, sites >1000 kg Cr(VI)/a	7.28E-03		2.11E-04	2.84E-03		2.27E-06	**2.11E-04**
90th percentile, sites <1000 kg Cr(VI)/a	5.97E-04		1.73E-05	1.53E-04		1.23E-07	**1.73E-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

[c] Bold: large sites (with Cr(VI) consumption for electroplating >1000 kg/a).

Although tonnage is not the only parameter impacting environmental emissions it is obvious that it is an important parameter - in line with our principal understanding that handling large amounts of chromate have the potential to lead to higher environmental emissions. Figure 9-5 depicts the relationship between the tonnage used for electroplating and the overall calculated excess risk for the 21 sites.

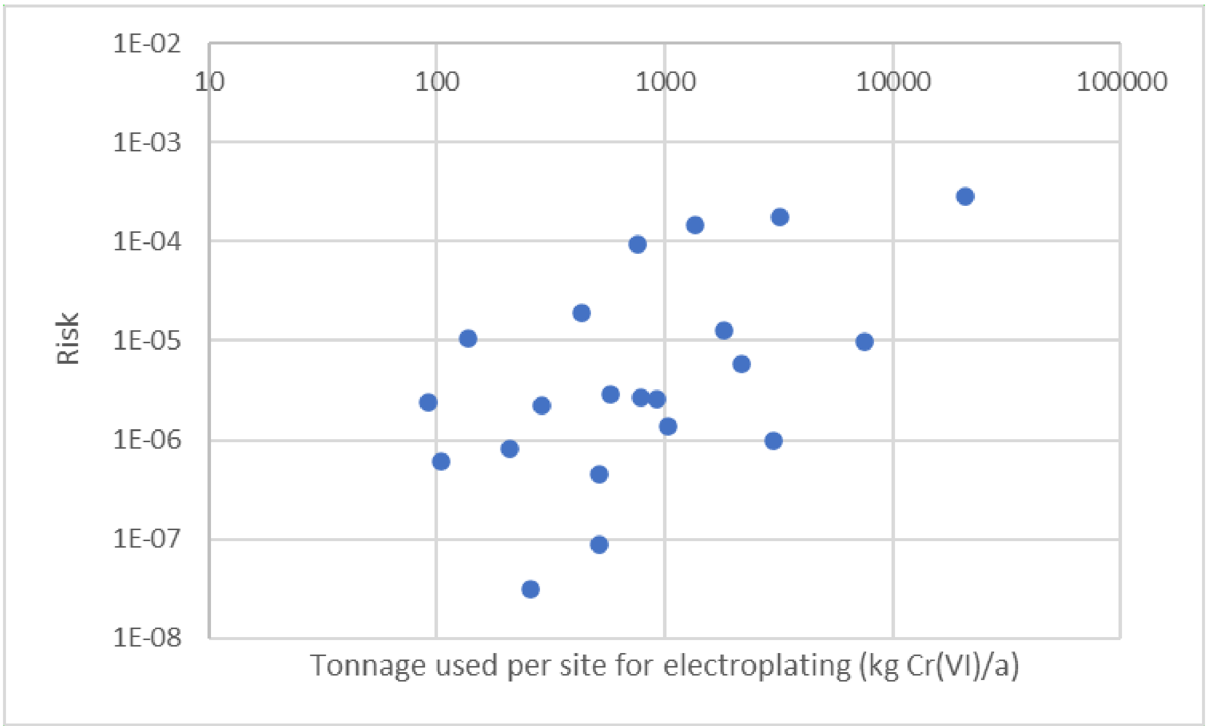


Figure 9-5: **Relationship between tonnage used per site for electroplating and calculated excess cancer risks for humans exposed via the environment**

The 90th percentile of risks calculated from all sites would substantially overestimate the risk for the many smaller sites performing electroplating. Therefore, in the following we differentiate between larger (>1000 kg/a for electroplating, n = 8) and smaller (<1000 kg/a for electroplating, n = 13) sites.

Table 9-15 (two bottom lines) gives the excess cancer risk calculations for the two types of sites. **The 90th percentile for the combined risk of humans via inhalation and oral exposure is 2.11E-04 for large sites (i.e. with amounts used >1000 kg Cr(VI)/year) and 1.73E-05 for small sites (<1000 kg Cr(VI)/year).**

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

Calculation of combined risks for cancer by inhalation and by oral route from the local assessment results in a excess cancer risk of **2.11E-04 for large sites (i.e. with amounts used >1000 kg Cr(VI)/year) and 1.73E-05 for small sites (<1000 kg Cr(VI)/year).**

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 an overestimation.

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

Comparison of outcome with initial application

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 (local PEC in air: 9.79E-03 to 1.07E-08 µg/m^3) and oral exposure (5.50E-03 to 1.32E-07 µg/kg x d) results in an estimated excess cancer risk of 2.11E-04 for large sites (i.e. with amounts used >1000 kg Cr(VI)/year) and 1.73E-05 for small sites (<1000 kg Cr(VI)/year).

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

Application ID	**90th percentile of PEClocal air,ann [µg/m^3]**	**Excess lung cancer risk**
0032-02 (CT)	2.85E-03	8.27E-05

The estimated excess lung cancer risk in the initial application, calculated with data from 2010-2013, is between the risk calculated in the present assessment for small and large sites. The local air concentrations calculated in the initial application are in a similar, although slightly narrower range (4.14E-03 - 2.69E-06 µg/m^3) as in the present assessment.

9.2.3.2 Worker contributing scenario 1 – Line operators

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

Main tasks

- Task 1: Electroplating of parts 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)

Secondary tasks

- Task 4: Bath make-up and addition, including decanting of substances and mixing them with water (PROC 5, PROC 8b)
- Task 5: Bath emptying and cleaning (PROC 28)
- Task 6: Waste management – Cleaning of empty chemical containers/bags (PROC 28)
- Task 7: Waste management – Handling of solid waste (PROC 8b)
- Task 8: Aliquot chemicals – Decanting of liquids (PROC 8b)
- Task 9: Aliquot chemicals – Measuring and weighing of solids (PROC 8b)

As tasks 4 to 9 are main tasks performed by the storage area workers, they are described in detail in the worker contributing scenario for storage area workers (see 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.

Machining (e.g., drilling, grinding) of parts or blasting of surfaces, which were electroplated will not lead to Cr(VI) exposure via inhalation of fine dust particles, as Cr(VI) is reduced in the process to Cr(0) and no Cr(VI) is into or on the surface. Thus, subsequent machining or blasting activities on treated parts are not further included in this assessment.

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 electroplating 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: = max. 28% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (up to 55% (w/w)) in the aqueous solution in the electroplating bath(s) ▪ 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: 20-200 min/shift (time spent close to the bath) (less for automated lines) ▪ Frequency of task: 144-240 days/year (3-5 days/week, 48 weeks/year)
Task 2: Sampling of treatment baths ▪ Amount: 5-300 mL sample ▪ Duration of activity: 1-15 min

- Frequency of task: 12-144 days/year (<1-3 days/week, 48 weeks/year)

Task 3: Cleaning of workplace, equipment, jigs

- Duration of activity: typically 5-30 min (with low frequency: up to 180 min)
- Frequency of task: 24-240 days/year (<1 day/week up to every day, 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)

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

Gloves

Chemical resistant gloves are worn during all tasks (Task 1 to 3), 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)

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)

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

Respiratory protection equipment

No RPE is required for Task 1 to 3.

Protective clothes

Chemical protective clothing must be worn during Tasks 1 and 3. 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

Eye protection as per relevant risk assessment is worn during all tasks (Task 1 to 3).

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 70 °C (range from room temperature up to 70 °C)
- Situation: Activities with open liquid surfaces or open reservoirs
- Open surface: >3 m^2
- Agitation: yes
- 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 70 °C (range from room temperature up to 70 °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: >3 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)

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 electroplating 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.

The work system at a site can be divided in 1-3 shifts per day. The shift duration is usually 8 h but may also be up to 12 h, depending on the organisation of the site and national law. Usually, one operator is sufficient to operate a line of electroplating baths. A typical situation would consist of a site operating two lines in a 3-shift system, resulting in six line operators per site. At large sites with several galvanic uses a larger pool of line operators may work on various lines of the galvanic department, and workers would change from electroplating to other uses and back.

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

<u>Task 1: Surface treatment by dipping/immersion</u>

The process of electroplating is always carried out by immersion of 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 or crab, 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.

The degree of automation for this process is highly dependent on the frequency of this application in the respective site (for high throughput applications processes are more likely to be 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 0.5 and 10 m^3 (up to 42 m^3 in special cases). The Cr(VI) concentration in the bath ranges from 10 to 28% (w/w) and the process temperature ranges between room temperature up to 70 °C. The immersion process is typically performed between 144 and 240 days per year and the assumed residence time of the line operator close to the bath is up to 200 min per shift. However, the part(s) may be immersed in the treatment bath for much longer (typically 5 min - 24 h; can be up to days). During a manual or semi-manual process, the line operator will leave the bath area during immersion processes of longer durations (several min up to several hours/days) if the process allows. In case of an automated process, the line operator is not in the proximity of the bath during the treatment process.

After electroplating, the parts are usually rinsed by immersion into one or two drag-out and/or rinsing tanks or spray rinsing is performed. 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. After rinsing, treated parts are cleared off excess water either by using compressed air or dripping off and then dried at room temperature or in an oven (up to 180 °C, also to avoid embrittling). In case, the surface has to be stripped off (e.g., because the electroplated coating layer is imperfect), in which case the part is subjected to a stripping process not involving Cr(VI), see section 9.2.2.1.

At some sites, when the electroplating baths, which are running on an elevated temperature, are not in use, they are usually covered with a lid to reduce the indirect Cr(VI) exposure for the workers in the vicinity.

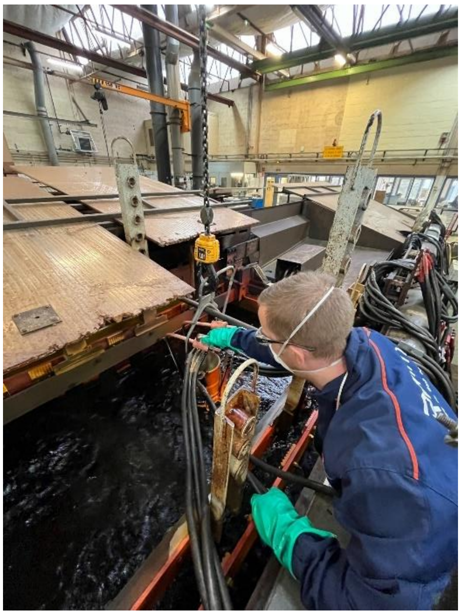


Figure 9-6: **Line operator at electroplating bath**

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 chemical protective clothing, as specified above in Table 9-16.

Task 2: Sampling of treatment baths

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 bottle is rinsed several times in the rinsing bath(s) (located after the treatment bath) and closed for the transport to the laboratory. When using this technique, the line operator takes care that the chemical resistant glove itself does not encounter the bath solution.
- Immersion of a beaker or sample cup (up to 1000 mL) by hand into the treatment bath. Afterwards up to 300 mL are carefully poured into a sample container, which is then closed for transport to the laboratory. When using this technique, the line operator takes care that the chemical resistant glove itself does not encounter 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 9-7).

The process of sampling and rinsing the sampling bottle/device takes up to 15 min (typically 1-5 min). The concentration of the electroplating bath is identical to that described for the immersion process (i.e., up to 28% Cr(VI)), the concentrations of the rinsing bathes are much lower. The sampling can be carried out at temperatures between room temperature and up to 70 °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 at the respective site, ranging between three samples per week and one sample per month.

During sampling, the line operator wears eye protection (as per relevant risk assessment) and chemical resistant gloves, as specified above in Table 9-16.

At some sites it may be the case that the sampling process as described above is not 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).

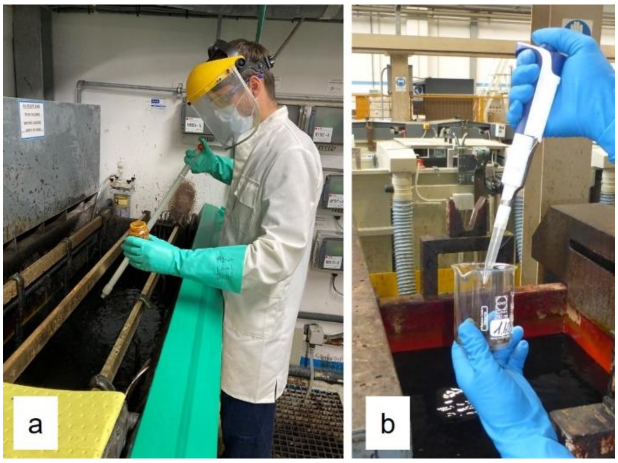


Figure 9-7: **Sampling with a sampling rod (a) or pipette (b)**

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 secondary containment pits below the baths; see Figure 9-8), 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 (e.g., grids, around and under tanks) or of equipment such as jigs, perforated baskets, 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 secondary containment pit (from where the water is sent to the wastewater collection tank(s)), it is necessary to clean the secondary containment pit (e.g., with a hose) (approx. monthly). Usually the entire secondary containment pit (below numerous lines and tanks) is cleaned by 1-3 workers. This cleaning work usually takes up to 3 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 and disposes 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 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 between 3 times per day to at least once every two weeks, i.e., on up to 240 days per year, with a total duration of typically 5 to 30 min per shift where cleaning is performed. The cleaning is carried out at room temperature and the line operators may come in contact with splashes of the treatment bath which contain a maximum of 28% 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 encounter 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. 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 as specified above in Table 9-16. Some sites also have work instructions that require RPE to be worn during workplace cleaning.


[redacted]

Figure 9-8: Hose for cleaning the edges of the tanks and the walkways surrounding the baths

9.2.3.2.2.1 Inhalation exposure

Measured inhalation exposure concentration

In total, 107 personal and 33 stationary measurements covering exposure from electroplating are available for this SEG. Four personal measurements were excluded from further analysis for various reasons: one was below an unreasonably high LOQ (i.e., <2.5 µg/m^3), two values are not reflecting the actual technique at the site and one value was marked as not being reproducible (limited information, as this value was part of an Art. 66 notification to ECHA).

Of the remaining 103 personal monitoring data, 71 are long-term (≥2h)[6], shift-representative and 32 are short-term (<2h) measurements. The 33 stationary measurements all are long-term measurements.

The personal monitoring data come from 31 sites in six countries in the EEA (101 measurements) and from two sites in the UK (4 measurements). Two values from anonymous Art. 66 submissions are of unknown origin. About 46% of the data are <LOQ and 54% are >LOQ.

Of the 33 stationary data 30 values come from 12 sites in two EEA countries and two values come from one site in the UK. One value is of unknown origin (anonymous Art. 66 notification). Two values were excluded, as they are not reflecting the actual technique at the site (same site and situation as above). Two further values were excluded because the measurement devices were located far away from the baths. One of the remaining 29 stationary measurements was <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)	71	44	27
- Short-term (<2h)	32	12	20
Stationary			
- Long-term (≥2h)	29	28	1

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

Long-term personal measurements were taken at operators working at lines where electroplating with CT is performed. For the larger part of the values (77%) electroplating was the only Cr(VI)-related activity at the site. For the remainder (23%) it is reported that pre-treatments, anodising, anodise sealing, chemical conversion coating applications were carried out, sometimes also passivation of

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[6] 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.

stainless steel or passivation of metallic coatings. The workers, especially in galvanic shops specialised on electroplating, may also have carried out Cr(VI) treatments for other industrial sectors (i.e., non-aerospace and defence sectors).

During the personal measurements, the line operators were mainly engaged in performing and controlling the immersion process (Task 1), hanging parts on racks, or unhanging them, performing masking activities, cleaning the workplace or equipment (Task 3). Also, sampling the treatment baths is explicitly mentioned for several of the samples (Task 2). Only one value is reported to be taken at a worker working on an automated line.

Most of the personal measurements are from 2019-2021 (only one long-term measurement from the year 2018 and one short-term measurement from 2017 are included).

The arithmetic mean (AM) over the total of long-term personal measurements is 0.459 µg/m^3 and the 90th percentile is 0.955 µg/m^3 (Table 9-18). As explained above, 55 values (77%) are reported to be taken from workers engaged only in electroplating (no other Cr(VI)-related use reported). The AM for these single-use personal measurements is 0.538 µg/m^3 and the 90th percentile of these measurements is 1.10 µg/m^3, which is very close to the respective values of the total personal long-term measurements.

Personal measurements – short term

The AM of the 32 short-term exposure values is 0.988 µg/m^3, the 90th percentile is 3.27 µg/m^3. The measurements cover sampling of the baths but also activities related to Task 1 (dipping/immersion). The relatively high 90th percentile is caused by 4 values in the range 3 – 4 µg/m^3, all of them with a measurement period of 15 min. In two cases respiratory protection was applied, no information is available for the other two.

Stationary measurements

The AM of the 29 stationary measurements available is 0.649 µg/m^3, the 90th percentile is 1.66 µg/m^3. The values are slightly higher than the respective long-term values from personal monitoring. However, the data set of stationary measurements is smaller than the personal monitoring data and show a high variation. All measurements are from the period 2019-2021.

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.

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

Personal – long-term (measurement period 2018-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	71	100	0.459	0.651	0.210	0.955
Only this use covered by the measurements	55	77	0.538	0.711	0.272	1.10
Personal – short-term (measurement period 2017-2021)						

	N	% of total	AM [µg/m³]	SD [µg/m³]	Median [µg/m³]	90th Perc. [µg/m³]
Total	32	100	0.988	1.08	0.500	3.27
Stationary – (Measurement period 2019-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Total	29	100	0.649	0.748	0.330	1.66

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

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 electroplating may have contributed to some of the exposure values assigned to this use. However, the majority of values come from workplaces without other sources of Cr(VI) exposure and no significant difference is discernible between the exposure levels of the two cases. Therefore, we assign 100% of the shift average exposure value (90th percentile of all long-term measurements) to this use.

As explained above, we assume as a typical situation that **six line operators** per day are engaged in this use per site (an average-size site operating two electroplating lines in a 3-shift system). 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 sometimes worn for specific, short-term activities only (e.g., during sampling), but usually not for Task 1 (immersion). 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	71	0.955	1	0.955	0.955

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 calculated 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	0.955	4.00E-03	3.82E-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/m³ 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 3.82E-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 or sampling).

As described above, it is considered for the assessment that on average **six line operators** per day and site work on the line(s) where electroplating 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

Inhalation exposure

In the initial application, 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 sampling activities were reported but it can be assumed that cleaning of workplaces was performed as well. Accordingly, the worker monitoring data reported in the initial and in the present assessments are broadly comparable:

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]**
0032-02	CT	1.42	5.68E-3	0.955	3.82E-03

As shown in the table above, the excess lifetime lung cancer risk for line operators in the present assessment for electroplating is slightly lower than the risk calculated in the initial application.

Sampling

In the initial application, inhalation exposure from sampling was modelled with ART 1.5 as part of the WCS "Laboratory analysis":

- 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.

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 long-term and a few short-term measurements performed on line operators. Therefore, the exposure during sampling is considered to be covered by the 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 (for CT) in the initial application. The excess lifetime lung cancer risk for shift average measurements (including sampling activities) in the present assessment is with 2.00-03 slightly lower than the risk calculated in the initial application, 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 (covering sampling and lab. analysis)				**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]**

0032-02	CT	0.69	2.76E-03	included above (0.955)	included above (3.82E-03)

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 electroplating 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 electroplating with potential for Cr(VI) exposure, but these tasks account only a small fraction of their working time and mostly they are occupied with activities not related to electroplating and without Cr(VI) exposure.

The storage area workers are responsible for ordering, storing, transporting, delivering, and managing the chemicals used at a site. A considerable part of their working time they spend 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. 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 electroplating 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) for Task 2, Task 3, and Task 5 ▪ Substance product type: Granules, or pelletised material ▪ Dustiness: Flakes ▪ Moisture content: Dry product (<5% moisture content) ▪ Weight fraction: Pure material (100%) ▪ Concentration in pure substance: 52% Cr(VI) for CT
Product 2: Aqueous solution of CT for Task 1, Task 3, Task 4, and Task 5 ▪ Concentration of substance in mixture: max. 26% (w/w) Cr(VI) o Concentration of Cr(VI) based on ranges of CT (typically 50% (w/w)) in 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: = max. 28% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (55% (w/w))) in the aqueous solution in the electroplating 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 (bath addition) ▪ Amount per aliquot: up to 200 kg Cr(VI), corresponding to up to 770 kg product 2 ▪ Duration of activity: 10-30 min ▪ Frequency of task: <1-96 days/year (up to 2 day/week, 48 weeks) Task 1: Aliquot chemicals – Decanting of liquids (bath make-up) ▪ Amount per aliquot: up to 520 kg Cr(VI), corresponding to up to 1000 kg product 2 ▪ Duration of activity: 10-30 min ▪ Frequency of task: <1-2 days/year
Task 2: Aliquot chemicals – Measuring and weighing of solids (bath addition) ▪ Amount per aliquot: up to 200 kg Cr(VI), corresponding to up to 385 kg product 1 (in rare occasions (removal of sludge) up to 350 kg Cr(VI)) ▪ Duration of activity: 5-60 min ▪ Frequency of task: <1-240 days/year (up to 5 days/week, 48 weeks/year, for sites with several baths)

Task 2: Aliquot chemicals – Measuring and weighing of solids (bath make-up)

- Amount per aliquot: up to 2700 kg Cr(VI), corresponding to up to 5200 kg product 1
- Duration of activity: 5-180 min
- Frequency of task: <1-2 days/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 day/year up to 1 day/week, 48 weeks/ year)

Task 4: Waste management – Handling of solid waste

- Duration of activity: 2-15 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 Product 1: up to 2700 kg Cr(VI) (bath make-up); up to 150 kg Cr(VI), in rare occasion up to 350 kg Cr(VI) (bath addition)
- Amount Product 2: up to 520 kg Cr(VI) (bath make-up); up to 200 kg Cr(VI) (bath addition)
- Duration of activity: 10-120 min (bath make-up) or 10-60 min (bath addition)
- Frequency of task: <1-2 days/year (bath make-up) or <1-96 days/year (bath addition)

Task 6: Bath cleaning

- Duration of activity: 60-180 min
- Frequency of task: <1-5 days/year

Technical and organisational conditions and measures

Task 1: Aliquot chemicals – Decanting of liquids

- 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: Aliquot chemicals – Measuring and weighing of solids

- LEV: situation-dependent
- 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 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, situation-dependent
- 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 ≥8 h 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 ≥8 h for aqueous CT solutions (50% CT) [a]:

- Fluorocarbon rubber (0.4 mm)

The following materials have a breakthrough time ≥2 h 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 ≥4 h 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 Task 6. During Tasks 1 and 3 to 4 RPE is worn if these tasks are not performed under a LEV and if industrial hygiene exposure assessment confirms that RPE use is required. During Task 5 RPE is worn 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

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 10–100 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)
- 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: >3 m² ▪ Activity class: Movement and agitation of powders, granules or pelletised material or falling liquids ▪ Situation: Transfer of 1-10 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 45 °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

Storage area workers most often work one or two shifts, with typically one or two workers per shift engaged in these activities. In the following, we assume that on average three storage area workers are working at a site per day. Large sites with several galvanic uses might have a larger pool of storage area workers but their relevant activities with Cr(VI) compounds would be spread over more uses. The shift duration is usually 8 h but may also be up to 12 h, 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 or close to the treatment bath(s).

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 (see Figure 9-9). The measured volume per aliquot is generally less than 385 L chromate solution (<200 kg Cr(VI); for bath additions) but usually 1-10 L chromate solution (<5.2 kg Cr(VI)), depending on the required Cr(VI) concentration in the bath and the tank volume. Then the storage area worker closes the storage container or canister and the measurement vessel with lids. The empty measurement vessel is immersed in the rinsing bath or rinsed with water and the rinsing water is collected and fed to the on-site reduction unit.

At some sites depending on the local conditions and the organisation at the site, the storage container is directly placed next to the tank and the required volume of product pumped into the tank directly, then aliquoting is not required. This activity is performed especially for bath make-ups were larger amounts are necessary (up to 520 kg Cr(VI)).

Figure 9-9: Aliquoting liquid CT with a hand pump

Task 2: For aliquoting solids, the worker opens the lid of a container with the solid substance (flakes) and transfers the required quantity of the substance with a shovel into a measuring container (e.g., bucket) or bag. The amount of substance to be aliquoted is up to 5200 kg chromate per aliquot (2700 kg Cr(VI); for a make-up of a large bath) but usually up to 290 kg chromate (150 kg Cr(VI)) and in rare occasions (removal of sludge) up to 350 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 aliquoted amount of substance.

Whenever possible, entire containers are used for bath make-ups and additives; aliquoting is then not required.

All measuring and weighing processes with solid chromates are carried out at a dedicated place, either in a fume cupboard or equipped with LEV or the storage area workers wear RPE during the measuring and weighing.

Task 1 + 2: The closed containers, bags containing the aliquoted chemical are transported to the treatment bath where they are used for a bath make-up or addition. 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 approx. 10-30 min. In case large quantities are measured, the procedure may take up to 180 min. Solids and liquids are each typically measured up to 48 times per year, in each case as often as bath make-ups or additions are necessary. During aliquoting, the storage area worker wears chemical protective clothing, eye protection (as per relevant risk assessment), and chemical resistant gloves. At least in cases where it is technically impossible to weigh solid chromates within a fume hood or at a station equipped with an LEV, workers also wear RPE (if industrial hygiene exposure assessment confirms RPE use is required), as described above. All relevant PPE is specified in Table 9-21.

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).

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, a reducing agent (e.g., sodium bisulphite) is added in order to reduce any remaining Cr(VI) to Cr(III) prior to the last washing step. 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 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 chemical protective clothing (for cleaning with a hose he also wears an apron and waterproof boots), eye protection (as per relevant risk assessment), 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 electroplating and cleaning activities (empty uncleaned bags and containers, contaminated wipes, rags, and PPE, sorbents, contaminated equipment, filters cartridges, filters, masking material) is disposed of in a waste container, typically by the worker who generates the waste. 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 electroplating baths, in the storage area and/or in the laboratory and is closed when it is not in use (Figure 9-10).

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 may take place up to 1 time per 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 15 min per day.

When handling solid waste, the worker wears chemical protective clothing, eye protection (as per relevant risk assessment), 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 9-10: **Drum for hazardous solid waste**

Task 5: Bath make-up or addition

For smaller bath make-ups or additions, the storage area worker adds the appropriate amount of chemical (either pure solid substance or liquid mixture containing CT) which he already aliquoted into a closed container or bag (see description for Task 1 and 2 above). Then he either dissolves the solid CT in water or fills it as it is (solid or liquid) in the treatment bath and if required mixes the treatment baths by using a stick or lance. In cases of make-ups or additions where higher amounts of chromates are required, the storage area worker transfers the product from the original chemical container by using a scoop (see Figure 9-11) or pouring at a minimal distance to the surface directly into the bath.

In case of bath make-up, the bath is either empty or filled by up to approximately 1/3-1/2 with water before the storage area worker slowly pours the chromate into the bath, taking care to pour at a minimum distance from the bottom of the bath or the water surface to avoid agitation, 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 CT to adjust the Cr(VI) concentration in the bath (after the bath solution was sampled and the amount of CT 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 2700 kg Cr(VI) for bath make-up and up to 150 kg Cr(VI) (in rare occasions up to 350 kg Cr(VI)) for bath addition. Both tasks are carried out at room temperature. For bath make-up the whole process of transfer to the bath, pouring it in the bath, mixing, and then filling the bath up with water takes up to 120 min and is typically carried out anywhere from once a year to every few years. Bath addition only takes up to 60 min and may be necessary at a maximum of 96 times per year (up to 2 days per week).

Typically, when a site performs very frequent bath additions (e.g., 1x/week), bath make-ups are rarely or never required. Accordingly, the total frequency of bath make-ups and additions performed per site is at maximum 96 times per year. For both, bath make-up and addition, the storage area worker wears chemical protective clothing, eye protection (as per relevant risk assessment), and chemical resistant gloves, and RPE (if industrial hygiene exposure assessment confirms that 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 9-11: **Bath addition with solid CT**

Task 6: Bath cleaning

The frequency of cleaning of bath(s) is variable as it depends on site use and conditions of the electroplating bath(s). For example, higher Cr(VI) concentrations can lead to discolouration and sludge formation or sites, which perform masking with wax, need to remove masking residues in bath(s) in order to comply with specifications and achieve a good quality surface treatment. Therefore, some sites clean electroplating bath(s) once per year during an annual shut down or when clean-up due to discolouration, sludge formation, or accumulation of masking residues (e.g., wax) is required. In this case, storage area worker pumps the bath solution in a container (e.g., Intermediate Bulk Container (IBC)) and cleans the emptied tank (see below for details). Afterwards the bath solution is pumped from the storage container back into the cleaned tank. Another cleaning option is that bath solution is pumped through a filter, which collects residues and sludge, and filtered bath solution is directly pumped back into the treatment bath(s). Depending on the existing filter technique, this can be a permanently installed filter, which is continuously cleaning the bath solution and only requires an occasional change of filters (2x/a) or an external filtering system (Figure 9-12), which is performed regularly (1x/ 2 weeks) by storage area workers, who have to set up the pump, filter system, and lines. The contaminated filters and sludge are disposed of as hazardous waste.

If cleaning of the baths is carried out during a bath renewal, 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 IBC or holding tank, in which case it is later disposed of externally as liquid hazardous waste[7], 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. The rinse water is pumped out and treated as wastewater. 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 180 min at the bath, but during the draining process (which may take several hours at some sites), the storage area worker may temporarily be away from the bath. Depending on the size of the plant and the number of electroplating baths, bath cleaning is necessary up to 24 times per year. However, this is a rather specific situation for sites performing cleaning of bath solution through an external filter system once every two weeks (no bath additions). Typically, bath cleaning is performed only up to twice per year (the same frequency as applies for bath make-up). 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 45 °C). At some sites, the LEV is running when the treatment bath is cleaned. For the bath cleaning the storage area worker wears chemical protective clothing, eye protection (as per relevant risk assessment), chemical resistant gloves, and boots, and respiratory protection, as specified 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 maintenance and/or cleaning workers (see section 9.2.3.5) or by an external service provider.

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[7] 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 1x every two weeks), the short duration in which the worker connects and disconnects the tank nozzle (approx. 60 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 9-12: **External filtering system**

9.2.3.3.2.1 Inhalation exposure

Measured inhalation exposure concentration

Twenty-six personal measurements covering exposure related to electroplating are available for storage area workers, consisting of six long-term (≥2h)[8], shift-representative measurements, and 20 short-term (<2h) measurement values. Further, six stationary measurements are available for storage area workers, including one short-term value.

It can be assumed that irrespective of the specific galvanic use for which the activities listed above are performed by storage area workers, the exposure is comparable as the tasks (e.g., weighing/measuring solids, bath make-ups/additions, bath cleaning) are performed in a similar manner. Thus, to support the database for workers engaged at sites where electroplating is performed, all monitoring data for storage area 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 present exposure assessment of storage area workers. Some of these measurements cover tasks not only related to galvanic but also to spraying uses (i.e., slurry coating and/or use of primer), e.g., when waste management was performed during these measurements. More than one chromate is used at many of the sites providing these measurements and the data are often not assignable to a single chromate. Therefore, stratification according to substance is not reasonable.

In total, 139 personal measurements are available for storage area workers but three values are excluded from further analysis: one value with an unreasonably high limit of quantification, plus one long-term measurement value (13 µg/m^3), which is considered as an outlier as it was performed in 2018 at one site and the same site reported three additional measurements for the years 2018 and 2019, during which the same activities were performed (weighing/measuring of solids, bath make-ups/additions, cleaning of empty chemical containers; even the same amount of chromate was used for bath make-ups during these measurements) at the same line, while the exposure values for these

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[8] 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 were all between 0.3 and 0.9 µg/m^3. In addition, one short-term measurement was excluded, taken in 2018 at the same site and bath where the long-term measurement from 2018 described above was taken. This short-term measurement of 15 min only covers the bath make-up and the exposure value of 170 µg/m^3 is orders of magnitude higher than other short-term measurements taken exclusively for bath make-ups (three measurements, 0.05-0.55 µg/m^3, durations of 7-44 min). We assume that a problem occurred during this short-term measurement, as another short-term measurement of this site covering bath make-up from 2021 showed much lower exposure (0.55 µg/m^3, 7 min).

Of the remaining 136 personal monitoring data, 44 are long-term, shift-representative and 92 are short-term measurements. The personal monitoring data come from 27 sites in nine countries in the EEA (121 measurements) and from six sites in the UK (15 measurements). About 47% of the data (64 values, including 45 short-term measurements) are <LOQ and 53% (72 values, including 47 short-term measurements) are >LOQ.

A total of twelve stationary measurements is available. Thereof, ten values are from long-term and two from short-term measurements. The twelve stationary measurements come from seven sites in the EEA. No stationary measurements for storage area workers are available from the UK. About 42% (five values, including one short-term measurement) are <LOQ and 58% (seven values, including one short-term measurement) 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 – related to electroplating			
- Long-term (≥2h)	6	3	3
- Short-term (<2h)	20	6	14
Personal – related to any Cr(VI) use			
- Long-term (≥2h)	44	25	19
- Short-term (<2h)	92	47	45
Stationary – related to electroplating			
- Long-term (≥2h)	5	4	1
- Short-term (<2h)	1	0	1
Stationary – related to any Cr(VI) use			
- Long-term (≥2h)	10	6	4
- Short-term (<2h)	2	1	1

Personal measurements – related to electroplating (long-term and short-term personal measurements)

For three of the six long-term measurements explicit documentation is available indicating that activities such as weighing of solids and bath additions were performed during the measurements. RPE was used by these workers. One value was taken from an operator mainly working in the wastewater department during the measurement. For two further long-term measurements the available description of activities was not informative. The arithmetic mean of these measurements is 0.187 µg/m^3 (Table 9-23).

Activities reported to be carried out during short-term measurements are weighing and decanting of solids or liquids, dissolving solids and bath additions with solids and liquids, disposal of solid waste. For most of the measurements it is documented that workers wore respiratory protection (half or full masks with particle filters). The AM of the 20 measurements is 2.38 µg/m^3.

Stationary measurements – related to electroplating (long-term and short-term measurements)

Four of the five long-term personal measurements were taken at storage area workers performing tasks exclusively related to electroplating with CT. During the fifth measurement the storage area worker also had potential Cr(VI) exposure from other uses (deoxidising, conversion coating, passivation of metallic coatings). All five values are well below 1 µg/m^3, the arithmetic mean is 0.143 µg/m^3 (see Table 9-23). Activities during these personal measurements are described as presence in the chemical storage area, waste management, wastewater management, and storage activities (no further details available).

The one available short-term measurement was taken at a worker during his presence in the wastewater treatment area. It was below the LOQ (<0.12 µg/m^3).

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

The AM of the total long-term measurements is 0.373 µg/m^3 and the 90th percentile is 0.870 µg/m^3 for the pooled personal monitoring data (Table 9-23). The exposure values cover decanting of liquids (Task 1), measuring/weighing of solids (Task 2), cleaning of empty chemical containers (Task 3), Handling of solid waste (Task 4), bath make-up or addition (Task 5), bath emptying and cleaning (Task 6), sampling of treatment baths (secondary task of storage area workers), logistic activities related to chemical storage (transport, ordering), and wastewater treatment. The AM of the pooled personal monitoring data is slightly higher than the AM of the monitoring data related to electroplating (0.187 µg/m^3), supporting the conclusion that it can be used to characterise exposure of this SEG also for the electroplating use.

Use of RPE (e.g., 3M protective half mask with filters 5935 P3 + absorber 6057ABE1 or RPE full face 3M model 7500, filter 6057 ABE1) was documented for approximately half of the long-term measurements (20 values).

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

The 92 short-term measurements cover all relevant tasks performed by storage area workers:

- Task 1: Decanting of liquids (four values, 0.052-13.9 µg/m^3, 9-101 min; all values also cover bath make-up/addition, and one value also includes bath cleaning)
- Task 2: Measuring and weighing of solids (37 values; 0.04-172 µg/m^3, 3-115 min; 19 values also cover bath make-up/addition, and one value also includes bath cleaning)
- Task 3: Cleaning of empty chemical containers/bags (one value, 28 µg/m^3, 15 min)
- Task 4: Handling of solid waste/waste management (nine values, 0.0425-0.54 µg/m^3, 15-118 min, two values also include diverse cleaning activities)
- Task 5: Bath make-up or addition, including decanting of substances and mixing them with water (55 values, 0.018-105 µg/m^3, 2-115 min; 24 values also cover measuring/weighing of solids or liquids, and one value also includes bath cleaning)
- Task 6: Bath emptying and cleaning (four values, 0.018-11 µg/m^3, 44-67 min; all values also cover bath make-up/addition, and two values also include weighing/measuring of solids or liquids)
- Wastewater treatment (six values, 0.09-6 µg/m^3, 10-75 min; one value also covers bath cleaning)

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

Although some measurements result in high exposure values due to the short measurement duration (e.g., the highest short-term exposure value is 172 µg/m^3 with a measurement duration of 7 min during measuring/weighing of solids, RPE with a high APF (Breathing apparatus - Constant flow airline) was used) the long-term measurements covering such tasks show that these activities only contribute to a low extent to the shift-average exposure of storage area workers.

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., all measurements with exposure values > 1 µg/m^3 and most of measurements covering measuring/weighing of solids and bath make-up/additions.

Stationary measurement – related to any Cr(VI) use (long-term and short-term measurements)

The AM of the ten pooled long-term stationary measurements for all galvanic Cr(VI) uses is 0.108 µg/m^3 (Table 9-23). During two of these measurements, decanting of liquids (0.05 µg/m^3) and measuring/ weighing of solids (0.0565 µg/m^3) was performed. Three measurements were taken in the area where wastewater is collected and/or treated (including the one mentioned above; 0.004-0.376 µg/m^3) and five values are from stationary sampling in the storage area (0.036-0.23 µg/m^3), e.g., in front of a chemical cabinet, in which Cr(VI) containing products are stored.

Of the two static short-term measurements, one was taken next to a collection tank and diverse activities of waste management and cleaning were performed during the measurement (0.14 µg/m^3, 30 min), the other the stationary sampling device was positioned in the wastewater treatment area (0.06 µg/m^3, 111 min).

As far as the low number of values allows a comparison, the values found in stationary measurements in the environment of electroplating activities are similar to the pooled stationary data.

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 the period 2018-2021.

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

Personal – related to any Cr(VI) use (measurement period 2016-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Long-term	44	100	0.373	0.512	0.195	0.870
Short-term	92	100	9.76	26.4	0.978	23.2
Personal – related to electroplating (measurement period 2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Long-term	6	14	0.187	n.a.	n.a.	n.a. (MAX = 0.420)
Short-term	20	22	2.38	4.74	0.595	6.44
Stationary – related to any Cr(VI) use (measurement period 2020-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Long-term	10	100	0.108	0.119	0.059	0.245
Short-term	2	100	0.100 [a]	n.a.	n.a.	n.a. (MAX = 0.14)
Stationary – related to electroplating (measurement period 2021)						
Long-term	5	50	0.143	n.a.	n.a.	n.a.
Short-term	1	50	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 0.06 and 0.14 µg/m^3.

[b] The value is 0.06 µg/m^3.

All personal long-term measurements of storage area workers performing tasks related to galvanic uses 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, exposure from sources and processes not related to the use electroplating may have contributed to some of the exposure values. Considering that storage area workers typically spend only a minor part of their working time on activities related to electroplating (rounded to 10%[9]), we assign 10% 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 two shifts per site. On average, we assume that **three storage area workers per day** are engaged per site and that **each worker spends a maximum of 10% of his working time on activities related to electroplating**. Consequently, the long-term exposure concentration is corrected by a factor of 0.1. 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/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	44	0.870	1.00	0.870	0.0870

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, see text above.

[c] The frequency/duration correction factor of 0.1 was applied for storage area workers: each of the three storage area workers spend up to 10% of his shift on activities potentially associated with Cr(VI) exposure in relation to electroplating

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).

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[9] 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 electroplating accounts for 23% of his shift ((30 min 96x/year (Task 1) + 60 min 240x/year (Task 2) + 10 min 48x/year (Task 3) + 15 min 240x/year (Task 4) + 45 min 96x/year (Task 5) + 180 min 5x/year (Task 6) = 587 h; 587h/1920h = 23%, assuming that one worker performs all activities; if the activities are divided between three workers the percentage is 7.7% per worker, conservatively rounded to 10%.

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	0.0870 µg/m^3	4.00E-03	3.48E-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 storage area workers is 3.48E-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 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 **three storage area workers** per day and site perform all tasks assigned to this SEG related to electroplating.

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

Comparison of outcome with initial application

Inhalation exposure

The tasks considered in the present assessment to be typically performed by the storage area workers were described in the initial application 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 application and no typical frequencies were specified. Therefore, it is not possible to calculate an aggregated exposure or shift-average exposure values from the individually modelled activities in the initial application. Consequently, we 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 risk based on inhalation exposure modelling in the initial application ranges from 2.90E-04 to 6.00E-03 for the various tasks modelled. In the present assessment, the excess lifetime lung cancer risk based on shift-average inhalation exposure values (3.48E-04) is at the lower end of the range predicted for the various activities in the initial assessment, however, without taking into consideration the effect of RPE, which is documented to be worn for many short-term activities.

Initial assessment				**Present assessment**	
Application ID	**Chromate**	**Inhalation exposure, 90th Perc. [$\mu g/m^3$]**	**Excess lifetime lung cancer risk [$1/\mu g/m^3$]**	**Inhalation, long-term exposure, 90th Perc. [$\mu g/m^3$]**	**Excess lifetime lung cancer risk [$1/\mu g/m^3$]**
Decanting of liquids (PROC 8b) CT: <60 min, up to 50% Cr(VI), contain. (99%), no RPE				0.0870 $\mu g/m^3$	3.48E-04
0032-02	CT	0.69	2.76E-03		
Decanting and weighing of solids (PROC 8b) CT: <60 min, up to50% Cr(VI), no containm./LEV, RPE (APF 30)					
0032-02	CT	1.5	6.00E-03		
Mixing of liquids (PROC 5) CT: <60 min, up to 50% Cr(VI), contain. (90%), no RPE					
0032-02	CT	0.17	6.80E-04		
Mixing of solids (PROC 5) CT: <60 min, up to 50% Cr(VI), containm. (90%), RPE (APF 30)					
0032-02	CT	0.12	4.80E-04		
Re-filling of baths – liquids (PROC 8b) CT: <60 min, up to 50% Cr(VI), fixed capturing hood (90%), no RPE					
0032-02	CT	1.1	4.40E-03		
Re-filling of baths – solids (PROC 8b) CT: <10 min, up to 50% Cr(VI), fixed capturing hood (90%), RPE (APF 30)					
0032-02	CT	0.073	2.90E-04		
Waste management (PROC 8b) CT: 30 min, up to 50% Cr(VI), containm. (90%), RPE (APF 30)					
0032-02	CT	0.22	8.80E-04		

The tasks *cleaning of empty chemical containers/bags (PROC 28)* and *bath emptying and cleaning (PROC 28)* were not described in the initial assessments and thus no comparison of inhalation exposure from these tasks between the initial application and the current assessment is possible.

9.2.3.4 Worker contributing scenario 3 – Laboratory technicians

Usually, there is a group of 0 to 4 laboratory technicians per site (depending, e.g., on the size of the site). Laboratory technicians may be involved in activities related to electroplating 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 electroplating.

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[10] 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 9.2.3.2.2).

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 electroplating 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 electroplating.

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 electroplating carried out by maintenance workers.

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[10] 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

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

Product (article) characteristics
Product 1: Aqueous solution of CT ▪ Concentration of substance in mixture: =max. 28% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (up to 55% (w/w))) in the aqueous solution in the electroplating 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 at a few days per year) ▪ Frequency of task: 48 events/year (once per week, 48 weeks/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) and [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 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 for activities with CMR substances 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 tasks.

Eye protection

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 tasks.

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 1 to 20 maintenance and/or cleaning workers is engaged (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 can be divided in 1-3 shifts per day. The shift duration is usually 8 h but may also be up to 12 h, 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 of pipes, pumps, sensors, rectifiers, filters and scrubbers, 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. 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 electroplating 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. 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 1 and 48 times per year and durations between 5 and 240 min per maintenance case. 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 28% Cr(VI). During maintenance in and at the treatment bath, the LEV of the bath is running. 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) they additionally wear chemical protective clothing and RPE (if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-26.

9.2.3.5.2.1 Inhalation exposure

Measured inhalation exposure concentration

For maintenance and/or cleaning workers, eleven personal measurements covering exposure of workers from electroplating are available. One personal long-term measurement value was excluded from further analysis as the worker did not follow the hygiene rules, resulting in an increased exposure value (6.94 µg/m^3). The remaining ten values are eight long-term (≥2h)[11] measurements, and two 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 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- (including electroplating) 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. However, in most cases CT was used.

In total, 34 personal monitoring values are available, but two values were excluded from the analysis: the one value described above plus one value which was below an unreasonably high LOQ (i.e., <2 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 electroplating			
- Long-term (≥2h)	8	3	5
- Short-term (<2h)	2	2	0
Personal – related to any Cr(VI) use			

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[11] 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.

- Long-term (≥2h)	17	10	7
- Short-term (<2h)	15	8	7

Personal measurements – related to electroplating

The eight long-term personal measurements were taken at workers performing maintenance activities related to electroplating. The arithmetic mean (AM) for these measurements is 1.126 µg/m^3 and the maximum value is 4.56 µg/m^3. Four of these measurements are exclusively related to this use. The remaining values cover activities related to multiple Cr(VI) uses (e.g., pickling/etching, inorganic finish stripping, anodising, conversion coating, anodise sealing). Activities performed during the measurements include general inspections, maintenance and cleaning of equipment and specific tasks such as repair of pumps, cleaning, and repair of wet scrubbers. The AM is dominated by two reported values of 4.56 and 3.29 µg/m^3 (all other values were below 1 µg/m^3). For these two values (measurement period approx. 3 hours) maintenance respectively cleaning of equipment is reported as main activities. Workers wear respiratory protection (reusable half masks, APF 10).

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 (Table 9-28). 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 electroplating, which further supports the total long-term measurements to be considered for the assessment.

The AM of the pooled personal monitoring data is approximately by factor 1.5 lower than the AM of the monitoring data related to electroplating. As explained above, this is due to two high values, for which it is documented that respiratory protection was worn by the workers. Use of RPE (reusable half mask – particle filter) is also documented for several of the measurements related to non-electroplating uses.

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 (Table 9-28). 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) is used, e.g., during line breakdowns or during maintenance of equipment.

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 the period 2018-2021.

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 electroplating (measurement period 2020-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Long-term	8	47	1.13	n.a.	n.a.	n.a. (MAX = 4.56)
Short-term	2	13	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 individual values are 0.230 and 0.530 µg/m³.

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.

Considering that maintenance workers typically spend only a minor part of their working time on activities related to Cr(VI) exposure in relation to electroplating (at maximum 5%[12]), 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 with activities potentially leading to Cr(VI) exposure (**each worker spending a maximum of 5% of his working time on activities related to electroplating**). 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 some of the measurements. However, it is assumed that RPE was worn during certain short periods

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[12] 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 electroplating 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%).

of the shift average measurements only. 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/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	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, see text above.

[c] The frequency/duration correction factor of 0.05 was applied for maintenance and/or cleaning activities related to electroplating: see text.

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	3.84E-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 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 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 electroplating.

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

Comparison of outcome with initial application

Inhalation exposure

Maintenance of equipment (PROC 8a)

In the initial application, regular maintenance of equipment at the baths (e.g., change of LEV or pump) is covered by personal monitoring measurements of line operators. The following activities are included in the initial assessment:

- 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**

Although comparability is limited, we present here the outcome of the initial assessment together with the present assessment for maintenance and cleaning workers:

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]**
0032-02	CT	1.42	5.68E-3	0.0960	3.84E-04

As shown in the table above, the excess lifetime lung cancer risk for maintenance workers in the present assessment for electroplating is lower (factor 15) than the risk calculated in the initial application.

9.2.3.6 Worker contributing scenario 5 – 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 electroplating 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 electroplating 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.

9.2.3.6.1 Conditions of use

Table 9-31 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 electroplating is carried out, from which the workers are incidentally exposed.

Table 9-31: Conditions of use – worker contributing scenario 5 – Incidentally exposed workers

Product (article) characteristics
Product 1: Aqueous solution of CT ▪ Concentration of substance in mixture: = max. 28% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (up to 55% (w/w)) in the aqueous solution in the electroplating 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*

9.2.3.6.2 Exposure and risks for workers

The number of incidentally exposed workers for the use of electroplating 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. 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).

The work system at a site can be divided in 1-3 shifts per day. The shift duration is usually 8 h but may also be up to 12 h, depending on the organisation of the site and national law.

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 electroplating may occur.

Task 1: Activities without direct Cr(VI) exposure

The tasks of incidentally exposed workers of electroplating 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
- un-/masking of parts
- transportation of closed chemical containers
- machining activities (on parts, where no Cr(VI) exposure is possible)

During all tasks performed by incidentally exposed workers at the same location as the treatment bath(s) for electroplating, the workers wear standard PPE, as specified above in Table 9-31.

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

The number of incidentally exposed workers and the share of working time that they spend in the relevant area can be highly variable between individual sites. Workers who only sporadically (<10% of their total working time) carry out the above mentioned or other activities (e. g. bringing and collecting jigs, engineering, environmental health and safety (EHS) duties, …) in the relevant area are not considered here. Based on information provided by representative sites, normally between 0 and 10 (up to 25 on rare occasions at large sites) incidentally exposed workers may work in the larger surroundings of the treatment baths. Typically, quality assessment workers and logistics operators spend between 10 and 20% and supervisors, and workers responsible for un-/jigging and/or un-/masking between 50-100% (at sites where jigging and/or masking is performed in the treatment hall). At some sites, several different uses with Cr(VI) are carried out in one work area, however, other sites might be specialised in electroplating. Considering that the number of incidentally exposed workers per site ranges widely (from 0 to >10 at large sites) and taking into consideration that at large sites typically several Cr(VI)-related uses take place (only one measurement is available from a site exclusively performing electroplating; this measurement resulted in a low exposure concentration) and that some incidentally exposed workers spend much less than 100% of their working time in the area where the treatment baths are located it is estimated that on average six incidentally exposed workers (working part of their shift in the electroplating hall, 240 days per year, being indirectly exposed during 50% of their working time to Cr(VI) from electroplating) are to be considered per site.

9.2.3.6.2.1 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) [13], shift-representative and one is a short-term (<2h) measurement.

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 9-32.

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

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[13] 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.

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. One of these measurements cover exposure exclusively from electroplating (0.08 µg/m^3) and two further measurements (both below 1 µg/m^3) are from a site where electroplating and passivation of stainless steel took place. 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 the specific galvanic use performed at a site. The arithmetic mean (AM) over the total of long-term personal measurements is 0.316 µg/m^3, the median is 0.290 µg/m^3 and the 90th percentile is 0.500 µg/m^3 (Table 9-33).

Personal measurements – short term

The short-term measurement has an exposure value of 1.0 µg/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 arithmetic mean (AM) over of these measurements is 0.0564 µg/m^3 (Table 9-33). 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. One of the static measurements cover incidental exposure from electroplating (0.105 µg/m^3).

Table 9-33 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 2018-2021.

Table 9-33: Summary statistics of inhalation exposure measurements for WCS 5 – Incidentally exposed workers

Personal (measurement period 2018-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Long-term	15	94	0.316	0.254	0.290	0.500
Short-term	1	6	n.a. [a]	n.a.	n.a.	n.a.
Stationary – (measurement period 2018-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
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 9-34 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 electroplating 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 9-34: Measured inhalation exposure concentration for WCS 5 – 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.

9.2.3.6.2.2 Risk characterisation

Risk for carcinogenicity

Table 9-35 shows the risk characterisation for carcinogenicity for incidentally exposed workers. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data 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 – Incidentally exposed workers

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	0.250	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/m³ 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 the previous application.

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.

10.1.1 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"[14]), 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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[14] 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 0.001 and 12.9 kg/year to air and between 0 and 7.27 kg/year to water, as shown in Table 9-14 and in detail in Annex III (Table Annex III-1) of this CSR. As emissions from the largest emitters are completely assigned to electroplating, the ranges related to electroplating alone are not different from the ranges above.

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) is 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.

<u>Physico-chemical properties of the other chromates covered by the ADCR consortium</u>

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		

Property	Description of key information	Value selected for EUSES modelling	Comment
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)
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

Property	Description of key information	Value selected for EUSES modelling	Comment
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

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 electroplating of the overall emission.

Note that two sites (sites 11 and 12) reported the air emission only as total chromium (Cr total); in these cases, the emission value was conservatively taken as Cr(VI). Still, the air emissions from these sites are comparably low.

The Cr(VI) amounts used by the sites shown in Annex III-1 for electroplating range from 90 to 20,800 kg/year.

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 sludge to agricultural soil/grassland	Dilution factor receiving water
1	2.04E-04	0.547	5.31E-04	1.42	0.679	0.679	2000 [a]	assume yes [b]	1000 [c]
2	2.54E-03	8.23	4.88E-03	7.27	0.991	0.991	2000 [a]	assume yes [b]	10 [d]
3	4.88E-03	7.27	6.72E-06	0.0100	0.920	0.920	2000 [a]	assume yes [b]	10 [d]
4	1.20E-03	0.00120	0, no water emission	0	0.353	0.353	-	-	-
5	6.18E-04	12.9	0, no water emission	0	1.00	1.00	-	-	-
6	1.76E-04	0.374	8.89E-05	0.188	0.0994	0.0994	275000	no	2.7 [e]

7	7.81E-06	0.00406	0, no water emission	0	1.00	1.00	-	-	-
8	3.54E-04	0.149	0, no water emission	0	0.689	0.689	-	-	-
9	3.92E-05	0.0205	2.14E-03	1.12	0.992	0.992	25228800	yes	10 [d]
10	5.33E-06	0.0192	1.67E-07	0.000600	0.0722	0.0722	2000 [a]	assume yes [b]	10 [d]
11	1.25E-04 [f]	0.134 [f]	8.50E-06	0.0091	0.860	0.860	2000 [a]	assume yes [b]	10 [d]
12	1.57E-04 [f]	0.123 [f]	5.77E-07	0.000450	1.00	1.00	2000 [a]	assume yes [b]	10 [d]
13	2.00E-03	4.48	1.79E-08	0.0000400	0.192	0.192	2000 [a]	assume yes [b]	10 [d]
14	2.59E-04	0.270	9.62E-07	0.00100	0.100	0.100	2000 [a]	assume yes [b]	10 [d]
15	1.20E-04	1.31	3.43E-07	0.00375	0.200	0.200	2000 [a]	assume yes [b]	10 [d]
16	2.16E-04	0.127	5.41E-05	0.0318	0.975	0.975	2000 [a]	assume yes [b]	10 [d]
17	5.54E-03	6.57	6.32E-05	0.0750	0.638	0.975	2000 [a]	assume yes [b]	10 [d]
18	1.30E-05	0.0390	8.33E-06	0.0250	0.638	0.638	2000 [a]	assume yes [b]	10 [d]
19	6.73E-09	0.0000140	2.85E-04	0.592	1.00	0.500	2000 [a]	assume yes [b]	10 [d]
20	5.85E-05	0.438	0, no water emission	0	1.00	1.00	-	-	-
21	3.48E-03	1.06	0, no water emission		0.451	0.451	-	-	-
MIN	6.73E-09	0.0000	0.00E+00	0.00	0.0722	0.0722			
MAX	5.54E-03	12.9	4.88E-03	7.27	1.00	1.00			

90th percentile	3.48E-03	7.27	5.31E-04	1.12	1.00	1.00			
Median	2.04E-04	0.270	9.62E-07	0.00375	0.689	0.689			
AM	1.05E-03	2.10	3.85E-04	0.512	0.660	0.652			

[a] No site-specific information is available for the STP discharge rate and thus the EUSES default of 2000 m^3/day was used.

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

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

[d] No site-specific information is available for the flow rate of the receiving water and thus the EUSES default of 18 000 m^3/day was used.

[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 STP discharge of 100 000 – 1 000 000 [redacted] m^3/day results in a dilution factor of 2.7.

[f] 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 electroplating**.

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

Site	**Local Cr(VI) PEC in air [µg/m3]**	**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]**
1	4.16E-04	8.10E-03	3.24E-07	8.10E-03
2	6.26E-03	1.55E-04	8.58E-06	1.64E-04
3	5.53E-03	1.37E-04	2.66E-07	1.37E-04
4	2.37E-04	5.86E-06	8.78E-09	5.87E-06
5	9.79E-03	2.42E-04	7.32E-08	2.42E-04
6	2.84E-04	7.02E-06	1.20E-07	7.14E-06
7	3.09E-06	1.25E-07	7.20E-09	1.32E-07
8	1.13E-04	2.80E-06	7.94E-09	2.81E-06
9	1.56E-05	8.92E-07	9.26E-09	9.01E-07
10	1.46E-05	3.78E-06	2.06E-08	3.80E-06
11	1.02E-04	5.42E-05	2.10E-07	5.44E-05
12	9.33E-05	4.86E-06	1.78E-08	4.88E-06
13	3.41E-03	8.46E-05	3.10E-08	8.46E-05
14	2.05E-04	1.08E-05	3.08E-08	1.08E-05
15	9.98E-04	4.60E-05	9.68E-08	4.61E-05
16	9.69E-05	1.84E-04	7.14E-07	1.84E-04
17	5.00E-03	5.50E-04	1.70E-06	5.52E-04

Site	**Local Cr(VI) PEC in air [µg/m3]**	**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]**
18	2.97E-05	1.43E-04	5.60E-07	1.44E-04
19	1.07E-08	3.38E-03	1.31E-05	3.39E-03
20	3.34E-04	8.26E-06	9.44E-09	8.27E-06
21	8.09E-04	2.00E-05	1.26E-08	2.00E-05
MIN	1.07E-08	1.25E-07	7.20E-09	1.32E-07
MAX	9.79E-03	8.10E-03	1.31E-05	8.10E-03
90th percentile	5.53E-03	5.50E-04	1.70E-06	5.52E-04
Median	2.37E-04	4.60E-05	7.32E-08	4.61E-05
AM	1.61E-03	6.26E-04	1.24E-06	6.27E-04

* 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 5.53E-03 µg/m^3 for the PEC in air and 5.52E-04 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.

Table Annex V-1: 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, powered & supplied air respiratory protection) TH3	EN 12941		200	100	200	200	40	40	**40**
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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